NATURE SKETCHES
IN TEMPERATE AMERICA

JOSEPH LANE HANCOCK

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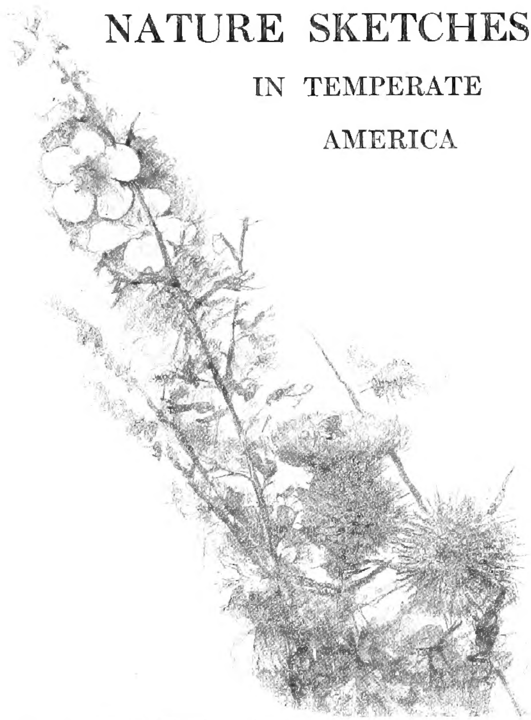


"Stranger, if thou hast learned a truth which needs no school of long experience, that the world is full of guilt and misery, and hast seen enough of all its sorrows, crimes, and cares, to tire thee of it, enter this wild wood and view the haunts of nature."

BRYANT.

From "Entrance to a Wood."

THE TROILUS BUTTERFLY
(*Papilio troilus*)

Visiting the cardinal flower (*Lobelia cardinalis*)
From a photograph

NATURE SKETCHES

IN

TEMPERATE AMERICA

A SERIES OF SKETCHES AND A POPULAR ACCOUNT
OF INSECTS, BIRDS, AND PLANTS, TREATED
FROM SOME ASPECTS OF THEIR
EVOLUTION AND ECOLOGICAL
RELATIONS

BY

JOSEPH LANE HANCOCK

M.D., F.E.S.

WITH TWO HUNDRED AND FIFTEEN ORIGINAL
ILLUSTRATIONS IN THE TEXT, AND TWELVE
COLORED PLATES BY THE AUTHOR

CHICAGO
A. C. McCLURG & CO.
1911

14
S23/VII/17

A.371825

Published, May, 1911

THE · PLIMPTON · PRESS
[W · D · O]
NORWOOD · MASS · U · S · A

TO

LOUISE LAMBERT HANCOCK

WHOSE UNTIRING INTEREST AND ENCOURAGEMENT
WAS ONE OF THE GREATEST INCENTIVES IN
ITS PREPARATION
THIS VOLUME IS GRATEFULLY
DEDICATED

PREFACE

IN a popular exposition of the facts gleaned from nature, such as the present work is intended to convey, it may be more agreeable to present the subject sometimes from the artistic or æsthetic point of view. This method does not sacrifice truth, which is the religion of science, but mitigates it, bringing about a wider reading circle and thereby serving a greater usefulness. This work consists essentially of suggestive essays drawn from observations afield, and treating of various insects, birds, and plants. In this account there is brought together a series of life histories of many of the animal forms. I have given more consideration here to the insects than to other groups of animals. I think this is justifiable when it is remembered how many more representatives of these animals populate the earth, as compared with other families of animals. The habits of some of the commoner species of Orthoptera, or grasshoppers and locusts, have been treated at length in the text. This feature, given in the last section of the book, along with the many photographic illustrations and drawings accenting their ecological relations, it is hoped, will interest the general reader in this group.

As above intimated, the relation of animals and plants to their natural surroundings has been kept constantly in mind throughout its preparation. I have treated the subject of protective resemblance and mimicry, as well as the various protective devices inherent in insects, in a series of chapters because of the unusual interest centred in this theme.

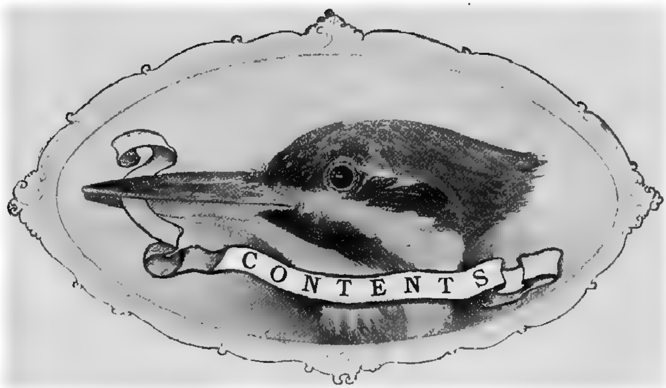
Many photographs are given, gathered with great care, of the actual live insects found in nature illustrative of protective resemblance and mimicry, and I have treated many of the examples given by Darwin in his "Origin of Species," but from the standpoint of my own views. It will be remembered that we have in the temperate region but a mere straggling of animal and plant forms compared to that found in the tropics. Yet the forms in this latitude tell us the same story of evolution as those of the hotter portions of the earth. I realize that I may color the facts at times with human imagination, but where there is danger of this I have always endeavored to support my contentions or optical proof with either photographic illustrations, or drawings from life, of what I saw. I am satisfied to let the reader draw his own conclusions.

The work has been divided into sections mainly through an endeavor to show the philosophy of evolution. First, I have brought forward sketches showing special adaptations and animal behavior. Secondly, by walks afield I have attempted in a simple manner to show the application of evolution to the objects viewed. In the table of contents will be found other subdivisions of the subject. When not otherwise stated, these word sketches have been drawn from my diary notes covering many years, made at Lakeside, Berrien County, Michigan.

It affords me great pleasure in this connection to acknowledge the generous assistance received in the correction of the manuscript to Professor Lillian V. Lambert, of the Iowa State Teachers College. My special obligation is also due Professor William L. Tower, of the University of Chicago, for useful suggestions while reading the manuscript, and to Dr. James W. Walker for carefully making typographical corrections in the page proofs.

J. L. H.

CHICAGO,
January, 1911.



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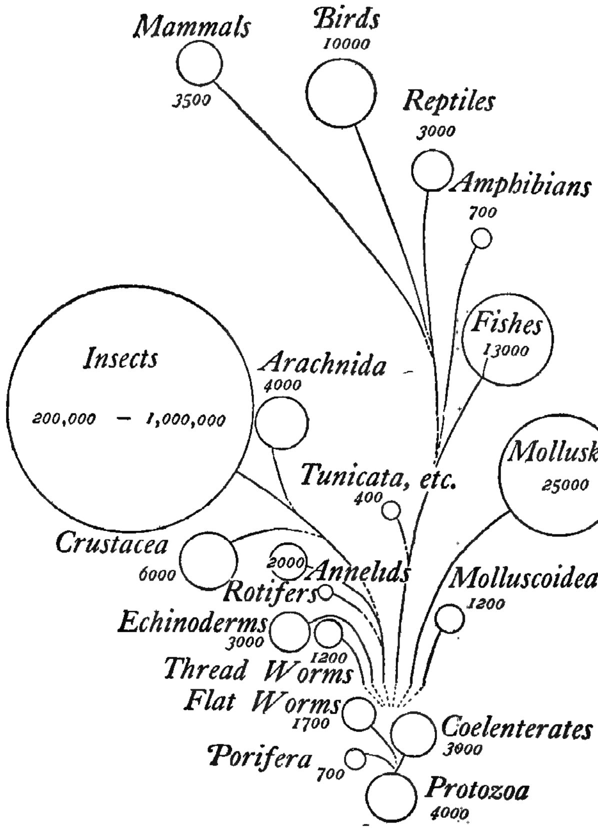
NOTE. — Unless otherwise stated the illustrations were made at Lakeside, Michigan.

I. EVOLUTION AND NATURAL SELECTION

INTRODUCTION


Mammals
3500
Birds
10000
Reptiles
3000
Amphibians
700
Fishes
13000
Insects
200,000 – 1,000,000
Arachnida
4000
Mollusks
25000
Tunicata, etc.
400
Crustacea
6000
2000
Annelids
Rotifers
Molluscoidea
1200
Echinoderms
3000
1200
Thread Worms
Flat Worms
1700
Coelenterates
3000
Porifera
700
Protozoa
4000

Nature Sketches in Temperate America

I. EVOLUTION AND NATURAL SELECTION

IT is my purpose to confine this brief historical sketch to some of the salient features of the theory of natural selection as applied to organic life. I shall attempt to show the presumed process by which organisms have changed and become modified into what are termed species. In so doing, I have stated some of the opinions of the principal workers in this field of biological science. Before the time of Linnæus the grouping of animals and plants was not founded upon any useful scientific plan, and it remained for him to bring forth system out of chaos. The system which he introduced comprised the grouping of animals according to their resemblance, both in external appearance and anatomical structure. This laid the foundation of systematic arrangement of animals which grouped them into class, order, genus, species, and variety. Until recently the majority of naturalists believed that species were unchangeable productions and had been separately designed and created. On the other hand, some of the earlier naturalists believed that species underwent modification and that the existing forms of life were the descendants of preëxisting forms.[1]

Passing over the allusions made to the subject by the earlier classical writers, we find that Lamarck was the first whose conclusions on the subject excited much attention. In his published views in 1809 he upholds the doctrine that all species, including man, are descendants from other species. He was the first who aroused attention to the probability of all change in the organic as well as the inorganic world being the result of natural causes, and not miraculous interposition. With respect to the means by which modification of animals was

[1] In this epitomized sketch I have borrowed freely from Darwin and the various other writers cited in the text.

brought about, he attributed something to the direct action of the physical conditions of life — something to the crossing of already existing forms, and again, much to the use and disuse of parts — that is, the effect of habit. To this latter agency, says Darwin, he seemed to attribute all the beautiful adaptations of nature, such as the long neck of the giraffe for browsing on the branches of trees. He also believed that all forms of life tend to progress, and in order to account for the existence of the present day simple forms of life, he maintained that they were spontaneously generated. Erasmus Darwin and Herbert Spencer held similar views, namely: that the effect of habit or increased use of structures leads to increase of their functional efficiency. These functionally produced modifications were supposed to be transmitted by inheritance.

Following Lamarck were Wells, Saint-Hilaire, Herbert, Grant, Matthew, Von Baer, and others. But we find that Darwin was the first to make the subject of evolution one of universal interest. "With one mighty stroke he released biology from the thraldom of supernaturalism, and the sciences all the way up to psychology have experienced a wonderful renaissance. To unveil that sacred mystery of mysteries and reduce it to the level of natural law was a shock to all Christendom."[1] In the place of special creation he set up progressive evolution through the operation of natural law.

SPECIES

In simple terms we speak of one of the higher animals as belonging to a *species.* This species is associated in the mind as having represented in its inherent ancestral make-up certain characters of genus, order, family, and kingdom, each of the characters being more and more fundamental as it goes back in its ancestral pedigree. Linnæus established the use of two names to apply to a species, one for the genus and one to designate the species. Modern science recognizes this method of naming species as the bionomic system of nomenclature.

Romanes[2] gives several definitions of species according to

[1] Whitman, "Congress of Arts and Sciences, Universal Exposition, St. Louis," Vol. V.

[2] "Darwin and After Darwin," Part II, p. 231.

the interpretations of naturalists, but the most satisfactory one is as follows: "A group of individuals which, however many characters they share with other individuals, agree in presenting one or more characters of a peculiar and hereditary kind with some certain degree of distinctness." Or another definition of a species may be: A group of individuals bearing close resemblance and primary relationships to each other. These resemblances include similarities even in minute structure, yet varying and occasionally mutating.

Those species living to-day are the latest surviving end product in the evolution of organic life. Individuals of a species interbreed freely. It has been held that one of the distinguishing points of species is that when they are crossed the resulting hybrid offspring are not fertile, but experimentation and observation have shown that in plants and animals this test of species does not hold good. Organisms are sensitive in their organization and respond to their environment, and this response to the surrounding influence is supposed to set up a tendency to vary. No two individual animals or plants are exactly alike. Systematic species as determined by eminent authorities are as a rule compound groups, often made up of two or three elementary types, and in some cases they comprise numerous constant and well-defined forms. The subdivisions of a species are distinguished from each other by more than one character, often by slight differences in nearly all their organs and qualities, and are designated elementary species. It is very difficult to estimate systematic differences on the ground of comparative studies alone, on account of the great number of varieties of the supposed type. The type from which a new species is described is to a certain extent only tentative, the final judgment in regard to it being more exactly determined only after direct experimental breeding. A mutation is usually rare and is often confined to one individual, while varieties are numerous in individuals. The difference exhibited by a sport may amount to a sudden, well-marked change, and present some modification strictly different from the parent type. A genus is an assemblage of species presenting many fundamental characters in common. Some genera are clearly definable, but others are not so clearly separated and are sometimes divided into subgenera, which is the lowest definable group of species.

In zoölogy the phylogeny, or descent, of only a portion of the groups of animals has been definitely ascertained, but the diagram from Galloway gives an approximate numerical relation of the groups as they exist on the earth. (See diagram facing first page of text.)

Struggle for Existence

In the past organic forms were recognized as species when intermediate forms were absent. When these connecting forms were living or were found in the fossil state, naturalists usually regarded the whole series as varieties and named all the members of it as belonging to the same species. In the naming of species they designated cases where connecting forms have not been observed.

In the systematic divisions of plants and animals in groups higher than species, such as genera, families, and orders, gradations have been traced which show these divisions should be regarded as conventional.

Although the pre-Darwinian students of nature recognized gradation among the groups of organisms, in the case of species they supposed them to be the miraculously created units of organic life, in contrast with the present conception that they are the product of natural evolution or gradual transmutation. Wallace states that so far as observation goes "every species has come into existence coincident both in space and time with preëxisting and closely allied species." Geological evidence shows that extinct species which now occur only as fossils on any given geological area, resemble the species still living upon that area.

It is obvious that the vast hordes of animals have a great struggle for existence, and it is to explain the philosophy of how these animals maintain themselves upon the earth, and the causes operating in perpetuating their lives, that the theory of natural selection is propounded. Darwin says:[1] "All organic beings without exception tend to increase at so high

[1] "Origin of Species."

a ratio that no district, no station, not even the whole surface of the land or the whole ocean would hold the progeny of a single pair after a certain number of generations. Even slow-breeding man has doubled in twenty-five years, and at this rate, in less than a thousand years, there would literally not be standing room for his progeny. In the same way all through nature every organic being may be said to be striving to the utmost to increase its numbers. The result is an ever recurrent struggle for existence. It has been truly said that all nature is at war. The strongest ultimately prevail, the weakest fail, and we well know that myriads of forms have disappeared from the face of the earth." Here we again recall the classic words of Darwin: "When we look at the plants and bushes clothing an entangled bank, we are tempted to attribute their proportional number and kind to what we call chance. But how false a view this is. What a struggle must have gone on during long centuries between different kinds of trees, each annually scattering its seeds by the thousand. What war between insect and insect, between insects, snails, and other animals, with birds and beasts of prey all striving to increase, all feeding on each other or on the trees, their seeds and seedlings, or on the other plants which first clothed the ground and thus checked the growth of the trees. But the struggle will almost invariably be more severe between the individuals of the same species, as they frequent the same districts, require the same food, and are exposed to the same dangers."

He further maintained that in all nature we see a strong tendency to variation. Now if any organic being varies even in a slight degree owing to change in environment, of which we have abundant geological evidence; if in the long course of ages inheritable variations ever arise in any way advantageous to any being under its exceedingly complex and changing relations of life, it would be a strange fact if beneficial variations never arose, seeing how many have arisen which man has taken advantage of for his own profit and pleasure. If, then, these contingencies ever occur, then the ever recurrent struggle for existence will determine that those variations, however slight, which are favorable shall be preserved or selected, and those which are unfavorable shall be destroyed, and from the strong principle of inheritance the selected variety will tend to propagate its new and modified form. Darwin says: "This preservation, in the battle of life, of varieties which possess advantages in structure, constitution, or instinct, I have called *natural selection.*" Spencer has well expressed the same idea by the *survival of the fittest.*

Darwin placed emphasis on the point that natural selection does not imply conscious choice. For brevity's sake he sometimes spoke of natural selection as an intelligent power in the same way as astronomers speak of the attraction of gravity as ruling the movements of the planets. Moreover, he often personified nature, but he adds: "I mean by nature only the aggregate action and product of many natural laws, and by laws the ascertained sequence of events as ascertained by us."

"Under domestication we see much variability caused, or at least excited, by changed conditions of life. Variability is governed by many complex laws, by correlated growth, compensation, the increased use and disuse of the parts,[1] and the definite action of the surrounding conditions, such as climate and food supplies. There is no question but that our domestic productions have been modified and these modifications have been inherited for long periods. Variability is not actually caused by man, but the organism is exposed to new conditions of life, and nature acts on the organization and causes it to vary."

But man can and does select variations given him by nature and thus accumulates them in any desired manner. "The key is man's power of accumulative selection, nature gives successive variations, man adds them up in certain directions useful to him. It is the magician's wand by means of which he may summon into life whatever form and mould he pleases." Taking the domestic pigeon, for example, he was able to trace its ancestry to the wild rock pigeon which is still extant. It is certain that man can select individual differences in a breed so slight as to be unappreciated except to an educated eye. Man can produce a great result by his methodical and unconscious means of selection.

[1] The variations caused by increased use and disuse of parts are not now considered by many investigators to be inherited.

"But man can act only on external and visible characters. Nature cares nothing for appearances, except in so far as they act on every internal organ, on every shade of constitutional difference, on the whole machinery of life. Man selects only for his own good, nature only for that of the being which she tends. Man keeps the natives of many climates in the same country — he feeds the long and short beaked pigeon on the same food. He often begins his selection by some half monstrous form, or at least by some modification prominent enough to be plainly useful to him. Under nature the slightest difference of structure or constitution may well turn the nicely balanced scale in the struggle for life and so be preserved."

"How fleeting are the wishes and efforts of man, how short his time, and consequently how poor will be his results compared with those accumulated by nature during whole geological periods! Can we wonder then that nature's productions should be far truer in character than man's productions; that they should be infinitely better adapted to the most complex conditions of life and should plainly bear the stamp of far higher workmanship? No breeder doubts the strong tendency to inheritance. That like produces like is his fundamental belief. Every one has heard of strange and rare deviations of structure being inherited. Now if these are freely admitted to be inherited, how much more are the less strange forms inherited." Darwin again says the laws governing inheritance are for the most part unknown. "Perhaps the correct way of viewing the whole subject would be to look at inheritance as a rule and non-inheritance as an anomaly. The whole subject of inheritance is wonderful. When a new character arises, whatever its nature may be, it tends to be inherited, at least in a temporary and sometimes in a persistent manner."

Castle has recently stated: "Every new individual arises out of material derived exclusively from its parents. This is the basis of heredity. But it does not follow that the new individual will resemble its parents merely. It may resemble remote ancestors more strongly than either parent. For it represents a combination of materials or of qualities derived from the two parents, and it is possible that neither parent may manifest all the peculiarities which it transmits to the offspring. For the parent is made up of two distinct parts, its own body and the reproductive substance contained within that body, and the two may not be identical in character."

The checks to inheritance as far as we know them are: firstly, circumstances hostile to the peculiar characters in question; secondly, conditions of life incessantly inducing fresh variability; and, lastly, the crossing of distinct varieties during some previous generation, together with reversion; that is, the tendency in the child to resemble its grandparents, more remote ancestors, or some distant member in a collateral line instead of its immediate parents.

A familiar example of reversion is the horns appearing in the young of hornless cattle. The offspring may present intermediate characters between those of the parents, which is known as *blended inheritance;* or the offspring may be more extreme than either parent, which is known as *intensified inheritance;* or, lastly, the offspring may exhibit characters differing from those of either parent, which is known as *heterogeneous inheritance.* In the case of sterile offspring, such as the mule, of course they are self-exterminating. Mendel brought forth the principle that the hybrid produces germ-cells like those of its parents in about equal numbers, and the character of its offspring will be dependent on the chance way in which these germ-cells are paired in fertilization. When the parental characters are preserved in the hybrids, that is unaltered, it is known as *alternative inheritance.*

Castle affirms that size variation is apparently continuous and its inheritance blending, while color variation is discontinuous and its inheritance is governed by Mendel's law.[1]

Brooks reminds us that in popular language specific stability may be said to be due to inheritance and specific mutability to variation. But in this connection these words have only a loose meaning, in so far as they convey the impression that the stability and mutability of species are antagonistic to each other. These terms are unfortunate, for we have good ground

[1] *Popular Science Monthly,* May, 1910, p. 426.

for believing that they are only contrasted aspects of the same phenomenon. For stability of species is due to survival in the same way that mutability is.

Evolution and Instinct

An action which requires experience to enable us to perform it, says Darwin, when performed by an animal, more especially by a very young one without experience, and when performed by many individuals in the same way without their knowing for what purpose it is performed, is usually said to be instinctive. A little dose of judgment or reason, says Huber, often comes into play even with animals low in the scale of life. Instinct has been defined as hereditary habit (behavior), comprising an element of transmitted experience. In all cases where instinct becomes complex or refined we seem compelled to accept the view that its origin is to be sought in consciously intelligent adjustment on the part of the ancestors. Many of the lower animals exhibit instinctive actions, such, for instance, as a spider spinning its web, a bird building its nest, and the beaver building a dam, these actions being performed the first time the animal tries almost as well as when it is older and experienced. Spencer supposed that intelligence first arose through the multiplication and coördination of reflex actions, and although many of the simple instincts grade into reflex actions, and can hardly be distinguished from them, yet the more complex instincts seem to have arisen independently of intelligence. Instinct has been described as being automatic obedience to the demands of external conditions. As these conditions vary with each kind of animal, so must the demand vary, and from this arises the great variety actually seen in the instincts of different animals. With others, instinct has been regarded as the natural survival of those methods of automatic response which were most useful to the life of the animal, the individuals having less effective methods of reflex action having perished, leaving no offspring.

As the mental qualities of animals vary and as instincts vary slightly in a state of nature, and as instincts are of the highest importance to each animal, there is no real difficulty under changing conditions of life, says Darwin, in "natural

The large parasitic Ichneumon Fly (Thalessa lunator), having a long ovipositor for drilling in trees. With extraordinary instinct it pierces the wood and deposits an egg in the burrow of the Tremex larva.

See page 13.

selection accumulating to any extent slight modifications of instinct which are in any way useful."

A remarkable example of perfected instinct is shown in one of the hymenopterous insects known as Thalessa (see illustration). This is an ichneumon fly having the end of the body provided with a long ovipositor with a chisel-like extremity. With this instrument she bores into the solid wood of a tree and with great precision strikes the burrow of the Tremex larva. After reaching the burrow she deposits an egg, which, soon after hatching into a larva, crawls along the burrow and attaches itself and feeds on the body of its victim.

Formation of New Species

It has been lately maintained by DeVries that species can come into existence within the space of a man's lifetime. This has been observed to take place in the evening primrose in a state of nature. Darwin maintained that natural selection acts by accumulating slight successive favorable variations. It can produce no great or sudden modification. But, according to DeVries, species have not arisen through gradual selection continued through hundreds of thousands of years, but through sudden, though small, transmutations, or steps.

In contrast with fluctuating variations, which are changes in a linear direction, the transformations called mutations diverge in new directions without apparent definite direction. MacDougal, after considerable experimentation, has gone so far as to say: "Having ascertained at what time in the life period of the individual mutations occur, I have been so fortunate as to secure results demonstrating that mutations may be induced in a species not hitherto active in this respect, and that it is possible to call out new species by the intervention of external agents during the critical period."[1]

Of DeVries' views on this subject Whitman says: "The so-called mutations of the primrose are undoubted facts, but two leading questions remain to be answered. First, are these

[1] "Heredity and the Origin of Species," 1905, p. 31.

mutations now appearing, as is claimed, independently of variations that took place in an earlier period in the history of these plants? Secondly, if species can spring into existence at a single leap without the assistance of cumulative variations, may they not also originate with such assistance? That variation does issue in new species and that selection is a factor, though not the only factor, in determining results is in my opinion as certain as that grass grows, although we cannot see it grow. It is then after all the slight individual differences that suffice for the work and are probably the sole differences which are effective in the production of new species."

Furthermore, Tower says: "Of late there has grown up, since the publication of DeVries' work, a tendency to ascribe to 'mutation' a far greater importance, and to a considerable extent to substitute that process for all others in evolution, even though DeVries distinctly points out that 'mutation' is complementary and not antagonistic to natural selection, and that the two are necessary in evolution — that is, 'mutation' explains the origin of variations in evolution, and natural selection their preservation." [1]

Weismann maintained that there are three principal stages of selection: that of personal selection as held by Darwin and Wallace, that of histonal selection as upheld by Roux in the form of the struggle of the parts, and, finally, that of germinal selection, the existence of which he endeavored to establish. He called the reproductive substance the germ plasm, and he maintained that this substance is distinct from the body and the influences that modify the character of the one do not necessarily modify the character of the other. These are the supposed factors that coöperate to maintain the forms of life constantly capable of life. It may be interesting to note that the study of variation has been aided considerably by mathematical science, that is, by the use of statistical measurements. This is accomplished by taking a series of hundreds or thousands of individuals of a species in a state of nature and, by making careful measurements of some of the more important structures of the animal and reducing them to figures,

[1] Investigation of Evolution in Chrysomelid Beetles of the Genus Leptinotarsa.

making deductions accordingly. In this way it has been shown by Galton that certain individuals of a species, represented by the mean measurements, survive in the struggle for existence, while those individuals which depart somewhat radically from this type, as represented by the maximum and minimum, are eliminated in the struggle for existence. This law was earlier known to Quetelet[1] and now bears the latter's name.

This law of trial by error has an important bearing on the question of evolution, especially on the origin of species, for it will be remembered that DeVries says the origin of species has been brought about by the sudden though slight changes that have been acquired and transmitted to the offspring. According to Quetelet's law, mutations would seemingly not be preserved in the struggle for existence (see under "Variation").

The question may be asked: If the tendency to variation is so great, why is it that some simple animals from the first apparently remain in the same condition? Why have not the more highly developed forms supplanted and exterminated the lower ones? In answer to these questions Darwin says that natural selection does not necessarily include progressive development, it only takes advantage of such variations as arise and are beneficial to each creature under its complex relation of life. He adds: "What advantage would it be to an earthworm or infusorium to be highly organized? If it were no advantage these forms would be left by natural selection unimproved, or but little improved, and might remain for indefinite ages in their present lowly condition. In some cases variations or individual differences of a favorable nature may never have arisen for natural selection to act on and accumulate."

There must arise something of a selective value, says Romanes, for natural selection to act on. Darwin further says: "In no case has time sufficed for the utmost possible amount of development. Nevertheless, low and simple forms will long endure if well fitted for their environment, namely, simple condition of life." Darwin's principle explains that selection takes place between individuals, while the mutation theory decides between whole species, and ultimately it is simply the ability for existence

[1] Discovered in 1846.

under given conditions that decides the permanence of a form. Variation is sometimes orderly tendency, — that is, there is definite variation, — or the species forming variability and mutability is indeterminate in direction. In either case it is not teleology, or adaptation to purpose, which was so effectually eliminated by Darwin. We find there is apparent difficulty for natural selection to account for the incipient stages of useful organs, and here *orthogenesis* attempts to remove this obstacle. The name was originally introduced by Haache, and later, among others, was championed by Eimer. The latter's work was dominated by a desire to show the inheritance of acquired characters.

Whitman [1] says that "without the assistance of some factor having more continuous directive efficiency, selection would fail to bring out of the chaos of chance variation or kaleidoscopic mutation, such progressive evolution as the organic world reveals. In order to show such a factor is essential, and that it is actually present, supplying the indispensable initial stages, and holding the master hand in the general direction of evolution, demonstrative evidence is, of course, required. Such evidence lies in *the history of specific characters*." After painstaking breeding experiments with pigeons covering many years, Whitman demonstrated by making phylogeny his guide as a starting point, that the orthogenetic process is a primary and fundamental one. By his researches, he found it comparatively easy to thread his way through the maze of color patterns existing among five hundred or more species of pigeons, and even to trace affinities farther back in the bird world.

Of the orthogenetic process he further says: "We find unlimited opportunity for the play of natural selection, escape the great difficulty of incipient stages, and readily understand why we find so many conditions arising and persisting without any direct help of selection."

Osborn [2] has recently given the influences which govern evolution as follows: "The life and the evolution of organisms continuously centre around the processes which we term

[1] "The Problem of the Origin of Species," Congress of Arts and Science, Universal Exposition, St Louis, 1904.

[2] Osborn in "Fifty Years of Darwinism," 1909, p. 238.

heredity, ontogeny, environment, and *selection;* these have been inseparable and interacting from the beginning; a change introduced or initiated through any one of these factors causes a change in all. First, that while inseparable from all the others, each process may in certain conditions become an initiative or leading factor; second, that in complex organisms one factor may at the same time be initiative to another group of characters, the inseparable action bringing about a continuously harmonious result."

Variation

Since Darwin's "Origin of Species" and especially in the last decade since DeVries' "Mutationstheorie" appeared, the statistical, quantitative, and experimental study of variation has received a new impetus, and there has developed a "biometric school." Experimental investigation of variation has made more exacting the study of the problem, but as yet no fundamental laws have been proved regarding the real causes of variation. As soon as a hypothesis is advanced, it is subjected to painstaking test and analysis, principally by breeding experiments of plants and animals. Variations dependent on environment or use are not now supposed to be inherited, while on the other hand, new characters are transmitted from parent to offspring. On this basis a classification of variations is formed on their heritability.

According to Jordan and Kellogg [1] variations may be either congenital or acquired; that is, may be such as are apparently determined in the organism at conception, or such as are imposed on it during its development by the influence of extrinsic factors. Or variations may be divided into determinate and indeterminate; that is, those (if there really are such) which are apparently controlled by some, to us unknown, influences and by these influences confined to certain lines or directions of change; and, on the other hand, those which are apparently wholly accidental, or rather which may represent any conceivably possible line or kind of change. Finally, variations may be distinguished as to their general character as continuous and discon-

[1] "Evolution and Animal Life," pp. 140, 141.

tinuous; that is, variations occurring irregularly, mostly large and comparatively rarely, and small abundant variations occurring in gradual series. Among the former are to be ranked the occasional sports and monsters familiar to breeders, while in the latter, Darwin believed himself to have at hand the necessary, ever-present materials to serve natural selection as a basis for species transformation. Hence the slight, but abundant and ever-present, fluctuating, continuous variations are often called "Darwinian variations."

The law of Quetelet applies solely to the Darwinian variations. The law is "that these variations occur according to the law of probabilities (or law of error); that is, that the slightest variations away from the modal or average type will be the most abundant, and that the number of varying individuals will be progressively less the farther away from the modal type the variations of these individuals are."

DeVries maintained that species have arisen without the aid of natural selection; the actual production of species being due to saltation or mutation quite in contrast with the gradual transmutation of Darwin.[1] This conception of species formation is different from the theories of Nägeli, Eimer, and Cope, who maintained that non-fortuitous and determinate variations were determined by certain causes inherent in life (Nägeli), or causes extrinsic to life, but imposed upon it (Eimer).

Recently Johannsen has endeavored to interpret by experimental investigation those slight variations that seem to be independent of environment, which the biometric students call "frequency polygon." Davenport,[2] in reviewing the work of Johannsen, says:

"The biometric 'school' laid stress on this sort of variation and held that by selective breeding from the extreme variants through many generations an indefinitely wide departure from a starting point might be effected. This DeVries denied, but held that, while such selection might lead to a certain departure from the mode, the degree of such a departure was restricted through a strong regressive tendency. Here

[1] Natural selection determines the future existence of the form in either case.
[2] *Science*, N. S., XXX, 1909, p. 852.

Johannsen steps in, analyzing more completely this result of breeding from the extremes of the frequency polygon.[1]

"The fundamental principle of Johannsen is that an ordinary frequency polygon is usually made up of measurements of a characteristic belonging to a non-homogeneous mass of individuals; that it is really analyzable into several elementary masses each of which has a frequency polygon of its own. In each elementary polygon the variation is strictly due to non-inheritable somatic modifications, selection of extremes of which has no genetic significance. But the selection for breeding of individuals belonging to different elementary polygons, lying, say, at the extremes of the complex, may quickly lead to an isolation of these elementary polygons, the constituent individuals of which reproduce their peculiarities as distinct elementary species. Thus Johannsen holds that not only do individuals with qualitatively dissimilar characters belong to distinct elementary species, but often such as are only quantitatively unlike. The complex variation-groups are called by the author *phaenotypes*, or false types, the elementary variation-groups are *genotypes*, or genetic types."

Utility and Natural Selection

Perhaps no principle has created more discussion than that which Darwin so earnestly impressed upon us, namely: that no special organs, no characteristic form of markings, no peculiarities of instinct or habit, no relation between species or races can exist but must now be, or at a previous time have been, useful to the individual or species which possesses them. Natural selection cannot possibly produce any modification exclusively for the good of another species, although they often take advantage of beneficial structures. Darwin also maintained that if it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate his theory, for such could not have been produced by natural selection. Wallace tells of the varied ways in which the coloring and form of animals serve for their protection,

[1] For further study of so-called frequency polygon consult "Davenport's Methods," second ed., 1904.

their strange disguises. The simulation of animals to other objects has been designated as "protective resemblance and mimicry." A great amount of attention was bestowed on this subject by Wallace in supporting the theory of natural selection.

Almost every one is familiar with some type of animal which resembles in a remarkable degree either the ground, or the bark of trees, or the vegetation upon which it lives. I will draw attention here to only two examples, namely: the arboreal katydid and cone-head grasshoppers, the legends under each figure explaining them. In the following pages are shown the walking-stick, common grasshoppers, stick larva, moths resembling leaves, as well as other examples serving as illustrations.

Examples of protective resemblance differ from examples of mimicry in that the former have the body colors assimilate with their environment, while in mimicry the animal bears a resemblance to a living animal usually possessing some special means of protection and supposed thereby to enjoy a certain immunity from attack by predaceous animals. The animal mimicked has some special structure which makes it distasteful to its enemies which prey upon it. Common examples of mimicry are found in butterflies, where one species possesses a scent which is said to be nauseous to birds, and the color pattern of that species is mimicked by other species of butterfly belonging to another genus. Then, there is the robber fly (described further on), which masquerades as a bumblebee, and in this mimicry is not only presumed to be protected, but is able to steal upon its prey unsuspected. In this means of protection natural selection is supposed to have been a factor in preserving modifications of structure. It is through slight differentiations and modifications of structure with transmission by inheritance that these extreme specializations of form appear to have been brought about.

Coexistent with these changes in animal life are modifications in the structure of plant life. For example, in some of the higher plants we find a great variety of the blossoms so modified and dependent upon the insect life that it is supposed that they would become exterminated were the insects that effect pollination to die out.

The period in which plants blossom is presumed to be brought

THE FEMALE ARBOREAL KATYDID
(*Cyrtophyllus perspicillatus*)

The green arboreal katydid is perfectly concealed while living among the foliage of trees. The male gives forth the familiar notes "katy-did." From a photograph.

about primarily by climatic conditions, but secondarily by natural selection. These adaptations have been affected by reason of the interrelation of insects and humming-birds to flowers, and also their adjustment to change of climate. The columbine blossoms in May at a time when the humming-bird and hawk-moth, which participate in its pollination, make their appearance. One of the most beautiful examples of adaptation found in our temperate climate is the little orange-tip butterfly with its associated white-flowered Arabis. The butterfly pollinates this flower while it feeds upon the sweets, and in the insect's visits it alights on the blossoms, closing its wings, and becomes almost invisible to human eyes. The greenish white markings on the underwings cause the butterfly's body to assimilate perfectly with the flower head, thus affording it protection from predaceous foes. Further on in the text I have treated this subject at greater length, and there will be found a colored illustration of the butterfly as it appeared on the flower. (See plate facing page 84.)

Other flowers, such as I have shown in the colored illustrations, blossom at other periods throughout the various seasons, each being adapted to its respective insect visitors upon which it is dependent for fertilization. Each of these flower forms presents a different type of color pattern and hue, often disposed to lure unconsciously its winged insects. This periodicity of the appearance of flowers has received considerable attention by naturalists, and they have shown in many instances the marvellous perfection of adaptation of structure having particular value to both insect and flower.[1]

Not only do we find many flowers luring visiting insects serving for fertilization, but we have instances of plants trapping insects and absorbing nutrition from them. These plants are provided with special structures which catch their insect prey. A familiar example is the common sundew, Drosera, which ensnares insects by means of sensitive tentacles disposed on the surface of the leaves. Similarly, the pitcher plant of our Northern States is provided with tubular leaves which contain water, to which insects are attracted and in which they drown. A digestive ferment is secreted which acts upon the bodies of the

[1] See under Plant Adaptations, p. 31.

insects, supplying the plant with nitrogenous food. Thus the insect and plant oscillations go hand in hand. Not only are these adjustments of structure to the environment presumed to be perfected by natural selection, but the physiological adjustments of plants and animals to the climate, temperature, and humidity are so poised that without adaptation life seemingly could not exist.

In our foregoing account we have explained but a small part of the great factors of evolution, treating natural selection in a brief *résumé*. We will now outline a phase of evolution which has proved a factor hand in hand with natural selection, namely: sexual selection.

Sexual Selection

Sexual selection must necessarily operate in animals where there are two sexes, such as birds, which exhibit quite a difference in the ornamentation of their plumage. This difference between the male and female coloration was thought by Darwin to have been brought about by a rivalry between the males in a struggle to win admiration from the opposite sex. This form of color modification may go hand in hand with structure, such as the wattles and combs and spurs which essentially belong to the male. These are presumed to have been perfected in the battle among themselves, the successful combatant winning the female and thereby transmitting these characters to the offspring.

It is not always possible, in the nature of the case, to determine how far sexual selection of this sort plays a part in the perfecting of these peculiar structures of the male, for after all it may be that natural selection has had something to do also in perfecting them. On this very point there was a difference of opinion between Darwin and his contemporary, Wallace. The latter did not make the fine distinction of supposing sexual selection to be a contributing factor in these cases, but relied on natural selection as being sufficient for their production.

Even in insects we find the so-called secondary sexual characters, but they are present only in the male. A most remarkable example of this type of structure in insects occurs in the striped meadow cricket, described at some length further on. It has an alluring gland on the back between the wings which

A PAIR OF THE SLENDER CONE-HEAD GRASSHOPPERS
(*Conocephalus attenuatus* [*ensiger*])

On golden rod; the female is shown below. The top figure is the male of the very small striped meadow grasshopper (Xiphidium fasciatum). From a photograph

secretes a plasmatic fluid quite inviting to the female. This pale green insect, in the male sex, has his forewings also so modified that when he shuffles them together over his body they produce a high-pitched shrilling, which attracts the female, if within hearing distance. Then he brings into action both the wings and the organ above referred to. The shrilling sound, together with the secretion in the hollow glands on his back, entices her to climb on him, and there she partakes of his loving cup. This performance is preliminary to the nuptial joining of the sexes.

The instrumental sounds made by the Orthoptera (grasshoppers, locusts, and crickets) are produced by various mechanisms, the basis of which is usually in the nature of file-like surfaces rubbed together. The music or sounds thus produced make up the majority of the medley of sounds to be heard in late Summer while walking through the meadows. These stridulating organs are secondary sexual in character, and are possessed only by the male. They, as Weismann says, "are of undoubted importance to the sex. These can certainly be attributed with great probability to sexual selection."[1]

Summary of Natural Selection

One of the most familiar criticisms of natural selection, says Brooks, is "that it does not produce, but only preserves the fitness which exists. It does not show why there should be any fit to survive, but only why the unfit are exterminated. They who challenge the sufficiency of natural selection on these grounds must remember that all science is inadequate in the same degree; for in no case does science tell us why natural phenomena do occur in order, although it does tell what order we may reasonably expect. However, the common verdict of mankind is that scientific knowledge is very adequate and sufficient for all the practical needs of living beings, even if it does fail to show us in nature any efficient cause for phenomena."

Natural selection, says Jordan,[2] "very likely is not *allmächtig*. Darwin never claimed that it was. But it is potent for all that, and the other factors in evolution work with

[1] "Studies in Theory of Descent," p. 62.
[2] *Science*, N. S., Vol. XXX, 1909, p. 528.

it, and not in place of it. The scheme of the evolution of species, through variation and heredity on the one hand, and the selective influence of the environment on the other, has not greatly changed since the date of the 'Origin of Species.' The method, degree, and to some extent the causes of variation, have been critically and successfully studied. The meaning and the machinery of heredity have been the subject of most fruitful investigation and experiment. Natural selection has been subjected to the most searching analyses, and the fact is that it remains the only general cause of the universal phenomena of adaptation of life to environment.

"Isolation has been separated from selection as a factor theoretically distinct, but practically coexistent. The supposed Lamarckian factors have disappeared, to reappear again in unknown and perhaps unknowable forms. Theories of elemental species, unit characters, and the like, have arisen to meet the facts and guesses involved in the investigation of mutation and the rediscovery of Mendelism, taking their place alongside of Darwin's bold hypothesis of pangenesis, to pass away when the hypotheses are no longer needed. With all this, on the whole, the scheme of organic evolution, as presented in the 'Origin of Species,' still holds as an outline. The work of fifty years has intensified the main features of the sketch, and has constantly added to the work of the master, without obliteration of any essential details."

With all the advance made in biology up to the present time, it may be stated that Darwin's work stands to-day as an ideal for biological research the world over, and natural selection, as Romanes says, "is the greatest idea that has ever entered the mind of man." [1]

[1] Those who are interested in organic evolution will find the following books of reference of particular value:

Darwin, "Origin of Species," and "Descent of Man."

Wallace, "Darwinism," and "Natural Selection and Tropical Nature."

Romanes, "Darwin and After Darwin," and "An Examination of Weismannism."

Lock, "Recent Progress in the Study of Variation, Heredity and Evolution."

Huxley, "Evolution in Biology," Encyclopædia Britannica.

DeVries, "Species and Varieties," and "The Mutation Theory" (English translation).

Kellogg, "Evolution and Animal Life," and "Darwinism To-day."

II. ADAPTATIONS IN ANIMALS AND PLANTS, WITH EXAMPLES

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Adaptation

IT is common knowledge that animals and plants respond to their environment, that is, to the physical influences exercised over them, and this gives them the power to continue to exist. Many of these responses are purely physiological and temporary, but some of them result in permanent structural change. Romanes states,[1] in regard to plants, "that it may fairly be doubted whether there is any one species of plant whose distribution exposes it to any considerable differences in its external conditions of life, which does not present more or less considerable differences as to its characters in different parts of its range." This is due largely to the effects of climate, the chemical and mechanical nature of the soil, temperature, intensity and duration of light, moisture, and the presence of certain salts in the air, as well as more unknown causes. Similarly, as a necessary part in the maintenance of existence, every animal adjusts itself to the surroundings. It must adapt itself to the food it finds, the air it breathes, as well as the climatic conditions. In consequence of these adjustments, modification with descent causes them to be transmitted from generation to generation. Of these vital adaptive characters, natural selection is presumed to be the important factor in their preservation. Those characters of a supposed non-essential type, such as some color markings on butterfly wings, due to variation, are supposed to be maintained by heredity and aided by isolation. By isolation, Romanes says, is meant "the prevention of intercrossing between a separated section of a species or kind and the rest of that species or kind, whether such a separation

[1] "Darwin and After Darwin," Part II, p. 206.

be due to geographical barriers, to migration, or to any other state of matters leading to exclusive breeding within the separated group."[1]

Numerous examples of special adaptations are given throughout this book. For instance, in the tree toad, which often selects the bark of trees to rest upon, the color changes so as to simulate exactly the colors of its surroundings, its body often appearing like a rounded excrescence on the bark. All the grasshoppers, notably the katydids, such as shown in the colored plate of the cone-head (facing page 22), are colored in simulation of their surroundings.

Then we have the walking-stick whose attenuate body resembles the twig of a tree. The humming-bird's bill and tongue are so modified as to gain ready access to flowers such as the columbine. Again, the modifications of the biting mouth-parts of grasshoppers and the suctorial tongue of the butterflies offer examples of adaptations familiar to all. It is readily conceived that the front legs of the mole cricket and those of the ordinary garden mole have been adapted and perfected to a particular kind of environment, of tunnelling under the ground.

While the conditions under which organisms of a specialized type remain the same, the species may be able to maintain themselves, but it is readily seen that extermination would likely follow any radical changes in the environment.

Plant Adaptations

In the dispersal of seeds of plants many contrivances have become specialized to assist in carrying them to places favorable to their germination and growth. The winged seeds of the maple and elm, the small, downy, and parachute-like structure of the milkweed and wild lettuce, present broad surfaces to the wind by which the seed is carried abroad. Others are provided with hooks, such as the burdock, and often become attached to the fur of animals. Again, there are many hard seeds that are contained in eatable fruits which are devoured by birds and mammals, and pass through

[1] Post-Darwinian questions in "Darwin and After Darwin," Part III, p. 2.

Plant and Insect Association of the Meadow in September

The blazing star (Lacinaria spicata) with its insect visitors, the butterfly (Argynnis bellona), and the clear-wing moth (Hemaris axillaris). From a photograph

their bodies unaffected. These seeds are favored in their germination by the heat and moisture to which they have been subjected, and perhaps later derive nourishment from the *excreta* passed with them. The fruits bearing the seeds often possess bright colors as they ripen and are charged with agreeably tasting juices which render them edible to animals. Some of these fruits are poisonous to some animals, but harmless to others. The bright orange mountain-ash berries are much enjoyed by the common waxwing; the black elderberries are consumed by several species of birds; and Wallace states that there is probably nowhere a brightly colored pulpy fruit which does not serve as a food for some species of bird or mammal. The drupes of the poison ivy are freely devoured by crows and in this way the plant is widely disseminated in our woods.

While the seeds are often dispersed as above described, it is an interesting fact, as Grant Allen has mentioned, that the fruits of our forest trees are protected during their development. At this time they are green when on the tree and hardly visible among the foliage, but as they ripen they turn brown and fall to the ground. Such, for instance, are the beech, butternuts, chestnuts, and the walnuts. The beechnuts and chestnuts are provided with a prickly coat that protects them to some extent, while the butternuts and walnuts have an acrid, pungent covering before they are ripe. I have seen young red squirrels eat nearly ripe beech and butternuts, biting through and discarding the outer covering. Out of the enormous quantities of these nuts that are produced some are doubtless able to propagate and produce young trees. The wild pigeons that formerly ranged over North America in such enormous flocks fed on acorns, which they swallowed whole without bruising, and these were digested and used up in nutriment. Squirrels and gophers are fond of acorns, and these nuts are destroyed by the acorn weevil, yet with all the great number of them consumed, there are enough produced that some of them find favorable places for germination and growth.

The smaller plants, such as grasses, sedges, composites, and umbelliferas, drop their seeds directly to the ground, and these have obscurely colored capsules and small brown seeds. Plants, such as the wild columbine, eject their small seeds by the bursting open of their capsules.

Wallace intimates a suggestive fact that dominant groups of our large forest trees, such as oaks and beeches, are among the most ancient of known dicotyledonous plants, going back to the cretaceous period with little change of type, so that it is not improbable that they may be older than any fruit-eating mammal adapted to feed upon their fruits. The attractive colored fruits, according to Grant Allen, on the other hand, having so many special adaptations to dispersal by birds and mammals, are probably of more recent origin.

Wallace maintains, "The apple and the plum tribes are not known earlier than the miocene period; and although the record of extinct vegetable life is extremely imperfect, and the real antiquity of these groups is no doubt very much greater, it is not improbable that the comparative antiquity of the fruit-bearing and nut-bearing trees may remain unchanged by further discoveries, as has almost always happened as regards the comparative antiquity of animal groups."

At the present time adaptation "is precisely one of the things evolutionists are trying to find the causes or causal factors of. But nevertheless the adaptability of life stuff, its plasticity and capacity of advantageous reaction, is, to many biologists, a fundamental fact in organic nature, like gravitation or chemical affinity in organic nature; a thing basic and inexplicable, and in itself a factor whose consequences are to be determined but not further to be questioned as to their cause." [1]

Flower and Insect Adaptations

Lubbock says that "not only have the form and colors, the bright tints, the sweet odors, and the nectar been gradually developed by the force of an unconscious selection exercised by insects, but even the arrangement of colors, the shape, the size, and the position of the petals, the relative position of the stamens and pistil are all determined by the visits of the insects, and in such a way as to assure the great object (fertilization) that these visits are intended to effect."

[1] Jordan and Kellogg, "Evolution and Animal Life," p. 56.

Many facts have been brought forward to prove that this relation actually exists, but not entirely on the assumption laid down by Lubbock. Recent studies by Bouvier, on the "Relation of Bees to Flowers," are summarized as follows: Nectar and nectaries are certainly intended primarily for the plant itself and do not prove an adaptation of the flower to insects. The colors and perfumes of flowers may be, perhaps, the result of such an adaptation, but in any case they strongly attract anthrophilian insects, signalling to them the presence of booty. In many cases, if not all, the complicated forms of the flowers must be attributed to the adaptation of flowers to their visits. It is almost unanimously conceded nowadays that Mellifera (or bees), at least in so far as their collecting apparatus is concerned, are beautifully adapted to the flowers, but, despite the fact that practice has shown that plants are in every way more plastic than animals, it is still strongly disputed that flowering plants have adapted themselves to bees. "If there does not exist any reciprocal modification," says Bouvier, "between the Mellifera (bees) and the flowering plants, it is not at all necessary to suppose that one group has been modified for the benefit of the other. Each has evolved on its own account." Explained thus, the many objections to the theory of reciprocal adaptation are overthrown. The bee has but one object, the pursuit of food, and all things which aid him in it are welcome. Usually, the plant profits thereby; sometimes it suffers. On the other hand, the plant seeks only to assure its propagation and all its modifications tend toward that goal. M. Gaston Bonnier quotes Claude Bernard as saying, "The law of the physiological finality is in each individual being and not outside it; the living organism is made for itself; it has its own intrinsic laws. It works for itself and not for others."

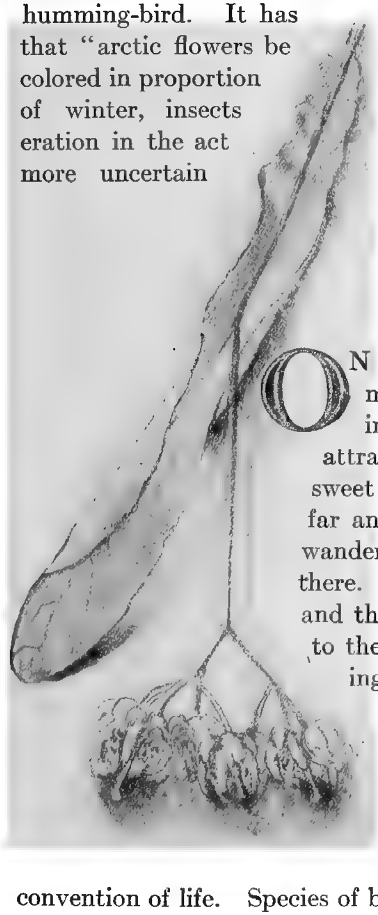
Darwin, Müller, Lubbock, as well as others, have written detailed accounts of the adaptations of flowers to insects.[1] During the visits of insects to flowers for the purpose of obtaining secretions of nectar and pollen, they involuntarily carry the pollen of one flower to the stigma of another, and thus

[1] For a discussion of this subject consult Wallace, "Natural Selection and Tropical Nature," p. 400.

effect cross-fertilization. Darwin was the first to demonstrate that the vigor and fertility of the next generation of plants were greatly increased by this process. It was, moreover, this discovery that led to researches which disclosed the most wonderful and complex arrangements that exist in flowers, all having for their object the prevention of constant self-fertilization; but that pollen shall be carried, either constantly or occasionally, from the flowers of one plant to those of another. There was thus established the fact that the arrangement, length, and position of all the parts of the flower have a definite purpose, though a great variety of ways exist by which this same result is obtained. Open cup-shaped and quite regular flowers, in which it seems inevitable that the pollen must fall on the stigma and produce constant self-fertilization, are often prevented from doing so by a physiological variation. In these cases the anthers, continually emitting their pollen, wither either a little earlier or a little later than the stigmas of the same flower or of other flowers on the same plant when in the best state to receive it. As individual plants differ somewhat in the time of flowering, the pollen of one plant would often be conveyed by insects to some other plant whose stigmas were in a proper condition to be fertilized by it.

Variations occurred in first one part, then in another, which have resulted in various adaptations for insect fertilization. Odors are developed as an attraction or guide to insect fertilization. Inconspicuous flowers are often possessed of strong, sweet odors, to be detected some distance away, while very showy flowers are seldom thus provided with scents. White flowers are usually exceedingly sweet perfumed. They are mostly fertilized by night-flying moths.

The grouping of flowers so that they attract insects is often of considerable advantage. They are often conspicuously displayed in a broad flat top, such as is exhibited in the elderberry and wild carrot. These groups are made up of many individual flowers. Then there is the grouping shown in those of the lilacs and horse-chestnut. Again, we witness them closely packed together in tiny florets forming dense heads, as in the clover and all the Compositae, and in these the marginal florets are modified into rays such as shown in the daisy, aster, and sunflower. Bees are much more of a factor in fertilization in the temperate zone than butterflies. It is a general rule that flowers fertilized by the latter are much more conspicuous than those fertilized by bees. It is generally the case that the time of blossoming of these plants corresponds with the appearance of certain insects and in a few cases adjusted to the time of arrival of the ruby-throated humming-bird. It has been asserted by Grisebach that "arctic flowers become larger and more richly colored in proportion as, by the increasing length of winter, insects become rarer, and their coöperation in the act of fecundation is exposed to more uncertain chances." [1]



Why the Nectar Gatherers Assemble on the Basswood Blossoms

ON a warm sunny day in the middle of July, the linden tree in blossom affords a centre of attraction for many insects. The sweet perfumed blossoms are scented far and wide by a host of busy little wanderers that come and congregate there. Such insects as the bumble and the honey bees are seen hanging to the pendent flower clusters, drinking the honey, while on the surface of the leaves many small flies play in the sunshine, and now and then take their lunch from the flowers. Argynnid and skipper butterflies participate in the grand convention of life. Species of bees, flies, and wasps collectively fly out into mid-air about the blossoms at every stir of the limbs and foliage. The birds, too, become aware of this meeting

[1] Wallace, in "Natural Selection and Tropical Nature," p. 407.

ground, and while viewing these sights, a Baltimore oriole snaps at some selected winged morsel. Like the mulberry tree in its attraction for birds, so the linden tree, in full blossom, is a delight to the senses of insect life, causing them to divide their attention between it, the chestnut, and the elderberry, which all blossom at the same time. Near one of the large basswood trees, where a view may be gained into its upper branches, the floral display alone, with its treat of perfume, is sufficient attraction; but, coupled with the harvest of insect visitors, one may easily spend a profitable hour contemplating the wonderful view, and adding something to the meaning of this great activity.

On examining the flowers of the basswood, the honey is found secreted and held in the hollow sepals. "The petals and sepals are overtopped by the numerous stamens which curve outward so that insects can only alight on the anthers, or on the stigmas and the space between them. The possibility of self-fertilization is almost excluded by the stamens remaining bent outward to the last, while the pistil occupies the axis of the flower; only rarely is a flower met with in which an anther has become curved inward to touch the stigma." [1]

The honey is only accessible to insects with short tongues. As none of the bees visiting the basswood blossoms had pollen in their baskets, Müller concluded that these insects visited the flowers for the honey and not for the pollen. There is an explanation of the cause of the diverse forms of insect frequenters to the basswood blossoms if we remember the observations of Knuth: "First, the more specialized a flower — *i.e.*, the more complex its structural arrangements and the more deeply seated its nectar — the less are its insect visitors indiscriminately drawn from the entire insect fauna of a district, and the more do they belong to one or several similar species adapted to pollination. Secondly, the flatter and more superficial the position of the nectar, the more varied are the visitors in different regions, and the more are they indiscriminately drawn from the entire insect fauna of the region in question." [2]

The basswood blossoms, shown in the plate illustration,

[1] Müller, "Fertilization of Flowers," p. 146.

[2] "Handbook," Vol. I, 1906, p. 196.

Insect Visitors to the Basswood Blossoms (Tilia americana). The insect on the flower to the right is a honey bee; the one to the left and the one flying are Syrphus flies (Sphaerophoria cylindrica). The lower insect is a small beetle flying.

have the nectar shallowly held in the hollow sepals accessible to a great variety of insect guests. The scent of these flowers is perceived for a distance of several hundred yards; the paraffinoids composing it have the peculiar property of increasing in intensity the farther away the perfume floats on the air up to a certain distance, when it finally disperses by diffusion through the air. In view of these facts, it is not difficult to perceive why the nectar gatherers have preference for the basswood flowers.

How the Milkweed Profits by the Visits of its Insect Guests

IN another chapter on the Monarch Butterfly and its Mimic, I will refer to the familiar banded larva found on the milkweed. On this plant are also found certain other insects. One can hardly think of the greenish purple umbels of the common milkweed without associating with these exquisitely perfumed flowers the red, four-spotted beetle, *Tetraopes tetraophthalmus.* This small beetle, which has blackish antennæ, is often seen in July resting on the leaves, singly or in pairs, as depicted in the colored plate (facing page 36). On sunshiny days it is also seen flying from one plant to another. The life of this insect is intimately connected with the milkweed, the roots and lower parts of the stems of this plant furnishing nutrition for the larvæ which penetrate and feed upon them.

Besides the almost constant presence of the red, four-spotted beetle, the perfumed flowers entice winged insects of many kinds. These include such forms as bees, wasps, flies, butterflies, moths, beetles, and occasionally bugs. Guided by the scent, the insects are easily led to the honey. But while the insects are in quest of this food, there is a reciprocal process between plant and guest. At the same time they visit the flowers they perform pollination, which is of great importance to the plant's perpetuation. The dependence of these plants upon insects as agents for transferring pollen is shown by the peculiar structure of the flowers, many of them

Insect Visitors to the Milkweed
(*Asclepias cornuti*)

The insects are the red-spotted beetles (Tetraopes tetraopthalmus), whose lives are intimately associated with this plant.
From a photograph

The Swamp Milkweed (Asclepias incarnata). It appears at the borders of ponds and swamps, lending color to these surroundings.

being as interesting in their adaptation to insect visitors as are the remarkable orchids.

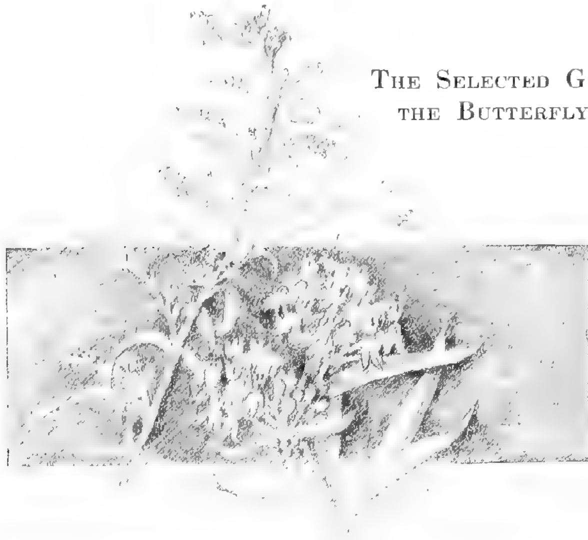
A more minute examination shows that the purple flower has the corolla deeply divided into five parts. Next to the corolla is a crown of five spreading hoods, each bearing within a slender incurved horn. The five stamens are attached to the corolla; the filaments are joined into a tube enclosing the pistil. The anthers are joined to the stigma and flexed inward and winged, broadening below the middle; and between these anther wings is a slit — the stigmatic chamber. This fissure is bridged above by the pollen-bearing organ known as the corpusculum. The latter may be compared to a wish-bone in shape; each flattened side is called a pollinia and forms part of two neighboring anthers. The upper part is formed into a wedge-shaped slit. One of the corpuscula lies within each of the five slits of the crown. Opposite the anthers there are five fleshy, leaf-like organs which secrete a large quantity of honey.

Müller says: "When insects creep about the umbels in search of honey, attracted by the sweet scent of the flowers, they slip upon the smooth parts of the flower until a foot enters the wide inferior part of the slit, in which it gets a firm hold. When the insect tries to draw its foot out in order to proceed farther, the diverging claws are caught by the opposed edges of the anther wings and guided upward in the slit, so that one or the other of the two claws is brought without fail into the notch in the lower border of the corpusculum and there held fast. If the insect now draws its foot forcibly out, it brings with it the corpusculum and two pollinia attached to it by their retinacula. The pollinia stand wide apart when they are extracted, but the retinacula twist upward as they dry, bringing the pollinia so close together that they may easily be introduced into another slit. As the insect moves over the umbel, its foot, bearing the pollinia, slips into the lower part of a slit of another flower; and this time, as the leg is drawn up, the pollinia are left in the stigmatic chamber opposite to the stigma, since the slit is too narrow to admit of their further passage upward, and the insect, freeing its foot by a violent pull, snaps the retinacula and so extricates itself. The pollinia are left behind in the stigmatic chamber while the corpusculum and its broken retinacula are carried off, still firmly attached to the insect's foot. The insect continues its visits and the retinacula attached to its feet now get fixed in corpuscula as the claws did before, and the insect's foot, after repeated visits, may sometimes be seen bearing corpuscula with their retinacula often dichotomously arranged."[1]

While the pollinia of the common milkweed is frequently attached to the claws of insects and rarely to the hairs and mouth parts, in the allied species of milkweed, *A. verticillata,* the pollinia are usually attached to the hairs of insect visitors. The peculiar structure of the milkweed flowers is such that small, weak insects are often entrapped and lose their lives by getting their feet entangled in the pollen masses or caught in the slits of the crown, from which they are unable to release them. I have found numbers of dead house flies on some of the flowers of the common milkweed, which had been too weak to extricate their feet from the slits. Similarly, on other occasions, I have found honey bees and Syrphus flies which had been held captive in the same way. Among unbidden guests of the common milkweed, ants are frequently seen, especially the larger, dark-colored species. At certain times I have seen them swarming over the stems and flowers. The species of swamp milkweed, *A. incarnata,* shown in the illustration, is easily distinguished from the common milkweed species. The dull crimson pink blossoms appear from July to September. It is fertilized by bees and bee-like flies and will be found full of interest when studied from the standpoint of its insect visitors acting as fertilizers of the flowers. It is also found at the border of ponds and in wet meadows. The common milkweed, on the other hand, grows in great luxuriance on dry, sandy ground.

[1] "Fertilization of Flowers," p. 398.

The Selected Guests of the Butterfly Weed



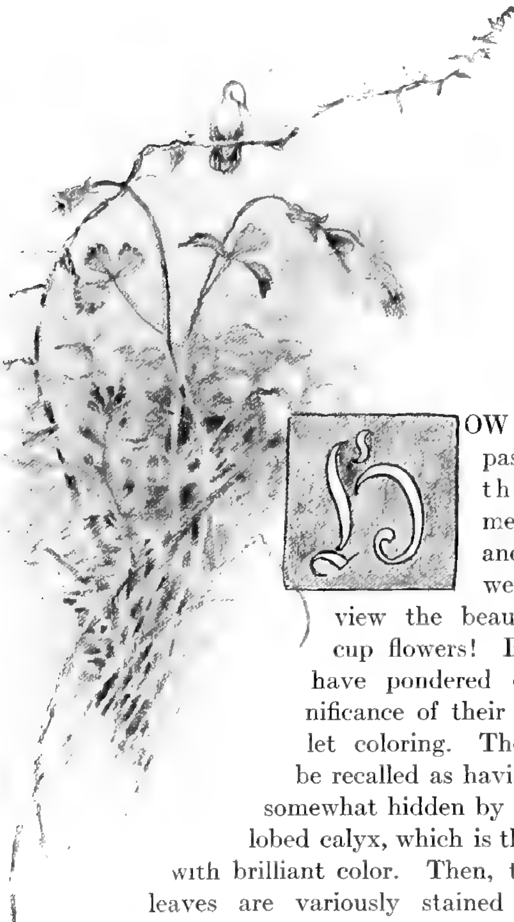
HOW brilliant the flowers of the orange butterfly weed appear in the field, when viewed in the bright sun of a July day! Under these conditions they show with a splendor only known to the flowers of this species. Not only the rich color of the blossoms appear to have charms for insect guests, but the pollen and sweets seem to meet their most exacting whims. A veritable entomological garden is spread before us as we approach. Various winged insects, from butterflies to small flies, are all busily occupied among the blossoms. Nearby are half-opened flowers of the goldenrod and the pretty, scented, lace-like flowers of the wild carrot, but they are for the moment completely ignored by these special insect guests.

I have already considered the structure of the blossoms of the common milkweed and have endeavored to show how the delicate and weaker flies and bees sometimes fall victims by having their feet entangled in the pollen masses of the flowers. These pollen organs or corpuscula become clasped, as if animated, to the feet of certain insects. Some of the weaker insects are unable to disentangle themselves, and these captives either die of exhaustion or fall prey to the ants, which often swarm upon these plants. The larger insects, such as the wasps, make their escape, carrying away the pollinia, which they transport to other blossoms during their visits. In this way they bring the pollen in contact with the stigma, and thus fertilize the flowers. But the butterfly weed differs from the common milkweed in possessing the allurements of brilliant color, though without fragrance. The weaker insects that frequent these blossoms are not destroyed in such numbers.

To the butterflies, the floral spread presents an enticing playground, as well as a place to banquet. And even the weak flies and small bugs move about among the bright flowers with impunity. But upon one wasp, Ammophila, and several bees, Bombus, the butterfly weed unconsciously enforces the more serious burden of literally compelling the transfer of pollen. When I carried this inquiry a little further, one day, by sweeping the insects one by one into my net, I found in the general round-up the following representatives: one large, slender-waisted wasp, Ammophila; three Argynnid butterflies, *Argynnis cybele;* one of the crescent-spot butterflies, *Phyciodes tharos;* one Ajax butterfly, a number of bees of the genus Bombus; several small, clear-wing flies, and two small bugs.

On examination of their feet with a hand magnifier, the real pollen carriers were revealed at once. The wasp's feet had a number of the pollinia attached to the hairs at different parts of the tarsi, while the bees' feet were fairly loaded with them. But as to the rest of the insects enumerated, I found their feet entirely free from polliniæ, they having escaped the pollinia traps set only for the larger forms that I have mentioned.

When finding the butterfly weed on some bright day, let the reader stop and meditate, and study the insect visitors, before thinking of recklessly picking these exquisite flowers that adorn the outdoor landscape. Then let me hear from those who have made new additions to the list of these flower frequenters, which I have only suggested in my sketch.



Bird Flowers

HOW many times in passing through the low, wet meadows in May and June, have we stopped to view the beautiful, painted cup flowers! But few of us have pondered over the significance of their brilliant scarlet coloring. The flowers will be recalled as having the corolla somewhat hidden by the long, two-lobed calyx, which is the part tipped with brilliant color. Then, too, the green leaves are variously stained in the same vermilion or scarlet, or, they may rarely be colored yellow. One day I was fortunate in coming on the scene at the proper moment, to view the pretty little ruby-throated humming-bird, thirsting after his long flight, dart down to sip the nectar from some of these blossoms. Only a short time previously I had seen him poised in mid-air before the blossoms of the columbine, which grew in the opening near the woods. The preference this bird shows for these flowers has a far deeper meaning than appears on the surface. On a previous page, attention was called to the pollination of flowers by insects, and here I have just witnessed the same phenomenon exhibited by the ruby-throat. If observations are carried further along in the season in July, August, and September, it will be found that certain flowers, such as the trumpet creeper, the spotted touch-me-not, and the cardinal flowers are really "bird flowers." In these flowers there is existing a reciprocal relation between the bird and flower, just as we have observed existing between flowers and insects.

The following are the characteristic features of these bird flowers: they are erect in position; are either pouch-shaped or cylindrical in form; are noted for their brilliancy of color, generally either scarlet or yellow, and for the great amount of nectar that they secrete.

In the tropics, they reach great perfection and variety of form, and in that latitude there exists coincidentally a great variety of humming-birds, with various elongated bills, to visit them. With us, there are fewer real bird flowers. These are all visited by the single species of humming-bird, the ruby-throat, that is found in summer over the whole temperate eastern North America. It proceeds north in the spring, during the vernal change in vegetation, and stays with us through the summer, and in the fall returns to the south. The migration of this species over such a vast extent of country is of particular interest in the present connection, for in carrying pollen from one flower to another situated widely apart, the cross-fertilization influence gives an impetus and strengthening character to the plants, as is well understood by students of plant breeding and was especially noted by Darwin.

The relation between the ruby-throat and the period of blooming of bird flowers has received considerable attention by naturalists. Robinson suggests[1] that the spring and autumn migration of this bird may account for the tendency of these bird flowers to form an early and late group. Sprengel showed in his writings, in 1787, that he believed that the nectar of flowers is secreted for the sake of insects and is protected from rain in order that the insects may get it pure and unspoiled. Without going into details here, he was evidently the first, as Müller believes, to "view the subject in the light of adapta-

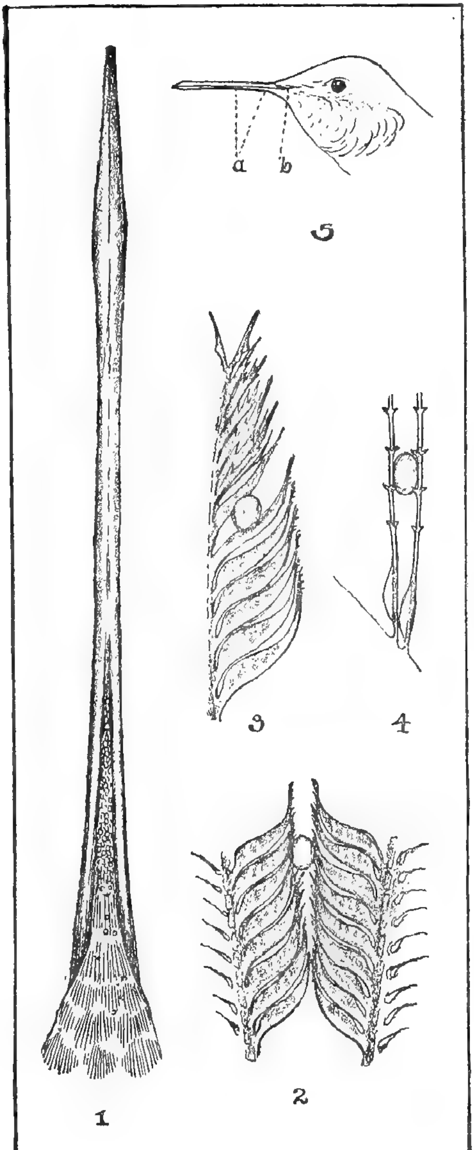
[1] *American Naturalist*, February, 1895, p. 113.

tion, and to show how all the colors, scents, and singular forms of flowers have some useful purpose."

Sprengel made no mention of bird-pollination at the time of his writings, and overlooked the fact that some of these flowers are adapted more to birds than to insects. It is readily seen that a strictly specialized type of humming-bird, such as the foreign Hermit species, would fail to exist in our latitude. It is adapted to certain South American plants having the corolla often several inches in length.

On the other hand, it was possible for a less differentiated bird type, with less specialized feeding habits, like our ruby-throated humming-bird, to succeed in establishing itself here. It is my opinion that insects were probably the first to visit flowers, but birds in search of these animals as food acquired a taste for the nectar, incidentally at first, and finally established an inherent taste for honey. Our own ruby-throat changes his diet from nectar to small spiders, or back again, according to the whim of his individual taste. While insects that frequent flowers often bear strictly specialized mouth parts in adaptation to their mode of life, the humming-bird's head and body appear to have been changed in accordance with his habits. Aside from the bill, which is modified in a remarkable manner, our ruby-throat bears unmistakable evidence of possessing devices which aid in the transference of pollen from one flower to another. The first account describing these structures I have published under the title of "Ornithophilus Pollination" in the *American Naturalist*, 1894. Moreover, it is from this source I have abstracted the following account of the method by which this bird pollinizes plants.

"The common ruby-throated humming-bird bears upon careful study evidence that the mouth parts and feathers have certain means for the harboring of pollen. The anatomical peculiarities of this bird's head allow access to flowers covering a wide range of forms. By reason of some flexibility, the bill is capable of probing to the bottom of nearly all the forms of flowers commonly met with. In the feeding process, familiar to almost every one, the flower is often bent over to be relieved of its juices. A cursory examination, with the naked eye, of this bird's head does not reveal with



Bill, Head, and Feathers of Ruby-throated Humming-bird, showing how pollen of plants is carried.

clear distinctness the main facts brought out by the use of a microscope, consequently, this instrument was brought into use in furthering research. Pollen is carried in several ways by this bird. On the lower mandible, just in front of the angle of the mouth, overshadowed by the nasal scale when the bill is closed, a faint yellowish line usually marks the deposit of pollen grains resting in a small groove, clustered together, as shown in Fig. 5 at point *b*. Pollen grains work their way free to the summit or vanes of the feathers about where they were seen scattered, and, as will be described further on, caught up by the barbs of feathers, along the sides of the chin and lores ready to be deposited when a more suitable surface presents. Under the lower bill, as shown in enlarged view, Fig. 1, and also

5a, the deep median groove, and the point of meeting of the rami, which traverses alone for nearly one-half its length, acts as a second repository. This pollen repository groove becomes divided backwards on either side for a short distance. Pollen lodges in larger quantities here and can be detected deep within the median portion of the groove. With a needle, the mass of grains which cluster together can be removed and separated with care. A small mass, only a fractional part of what still remained, showed, with a focus of one-fourth inch objective, hundreds of pollen grains. The long shaft of the bill also had upon its surface a few scattered ones. The most noteworthy phase of this subject remains yet to be recorded when the feathers are analyzed in greater detail, for here is to be found the real means of scattering the pollen, or pollination. The chief repositories having been just described as occurring below the angle of the mouth and in the median groove under the lower mandible, it remains to mention the part taken by the feathers.

There are four ways by which the pollen becomes engaged or held by the feathers, which will be better understood after the anatomy of the latter structure is touched upon. The feathers from the sides of the head, lores, and below, are mainly instrumental in this work. In general, they are much like feathers of other birds, of the contour type, plumulaceous at the base, composed of a short, weak calamus, a rhachis, vanes, barbs, and barbules, the latter being peculiar in that at the extremity of the vane the barbules are armed with sharp, thistle-like projections (barbicells), some of which are somewhat curved. The vanes at the base of the feathers are long and thread-like, near where they join the shaft are flattened, oar-fashion, as seen in Fig. 4. Little pointed barbs divide these filamentous vanes at regular, short distances.

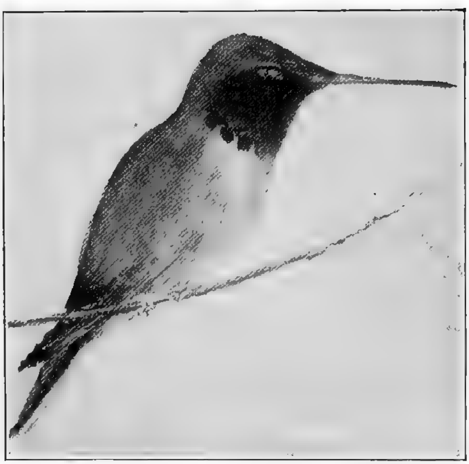
One of the methods of carrying pollen is here met with, between two of the vanes, as shown. The vanes of the upper part of the main body of the feather are made up of narrow, acute plates or barbs, resting close together. The barbs of another vane encroach or touch the barb of a neighboring vane, so that between them are found entrapped many pollen grains, as demonstrated in Fig. 2. Another way by which pollen is effectually engaged is by being held between two of the barbs, which are merely spread apart, giving room for the grain, as in Fig. 3.

The fourth method observed of carrying these fertilizing agents is an extraneous one, depending upon the glutinous secretion from the stigma of plants that adheres to the feathers, thus assisting the pollen to stick fast to the feather. Through a high magnifying power is seen the thistle-like ending of the vanes, the barbules frequently matted together by the sticky secretion referred to, gathered from the flowers while the birds are in search of food. Attached to the many pointed and flattened surfaces are seen pollen grains of many kinds, chiefly of very minute size, ready to depart or be taken on anew at the next visit to a flower. In flowers in which the wind is the agency for carrying the pollen, the grains are usually small, light, and more or less dry and spherical, while in insect flowers, the pollen of which is carried from one plant to another by insects in search of honey, the parts are variously adapted to cause the grains to adhere to the hairy underside of the insect's body to promote their dispersion. In bird pollination the grains are carried in such diverse ways that this, together with other data, combine to make it possible that the humming-bird is the most wonderful distributer of pollen known to the animal world.

I am not content to leave the subject without noticing that, as compared with insects, the local range of flight of humming-birds is undoubtedly greater, and during the regular migrations they make extensive flights, as I have already indicated. Their summer home in eastern North America extends from the Gulf of Mexico to half way across the British Provinces and from the Atlantic Coast to beyond the Mississippi River. In winter its range is southward, reaching into southern Florida, into Veragua and the eastern portion of the Isthmus of Panama, about eight degrees north of the equator. The equivalent of some 2,000 statute miles is thus represented in the migrations of this diminutive bird. The pollen taken *en route* during migration, as the humming-bird takes its sip of nectar from flower to flower, may gather in its repositories and be transported from place to place anywhere throughout its range.

That some strange pollen grains are found entangled upon the bird is not surprising, especially in the spring. Taking all these suggestions into consideration, what wonder is it that we are called upon to say that the phenomenon of so widespread a means of pollination of plants by the humming-bird is perhaps unparalleled.

In conclusion it may be said that some colors of flowers serve to make them visible and easily recognizable by insects, which are attracted thereto by the secretion of nectar and pollen. White flowers are nearly always excessively fragrant and are visited by night-flying insects. Bird flowers which have almost no fragrance, usually secrete an abundance of honey, are bright colored, and are visited in daytime by humming-birds. Both forms of these flowers seem to blossom at a time when their guests appear in greatest abundance.



Male Ruby-throated Humming-bird (Trochilus colubris).

The Little Pear-Shaped House on the Witch-Hazel Bough

EVERY one remembers the childhood rambles among the hazel bushes, and the green clusters of nuts growing upon their branches. How many times have we tasted the acrid coverings and turned them back to determine their stage of ripeness! This reminder is probably all that is necessary to dispel the possible confusion between the hazel shrubs and those of the witch-hazel, which are seemingly less familiar to the average person, but for the sake of those who do not recall the witch-hazel shrub, the illustration on this page will aid in this identification.

The seed capsule of witch-hazel is quite unlike that of the hazel nut, the former being outwardly formed something like an acorn covered with pubescence. The basal portion of the seed receptacle is like a little saucer, with four projecting processes, and colored the same dingy green as the top. The apex is divided into two small lips which are turned a trifle outward and are spined at the middle. In the fall, some of the witch-hazel branches are often fairly covered with the seed capsules, and when ripe they snap apart in the middle with considerable violence, throwing the hard, woody seeds in every direction over the surrounding ground. Frequently, in the open forests where these bushes abound, they attain a height of from ten to twelve feet.

On the branches of the witch-hazel one may come across some queer little prickly, pear-shaped galls, to which our attention is here directed. What an interesting piece of architecture one presents! It is covered with spiniform projections externally, while at the attached extremity it has a little round doorway. In the early summer, these spiny galls are greenish in color, but in the fall they shrivel and turn dark brown. One day, on dissecting some of these galls with the blade of a pocket knife, I found that they were shaped into a hollow shell, daintily lined inside with a fine frost-like coating. Under the magnifying glass I found a clue as to who the architect was, though he had doubtless disappeared some time before. He had, however, left some cast-off skins and waxy secretions, and through this means I identified him as a species of plant louse, *Hamamelistes spinosus.*

The gall has a single roomy chamber and its entrance opens in a funnel-shaped doorway at the small attached extremity. Through this opening the tenants have free access to the outer air. On further search, I found among the whitish particles the remains of some Brachonid parasites. Here, too, a live spider was found, hidden among the exuviæ. Each one of these dwellers had its day of residence. But the spider was determined that no more strangers should enter, and had sealed the passageway against further newcomers with strands of silk.

It was not until the following season that the opportunity finally came of my making the acquaintance of the adult, migrant, gall-making plant louse. On August fourth, when examining one of these galls, there poured forth from the entrance a quantity of aphids in the pupa stage. They soon swarmed out from the entrance of the gall upon the stem of the witch-hazel twig, and in the course of several hours they had nearly all shed their last skins. As fast as these pupæ shed their final epidermal coverings they flew away, dispersing in the air. Where they went will be described in the sequence. I took the opportunity of photographing the branch of witch-hazel containing some of the aphids as they were making their final departure from the gall, as shown in the illustration.

From Pergande, we learn that the early generations live upon the witch-hazel. The eggs are laid between the crotches

The Spiny Gall on the Witch-hazel, showing the gall-producing aphid (Hamamelistes spinosus) in the act of leaving the gall to fly to the birch trees. The stem mother which produces the gall is shown in the upper right of the plate.

formed by the twigs and petioles of the flower buds. The young, after hatching from these eggs, settle down on the side toward the twig near the base. In one of the grooves of the buds, the young individual called the stem mother (see plate) inserts her beak, and feeding on the juices, together with some subtle, irritating substance which she injects, causes the remarkable transformation of the embryo bud into the spiny gall. The formation of the young gall is quite rapid, the bud on the side toward the insect lengthening and growing over the gall-maker. At first it is a rosy color, but after a time, when it becomes about half-grown, it loses the red tint and becomes green. By the end of June or the beginning of July it is mature. Within the chambered house, the stem mother has become very prolific, giving birth to as many as two hundred of her own progeny. Early in July, or about a month and a half after the hatching of this stem mother, the earliest migrants, her descendants, are fully developed. They then commence leaving the gall and continue to issue forth until late in the fall, migrating to the leaves of the birches where they deposit their larvæ. The latter, after feeding on the birch leaves, settle down close to the bud, getting ready for their transformation and for hibernation.

These larvæ represent the third, or Coccidiform, generation and their growth is very slow, many of them perishing here before spring, so that few adult females survive. These Coccidiform adults that come forth deposit their larvæ on the tender leaflets just budding out. By their sucking process, irritation is set up at the edges of the young leaves, making certain changes that cause them to turn down and also cause bulging of the upper surface. This gives rise to corrugation, or pseudo-galls, of reddish or crimson color. It must be remembered that this is quite a different gall from the spiny gall on the witch-hazel, yet produced by the same insect species.

Between the folds of the gall these insects live and grow rapidly, reaching full development by the end of April or early May. The fourth generation is quite unlike the Coccidiform generation. It is during the fifth generation that the winged return migrant is produced, which is much smaller than those leaving the witch-hazel, and it returns to the witch-hazel in June. From these individuals are produced the sixth generation. The sexes now come together for the first time and after union lay their eggs on the witch-hazel. These eggs in turn hatch into the stem mother first described. The sixth generation are wingless forms and reach maturity in two or three weeks. Their eggs are laid about the middle or end of June and it is the young from these eggs that hatch about the time the flower buds are developing on the witch-hazel.

In this cycle of life is exemplified a remarkable case of parthenogenesis, or the giving forth by birth of individuals from an unimpregnated female. The virgin female here has the latent power to give birth to live larvæ, and each generation, from the first to the sixth, has similar power. All the adult females have some easily recognizable differences in structure, and the whole cycle starts over again each alternating year, commencing with the egg.

Cockerell has advanced the idea of accounting for the evolution of galls on the theory that the secretions of certain earlier mining insects caused a swelling to appear, where the larvæ lived, on which excrescence they fed. "It is easy to see that the greater the excrescence, and the greater the tendency of the larvæ to feed upon it instead of destroying the vital tissues, the smaller is the amount of harm to the plant. Now the continued life and vitality of the plant is beneficial to the larvæ, and the larger or more perfect the gall, the greater the amount of available food. Hence natural selection will have preserved and accumulated the gall-forming tendencies as not only beneficial to the larvæ, but as a means whereby the larvæ can feed with least harm to the plant. So far from being developed for the exclusive benefit of the larvæ, it is easy to see that allowing a tendency to gall-formation, natural selection would have developed galls exclusively for the benefit of the plants so that they might suffer a minimum of harm from the unavoidable attacks of insects." [1]

The great number and variety of galls agree in presenting a more or less elaborate structure, says Romanes,[2] which is not only foreign to any of the uses of plant life, but singularly

[1] *Entomologist,* March, 1890.

[2] "Darwin and After Darwin," Part I, p. 293.

and specifically adapted to those of the insect life which they shelter. Yet they are produced by a growth of the plant itself when suitably stimulated by the insects' inoculation — or, according to recent observations, by emanations from the bodies of the larvæ which develop from eggs deposited in the plant by the insect. Evolution may have acted through the insects, for "it may very well have been that natural selection would ever tend to preserve those individual insects, the quality of whose emanations tended to produce the form of galls best suited to nourish the insect progeny; and thus the character of these pathological growths may have become ever better adapted to the needs of the insects."

The Guests of the Wild Bergamot

In late summer the wild bergamot often grows in clumps covering large patches of ground, in pastures, fields, and roadsides. Where these flowers are thus assembled, bumblebees and butterflies are often seen drinking the sweets. It is not until one carefully studies the flowers of this plant, together with its insect guests, that some interesting facts are brought to light concerning adaptations. In the first place, the tubes of the flowers are seen to be quite long, indicating that they are more nearly adapted for long-tongued insects such as butterflies and moths.

According to Robertson, the peculiar form of the tube, the two-lipped corolla, and the position of the stamens and style, indicate that the flower is a modification of a flower originally adapted to bumblebees. The level-topped heads, the erect corollas, the exposed organs, and rose color make it an attraction for butterflies, — the principal guests. Pammel says that the Iowa flowers, as well as those of Wyoming and Colorado, are frequently visited by bumblebees, though butterflies are not uncommon on the flowers in Iowa. In Michigan, I have found that the bees far outnumber the butterflies as frequenters of the flowers.

These flowers are probably in the process of active changes from bee flowers to butterfly flowers. The change is, perhaps, somewhat hindered, owing to the different insect visitors they

The Wild Bergamot (Monarda fistulosa) and its little yellow butterfly visitor, Terrias lisa.

have as guests from year to year. One species of butterfly which is frequently found on the blossoms is the pretty little yellow species, *Terrias lisa*, which is shown in the illustration, just as it is about to alight on a flower. As the larvæ of this insect feed on a species of cassia and on clover, the visits of the butterfly to the wild bergamot are for nectar. It must be admitted that structures of flowers often appear to have indifferent characters which are difficult to account for on the ground of natural selection. It is, however, more often our ignorance of the complex life as well as a quantitative analysis of variations of a flower that lead us astray in interpreting these structures.

The Seasonal Procession of the Flowers, Insects, and Birds

HARDLY can we realize the changes being wrought in the woods and meadows unless we keep in close touch with the varied conditions of nature. On August twenty-second, after a night of rain, I find the following summing up of the day's reflections: The flowers of the wild bergamot, which a few weeks ago appeared in their best colors, are now fast fading. It is rare that a perfect, fresh flower can be found unless it may be one growing in some shady spot. With the going out of the bergamot are contrasted the cardinal flowers, which are now

The Troilus Butterfly (Papilio troilus) visiting the Cardinal Flower (Lobelia cardinalis). This butterfly, along with the ruby-throated humming-bird, aids in the cross-fertilization of this flower. It mimics the butterfly Pharmacophagus (Papilio) philenor on both upper and lower wing-surfaces. See colored frontispiece.

at their height. I found them at one point skirting the wet woods; in another they grew in the swampy portions of the meadows, giving a glorious effect to the plant groups there gathered. Here I saw the black butterfly, *Papilio troilus*, as shown in illustration on page 57, flitting down upon these blossoms, dividing its time, one moment here and the next moment on the boneset. I have just observed this exquisite swallow-tail as it flits away, to be suddenly replaced by the allied species, *philenor*. In its turn comes the dashing little ruby-throated humming-bird that especially loves to delve in these blossoms, while keeping company beside it is the bumblebee, *Bombus americanorum*, which sometimes illegitimately steals the nectar through the slit.

On viewing these brilliant cardinal flowers, one is reminded of Robertson's remarks concerning them: "The pendent lip shows that the flower is intended to be visited by a bird or insect which is in the habit of sucking the sweets from flowers without resting upon them."[1] What a suggestion in the philosophy of the flowering seasons lies here; the procession of the flowers being timed to the appearance of this bird as well as the bees. But I have already touched upon this topic more at length in the part on Bird Flowers.

At this time the pods of the large, common milkweed are well developed, while the flowers are getting scarce. The white blossoms of the wild carrot are presenting their exquisite heads; they spring up in the mowed fields, breaking the monotony of the wide, open stretches. The bugle-weed, like the boneset, now thrives luxuriantly, seemingly competing with the goldenrod in suitable places.

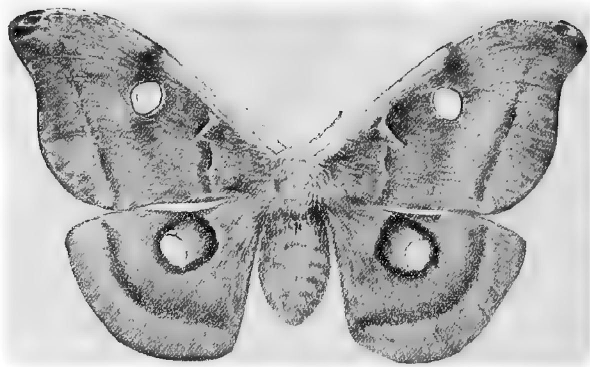
Blight among the leaves of plants, parasitic invasion, and the many ragged leaves from the attacks of developing larvæ or hungry grasshoppers, bring on a noticeable change; withering and senescence show their effect on the one hand, while on the other hand new life springs into existence.

The flowers of the button bush have entirely disappeared; the green seed balls now hang from the bushes. With the dropping of the white flowers there passed a beautiful scene of insect activity about these perfumed heads. Peering out

[1] *Botanical Gazette*, Vol. XVI, 1891.

near the top of the giant mullein stems, which have taken on a brownish hue, are just a few of the yellow blossoms. As I wander through the wet meadow, I find in various stages of blossoming the daisy and common fleabane, the spotted jewel weed near the woods, scattered vervain, knotweed, evening primrose, self-heal, Joe-pye-weed, pearly everlasting, and pasture thistles, showing their season of blossoming. In my previous rambles I have noted the progressive steps of growth, maturity, and senescence through the seasons, the maximum number of flowers seeming to appear and to be timed to correspond to the presence of the greatest number of insects upon which the flowers are dependent for fertilization. At this time among the thickets of ferns, the matured katydids, the meadow grasshoppers, and the crickets are answering each other from every quarter with their day calls; while there is an appreciable increase everywhere in mature grasshoppers and locusts. Among the open groves of trees new cicada songsters are heard, adding more and more to our procession of maturing life.

Little by little the barn swallows are flocking together, getting in readiness for the pending vital migration. The clump of wild rose bushes in the pasture, which furnished so much interest, of late has lost its little nestling song sparrows. They have reached the proper age and dignified size to leave the nest and are being fed by the parents in the willows. The flight into the bushes shows the muscular power of their wings to be excellently developed, and the family of four are accumulating strength for the advent of migration, and thus we view the fast changing scenes.



What the Polyphemus Moth and Caterpillar Suggest

THE moth given in the illustration above is a common species, known as *Telea polyphemus.* Toward the end of July and during August, I found the full grown larvæ of this moth on the leaves of the oak and lime trees. It is said to feed also on the leaves of a great variety of trees, including birch, maple, elm, chestnut, sycamore, and beech.

The caterpillar of this moth, shown in the illustration, is a delicate shade of green, having the sides of the body ornamented with lines of pure white. The feet and head are brown, while there is a V-shaped border of the same color at the end of the body. It is here figured in a state of rest, the body being contracted in length. The hairy warts are tinted with orange and red in life. It resembles the luna caterpillar quite closely, but its food habits are somewhat different as the latter is found almost entirely on the walnut and hickory.

The cocoon of this caterpillar is made like that of the luna moth, being usually constructed of two or three leaves drawn together with silken threads. Within this recess of leaves it spins a very densely woven structure, and into the fibres composing it the larva mixes a brownish substance that soon dries and hardens. The cocoon is about an inch and three-quarters in length. After its completion, the caterpillar proceeds with its transformation into the pupa stage. In the

The Polyphemus Caterpillar on basswood in contracted attitude. This large larva is excellently protected by its green coloration against the leafy background in its natural surroundings.

fall their cocoons drop to the ground where they remain until late spring or early summer (June) when the moths finally emerge. The polyphemus caterpillar is often the victim of the ichneumon insect known as *Ophion macrurum;* the latter parasite laying its eggs on the skin of the caterpillar's body and finally causing its death.

Before reaching maturity this larva passes through five different larval stages, or four moults; Trouvelot[1] states that he has observed six larval stages. Sometimes the eggs of the moth are parasitized by the little parasitic insect, *Telenomus sphingis.* In warm seasons when the summers are very long, there appear to be two broods.

The large, ochre-colored moth, whose wings expand over five inches, is subject to great variation, as many as six varieties being recorded. The moth, at about the middle of the forewings, presents a transparent spot encircled with a very thin edging of black. The front margin of the wings is gray, while just behind it the ground color is often tinged with brown; near the base of the forewings are broken white lines, edged outwardly with black or dark brown. There is a dark, curved, clouded line that extends across the lower wings parallel with the edge, and is continued on the anterior wings forward more than half-way across. The hind wings are exquisitely marked, bearing a conspicuous eye-like window near the middle, margined with deep black and inwardly reflecting a blue shading, which disappears into the black. Darwin suggests that the eye spots on the hind wings of moths are pierced by birds in their attacks on these insects and thereby save the vital parts from destruction. The geographical range of this species is across the entire continent of America, extending into Mexico.

There are several questions that present themselves as we review the above sketch of its life history. These resolve themselves as follows: First, the cause of the seemingly great abundance of this spécies; second, the cause of the number of varieties; third, the cause of its polyphagous habit, or ability to feed on a great variety of food plants; fourth, the cause of the wide distribution of the species.

It is obvious that the abundance of this insect shows that

[1] *American Naturalist,* Vol. I, 1867.

it is well protected in some important ways against its enemies, notwithstanding the fact that many individuals are sacrificed in the egg and larval stages by parasites, and later on in life, by larger enemies. The tubercles and hairs of the larva, as well as the markings, play an important part in protecting the body against birds and lizards. Moreover, the green larvæ are well protected when on their food plants, for I have repeatedly observed how perfectly they blend against the leafy background. There are undoubtedly other unknown factors, besides those considered, which act in a beneficial way to preserve the species.

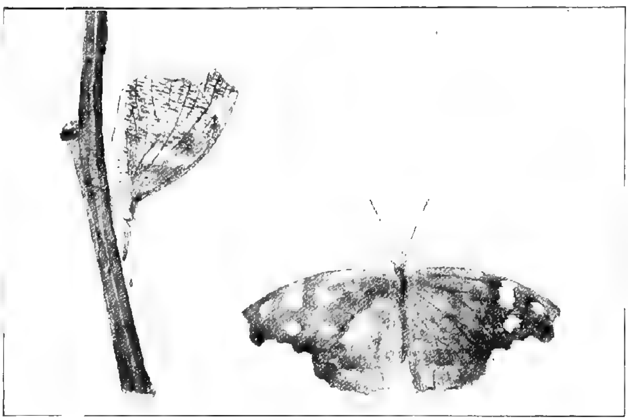
As to the variations noted in this species, I surmise that the color varieties may be influenced by the larvæ feeding on diverse food plants, and the difference in the amount of nourishment they obtain thereby. Then, too, there is the difference in the temperature and humidity the species is subjected to, as a result of covering such a wide range of territory. Pictet[1] has shown in experiments on several moths, notably *Ocneria dispar*, that by changing the food of the caterpillars of one or two generations the moths showed great variations from the normal forms in color and size.

The wide distribution of the polyphemus moth seems to have been brought about largely by the very fact of its adaptation to many food plants, polyphagous habits, which would facilitate its adaptation to new fields. It is obvious that a species living on many food plants would stand a much better chance of being preserved than if its food were restricted to one plant.

Passing briefly in review, it is found that there is a series of adaptations which begin in the egg and end in the adult moth. Each stage has its special contentions independent of the others. It is easily conceived that out of the hundreds of eggs laid by this moth, comparatively few individuals, after escaping parasitism, pass through the struggle of life and are able to perpetuate the species. Yet in spite of the hazards encountered during the egg, larval, and pupa stages the polyphemus is one of our most common moths. Darwin[2] says in a letter to

[1] Mentioned by Morgan, "Experimental Zoölogy."
[2] "Life and Letters," p. 132.

Lyell, "I always repeat to myself that we hardly know why any one single species is rare or common in the best-known countries." Whether a species is abundant in a given locality is necessarily determined by natural causes. Chief among the conditions favoring existence of a species are its adjustment to its surroundings, that is, maintaining itself against competition with members of the same species and other enemies, and the resistance to climatic conditions. I have attempted in the foregoing account to exemplify by the polyphemus moth some of its adaptations to these varied conditions.



Protective resemblance in the snout butterfly (Libythea backmanni). The palpi project forward so as to resemble a stem, the underside of the wings simulate a dried leaf. This insect appears in May.

III. PROTECTIVE RESEMBLANCE, WITH EXAMPLES

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Darwin's Theory of Protective Resemblance

WHEN we study animal life in general, it is remarkable how many animals are afforded concealment by their outer colors. This adaptation of external coloring to the conditions of life is often associated with corresponding changes of structure and secures to the animal still further safety by concealment. In the one case it is *color protection,* in the other *form protection,* the two sometimes appearing in the same animal.

Modification of color so that it assimilates with that of the surrounding environment has become highly specialized in some animals. The protective hues of the small ground sparrows, the quail, grouse, and whip-poor-will are familiar examples among birds, while in the whole family to which the grasshoppers belong the insects present more or less monochrome color patterns that aid in their concealment.

Wallace writes: "It seems to be in proportion to their sluggish motions or absence of other means of defence, that insects possess the protective coloring. In the tropics there are thousands of species of insects which rest during the day, clinging to the bark of dead or fallen trees, and the greater portion of these are delicately mottled with gray and brown tints which, though symmetrically disposed and infinitely varied, yet blend so completely with the usual colors of the bark, that at a distance of two or three feet they are quite undistinguishable."

It will be remembered that Darwin[1] placed considerable stress on this subject. In his "Origin of Species" he says: "Insects often resemble for sake of protection various objects,

[1] "Origin of Species," pp. 214, 215.

such as green or decayed leaves, dead twigs, bits of lichen, flowers, spines, excrement of birds, and living insects; . . . The resemblance is often wonderfully close and is not confined to color, but extends to form and even to the manner in which the insects hold themselves. The caterpillars which project motionless like dead twigs from the bushes on which they feed offer an excellent instance of a resemblance of this kind. The cases of the imitation of such objects as the excrement of birds are rare and exceptional. . . . But in all the foregoing cases the insects in their original state no doubt presented some rude and accidental resemblance to an object commonly found in the stations frequented by them. Nor is this at all improbable, considering the almost infinite number of surrounding objects and the diversity in form and color of the hosts of insects which exist. As some rude resemblance is necessary for the first start, we can understand how it is that the large and higher animals do not (with the exception, as far as I know, of one fish) resemble for the sake of protection special objects, but only the surfaces which commonly surround them, and this chiefly in color. Assuming that an insect originally happened to resemble in some degree a dead twig, or a decayed leaf, and that it varied slightly in many ways, then all the variations which rendered the insect at all more like any such object and thus favored its escape would be preserved, while other variations would be neglected and ultimately lost; or if they rendered the insect at all less like the imitated object they would be eliminated."

Wallace placed both protective resemblance and mimicry in the same category, claiming both to have resulted from natural selection. But there are a certain number of English naturalists, including Poulton, who have elaborated on this subject and have contributed a quantity of very interesting data in support of the desirability of drawing a distinction between protective resemblance and mimicry. The supposed difference between them is that in mimicry one animal mimics another living animal, in contradistinction to an animal that resembles the surrounding medium in which it lives. Of late, moreover, there has arisen another group of physiological experimenters who place the coloration of animals on a chemical footing, giving a physical, as distinguished from an æsthetic, explanation.

Besides the examples given above, there are in the temperate region a number of common animals that clearly show protective resemblance. For instance, *color resemblance* is seen in the tree-toad, which resembles the gray or lichen-colored bark; the bark weevil, which simulates the uneven surface; the catocala moth, whose mottled wings blend with the bark. The foregoing are examples of a type of color that blends with and simulates the general background of their environment.

There are others which bear *form resemblance*, illustrated by such examples as the walking-stick, which resembles a leafless twig, moths which resemble bird droppings, and those which can scarcely be distinguished from a dried leaf; others like some of the Plusia moths, which often alight on the ground, appearing like broken-off twigs. With the exception of the latter, all of these forms are described elsewhere in this book.

Poulton has divided the colors of animals as follows:[1]

I. *Apatetic Colors*

Colors resembling some part of the environment or the appearance of another species.

A. Cryptic Colors.
Protective and aggressive resemblances.
1. Procryptic Colors.
Protective resemblances.
2. Anticryptic Colors.
Aggressive resemblances.

B. Pseudosematic Colors.
False warning and signalling colors.
1. Pseudoposematic Colors.
Protective mimicry.
2. Pseudopisematic Colors.
Aggressive mimicry and alluring coloration.

II. *Sematic Colors*

Warning and signalling colors.
1. Aposematic Colors.
Warning colors.
2. Episematic Colors.
Recognition markings.

III. *Epigamatic Colors*

Colors displayed in courtship.

[1] This classification has been elaborated by Poulton in his work on "The Colors of Animals," and also in a more recent work by him.

Wallace sums up the various modes in which color is produced or modified in the animal kingdom as follows: "The various causes of color in the animal world are molecular and chemical change in the substance of their integuments, or the action on it of heat, light, or moisture. It is also produced by interference of light in superimposed transparent lamellæ, or by excessively fine surface striæ. These elementary conditions for the production of color are found everywhere in the surface structure of animals, so that its presence must be looked upon as normal, its absence as exceptional. Colors are fixed or modified in animals by natural selection for various purposes; obscure or imitative colors for concealment; gaudy colors as a warning; and special markings, either for easy recognition by strayed individuals, females or young, or to divert the attack from a vital part, as in the large, brilliantly marked wings of some butterflies and moths."

Colors are produced or intensified by processes of development, either where the integument or its appendages undergo great extension or modification, or where there is a surplus of vital energy, as in male animals generally and more especially at the breeding season. Colors are also more or less influenced by a variety of causes, such as the nature of the food, the photographic or physiological action of light, and also by some unknown local action, probably dependent on chemical peculiarities in the soil or vegetation. These various causes have acted and reacted in a variety of ways, and have been modified by conditions dependent on age, or sex, on competition with new forms, or on geographical or climate changes.[1]

According to Tower, the colors of insects, when grouped according to their causes, can be assigned to three categories: namely, chemical or pigmental, physical or structural, and chemico-physiological or combination. The colors due to chemical or pigmental changes are black, brown, orange, yellow, drab, many reds, rarely blue, green, and white. The pigments which produce them are soluble in various reagents. These compounds may be the product of the metabolism of the animal, or derived from food, or they may be accidental inclusions.

[1] "Natural Selection and Tropical Nature," pp. 391, 392. Of other specific causes may be mentioned temperature and moisture.

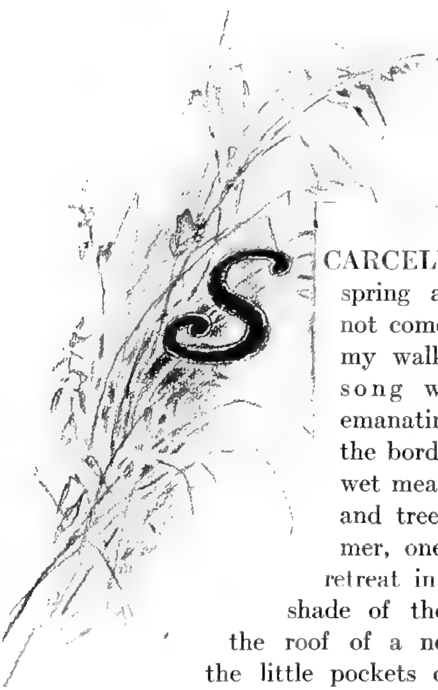
Hagen divided color-producing substances into dermal and hypodermal, the former being located in the cuticula and the latter in the cells of the hypodermis which lies under the cuticula. Poulton has shown the existence of color producing substances in the fat body and hæmolymph, which Tower designated as subhypodermal colors. Wallace states that the pigmental colors have a different character in animals according to their position in the integument. These epidermal or cuticular colors appear in the external, chitinized skin of insects, in the hairs of mammals, and partially in the feathers of birds. To the hypodermal colors belong many of the reds and yellows of butterflies and birds. Tower relates that the dermal colors and the substances which produce them are located in the outer portion of the cuticula and are diffuse pigments, which is contrary to the views of Hagen and Enteman who maintained that they were present in the form of granules. The hypodermal colors are usually in the form of granules located in the hypodermal cells or more rarely derived pigments. Many of them fade after death, while others are permanent.

Physical or structural colors are usually produced by the interference of light, either by reflection or by fine striæ, or modification in some way by the light impinging on the body. These results are brought about by polished surfaces, lamellæ, pits, striæ, scales, or other modifications. White is the only physical color in insects, which is produced, according to Poulton, by the enclosure of minute air bubbles or transparent globules often enclosed in scales, which scatter the various rays in all directions. White is also produced by the flat faces of crystals and by fine granules in the fat body.

The physical color, so-called, or white, is usually combined with chemical or pigmental colors, which give varied and brilliant hues to insect coloration. The chemico-physical or combination colors are explained by the light of one wave length being neutralized, owing to one set of such waves being retarded or shifted so as to be half a wave-length behind the other set. The complementary color of that which is neutralized is seen. To this class belong glossy or metallic tints in insects and in birds, and also the iridescent blue, red, green, and violet hues.

These colors are often produced by pigment and striæ in the same scales of butterflies.

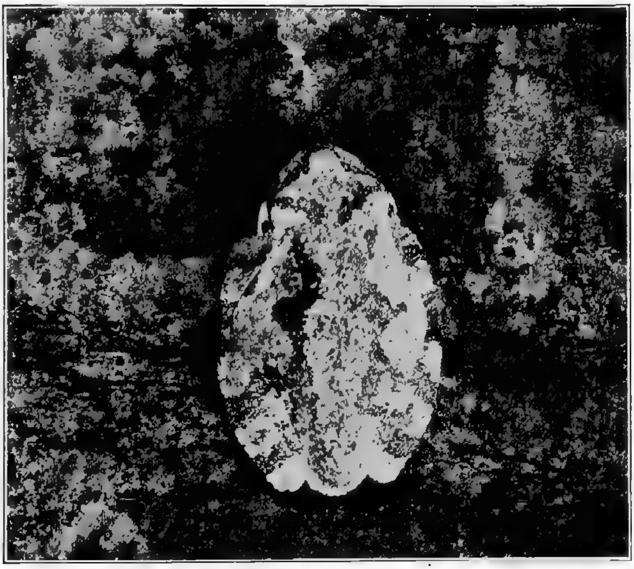
The laws which Wallace believed governed the production of all cases of protective resemblance were rapid multiplication, incessant, slight variation, and the survival of the fittest, in other words, natural selection. Those cases which furnish striking examples of protective resemblance, such as the walking-stick and leaf-like insects, represent instances in which the process of modification has been going on during an immense series of generations. The great majority of such species occur in the tropics where the conditions of existence are most favorable, and where climatic changes have for long periods been hardly perceptible.



The Tree Toad

SCARCELY a week passed during spring and summer that I did not come across the tree-toad in my walks afield. In April its song was heard at twilight, emanating from the lowlands at the border of ponds, ditches, and wet meadows, or from the shrubs and trees nearby. During summer, one of its favorite places of retreat in the daytime was in the shade of the wooden rafters under the roof of a neighbor's porch. Again, the little pockets on the trunks of beech trees in the woods were especially attractive places for them. In September, the openings into the old apple trees often afforded choice locations in which they took up their residence, staying in the cavernous interior until frosts. The photograph shows a tree-toad on the bark of a water beech, taken in the middle of July.

In this species the stripes on the legs are much less variable than those on other parts of the body. These show very plainly in the photograph. The color of this individual was almost white with grayish mottlings. Against the background of the bark it presented an excellent example of protective



The Tree-toad (Hyla versicolor). He becomes invisible by changing his color within an hour to harmonize with the green leaves or gray lichen-covered bark.

resemblance. This effect was even more striking before the little subject suddenly turned crosswise on the bark as I was about to open the camera shutter. It is only occasionally that one hears the sound of the tree-toad in July In the middle of the day I heard one while it was on the bark of a walnut tree. It uttered a slight clattering note, similar to the notes made by the red-headed woodpecker, and could scarcely be distinguished from it.

One of these toads, which I had taken indoors, fed eagerly on grasshoppers and other insects, taken from my fingers. On one occasion it caught sight of a full-grown female walking-stick insect which it seized about midway along its body. Then the toad doubled the insect up, bringing the two halves together, and slowly but surely began to swallow it. To facilitate the operation the toad used its front feet, much as we would our hands, guiding and pushing the morsel down its throat. In view of the great length of the walking-stick's body, it was surprising that such a small animal could swallow this insect whole without at least first removing the slender legs; but the tree-toad was fully equal to the occasion. The result of the meal was that the ungainly walking-stick produced a noticeable angular protuberance at the side of the toad's body, which, however, was only temporary as it only lasted for an hour or thereabouts after it was swallowed.

The appetite of the tree-toad for insects is prodigious, especially after its day's fasting. One evening I offered my toad guest one of the familiar saw-fly larvæ, which is a large, light colored, bulky grub that feeds on the heart-shaped willow leaves. After the larva, which was at first curled up from fright, began to gain confidence and straightened out in its attempt to crawl, the toad became much interested in its actions. Then, after watching it intently a little longer the toad finally sprang toward it, catching hold of the forward extremity, and hastily swallowed a fourth of its body. The powerful larva now protested by suddenly curling its body, at the same time becoming perfectly rigid. The toad was put at a great disadvantage by this manœuvre and was obliged to disgorge the part swallowed, but did not do so without a struggle to retain its hold. The larva then remained perfectly quiet, seeming to be conscious of danger, while the toad in the meantime made no further attempt to swallow it again, though standing over it and watching quite a while for a final move on the part of the larva.

The performance of suddenly curling the body is quite characteristic of this and some other larvæ, and here I had convincing proof that this habit could be useful in the preservation of the individual against the attacks of toads, and has quite a biological significance. How birds would act toward this larva would be quite interesting to determine. The boldness and heroic courage of this little tree-toad in attempting to swallow so large a larva was admirable. But what must be said of the courage of this same little batrachian which was displayed a few minutes later! I happened to have at hand a plump, half-grown larva of a large moth, *Telea polyphemus*. This green larva had been feeding on the leaves of hazel and was much larger than that of the saw-fly species. On seeing this larva the toad at once seized it and in a few moments had it half-way down, but after struggling some time with it the toad again disgorged its bulky prey. I later supplied the toad with its regular diet of beetles and small moths. Occasionally it ate cabbage butterflies and small dragon-flies which I caught in a net during the day and reserved for its supper.

The tree-toad varies much in color, depending on the background environment, humidity, and degree of light. On certain occasions it changes from yellowish white to a deep gray or brown, after moving to a new position in a darker place. Similarly, sometimes it may change from white to a beautiful green, or green and gray, if moved to a background of green leaves. This color transformation requires about an hour's time. The male and female are very similar in size and color, the former being distinguished principally by his darker throat and larger tympanum, or ear. This species can be distinguished from other tree-toads by the orange-yellow or brownish concealed coloring of the leg surfaces where they fold in contact. The eggs are laid in the spring of the year in small clusters in the water of ponds and marshes, and are attached to the stems of plants. They hatch into tadpoles within two or three days after they are laid. Dickerson states in her interesting "Frog-Book" that about seven weeks are required for the tadpoles to complete their metamorphosis. The little green frogs then leave the water for their land excursions.

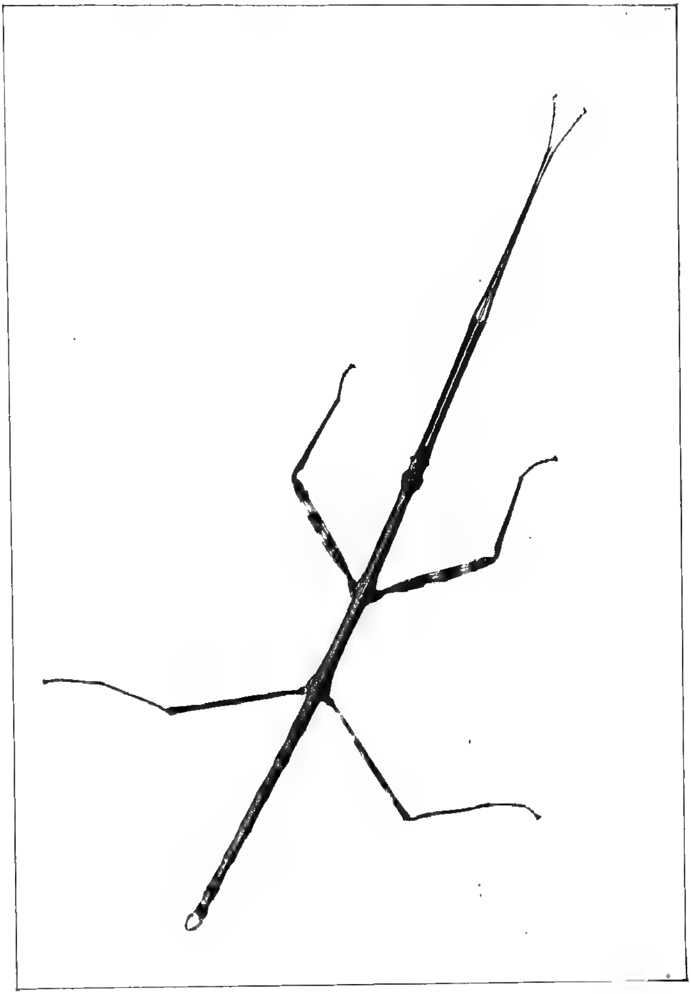
I believe from observation that the tree-toads, when common in a locality, exercise an important influence or control over insect life, especially in beech forests and swamps, and act as a selective factor.

The Habits of the Walking-Stick

Among the most curious members of the Orthoptera, or grasshopper family, are the walking-sticks. This name is applied to these insects because of the resemblance their long cylindrical bodies bear to sticks or twigs of trees. I have found them in greatest abundance among the undergrowth and herbage in the mixed beech forests. Here, between the first of June and the last of August, the various green stages of the young insects are frequently met with, while after this period the large, mature gray and brown forms scatter out among the open woods. At this period, moreover, the adults are often found on the trunks of the fruit trees in orchards. The males are much smaller than the females, and not infrequently the former retain their green color in adult life.

There is but one generation of these variable insects each year, the numerous eggs being dropped one at a time on the ground by the females in September. These eggs usually fall among the leaves in the forests. They are shining black and have a bright stripe on one side which gives them a near resemblance to a small seed of some leguminous plant. Being laid in the fall, the eggs remain on the ground during the winter and hatch in the following spring. The first young appear, as I have above intimated, about the first week in June, but the exact time of incubating and hatching varies to a considera-able extent. On June 22, 1906, I found the average size of the young to be three-eighths of an inch in length.

I never fully appreciated the value of the green color to young walking-sticks, and conversely, the use of the gray and brown colors to the adults, until one day on examining the foliage of a sapling oak I happened to be in a position to look down upon a cluster of its rich green leaves. Here I observed a young, half-grown walking-stick astride one of the leaves. His body was directly in line with the middle of the leaf, with his head directed toward the stem. When I first discovered him his forelegs were, as usual, closed together alongside the slender antennæ which projected forward. The leaves of this oak were deep green, with the light pale green veins contrasting somewhat conspicuously. The position of the insect was such



The Male Walking-stick (Diapheromera femorata). The characteristic attitude of protection is shown by the extension of the forelegs in front, one on each side of the slender antennæ.

that he stood over the veins, the legs being arranged almost parallel with them. From this view of his body, he was so closely in accord with the veins that he was almost invisible. I wondered at the time if this position was a mere coincidence or was a common behavior. It is obvious that in this attitude and at a little distance the young walking-stick may stand on the upper surface of the leaves and defy the sharp-eyed birds or other vertebrates to discover his attenuate form.

While I found this resemblance of the walking-stick to the central and radiating veins of the oak and other leaves to be remarkably perfect, there is another point that I noticed in this connection worthy of consideration. I found that when these Orthoptera become unduly alarmed their usual impulse seems to be to seek the under surface of the leaf. After some study I also found that he is here even more protected than when standing on the upper surface, not only on account of the shadows cast on his body, but from the fact that the assimilation is made far more perfect by reason of the median and lateral veins of the leaves being more strongly and roundly in relief here than they are shown above. I have photographed one of these insects on the underside of the oak leaf just as I found it, that the reader may get a better idea of the remarkable protection afforded by this resemblance to the veins. The resemblance of the walking-stick to the venation of the oak can be demonstrated in quite a striking manner, if the main median vein with two pairs of laterals are cut out carefully with a pair of scissors. The result is a fair *facsimile* of the young walking-stick.

Of course, in the position which the young walking-stick naturally assumes in foraging, it does not always accurately lie over the veins of the leaf, for the veins slightly alternate. I have found, however, by observations, that if the insect stands at any angle on the leaf, and if he is viewed from below, his resemblance to the veins is sufficient to protect him. The nearer the position of the body corresponds to the central vein structure the greater the safety from attacks. The oak is doubtless the most often chosen as the natural habitat of the common walking-stick, but I have often found the young at home on a variety of herbage, shrubs, and small trees, where

Leaves of Red Oak. The upper figure shows a young Walking-stick protected by its resemblance to veins of the leaf; lower figure a young Round-wing Katydid which is green in life, like the walking-stick, and almost invisible against the leaf background.

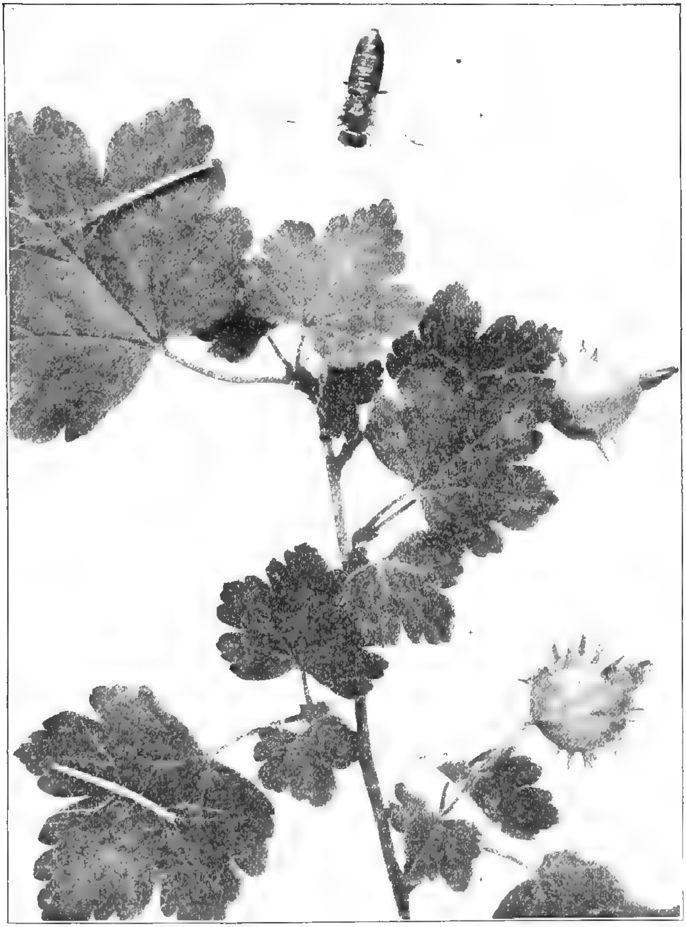
they live on the leaves. This in no way mitigates the special adaptation of his body referred to, for I have found that his attenuated form resembles almost as well the leaf veins of various other plants.

In the latter part of July, I found on the wild gooseberry two very small individuals. These young readily sought the underside of the leaves when they were rustled. In the accompanying plate photographic illustration of the wild gooseberry branch, I have portrayed them on the upper surface of the leaves, though on the underside there were far more individuals.

Again, in the plate photographic illustration of the oak leaves, the reader may also note a shadowy picture of another Orthopteran frequenter on the largest leaf near the middle. This is a young round-wing katydid, quite plainly visible to the eyes while viewed in nature, but in the photograph his dark, rich green body blends and appears like a shadowy outline. This youthful individual walked stealthily over the leaf, protected by his dark green coloring which was effectually tinged with light brown. His blackish antennæ were very long and broken by alternating dark and light rings. These ring markings were effective against the green of the leaf and faded parts which surrounded him. Even the camera with its sensitive film failed to bring out his distinctive features.

The adult walking-sticks often exhibit a most singular performance when they are attacked or frightened. Either they walk off with an ungainly stride in their attempt to escape, or they may fall to the ground. In the latter case they often "play possum" by lying perfectly rigid on the ground among the *débris*, feigning death perfectly. On such occasions they will sometimes allow themselves to be handled and still retain the stiffened attitude for minutes, or even hours afterwards, without regaining their feet. One of these feigning insects which I brought indoors was left on a table at ten o'clock in the forenoon and it stayed in the same position on its back until half-past three in the afternoon of the same day, or a period of six and a half hours. In the meantime it passed fæcal matter three times, showing that internal functions were actively carried on during this apparently intense nervous suspense.

Preyer ascribed the "shamming dead" of insects to the



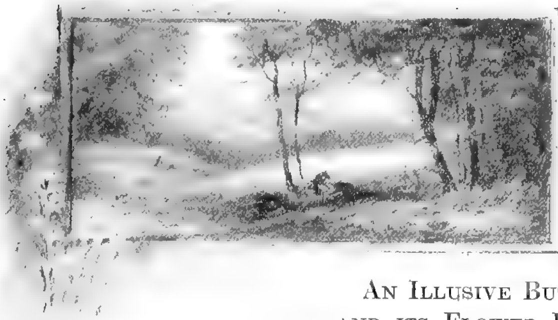
Wild Gooseberry Branch, showing young green Walking-sticks (Diapheromera femorata) on the upper surface of the leaves. The upper figure is that of a saw-fly.

influence of kataplexy or hypnotism, this state being induced by fright. Darwin looked upon the instinct of "shamming dead" as simply the result of remaining motionless and thus inconspicuous in the presence of its enemies; this instinct having developed by natural selection without ever having been of an intelligent nature. Those individuals which were least inclined to run away from enemies being preserved rather than those which rendered themselves conspicuous by movement. Romanes [1] says, "There seems to be at least not more difficulty in developing an instinct to remain motionless under certain circumstances, than in developing one to run away, and as a matter of fact, all animals which are protectively colored have either as cause or sequence developed their instincts in the former direction."

In the above word sketch, I have stated that the eggs of these insects bear a close resemblance to the seed of plants, and secondly, that the young show remarkable adaptation to a life on the leaves, their attenuate bodies being deceptively like the venation of the leaves. Finally, I will now call attention to the fact that the adults are protected in their resemblance to twigs even to the minutest detail. In the fall the sexes are found together in large numbers, in pairs, often on the bark of the forest and fruit trees. Again, I have found them on such shrubs as the sumach; here they are all but invisible as they hold on the main stems. When I discover them sometimes by accident, I often marvel that they are ever seen at all by human eyes, so close do their bodies imitate the twigs. Even the leaf scars are wonderfully represented. And why, may I ask, do these insects choose as a place of refuge the very spot on the sumach where there are dead branches near the main stem?

Here is certainly a group of insects for the naturalist to work on. The problems presented are certainly accessible by experimental research, and if they are coupled with observations in the great biological experiment grounds of nature, there is still room for interesting discoveries. Such adaptations as are shown in the form and color of the walking-sticks are the most striking of any in our temperate fauna. They doubtless offer the most powerful argument in favor of natural selection.

[1] "Mental Evolution in Animals."



An Illusive Butterfly, and its Flower Protector

On one of my excursions to the sand dune region of Indiana, in April, I occasionally saw a small white butterfly flit about in the air. When it descended near the ground it suddenly disappeared so completely that I was at first at a loss to explain the cause. I afterwards discovered that the deception practised had been caused by the butterfly alighting on the little white flowers of *Arabis lyrata*. The resemblance of this butterfly to these flowers is so remarkable that even a trained eye would easily overlook this insect in nature. When I came near, the insect was found with its wings folded together, and it was resting upon the small, pure white flower heads. In this position the protection was heightened by the disposition of the yellowish green markings on the underside of the lower wings. I seized upon the opportunity thus afforded to make a drawing of the insect shown in the colored plate.

The green markings of the underside of the wings are so arranged as to divide the ground color into patches of white, which blend with or simulate perfectly the petals of the clustered flowers. The eyes of the butterfly are delicate, pale green, and the antennæ are whitish, all of which adds to the effectiveness of the blend. The flowers of Arabis have white petals, with the centre yellowish green as is also the calyx. There is a shade of pink outside the base of the petals. All in all, the adaptation of insect to flower here displayed is one of rare exquisiteness.

One day, in May, I studied the behavior of three of these little butterflies, which are known by scientists as *Anthocharis* *genutia.* They were quite active in the warm sunlight, and when I first saw them, two of them flitted about, here and there, one moment alighting on the flower of Arabis, and the next moment depositing their eggs on the stems. Again they would indulge in a sunlight bath on the ground, where they would alight and spread their wings as if enjoying the heat of the sun. At one time I came across a group of Arabis plants covering a small area on a wooded sand dune. On searching the flowers, one of these butterflies was found, resting on the flowers in the protected attitude above described. The wind was strongly blowing at the time, and the insect clung on the flower with more than ordinary persistence, turning its body so that its head was directed toward the source of the air currents. It was so persistent in its desire to remain on the flower, that it submitted to be taken up with the plant, and laid in a box. But after a time, on jarring the box accidentally, the insect became startled, and flew away.

As long ago as 1868, Wood [1] pointed out that the little orange-tip butterfly, in England, often rests in the evening on the green and white flower-heads of an umbelliferous plant,—the wild chervil, *Anthescus sylvestris,*— and that when observed in this position, the beautiful green and white mottling of the under surface completely assimilates with the flower-head and renders the insect very difficult to be seen. It is probable that the rich dark coloring of the underside of our peacock, tortoise shell, and red Admiral butterflies, answer a similar purpose.

All of these butterflies seem to have a tendency to remain very still when on the flowers, giving one the erroneous impression that they are conscious of the protection afforded by their surroundings. Grossbeck [2] mentions that he found this butterfly depositing its eggs singly on the stems of Arabis, usually below the terminal bud. On very large plants as many as four eggs are sometimes found. I have confirmed these observations. Hornig [3] found this species of butterfly laying its eggs on the common plant known as mouse-ear, *Sisymbrium thalianum.* I found upon looking into the subject that wherever

[1] Wallace, in "Natural Selection and Tropical Nature," p. 43.

[2] *Entomological News,* May, 1908.

[3] *Ibid.,* Vol. XVI, p. 252.

THE ORANGE TIPPED BUTTERFLY
(*Anthocharis genutia*)

Resting on flowers of Arabis lyrata. An exquisite case of protective resemblance. The figure at the right shows the markings on the upper surface of the wings

the food plant of this butterfly appears, it is reasonably certain both plant and insect will be found associated.

For instance, the range of *Arabis lyrata*, according to Britten and Brown, is found to extend from Ontario to Virginia and Kentucky, west to Manitoba and Missouri. It ascends to twenty-five thousand feet in Virginia, and occurs on rocky and sandy places. Now let us examine the range of the orange-tip butterfly under consideration, and we find in Holland's "Butterfly Book" that it ranges from New England to Texas, but it is not found, so far as is known, in the regions of the Rocky Mountains and on the Pacific Coast. Where this little butterfly occurs, it is likely to be quite local. I have only found it in the sand dune region skirting the border of Lake Michigan, which is particularly rich in objects of zoölogical interest. I have been told by John B. Smith that this butterfly was very local in its distribution in New Jersey. It is single brooded in the northern states and I found it mating at Dune Park, Indiana, in May. In North Carolina, Holland found that it was double brooded, judging this to be the case because he found it late in autumn.

There are numerous species of the orange-tips of the genus Anthocharis (Euchloe of some authors) in North America. They are all small white butterflies, having the apical region of the primaries spotted or banded with yellowish orange or crimson. On the underside of the wings they are usually more or less protectively mottled, as in the species *genutia* that I have described above, each possessing yellowish green spots or striæ. The orange coloring of the apex of the fore-wings is confined to the male in some species, and this patch of coloring must be considered as of entirely different significance, biologically, from that on the underside of the wings. The orange coloring is, perhaps, a distinguishing sexual mark belonging to the epigamic colors classified by Poulton.

Darwin[1] cited the case of the orange-tipped butterflies in support of his theory of sexual selection. He says: "The same reason which compels us to believe that the lower surfaces have been colored for the sake of protection leads us to deny that the wings have been tipped with bright orange for the

[1] "Descent of Man," p. 313.

same purpose, especially when this character is confined to the males."

Wallace,[1] on the other hand, maintained that the orange coloring may have served in directing the attack of birds away from the vital parts of the body and, therefore, were also protective in character.

I might add that the little butterfly, *Anthocharis genutia*, while polyphagous, that is, having the ability to feed on various plants, lives on cruciferous plants, such as Arabis, Sisymbrium, and Cardamine. There is, however, a substance having a mustard taste, common to all these plants, which the larvæ of these butterflies seem to enjoy. The butterfly probably functions as a cross fertilizer, as well as using them as food plants. This has contributed in establishing a reciprocal relation between them and their exquisite little butterfly guests.

The Animated Rolled Leaf

N other chapters the subject of protective resemblance has been treated and demonstrated by the walking-stick, the geometrid larva, the automeris moth, and other examples. This subject would not be given full justice without mentioning the rolled-leaf moths, belonging to the genus Datana.

After a slight shower one morning in July, I made a search at the edge of a mixed beech forest where the trees are somewhat scattered. I had strolled but a short distance among the undergrowth in quest of study material before I found three examples of the night-flying moths known as *Datana contracta*. It will be seen from the first plate illustration, bearing two figures of these insects, that they resemble a withered, rolled leaf. Recording these insects just as they were found in nature, the first example appeared on the green leaf of a brier, the second one on the wild raspberry, and the third on the green leaf of the sassafras. These situations indicate that the moths showed

[1] "Natural Selection and Tropical Nature," p. 371.

Two Moths (Datana contracta). Upper figure, pale individual, viewed from above, showing resemblance to a withered rolled leaf; lower figure, a darker individual, viewed from the side, showing arrangement of markings in simulation of veins and shadow in front. Plant leaves of wild raspberry.

an indifference as to the kind of leaf they chose to rest upon. Others found later were either on the ground or were near it, ranging within a distance of from two to ten inches above it. Those resting on the leaves showed, moreover, an instinctive indisposition to fly when I carefully handled or picked the leaves.

Three days previously, during a strong wind, my attention was drawn to one of these moths conspicuously exposed on the upper surface of a leaf, which remained there for a number of hours despite the waving of the plant by the wind. The marked indisposition of these moths to fly when I came near them indicates in an excellent manner an inherent behavior which seems to develop coincidently with adaptive changes of form and color to their surroundings.

Another species of these rolled-leaf moths which I found possessing similar habits and associated in the same environment with the foregoing species, is the *Datana angussi.* It is shown in the second plate illustration, also photographed from life. This is a strikingly beautiful insect and is richly marked. But little conception of its specially protected life among forest herbage can be gleaned by viewing the usual museum specimens with their wings dried in an open position. In the daytime when these moths are resting and require greatest protection, the wings are close to the sides, and it is in this position only that they present the leaf-like form. The front of the thorax is colored a rich velvet chestnut-brown, the upper wings being transversely streaked with brown on a yellowish color ground, and the edges of the wings have a brownish, lightly scalloped border. These colors and markings are highly variable, and thereby aid in matching the variously colored dried leaves. Likewise, the oblique stripes bear a marked illusion to the veins.

This moth, on the whole, presents a general, rather than a special resemblance to leaves. The dried leaves composing the background were mostly beech and averaged in length longer than the moth's body. They were thrown about on the ground by the wind, causing a criss-crossing and overlapping in arrangement. Again, some of them that were curled up quite strongly lengthwise, were of variable hues.

A Moth (Datana angussi) viewed from above, showing markings in simulation of a dried rolled leaf.

Notwithstanding this, the color of these leaves as compared with the colors and form of the moth's wings, matched very closely, and, generally speaking, formed a most deceptive simulation. The oblique lines across the wings ran in the same direction as those of the rolled leaves on the ground and were highly suggestive of veins. When the moths are on the ground, perhaps the protective coloring and form of the moth are most deceptive. Yet it was remarkable how easily the moth, while it was on a green leaf, was taken for a dried leaf which had simply been arrested in its fall to the ground.

Perhaps one of the most notable features of protection afforded these moths is the disposition of the chestnut coloring on the forward part of the thorax. This arrangement of color has the effect of an abrupt shadow at the front end of the body, corresponding to the hollow and shadow at the stem end of the leaf. The distal ends of the wings often have a scalloped margin, simulating the opposite wavy or toothed margin of the leaf. It is obvious that this arrangement of the color and form of these insects is especially useful against the beech forest bed. The instability of form and color exhibited in these Datana moths is probably due to the varying effect of temperature, light, and moisture, coupled with a changeable environment, and the crossing of the color forms.

Where intricate adaptations appear in the adult, such as I have just illustrated, it not infrequently happens that the early stages, or instars, in their life history are afforded similar mechanisms of protection.

I was much surprised one day later in August to find a leafless stem of a bush along the wayside adorned at the top by what looked like, at first glance, some floral display. My error was soon discovered when the branch was pulled down for closer inspection. This pseudo-floral form was shown to consist of numerous Datana caterpillars grouped together in a bunch, in such a way as to produce the illusion of a flower. Each little yellow striped caterpillar had selected its place, acting its part instinctively. Both ends of the body of each larva were curved outwards, and all seemed as rigid and motionless as the petals of a flower. (See plate photographic illustration.)

These little gregarious caterpillars still immature, were

Datana Caterpillars grouped at the top of a branch in simulation of a flower. They are striped and marked with bright warning colors, and they disgorge a yellowish fluid when threatened.

five-eighths of an inch in length. They were warningly colored yellow and striped with reddish brown. The head and legs, together with the last joint, which has two hairy appendages, were intense black. Their bodies were sparingly covered with quite long whitish hairs. When touched, these caterpillars disgorged a yellowish fluid from their mouths, which might make them distasteful to birds.

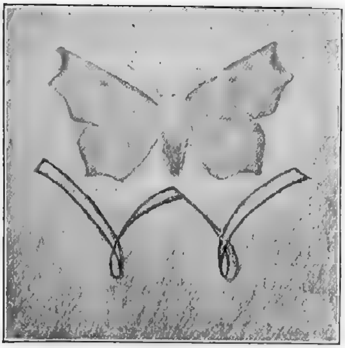
While I have shown the protection afforded the imago and larva, the eggs of Datana do not share this immunity. They are open to the attacks of parasitic Hymenoptera. The species known as *D. interrigima* and *D. ministra*, we are informed by Girault [1] are destroyed in the egg by the parasites, Telenomus and Eupelmus, respectively. The egg seems to be a vulnerable point of attack which nature has not perfectly protected. It may be, however, that these parasitic Hymenoptera by increasing in numbers in one season may limit their own larval food supply. In the next season this would cause a reactive extermination of their own species out of mere lack of the Datana larvæ food supply, thus creating a condition of isolation.

Considering all these facts of the life history of Datana, what a remarkable display of illusive and protective devices seems necessary for its existence! Romanes [2] says, when there is supplied to us the suggestion of natural selection as a cause presumably adequate to account for this continuous growth in the number, the intricacy, and the perfection of such mechanisms, that it is only the most unphilosophical mind that can refuse to pause as between the older hypothesis of design and the newer hypothesis of descent.

[1] "Psyche," Vol. XIV, 1907, p. 33

[2] "Darwin and After Darwin," p. 282.

The Twig Impersonator



WHEN viewing the branches of pine trees, I have many times seen peculiar green caterpillars bearing light stripes, making themselves next to invisible when resting on the needles of these trees. Similarly, the oak has its complement of larvæ resembling the twigs, the latter species often exhibiting little tubercles, or scar-like spots, as well as being colored in close resemblance to the twigs. It was my good fortune on July fifteenth to find one of these twig "impersonators" on the green leaf of sassafras in the process of feeding. This geometrid larva was cylindrical, nearly one and three-quarters of an inch in length, and colored grayish. After keeping my eyes on this individual for some time, I noticed that he had finally satisfied his appetite and with looping strides crawled to the top of the twig. Here he straightened himself out and was soon transformed into an exact counterpart of a leafless twig. I have succeeded in photographing him from life in this position, and his portrait is shown on the plate, page 95.

It will be observed that the posterior extremity of this larva is attached by two fleshy pseudo-legs, rather widely separated. In the act of stiffening out at an angle to the twig, the forward three pairs of legs are suddenly crowded together and the head brought forward. In this way the larva assumes a much more perfect resemblance to the end of a twig upon which there is an old bud. There is also a pair of dark dorsal tubercles near the posterior third of the larva which is the perfect representation of a leaf scar. Every one is familiar with some of the various species of these measuring worms belonging to the Geometrina. The moths have both pairs of wings colored alike, and live in our forests in great numbers.

The means of protection, such as we have seen in the above geometrid larva, is a remarkable form of adaptation, both in the form and coloring of the body. Poulton has shown that some of the caterpillars frequenting trees have become so adapted to certain provinces on the trees that to go beyond these sections is at the peril of meeting death. Witness, for instance, different kinds of larvæ occupying the upper, the underside, or the edge of the leaves, or again, on different colored and different sized twigs which present leaf scars, scales, and eminences of various kinds. All of these areas and inequalities of surface and places are so many little provinces or habitats within whose limits a particular larva may live with comparative immunity, but not elsewhere.

How the Acontia and Stenoma Moths are Protected

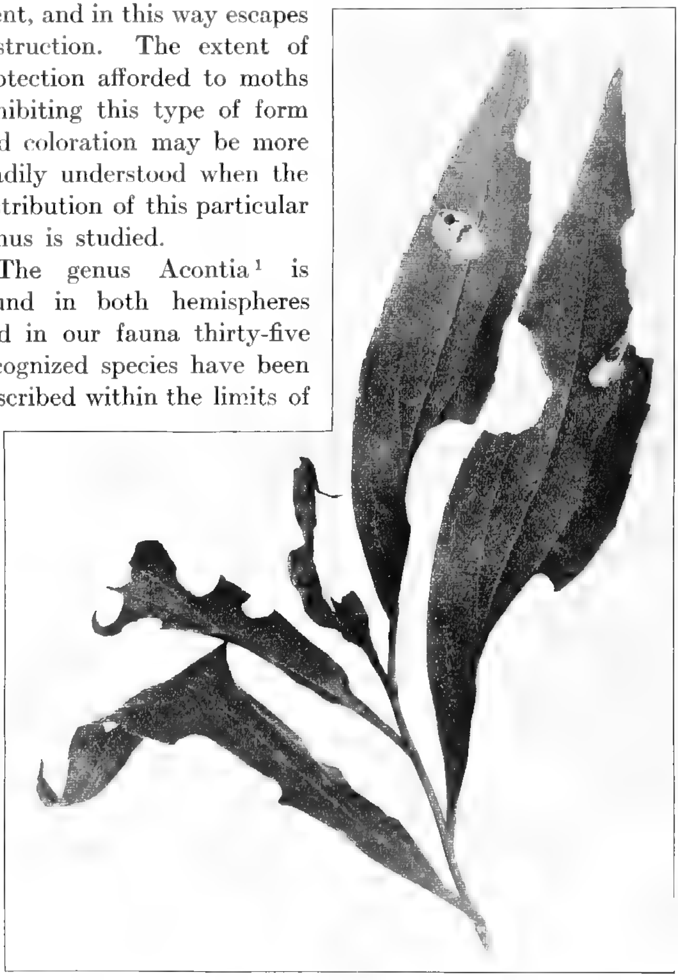
WHEN we view moths in entomological collections, with wings spread and neatly arranged on pins, how little do we appreciate the real philosophy of their varied markings! Who, for instance, would understand the meaning of the form and markings on the wings of the little moth, *Acontia erastriodes*, here portrayed, unless it were studied with relation to its natural surroundings. This moth in nature bears a close resemblance to the excrement of a bird. During August, I found it quite common on the leaves of low herbage in a pasture. When disturbed, it often flies from its exposed position on the upper side of a leaf, to some other similar position on plants a few yards away. I have flushed as many as three of these moths within an area of a few yards.

The one shown in the photograph is a typical representative. It appears just as it was found on the leaf along with a bird

Geometrid Larva on twig of Sassafras. Note the general resemblance to a branch and a leaf scar at the middle of the body.

dropping which it resembles. While this moth remains quiet on the leaf, it may be mistaken by birds for their own excrement, and in this way escapes destruction. The extent of protection afforded to moths exhibiting this type of form and coloration may be more readily understood when the distribution of this particular genus is studied.

The genus Acontia[1] is found in both hemispheres and in our fauna thirty-five recognized species have been described within the limits of



The Moth Acontia erastriodes and bird excrement which it resembles. From nature just as the objects were found.

Canada and the United States. The species are marked in various ways on their forewings, so that all of them are protected in the way mentioned. The significance and extent

[1] Or Tarache of some authors.

of this means of protection have heretofore been but little studied in our North American species of moths.

Another view appears in the illustration below of a moth, *Stenoma schlaegeri*, which I found in the woods.[1] The circumstances under which this moth was found show how persistently certain sluggish behavior is associated with color markings and form. When I came through the woods, this moth was

The Moth Stenoma schlaegeri on the upper surface of a strawberry leaf. Its resemblance to bird excrement is striking.

found resting on the upper surface of a leaf of wood strawberry. The wind was blowing quite strongly at the time, which caused the leaf on which the moth was resting to sway back and forth, yet the moth held fast to its position.

In the sketch of the Animated Rolled Leaf will be found observations on similar habits of Datana moths, of openly exposing themselves on the surfaces of leaves. The resemblance of this moth to bird excrement was so close that when first noticed I almost decided to pass it by. The peculiar habit of drawing and rounding its wings close to the sides of the

[1] At Mill Creek, Illinois, May 30, 1903.

body give to the insect an elongated, rounded form which is very characteristic.

The protective resemblance of these moths in the manner shown might be ascribed by some to mere coincidence. But when one studies the subject carefully the measure of resemblance is so detailed that some especially adaptive cause is demonstrated. Here there seems to be exercised a selective factor that cannot be ignored, picking out the best imitations in the face of more highly discriminative perception of those enemies against the depredations of which this type of protection is developed.[1]

[1] Under the title of "The Disguises of the Cresphontes Caterpillar," I have shown that this larva imitates bird droppings, so this is by no means an uncommon form of protective resemblance.

PROTECTIVE RESEMBLANCE TO BARK IN CATOCALA LARVA

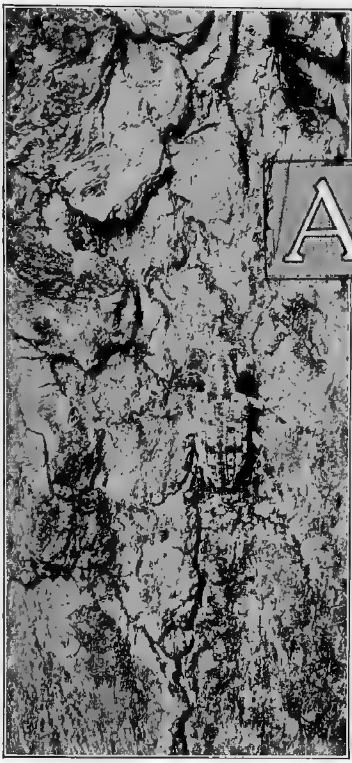
THE above photographic reproduction shows a caterpillar which I found resting on a leafless twig. This species has the habit of lying flattened and very closely pressed against the bark. Moreover, the line of shadow separating it from the twig is effaced by a number of short bristly hairs arranged along the side of the body.

This larva rests on the bark of twigs in the daytime and feeds on the leaves at night, therefore, the green coloring often found in caterpillars is not displayed in this species. The moths of the genus Catocala have the underwings either red, crimson, yellow, or white, and often barred with black; or they are plain black. The upper wings are variously colored in simulation of the bark of trees upon which most of the species rest during the daytime. Often their wings are such a perfect match to the bark that even an experienced entomologist overlooks them. The underwings are hidden by the depressed, over-lapped upper pair when they rest on the bark, and the bright colors I have referred to are displayed during flight. The larvæ of members of this genus resemble the one presented above. They are often colored like the bark and twigs of their food plant and are in consequence so well protected that this extensive genus comprises about a hundred species in our North American fauna.

The drawing of the moth shown in my initial illustration is that of the nearly allied *Homoptera cingulifera*, one of the night-flying moths. Its underwings are streaked grayish brown, somewhat like the front pair. Its larva is almost indistinguishable from the one I have shown at the top of the preceding page.

Poulton, in his "Color in Animals," gives some interesting experiments on similar larvæ which resemble twigs or the bark of their food plant. They were carried out to determine what influence, if any, the environment might have in determining the color. The caterpillars were surrounded by the leaves upon which they fed, and also by white or green surfaces. No brown twig, or anything dark colored, was allowed to come near them during their whole life. Under these circumstances the larvæ in the majority of the species selected for experiment became very light brown or light gray in color and quite unlike the darker larvæ of the same kinds which were produced when an abundance of dark twigs had been mixed with the leaves of the food plant. Thus it was shown that the environment had some influence on the colors of these larvæ.[1]

[1] See also Morgan, "Experimental Zoölogy," 1907, p. 12, on the influence of external conditions.



The Weevil Bark Imitator

At first glance at this photographic view of burr-oak bark, one would little suspect the presence of an insect resting on it. Yet the weevil shown near the middle of the picture is an actual portrayal of this insect just as I found it.[1] This well protected gray weevil is known as Ithycerus. The larvæ feed on the tender shoots of the burr-oak, while the adult feeds on the bark of this tree. The gray body of the weevil is dotted with black, and bears longitudinal indented lines, which blend very perfectly with the uneven or craggy spaces in the rough bark. In the section on the Twig Impersonator, I referred to it as a case of *special* protection. The whole body of the geometrid caterpillar bears a strong resemblance to a twig. In like manner the walking-stick presents the same kind of *special* resemblance.

But in the present case of the weevil, the markings and sculpturing on the upper surface of its body are the features most effective in concealment. The most singular thing about this resemblance is the impression of bark-like roughness conveyed by the weevil's color. Viewed at a distance the beetle is detected with the greatest difficulty.

One of the most fertile sources of evidence supporting the theory of natural selection was drawn from cases of protective resemblance or what some have termed defensive coloring. Samples are numerous among the insects in nature if only one

[1] At Mill Creek, Illinois, May 30, 1903.

may open his eyes to these objects. The weevil just described belongs to that type which is rendered less conspicuous by resembling the surface on which it habitually rests. There is always an instinctive behavior possessed by these insects. They remain perfectly quiet when resting on the surface of the bark. In a broad sense what we witness here is protective coloring, similarly shown in the rabbit, the plover, or the partridge, all of which instinctively crouch upon the ground surface, the color of which they resemble.

The Arboreal Katydid

The common arboreal katydid is rarely seen, owing to the resemblance of his leaf-like wings to the green leaves of the trees he inhabits. During one summer a katydid preëmpted a claim in one of the old apple trees near our country home. It was not until the second day in August that he arrived at maturity. This fact was first made known by the exercise of his musical powers. He kept strictly to the green canopy of dense foliage, where I never caught a glimpse of him. From this time on until the arrival of frost he kept up his stridulation, rarely missing a night. In September, he generally commenced his "song" between six-fifteen and six-thirty in the evening, varying a little from time to time, and, as near as could be ascertained, closed it at about five o'clock in the morning. The latter time corresponded with the dawn of day.

Whether or not it was the darkness that came over the earth by six-thirty in the evening which excited him to start his musical apparatus, could not be determined. No artificial sounds of a mimicking nature which I devised could induce him to start earlier in the evening than the time mentioned. When this katydid in the tree commenced singing, another male which I had kept in captivity would often start almost simultaneously with him. But when he was kept indoors, which excluded outside sounds entirely, this sympathy was not exhibited. It would seem from this experience that he was awakened into activity by recognizing his neighbor's sounds.

After their silence through the day, I heard one katydid stridulating in the nearby woods on September twentieth at six-fifteen o'clock in the evening. This forest-loving insect was a little in advance of the rest of the katydids living in his immediate locality. After he started his notes, in a few seconds another companion responded. Then in a moment he was followed by more of the colony, until within another minute or two the whole woods of several acres in extent was resounding in *katydid, she did* orchestration.

A cold period, beginning September twenty-third and lasting until the twenty-eighth, silenced these Orthoptera entirely. On the evening of the twenty-eighth, with a temperature of fifty-nine degrees Fahrenheit, the apple tree katydid was heard again, but the sounds were somewhat hesitating and slower than usual.

Ordinarily, this katydid is first heard when he begins to mature in the last of July or early August. He is then heard above the din of the chorus emanating from the trees, underbrush, and earth. He is a Mozart in the insect world, sending out his strain upon the evening air. His stridulation holds a distinct place among the various array of night sounds. All the time he is singing he remains unobserved among the leaves of the elm, maple, oak, or some fruit tree. His pure green dress aids him in this seclusion. He scarcely ever moves from one place where he establishes himself for the night. In fact, he often lives on one tree throughout his career. His rounded, foliaceous wing-covers give him a robust form. This adds to the resonance of the sounds emitted by the wings of the male.

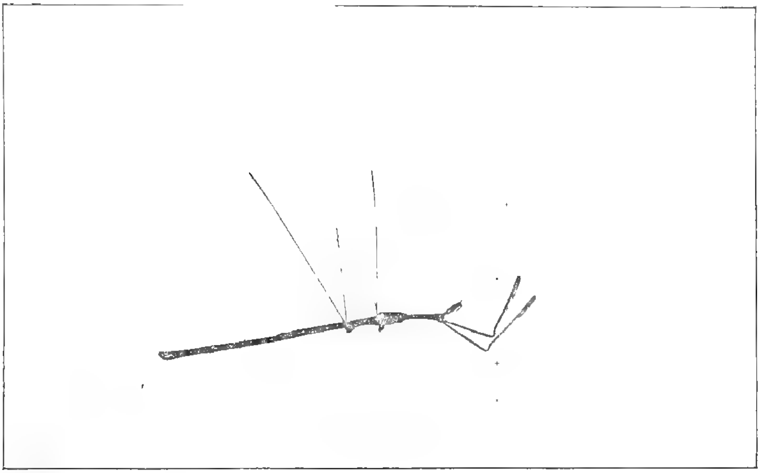
When the sound, which lends such enchantment at a distance, is heard at close range it seems curiously rasping. Some of these insects prevented our sleeping in the same room with them, and in the stress of circumstances they were put in a large paper bag and set sufficiently far away to soften the sounds. The next morning they were given the freedom of the room and provided with plenty of foliage and water. They were content to stay on the flowers almost continuously, but I rarely saw them feed while on these plants or leaves. The musical sound, which has been the theme of poets, is produced by the friction caused by partially opening and closing the wing-covers, each one of which is furnished at the base with an irregular-shaped frame work, with a drum-like covering of transparent chitinous material stretched over it. The upper, or left-hand wing, as viewed from above, has underneath, in front of the membranous covering, a curved file with fine elevations. A sharp ridge at the inner margin of the opposite drum plays over the file when the wings are shuffled together, giving rise to the very effective "katy-did."

This insect possesses a stronger stridulatory apparatus than his smaller neighbors. His arboreal habits necessitate his sound being heard a long distance away. He does not invariably take the initiative in opening the whole insect and frog chorus as evening comes on. The little thin-voiced crickets of several species, hidden away in the darker recesses, or even the green meadow grasshoppers and narrow-winged katydids, with the host of other members of this group, may precede him, but they are sure to be joined at the proper moment by the Mozart of them all.

Among our household treasures one fall season was an angular winged katydid who always led the evening prelude of those in the vivarium, but he was usually awakened to activity by first hearing the out-of-door musicians. When once the shrilling was started, first one, then another, came the succession of night sounds, each one of the insects at intervals trying to outdo the others, the medley being kept up until the light of morning.

One time in September, I observed one of these insects laying her eggs. When found, she was at a point five feet above the ground on the bark of a large scarlet oak, with her ovipositor wedged into the side of a strip of bark. She worked there some minutes, pushing and moving her body in an attempt to bury this organ farther into the side of the bark. Her body rested on its side against the bark surface, cramping the left foreleg so that it was stretched out on the corresponding side ahead of the body. The eggs of this katydid are about one-quarter of an inch in length, or about twice their breadth. They are pointed at each end, dark, bark-colored, and often laid in small series, sometimes compactly crowded together in the crevice of the bark. When the young hatch in the early summer, they climb up the trunk and feed on the foliage of the tree. Here they live during the remainder of their existence unless devoured by some predaceous enemy.

This katydid, like its related forms, is of particular interest in showing special adaptations to an arboreal existence. It affords one of the most beautiful examples of protective resemblance found in our temperate fauna.



THE INVISIBLE OR THREAD-LEGGED BUG

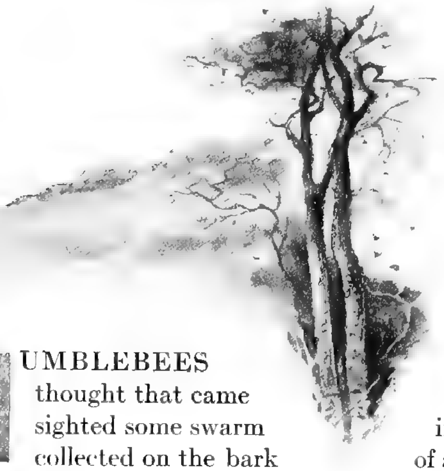
WE called attention in another chapter to the thin-bodied walking-stick insect. The efficacy of his attenuated form is at once seen to be of use in concealing his body from his enemies. It will be remembered that the walking-stick is a member of the Orthoptera or grasshopper order. Among bugs we have a parallel case, where natural selection seems to have effected the same object of attenuation of body, but even to a more marvellous degree. I refer especially to the invisible or thread-legged bug which is portrayed above. It certainly occupies a place among the quaintest of the insects. In our common species the body is so thin and thread-like that it has been given the Latin scientific name, *longipes,* in deference to its extremely long legs. The resemblance of the walking-stick to the thread-legged bug was impressed upon me by a remark from my junior companion afield. On seeing one of the thread-legged insects for the first time, he exclaimed, "Come quick and see the walking-stick flying." The thread-legged insect mentioned was flying low under the shelter of an apple tree.

One of these bugs was seen in August on the side of a wooden house, walking slowly upwards in an ungainly manner. When I attempted to take it in my hands it used its little wings in flight with surprising dexterity, though these organs are unusually small and out of proportion to the length of the body. When the insect is flying in mid-air it becomes almost invisible. At rest the wings are very narrowly folded longitudinally on the back, thereby taking up very little space. They appear to occupy a place which corresponds with the centre of gravity of the body. The thread-legged bugs are predaceous and forage for insect prey, which often consists of small gnats. In the fall they lay their eggs, one at a time, indiscriminately attaching them to the flat surfaces of walls. According to Wickham [1] one female may lay as many as nineteen eggs. They are often seen swinging by their legs from the roofs of sheds. A peculiar feature of the anatomy of these insects is shown in the modification of the forelegs which are used for grasping their prey. Moreover, one may be deceived at first glance into thinking that the long, peculiarly bent antennæ attached to the head are a pair of legs. This illusion arises from the abrupt bending downward of the antennæ, at an angle near the middle. The thread-legged bug is known to the naturalist as *Emesa longipes.*

In closing I may suggest that the thin body of this insect may not only serve as protection against its enemies, but also the useful purpose of allowing it to approach its own prey unobserved.

[1] *Entomological News,* January, 1910, p. 27.

Quaint Visitors to the Sap Fountains on the Oak



BUMBLEBEES — was the first thought that came to mind, as I sighted some swarming flower beetles collected on the bark of a young burr-oak. There was something in their flight which suggested that of a large bee. As I cautiously neared the spot, I found there were nineteen bumble flower beetles, *Euphoria inda*, yet they so perfectly simulated the bark that it required careful examination to count them. Some were closely packed together, others moved about here and there within a small circumscribed area of about four inches while still others crawled over the backs of the quiet ones struggling for places of rest. Sometimes one, or perhaps several, would become crowded from their stations, and were forced to take wing. With loud buzzing of wings, the dislodged members of the group would make short temporary circuits into the air, they then would settle back on the bark, again joining the assemblage.

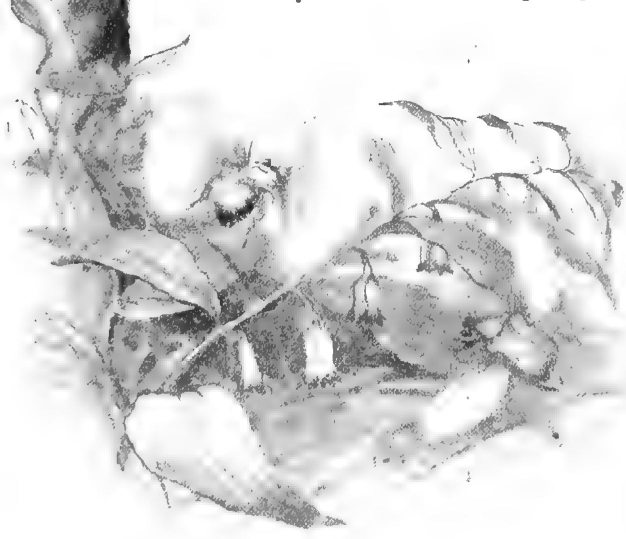
This harmless species of beetle is sometimes seen in sunny spots early in the spring before the snow is fairly off the ground. They then fly like the bumblebee alone near the earth among the herbage, making as much ado with their buzzing wings as the largest of our bumblebees. All through the summer they are rarely seen. But in the latter part of September, I found the special attraction on the oak that lures the fall brood. Destructive, boring insect larvæ have opened channels into the live trees, through which the oak sap pours out, wetting the bark. This comes in proper time, as food for the beetles, as the flowers upon which they feed in the fields are now nearly all gone. It is at these little fountains on the bark that one finds gathered the quaint family of bumble flower beetles. At other times, I have found them on the bark of willows. A little study shows that their appetite for the sap is intense, and that they know where to find it. Each little sap well has its patronage of beetles gathered around it. Further search revealed two more sap fountains on the tree trunks with many furry beetle attendants. In one party of feasters there were thirteen, while at the other, fourteen banqueters were variously disposed. The sexes were about equally divided in the colonies.

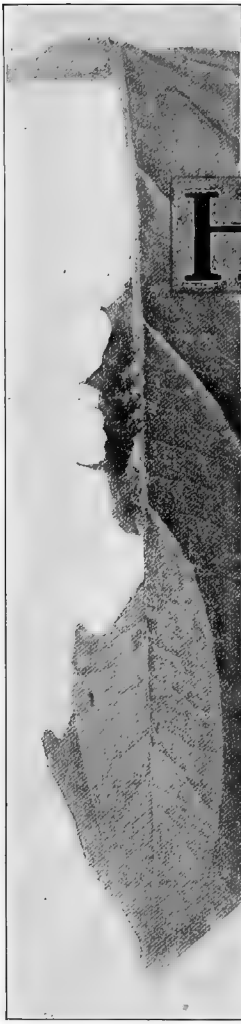
The sharpest eyes are necessary to detect the bumble flower beetle on the bark of trees, for he is securely protected by the blending of his minute yellow and black speckled markings with those of the background. When at rest, his wings are drawn in out of sight. On catching one of the insects in the hand, a peculiar nauseous secretion is given off. This is supposed to be useful in self-defence. The secret of his masquerading as a bumblebee while flying, lies in the fact that his thorax is clothed with yellowish hairs. Moreover, the ease with which he can spread and operate the smoke-colored wings, which resemble those of the bumblebee also aids in this deception. Unlike most beetles during flight, his wing-covers remain closed; the wings spreading out from beneath the base of these structures. The margins of the wing-covers are roundly excavated near the base, thereby allowing the wings to pass freely outward from the sides without the necessity of raising them.

One can quite easily conceive the advantages to be gained by this insect in even partially mimicking the bee while on the wing. Hovering about the flowers on which he feeds in the same situations as the bee, he probably enjoys protection in taking on the features of his well-armed ally, for the ceaseless, active birds are ever on the lookout for defenceless insects. It would also seem probable that the bumble flower beetle is exempt from these enemies, when it is remembered how easily we could pass him by while he was on the tree trunks, or take him for a genuine Bombus when on the wing. Similarly, the deception in his humming wings and the hairiness of the thorax carries out the resemblance still further.

It is during flight that this beetle would be more likely to be attacked by birds. At this time he is protected by a development of warning colors in his wings and body analogous to that of the bumblebee. On the other hand, while resting on the bark of trees he is protected by the body colors which simulate the background surface. Then again, his nauseous secretion makes him a distasteful object to devour. This combined protection, in a word, doubtless assists him from being destroyed in his various wanderings during life. As to his apparent mimicry of the bumblebee, it may be only a coincidence, but the fact remains that there are resemblances which seem to be demonstrated as favoring such a view.[1]

[1] Based on diary notes made at Chicago, September, 1904.

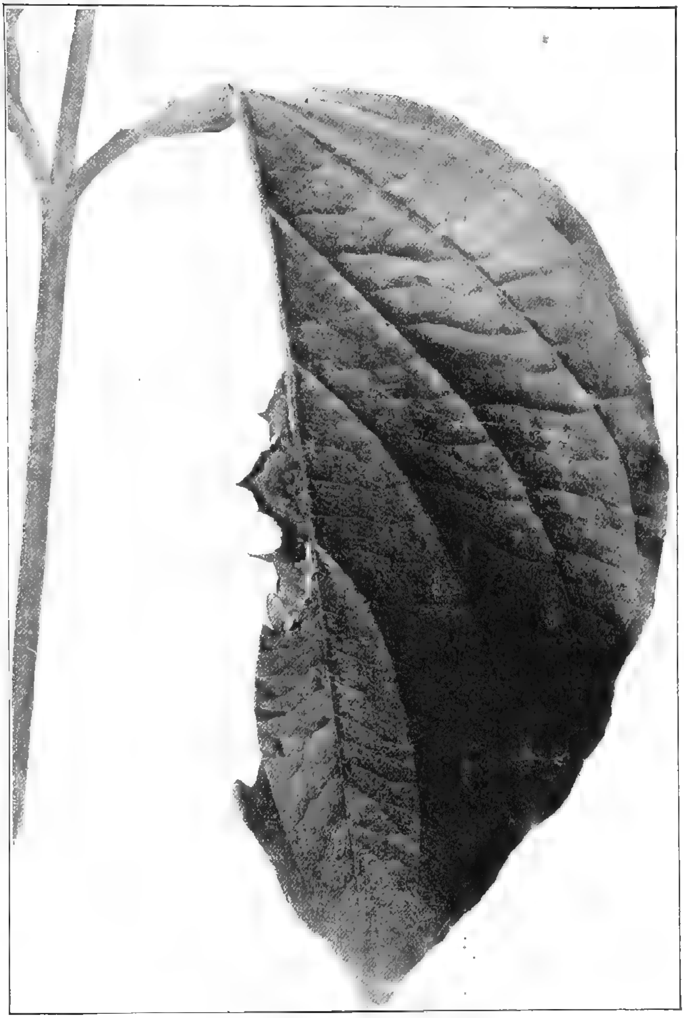




The Protected Schizura Caterpillar

HOW well protected certain insects are from the keen vision of predaceous birds and other higher animals is well exemplified in the *Schizura ipomeæ* caterpillars. During exposure in daytime and while feeding on leaves, this simulation of the surroundings is of paramount importance in their preservation. However, it may not preserve them from the attacks of the small Hymenoptera, which have a form of vision different to that of the birds. I present herewith two photographic reproductions of one of these moth caterpillars. The photographic plate caught the caterpillar while feeding on a half-eaten dogwood leaf. The initial photograph shows the same individual which, having taken alarm and stopped its feeding process, had backed off along the mid-rib of the leaf, where it remained motionless. In the first position this caterpillar's form was most difficult to make out. Its brown and green body presented the exact counterpart of a withered brown blotch on the dogwood leaf. Moreover, this resemblance was so perfect that the scrutiny of several uninformed persons, who were asked to examine it, failed in identifying it.

This deception is brought about by the adaptation of both form and color. The back or dorsal outline, being formed into tubercles and elevations, gives to the larva the effect cf being part of the eaten leaf itself, with an irregularly excavated



A case of protective resemblance both in form and color. The caterpillar Schizura ipomeæ is feeding on a dogwood leaf, and is the same as that shown in the initial figure. This larva is brown with a green pattern behind the head simulating the color of the leaf, the brown color resembling a dead portion of the leaf.

edge. Behind the head on the three thoracic segments is a green pattern, which causes this portion to blend with the color of the leaf.

With a view to learning something further of the life history of this interesting caterpillar, I took it indoors on July thirteenth. It readily ate dogwood leaves supplied to it until the fourth day; then it became restless, refusing to eat further. It kept moving about on the wooden bottom of the vivarium, but made no attempt to spin a cocoon, possibly because proper facilities were not at hand. Finally, it quieted down and cast off its caterpillar skin, transforming into a shiny, dark brown chrysalis, which was a trifle more than three-quarters of an inch in length, with a pair of barbed spines at the abdominal apex. It was nearly a month later, August twelfth, before this chrysalis underwent transformation into a moth. It then split open along the back at the forward end of the body and from it an unpretentious looking moth emerged. The thorax and forewings of the latter were light brown, with some slight shadings, while the underwings were nearly plain creamy white. The expanded wings measured nearly one and a quarter inches. The moth was unable to shake off a small triangular piece of the chrysalis that had broken off and adhered to its head.

Another singular incident happened to the caterpillar while I was first rearing it. The day after it was taken indoors I found it apparently drowned in the vessel of water supplied to sustain the food plant. The caterpillar had all the appearance of being dead, having sunk to the bottom of the glass bottle, and was perfectly "water-logged" when it was recovered. The sun was shining outdoors very warmly, and the thought occurred to me that possibly the caterpillar could be resuscitated by exposing it to the sun's drying rays. The insect was thereupon placed on a board out of doors in full sunlight, and before long the experiment bore fruit in signs of returning life. First the legs behind began to twitch a little, then in the course of several minutes, by industrious fanning and turning of the body, the caterpillar gradually regained its former live attitude, being able to use and stand on its legs. Finally it could cling to the leaves again, and ultimately recov-

An example of protective resemblance. A green caterpillar feeding on the leaves of wild gooseberry. The back of this larva presents a broken outline like a leaf margin, having spines.

ered. It lived for many days after and underwent the transformation into pupa and moth as described.

Packard, in his "Forest Insects," quotes some interesting observations by Riley on the allied species *Schizura unicornis.* The caterpillar feeds on quite a number of different plants, such as the oak, elm, plum, apple, dogwood, winterberry, rose, blackberry, and hickory. "This insect is evidently two-brooded, those of the first brood spinning their cocoons at the commencement of July, while larvæ of a second brood, often only about one-fourth grown, are found as late as October tenth. The cocoon is very thin, like parchment, and is frequently constructed of leaves drawn together for the purpose. The mimicry of the caterpillar when on the blackberry stem or leaf is exact, and the imitative resemblance of the moth when at rest on the bark of a tree is still more striking. The moth always rests head downwards, with the legs all drawn together and its wings folded around the body, which is stretched out at an angle of about forty-five degrees; the dull gray coloring of the wings, with the lichen green and flesh color, give the whole such a perfect appearance of a piece of rough bark that the deception is perfect. Some of the caterpillars are infested with Tachinids and the parasitic insect *Ophion purgator.*"

In the second plate illustration is given another photographic figure of a caterpillar, possibly allied to Schizura, which was found feeding on the wild gooseberry. This larva also presents a broken, dorsal outline, the forward tubercle here giving an appearance not unlike the spines on the twigs.

IV. MIMICRY, WITH EXAMPLES

IV. MIMICRY, WITH EXAMPLES

Bates' Theory of Mimicry

BATES, in 1862, was the first to observe in South America certain butterflies that were mimicked by others. These observations were published in the "Linnean Society Transaction," Volume XXIII. Four years later, Wallace described similar cases which he discovered in Asia and in the Malay region. Later, Trimen recognized similar cases in Africa. This subject has been elaborated by Belt, Meldola, Müller, Poulton, Marshall, and others.

The conditions under which protective mimicry occur, according to Wallace in "Darwinism," pp. 264, 265, are as follows: "The imitative species occurs in the same area and occupies the same station as the imitated. The imitators are always the more defenceless, are always less numerous in individuals, and they differ from the bulk of their allies. The imitation, however minute, is *external* and *visible* only, never extending to internal characters or to such as do not affect the external appearance." These observations were founded on butterflies occurring in the tropics where examples of mimicry are much more numerous than northward in the temperate region.

The females are much more liable to protective mimicry than the males. Wallace explains this by asserting that "their slower flight, when laden with eggs, and their exposure to attack while in the act of depositing their eggs under the leaves, render it especially advantageous for them to have additional protection." Weismann remarks [1] that "Whenever we find protected insects enjoying immunity from foes, we also see mimickers, sometimes only single, sometimes several, and

[1] "Studies in the Theory of Descent," 1882, p. 649.

generally from very diverse groups of insects, according to the general resemblance which existed before the commencement of the process of adaptation, and to the variations made possible by the physical nature of the species concerned."

Bates was the first to suggest that when two species exhibited similar patterns and one was distasteful to birds, the other had acquired a protective resemblance to it through natural selection. Darwin, as mentioned in his "Life and Letters," had praised Bates' paper with enthusiasm. Fritz Müller, in 1879, and later, Lloyd Morgan, attempted to show that birds have no intuitive knowledge of what forms of insects should be avoided. Young birds are said to destroy many distasteful forms before learning to leave them unmolested. It is also believed that when birds learn that individuals of a species, which may serve as prey, are disagreeable, other species which closely resemble the protected species profit by the mimicry, because each of the two species will need to contribute only a portion of the sacrificed ones instead of the whole. It is presumed that the greater the number of forms that mimic a favored species, the smaller would be the destruction of individuals, and conversely, the greater are the chances for existence for all. In this way associations of species called "Müllerian groups," resembling one another, yet being of diverse genera, may coexist and enjoy common immunity.

These suggestions of Bates and Müller were enlarged by Wallace, Trimen, Meldola, and Poulton, and as a result, much light has been thrown on the problem of the complicated relations of many forms. These views, like all theories when first propounded, have been called in question by a number of writers, principally because of lack of direct evidence that birds actually eat butterflies. Weismann, Judd, and others have made limited investigations of this character, and very recently Marshall[1] has shown that many birds eat butterflies. On the other hand, we find that Gadow, of England, has propounded a chemical theory of animal coloration to explain mimicry, maintaining that the pigments are physiological products of the organism, liable to chemical transformation with corresponding changes in color.

[1] Trans. Entomological Society of London, 1908, p. 329.

According to Lewis,[1] who is in accord with Gadow, what he interprets in the Viceroy butterfly is a transformation from blue and black to a red, like that in the Monarch butterfly. He assumes that this change occurs on the same theory that the autumn leaves turn from green to yellow and red through similar processes of chemical transformation, and he significantly says: "If a crimson leaf of the red maple resembles one of the Japanese ivy, it is not due to mimicry." Other facts have been brought forward by Piepers, in reference to the theory of mimicry.

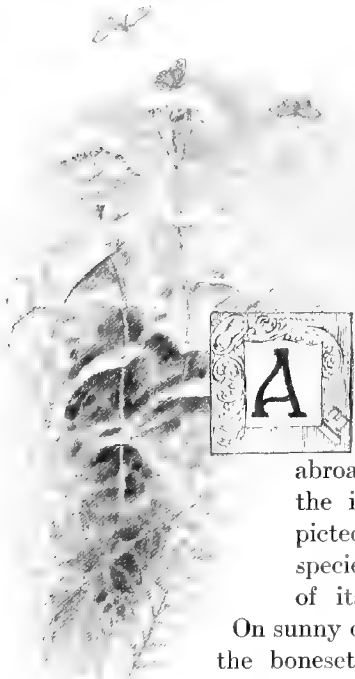
Poulton believes that the study of mimicry possesses special advantages for an understanding of the history and causes of evolution, and that North America is the most suitable area in the world to begin its study. In one of his most recent articles[2] among other interesting things, he has asserted that one of our common black species of swallow-tail butterflies known as *Pharmacophagus philenor*, is mimicked by three species of butterflies. These are the female of *Papilio asterius*, on both sides of its wings; the black female of *Papilio turnus* (see page 147), which is common in the southern part of its range, and both male and female of *Papilio troilus*, shown in the frontispiece illustration. From a study of these insects he was able to point out that the latter species may be regarded as the oldest mimic, *asterius* the next, and *turnus* (*glaucus*) the latest or youngest in the order of their mimetic evolution.

After summing up the bulk of the literature on this subject, and more especially the writings of Poulton, it is apparent that mimicry seems to stand on a firmer basis than ever. Moreover, as Jordan and Kellogg aptly remark: "Whatever other factors or agents have played a part in bringing about this specialization of color and pattern, exemplified by animals showing protective resemblance, warning colors, terrifying manners, and mimicry, natural selection has undoubtedly been the chief factor, and the basis of utility the chief foundation for the development of the specialized conditions."

[1] *American Naturalist,* Vol. XLI, p. 782; see also Dixey's article in *Nature.*

[2] "Annals of the Entomological Society of America," Vol. II, Dec., 1909.

The Monarch Butterfly and its Mimic



ALL through the summer and fall one may find the reddish colored Monarch butterfly abroad in the meadows. In the initial drawing it is depicted with its companion species, the Viceroy, on one of its favorite food flowers. On sunny days, wherever clumps of the boneset flowers were found, I was reasonably certain to find the Monarch, although it was a frequent visitor to many other flowers.

It lays its eggs on the leaves of the milkweed, and after hatching, the larvæ find their suitable food readily at hand during their development. These familiar larvæ are marked with light or lemon-colored bands traversed with shining black. The plump green chrysalis will be easily distinguished by its ornamentation of metallic golden-hued spots. The chrysalids are often attached to the stems of plants near to the ground, or they are sometimes found hanging from the lower edge of outside clapboards of houses. The Viceroy butterfly, shown in the plate illustration and on page 133, bears a close resemblance to the Monarch. Even after one knows both butterflies it is not easy in the field to distinguish the two. However, the resemblance is only superficial, being confined to color. The real structural characters show that they belong to distinct sub-families

It is the common impression among naturalists that the resemblance of these two species has been brought about by natural selection. For this reason I have summed up the leading facts upon which this assumption is based, especially as there has been some skepticism regarding the action of selection in bringing about the apparent mimicry here witnessed. In order to present these facts in a readily appreciable form, brief sketches of the salient points are given of each of their respective life histories, placed side by side:

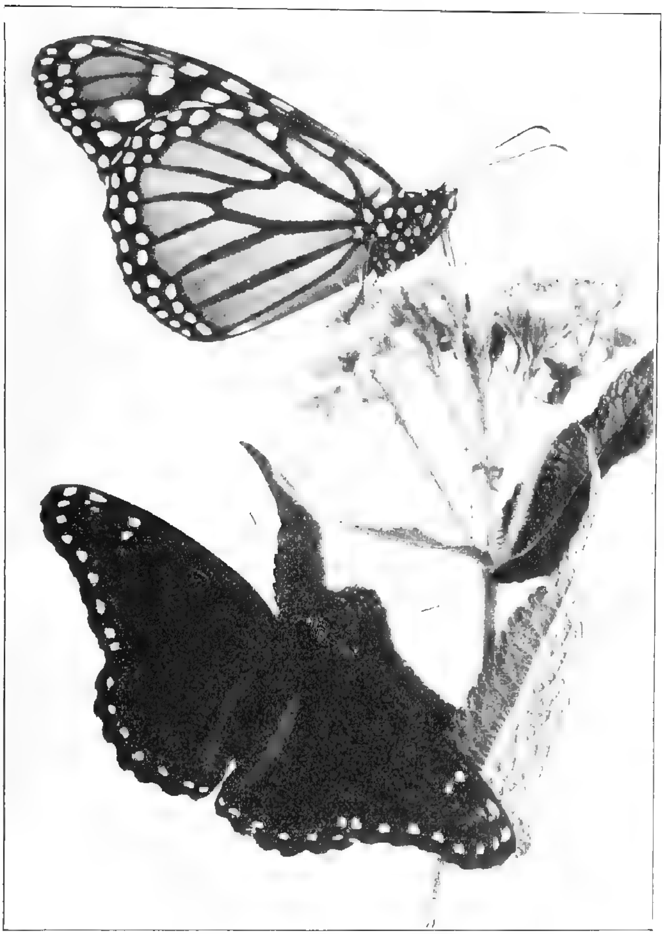
Caterpillar of the Viceroy butterfly on the leaf of heart-shaped willow.

Monarch	*Viceroy*
Adult resembling Viceroy; visits flowers in same company with Viceroy. Male provided with black pouch on hind wings containing scent scales or androconia.	Adult resembling Monarch; visits flowers in same company with Monarch. Male *not* provided with scent organ on hind wings.

Monarch	*Viceroy*
Egg unlike Viceroy, often parasitized by small hymenopterous insects, *Trichogramma intermedia.*	Egg unlike Monarch in shape and reticulations; often parasitized by *Trichogramma minuta* and *T. minutissima,* the two being hymenopterous insects.
Caterpillar when full grown presenting lemon-yellow bands with shining black, and provided with a pair of fleshy filaments on second thoracic and seventh abdominal segments; often parasitized by ichneumon flies.	Caterpillar when full grown often mottled grayish and white (see plate illustration), supplied with prothoracic and other spinous tubercles; parasitized by ichneumon flies.
Generally unlike Viceroy in form and coloration.	Generally unlike Monarch in form and coloration.
Feeds on species of milkweed exclusively.	Feeds on willow, poplar, etc., but *never on milkweed.*
Pupa stout, cylindrical, pale green, ornamented with golden spots.	Pupa slender, obscure gray, the middle of dorsum with a projecting boss. (See plate illustration.)

The first thing to note in the above brief comparisons is that only during the adult butterfly stage is there any resemblance between the two species, there being no trace of mimicry in either the egg, caterpillar, or pupa stages. Why is this mimicry confined to the adult stage? I have already shown that the two species are associated only during the adult life when feeding on flowers, and at no other time. Here is a significant suggestion in the answer to our inquiry. Are the adults especially exposed to the attacks of birds and lizards? The Monarch is said to be protected from these attacks by the presence of distasteful scent scales on the hind wings of the male, and the Viceroy is supposed, by virtue of its close resemblance, to share the same immunity.

Though theoretically thus protected, there are very few instances recorded where the Monarch and its mimic are attacked by birds, and for this reason some observers have thought the mimicry here is a coincidence. In August, during four seasons, I have seen the Monarch gather in swarms on the branches of cedar and on the leaves of the beech trees. While these congregations took place, lasting perhaps for a week or more, I could not discover that one of them was destroyed by migratory or resident birds. All the individuals constituting



The Monarch Butterfly (Anosia plexippus) above, with its mimic species, the Viceroy (Basilarchia disippus) below, visiting the boneset flowers. The under surfaces of the wings of the lower insect are very similar to those of the Monarch. See page 133 for another view of the Viceroy, showing underside of wings.

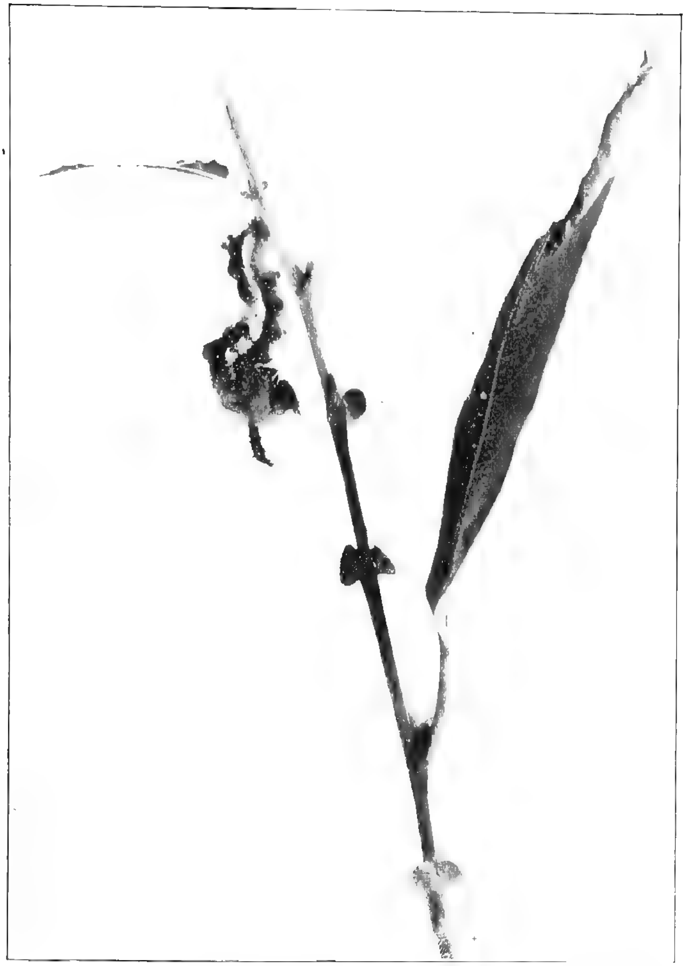
these assemblages, often numbering several hundreds, were fresh and bright appearing and without blemish.

I do not recall in Herrick's work on the "Home Life of Wild Birds" a single instance of a butterfly being taken to the nests of young birds during the feeding process, yet he notes carefully many other insects fed by parent birds to their young.

Herrick, in describing the action of nestling cedar birds, says: "They snapped at every ant and flying insect which came within their reach, but I never saw a single capture. The preying instinct is undoubtedly one of the most ancient among animals, and young birds peck instinctively at all kinds of small objects, but precision of aim which leads to success in capturing their prey must be acquired by practice."

The difficulty experienced by adult birds in catching butterflies while flying must be very great, and young birds would find the task of catching them still much greater. Then, after pursuit of butterflies, if the birds finally caught one of these insects, and found it distasteful, what a disgust would be formed for them. In such an event the species of butterfly in question would after a time enjoy immunity from further attacks. All evidence considered, our higher birds have acquired a dislike for many butterflies, and they form but a minimum portion of their diet. This cannot be said of many insect larvæ, flies, beetles, locusts, grasshoppers, katydids, dragon-flies, and so forth, all of which are preyed upon freely by birds. Young birds are taught to some extent by the parents what to eat, and as a result there has arisen a kind of special diet for each species of birds.

From this line of reasoning it follows that a former promiscuous diet among birds might become restricted, and this means the exclusion of some distasteful butterflies. The latter may have been eaten in generations past, but are now immune. If birds were the selective factor in perfecting the supposed mimicry or resemblance of the Viceroy butterfly to the Monarch, the bird-eating factor must have exercised the selective influence in time past, more than at present. At least it is so deduced from observations. While the adult butterfly enjoys a large share of immunity from birds, I am not in possession of facts as to how much destruction is caused the larvæ and pupæ by



The Viceroy Caterpillar about ready to pupate. It has fed on the leaves of the heart-shaped willow. Shortly after this photograph was made it transformed into the pupa, as shown on the next page.

birds. Nor have I a knowledge of the amount of destruction occasioned by birds to the eggs. But from actual observation I have seen numbers of the pupæ and eggs that were parasitized by Hymenoptera. It is in these stages that the butterflies generally suffer the greatest amount of destruction from animal enemies.

The Viceroy Pupa after transforming from the caterpillar shown in the preceding plate. Its queer form of body and color is highly protective.

The Monarch is seemingly much more abundant than its mimicker. This is one of the special conditions under which mimicry exists. The vital period of exposure is in the adult female when she is laden with eggs. At this time she is more exposed than the shorter lived male. Both the Monarch and the Viceroy enjoy freedom from attacks by predaceous birds and lizards at this time. On the whole, although there are features of the life of these butterflies not understood, the proof of mimicry is as obvious as it is in the usual run of these cases, yet there is a more plausible explanation on the ground of natural selection in accounting for it than there is in the purely chemical theory of coloring without definite use to the animal possessing such colors.

Poulton [1] has recently asserted that the Monarch butterfly, which is the old world ancestor of the Danaine butterfly, invaded the new world by way of the north at a time sufficiently remote to permit of the acquisition of generic distinction. The Monarch was mimicked by an indigenous species of Limenitis, closely similar to and probably identical with the banded purple *L. arthenus*, which thus originated the Viceroy.

[1] Trans. Entomological Society of London, 1908, p. 487.

The Bumblebee's Mimic

HOW unexpectedly nature introduces some of her guests to those whose minds and eyes are on the alert to receive them! One day in June I came suddenly upon a large robber-fly at the edge of the woods. He was flying low to the ground, foraging among the herbage. Before I could scarcely realize what had happened he had pounced like a tiger upon a rose-bug and in the next moment had settled with his prey upon a leaf of sassafras.

In the first photographic plate he is pictured with his proboscis buried in the rose-bug's body, sucking out its juices. I have also pictured on the same plate the æsthetic columbine plant that grew beside the young shoot of sassafras upon which he was resting. To all appearance the robber-fly was the very embodiment of a bumblebee. Here was the velvety covering of light golden hairs on the thorax, the yellow and black covering on the abdomen, and even going so far in the mimicry as the unconscious pose of a bumblebee. This same species of robber-fly, *Dasyllis sacrata*, was seen quite often during the early summer. His boldness often amounted to such familiarity that he would alight on my clothes. On such occasions he invariably caused consternation among the uninitiated members of our party, as he was always taken for a bumblebee.

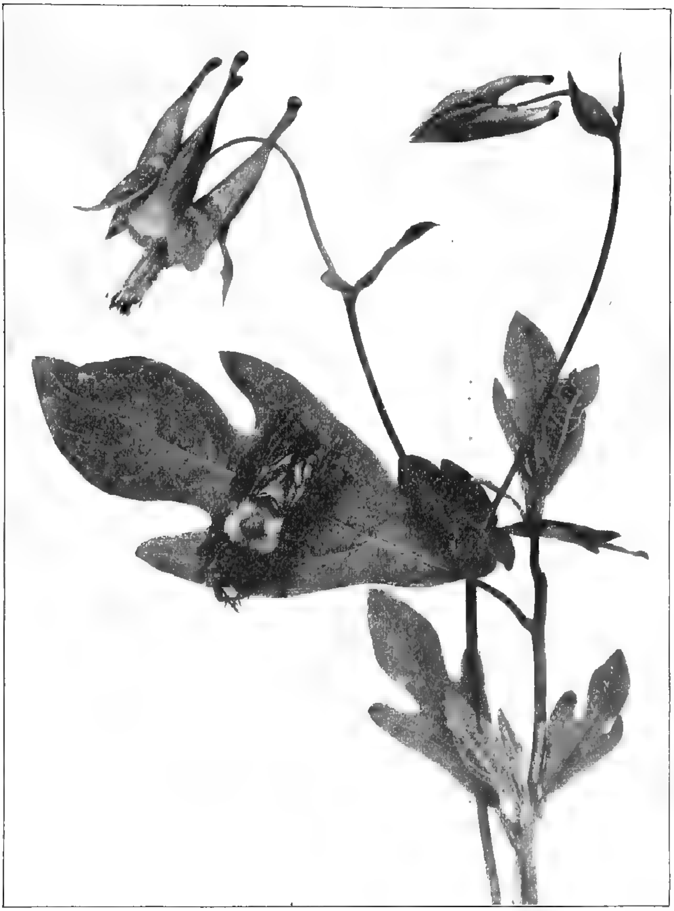
If I were to select a perfect example of mimicry in our temperate latitude, this insect might be chosen as the highest type, for he presents a striking likeness to *Bombus consimilis.*

When seen preying upon insects his identity may be recognized at once even by the novice, if he will remember that the bumblebee never captures living insects for food. It is only after taking him in hand that his real fly nature becomes evident; for his wings consist of but one pair, instead of two pairs, as in the bees and other Hymenoptera. I found the prey of this robber-fly quite varied in assortment, but it more often consisted of rose-bugs and winged insects. I am informed by C. T. Brues that it also feeds upon bees.

In the illustration, page 131, I have shown him in mid-air, carrying off a small insect. While I have seen gray-colored species of robber-flies eaten by the phœbe fly-catcher, who decapitates them before feeding them to her young, and have also seen them fall prey to the ant-lions living in the sand, I have never seen the mimicker of the bumblebee taken as prey by birds or other animals. But Herrick[1] records having seen one in the beak of a bluebird, which she fed to her nestlings within a hollow tree. The diet of this bird, however, consists mostly of grasshoppers, katydids, green larvæ, and crickets.

I have shown, in the chapter on the "Quaint Visitors to the Sap Fountains on the Oak," how the flower beetle, *Euphoria inda*, possibly mimics the bumblebee. The flower beetle, however, enjoys a protective resemblance to bark and but a partial mimicry to the bee, the latter being more particularly serviceable when on the wing. But in the robber-fly the mimicry is much more perfected, so that it enjoys all the immunity the bee experiences without possessing a sting. At the same time this mimicry may serve the purpose of facilitating the capture of bees which might fall prey to this insect's rapacious appetite. In the latter case we have what Poulton and others have designated "aggressive mimicry."

[1] "The Home Life of Wild Birds," pp. 73, 74.



The Robber-fly (Dasyllis sacrata) on a Sassafras leaf. It has just captured a rose-bug, and is feeding on its prey. The flowers are those of the columbine.

Flower Frequenting Flies

A NUMBER of little Syrphus flies were seen one day gathered about the blossoms of a giant mullein. Each dainty striped fly hung about the blossoms as if having a distinct mission to perform.

For light aerial flight the Syrphus flies are without rivals. One starts suddenly off, perfectly fearless in the moving currents of air, keeping a little distance from the flower, then poising in mid-air with quiet grace, its large staring eyes seeming to take in the surroundings at a glance. Alighting on the petals, it proceeds to the orange-tipped anthers where it partakes of pollen and licks the staminal hairs with evident relish. During the feeding it generally affects a nervous air by flexing the abdomen up and down. These motions resemble similar behavior exhibited by bees possessing stings, which the Syrphus flies mimic. During these movements the flies keep the wings widely spread. At other times they are found quietly resting on the flower or stalk, with the wings folded together over the back. This is probably the attitude they assume when they go to sleep. The familiarity of these flies is often amusing; they not infrequently alighting on one's hand. One is even now poised on the tip of my pencil, keeping his hold through the motions incident to writing these lines in the field. At times they seem almost omnipresent.

To get acquainted with these æsthetic dwellers of yellow blossoms, one should make a visit to the giant mullein. If one has a contempt for this wayside "weed," this opinion will

The Robber-fly (Dasyllis sacrata) with an insect just caught. The plant is Alsike, or Alsatian Clover (Trifolium hybridum). The grasshopper is the young of the Clear-wing Locust (Camnula pellucida).

be modified after the many biological interests that centre here have once been awakened. Müller found that a number of insects were instrumental in cross-fertilizing this species of plant in Europe. Among them were the honey bee and bumblebee, besides other species of bees, wasps, and Syrphus flies. He says: "From my own observations it is clear that the small pollen-feeding bees (Prosopis) and Syrphidæ are very frequently the fertilizers of this genus (Verbascium)."

Similarly, our forms play an important part in cross-fertilization of this plant, as well as others. The body vestiture of many of the Syrphus flies is composed of branched and spiculate hairs which gather pollen. Some of the Syrphus flies mimic the bumblebees and wasps, while others resemble the honey bee. In the colored photographic plate illustration is pictured one of these insects resting on the flower of a purple aster. It is known as the drone fly, *Eristalis tenax*. This insect's resemblance to a male honey bee is so perfect that inexperienced observers often mistake it for the real bee. In the late fall of the year, after the first frost, it becomes very sluggish, and many of them, benumbed by the cold, appear on sidewalks and sides of buildings. The larva of this insect is the well-known "rat-tail" form, which is sometimes found in hollow tree stumps where the rain water has stood for a long period. Here the larva living in the stagnant water is provided with a long, projecting, tail-like structure, at the end of which a number of spiracles occur, through which it can breathe the air when thrust above the surface.

On the same plant of the purple aster is shown the moth, *Plusia simplex*, as an associated guest. It is one of the night flying moths, but they are sometimes found on cloudy days visiting flowers in the afternoon. The forewings are marked by a pair of silvery spots; these spots, together with the rich brown coloring on the forewings, simulates the ground upon which they often rest during the day.

In another chapter is mentioned the aerial performances of the Tabanid flies. These insects obtain their nourishment principally by sucking the blood of animals, but the Syrphus flies are almost always flower frequenters. From these facts, and other interesting features gleaned from their life histories,

THE PURPLE ASTER, SHOWING INSECT VISITORS

The upper figure is the moth (Plusia simplex), the lower figure the drone-fly (Eristalis tenax). The rat-tailed larva of the latter lives on decaying vegetation in the water pockets of old tree stumps. From a photograph

it will be seen, first, that the Syrphus flies play an important role in the pollination of flowers; second, that they are among the most graceful of our flower frequenters; third, that evolution is thought to have wrought among their numbers perfect mimickers of insects. As mimicry becomes more thoroughly studied in our fauna many new examples will doubtless come to light. There are known at present a number of forms of flies, butterflies, moths, as well as other insects and spiders, that mimic other forms occupying the same district or area. One not infrequently finds flies mimicking bees, such as I have previously pointed out in this article; spiders resembling ants, and moths resembling wasps. "It is impossible," says Romanes, "to imagine stronger evidence in favor of natural selection as a true cause in nature, than is furnished by this culminating fact in the matter of protective resemblance, whereby it is shown that a species of a genus, family, or even order, will accurately mimic the appearance of a species belonging to another genus, family, or order, so as to deceive its natural enemies into mistaking it for a creature of so totally different a kind."

The Viceroy Butterfly, showing the underside of the wings, which resemble the markings of the Monarch species.

V. WARNING COLORS, TERRIFYING MARKINGS, AND OTHER PROTECTIVE DEVICES, WITH EXAMPLES

V. WARNING COLORS, TERRIFYING MARKINGS, AND OTHER PROTECTIVE DEVICES, WITH EXAMPLES

Wallace's Theory of Warning Colors

UNTIL the time of Wallace, the gaudy colors of caterpillars were a most perplexing problem. Darwin found that his law of sexual selection could not act in the case of sexless caterpillars. Wallace reasoned in this way: "Applying here the analogy of the other insects, I reasoned that since some caterpillars were evidently protected by their imitative coloring, and others by their spiny or hairy bodies, the bright colors of the rest must also in some way be useful to them. I further thought that as some butterflies and moths were greedily eaten by birds, while others were distasteful to them, and these latter were mostly of conspicuous colors, so probably these brilliantly colored caterpillars were distasteful and therefore never eaten by birds. Distastefulness alone would, however, be of little service to caterpillars, because their soft and juicy bodies are so delicate that if seized and afterwards rejected by a bird, they would almost certainly be killed. Some constant and easily perceived signal was therefore necessary to serve as a warning to birds never to touch these uneatable kinds, and a very gaudy and conspicuous coloring with the habit of fully exposing themselves to view becomes such a signal, being in strong contrast with the green and brown tints and retiring habits of the eatable kinds." [1]

Weir in England showed by experiments of feeding larvæ to birds, that hairy and spiny caterpillars were uniformly rejected by all his ten species of captive birds. In the case of the tortoise

[1] "Natural Selection and Tropical Nature," p. 83.

shell and peacock butterfly larvæ, they were rejected, not on account of the hairs and spines, but because they are distasteful. The young caterpillars in which no hairs were developed, as well as the smooth pupæ of the foregoing species, were refused as persistently as the spined larvæ. Hairs and spines here would seem to be mere signs of uneatableness.

Similarly, smooth, gayly colored caterpillars which never conceal themselves, but on the contrary appear to court observation, were subject to experiment. One species of these larvæ was pale yellow with a broad blue or green lateral band; another was greenish white with yellow bands and black spots, etc. These were given to the birds at various times, sometimes mixed with other kinds of larvæ which were greedily eaten, but they were in every case rejected, apparently unnoticed, and were left to crawl about till they died.

Lastly, dull-colored and protected larvæ were used in the observations, and the results of numerous experiments by Weir and given by Wallace are as follows: "All caterpillars whose habits are nocturnal, which are dull colored, with fleshy bodies and smooth skins, are eaten with the greatest avidity. Every species of green caterpillar is also much relished. All Geometridae whose larvæ resemble twigs as they stand out from the plant on their anal prolegs, are invariably eaten."

Other experiments of this nature have been made with lizards, frogs, and spiders, and Wallace was convinced that his theory of warning colors had received substantial support, for he says: "I think, fairly claim, this is a case in which the power of prevision has been successfully exerted, and therefore as furnishing a very powerful argument in favor of the truth of natural selection."

By referring to the part on the Saddle Back Larva, an excellent example of warning colors is shown.

It is the same theory of warning coloration, applied to caterpillars by Wallace, which is supposed to act in preserving the conspicuous and often brightly colored butterflies from attacks by predaceous animals. These insects possess to a large extent ill-tasting blood lymph or some specially secreted acrid substances that birds dislike. By the possession of these unsavory characters, the color pattern of the animals possessing them seems to be able to take on more brightly colored hues without sacrifice to life. But the attitude of butterflies and disposition of color also contribute to this protection.

The distribution of color in butterflies shows that all the brilliant coloring is on the upper surface of all four wings, while the under surface is almost always soberly colored, and often very dark and obscure. The moths, on the contrary, have generally their chief color on the hind wings only, the upper wings being of dull, sombre, and often imitative tints, and these generally conceal the hind wings when the insects are in repose. This arrangement of colors is therefore eminently protective, because the butterfly always rests with his wings raised so as to conceal the dangerous brilliancy of his upper surfaces.

Warning colors are not only possessed by butterflies, but wasps and bees which have stings are often conspicuously colored with yellow and black.

The Painted Lady Butterfly and Its World-wide Distribution

ONE of our handsomest butterflies, the Painted Lady, is portrayed in the accompanying plate illustration. This species of butterfly frequents the flowers of the thistle during July, and it is from the almost constant association of these insects with this flower that it is often called the thistle butterfly. This fact also led Linnæus to name it *Pyrameis cardui*.

In England, where the identical species is found, it is often known as the Painted Lady, in deference to its beautiful colors. Its life history is not without interest. It lays its eggs on several common species of thistle, the burdock, nettle, and marshmallow. The developing larvæ are in consequence of their varied diet characterized as polyphagous. This insect is not alone confined to America and England, but is one of the most cosmopolitan of all the butterflies. It is distributed, according to Holland, over the entire world, with the exception of the arctic regions and the jungles of the Congo in Africa. What, may we ask, are the factors conducive to this wide distribution?

The life of this butterfly, like many others, is exposed to attack by enemies during all the transitional stages, or instars, from the egg to the adult. The eggs, larvæ, and pupæ must in some way survive the effects of parasitism. It is probable that during the migration and dispersal of this species, the egg and pupa parasites did not follow their host at once, but in time the parasites followed. The butterflies were thus at first allowed to multiply more rapidly in the absence of these enemies. Parasites, by becoming numerous, probably create a scarcity of their own food supply. A sort of equilibrium is finally maintained between host and parasite, growing out of various contingencies.

An important factor in aiding the distribution of the Painted Lady is the fact that the food plants, upon which the developing larva depend, were well established prior to the distribution of the butterflies. Its predaceous enemies, such as birds, must be checked by some defensive structures, and these are found on the larvæ in the form of distasteful branched spines. In its migrations it was necessary to adapt itself to the physical changes of climate incident to the wide range of new conditions. The power of flight also, favored by the air currents, aided in this butterfly's dispersal.

The larva's existence on the thistle may be recognized by the silken web which it uses to cover itself, and also for the purpose of forming a little canopy out of a leaf for protection. Here the thistle spines may give it slight immunity from preying birds. The full-grown caterpillar attains a length of about an inch and a half. Its body is striped with black and interrupted lines of yellow. The head is black and the feet reddish. There are seven whitish branched spines, those behind the first segment being tipped with black; these spines form an armature to the body which is distasteful to

The Painted Lady, or Thistle Butterfly (Pyrameis cardui). It is distributed over nearly the entire world.

birds, and the warning colors doubtless function in connection with these spines in thwarting the attacks of birds and lizards.

The Saddle-Back Larva

OF all the queer tenants harbored by the witch-hazel, perhaps the most singular one is the saddle-back larva. It is an August visitor, coming about the middle of the month. A somewhat mutilated leaf, with a ragged margin, may give the first hint of the presence of the larva.

It lives in gregarious colonies when young, and a quainter brood can rarely be found. Fully exposed along the margin and lined up like a company of soldiers, they feed upon the leaf. Gradually this process goes on until only the veins or stems remain. Such a colony as described was found on the witch-hazel. A photographic illustration of this brood shows them in their favorite attitude when eating. They feed on the leaves of many species of trees, including the younger, fresh green underbrush of the oak and basswood, and sometimes they are found on fruit trees.

These caterpillars have short bodies and both ends look alike. Each extremity is provided with a pair of dark spiny tubercles. At the head they are somewhat larger and supplied with supplementary tufts of hair. On the back of the larva is a square green patch, while at the middle there is a purplish brown saddle, surrounded by a ring of white, edged with black.

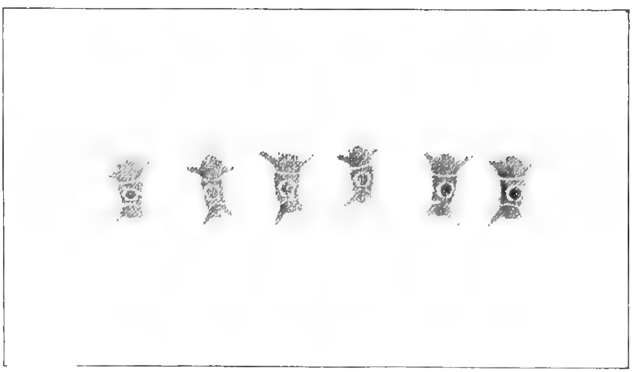
The larvæ are provided with stinging hairs fringing the sides of the body. On coming in contact with the human body where the skin is thin, they often cause a painful sensation, not unlike that of nettle. It is thought that the hairs break off in the skin, thus producing an irritating effect.

"It is a most suggestive fact," says Wallace, "that in cases where color is required only as a warning, as among the uneatable caterpillars, we find, not one or two glaring tints only, but

The Saddle-back Larvæ (Sibine stimulæ) on Witch-hazel leaves. These caterpillars are provided with warning colors and stinging hairs for protection.

every kind of color disposed in elegant patterns, and exhibiting almost as much variety and beauty as among insects and birds, yet here, not only is sexual selection out of the question but the need of recognition and identification by others of the same species seems equally unnecessary."

After the larvæ are full fed they spin parchment-like cocoons, which are oval, almost globular, and are protected by being flattened against the branch to which they are affixed. They are brown in color and simulate the bark. Just before the moth escapes from the cocoon, the larva prepares the way by cutting a circular flap at one end which the moth afterwards pushes open from within. The color of the small moth is dark, rich reddish brown, and it has a pair of twin golden spots near the apex of the forewings. These spots are nearly united, forming a short line in the female. In the male there are two more near the base of the wings beneath the median vein.



A row of Saddle-back Caterpillars.

THE SWALLOW-TAIL BUTTERFLIES AND THEIR CURIOUS LARVÆ

HOW many times I have seen the beautiful yellow and black tiger swallow-tail butterfly dashing here and there in his headlong flight through the woods! It is not often a near glimpse is had of this active species unless he is taken unawares. It is therefore a pleasure to show this butterfly in the photographic illustration while he is making a momentary visit to his favorite flower. This individual was found during the month of August in a field of red clover, where he was taking his sip of nectar. The female sex of this species has two color forms in the southern United States, where, besides the present yellow form, another black form also occurs. The black form was thought to be a distinct species by earlier naturalists, but it was later ascertained that both forms could be hatched from eggs of the yellow females, and conversely, the eggs of the black female after development often give rise to yellow females. A most interesting feature of this black form known as *glaucus* is that it mimics another common black swallow-tail butterfly, *philenor*. It forms one of a trio of butterflies which have this tendency to mimic the model *philenor*, as previously mentioned in the chapter on Mimicry, at the beginning of this section.

The caterpillar of our tiger butterfly, when full grown, is from two to two and a half inches in length. Besides the green ground color on the upper part of the body, it is adorned with rows of blue dots; the yellow, eye-like spots on the third segment have black centres with a blue streak; the yellow band across the fourth segment which might be mistaken for a mouth is shaded with black behind. The head and under surface of the body and legs are pink. It resembles the troilus caterpillar in form. The food plants upon which it subsists include quite a variety, such as the wild cherry, apple, alder, tulip tree, black ash, oak, lime, birch, sassafras, and magnolia. Its polyphagous habits may have aided its distribution which extends over the eastern portion of North America, from northern Canada to the Carolinas.

The green caterpillar of the tiger swallow-tail, shown in the initial photographic illustration, was found in the forest undergrowth skirting the bank of a river in June. It was a full-grown example, about two inches in length. As a glance at the picture will show, it is one of the most grotesque forms of caterpillars commonly met with. It had spun a glistening silken web in an exposed situation across a wild cherry leaf, and on these meshes had suspended itself with its back turned toward me. When I recall the first sight of this larva, the impression gained of it was a most curious one. The forward mask-like face was remarkably startling. This mask, bearing eye-like spots and the light transverse ridge, gave it an aspect which might easily be mistaken for real eyes and a mouth. This contrivance is only a false face in no way connected with the real eyes and mouth. One might imagine the shock that a bird, or other predaceous enemy, would experience when looking upon this grinning mask. This is in reality the effect produced, for I have seen small birds so alarmed that they lost their appetite and curiosity for these larvæ after a brief glance at them. It is certain that these singular markings have the effect of terrifying their bird enemies.

To really understand the meaning of these extraordinary forms of caterpillars one must go farther back than the foregoing observations. Some additional light on this subject may be gained by a study of the tropical species in their original environment. From the tropical species our

Male Papilio turnus Butterfly visiting the flower of the Red Clover. The female black form known as glaucus in the southern part of its range mimics the butterfly Pharmacophagus (Papilio) philenor.

forms may possibly have descended. Moreover, in the hot regions there is a great abundance of bush snakes and lizards which they might resemble, and if this is so there is a real mimetic connection here which our temperate forms do not seem to show. While full-grown larvæ of the swallow-tail seem to show recent adaptations, such as eye-spots, yet some of its peculiarities may have been handed down from a remote past. Many of these cases of mimicry are problematical.

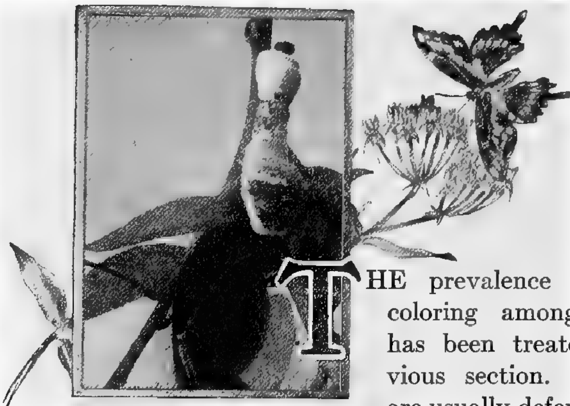
Poulton describes a species of large elephant hawk-moth somewhat common in England which may be classed in the same category as the tiger caterpillar as regards its terrifying markings. In this caterpillar the eye-like markings occur on each side of two of the forward body rings. It lives on the great willow herb. As soon as the leaves are rustled by an approaching enemy, the caterpillar swiftly draws its head and first three segments into the next two rings bearing the eye-like spots, giving to these rings a swollen appearance and resembling the head of an animal upon which four enormous, terrible looking eyes are prominent. The effect "is greatly heightened by the suddenness of the transformation, which endows an innocent looking and inconspicuous animal with a terrifying and serpent-like appearance."

In another species of caterpillar, *C. porcellus*, the eye-like spots are also conspicuous and Poulton says of this species that such caterpillars terrify their enemies by the suggestion of a cobra-like serpent, for the head of a snake is not large, while the eyes are small and not especially conspicuous. The cobra, however, inspires alarm by the large eye-like "spectacles" upon the dilated hood, and thus offers an appropriate model for the swollen anterior end of the caterpillar with its terrifying markings. It is noteworthy that the caterpillar should thus mimic a feature which is only deceptive in the snake itself. Bates has described a South American caterpillar, which startled him and every one to whom he showed it, by its strong resemblance to a snake, and it even possessed the features which are characteristic of a poisonous serpent.

An amusing incident relative to the nearly allied species, the troilus butterfly caterpillar, may be of interest in this connection. A neighbor was much annoyed by the depredations occasioned by something destroying the leaves of his young sassafras trees. Some of the leaves were finally found having their sides brought together with silk by some insect lurking inside. What was his surprise to find, on spreading them apart, a quaint looking caterpillar. In a humorous mood my friend brought one of these larvæ to me for identification, exclaiming as he came that he had found a young "hippopotamus." This absurd resemblance is not greatly overdrawn so far as the forward part of the caterpillar's appearance is concerned. On the back are located what look like a pair of black staring eyes and a broad head, which, in truth, is simply a deceptive mask such as I have described in the allied tiger swallow-tail larva. Another peculiar feature is added to the curious terrifying markings which give to this larva a mask-like appearance. This caterpillar can, like all the Papilio swallow-tails, on proper occasions of alarm, thrust out an orange or reddish colored scent organ at the forward end of the body, heightening the effect of its resemblance to a serpent. I have seen this contrivance especially effective in warding off birds who had the temerity to peek within the shadowy entrance of the leaf serving as a home for the younger caterpillars. The real head of this larva is tucked away under the fore part of the body. Before this caterpillar is full grown the back portion of the body is shiny and rounded, and colored so that it looks like bird excrement, thus affording it protection. Various sized individuals were found on the leaves of the spice bush and sassafras in August.

In this species, the last stage of the larva, which is nearly two inches in length, is thickened from the third to the fifth segment and the upper surface is bright green in color. Bright blue spots adorn the back. On the fourth joint there are eye-spots which are yellow encircled with black, and a large pupil fills most of the lower portion; a line of black appears in front of the segment, and a pale, pinkish spot above, margined with darker pigment. On the fifth joint there are also two eye-spots. Each side of the body is provided with longitudinal yellow lines. Just before the transformation into the pupa stage the caterpillar turns to a rich yellow ochre. They are then very uneasy, sometimes migrating about to find a suitable kind of place to pupate. They often cross wide, open stretches of grassy ground in their restless search. The caterpillars are particularly abundant on sassafras leaves, and here they are often associated with a small leaf-rolling tortricid moth. The latter cannot be easily confused with the troilus caterpillar, for it is small and nimble and springs out of its nest onto the ground at the first attempt to open the silk fastened leaves.

The Disguises of the Cresphontes Caterpillar



THE prevalence of protective coloring among caterpillars has been treated in a previous section. These forms are usually defenceless. Aside from their effective shapes and protective markings they seldom possess any armature. Other caterpillars are protected by nettling hairs and warning colors. In some instances, however, such as that which is described in the next chapter on the puss-moth larva, they are provided with special whip-like lashes at the end of the body which render them service in thwarting the attacks of enemies. Another method of protection, coming under a somewhat different category, is found in the Cresphontes swallow-tail butterfly larvæ. Though touched upon in the previous chapter, I shall take up the subject in more detail here. It is the presence of the fork-like scent organ in this caterpillar to which particular attention is drawn, as well as the protective resemblance to bird droppings.

I once found a number of these young larvæ in the woods upon the surface of some low prickly-ash leaves, in August. These caterpillars resembled in every detail the droppings of birds. When first observed an accompanying friend was skeptical in believing them to be real larvæ. When the foliage was rustled the head and forward part of the body of this caterpillar was thrown upwards, forming a curve over the back. At the same time occurred a remarkable display of the fork-like scarlet-colored osmeterium. This scent organ protruded from a slit just behind the head, but appeared like a snake thrusting out its tongue. From this fleshy process a peculiar scent not unlike valerian, diffused through the air. Just before this performance the slit partially opened, showing a pinkish tinge on each of the edges Instantaneously the forked tubular mechanism was then extended over a quarter of an inch; slightly leaning backwards when fully erected. After the fright is over the osmeterium is as suddenly withdrawn within the lips of the slit, which close in and completely hide all trace of its former existence. All the caterpillars of the swallow-tail butterflies have osmeteria or scent organs that are thrust out during excitement. The volatile substance which is given off during excitation is acid in reaction, and secreted in some oval glands at the base of the fleshy forked structures. If an unwary bird should by chance have the curiosity to try its bill upon the shiny, delicate skin, a hideous surprise that few of our feathered friends would wilfully invite awaits the aggressor. The innocent looking object suddenly turns into the most startling snake-like animal. The peculiar swollen shape of the forward segments, and shining eye-like tubercles give greater accent to this sudden transformation.

The larger the larva, the more pronounced is the scent given off when they are disturbed. In September, some of the full grown larvæ were found about ready to pupate. They were nearly two inches long. The young larvæ are dark brown, having the sixth and eleventh segments of a light straw color. This form of coloration exists until the third molt, when the skin becomes shiny, and some of the glazed tubercles which cover the body disappear. The photograph of the mature larva here reproduced shows it resting on a twig of its favorite food plant, the three-leaved hop tree. The markings are so well depicted that no further description is necessary, except that in the darker portions there is an olivaceous tinge instead of brown, as in the younger larvæ.

The cresphontes chrysalis is protectively colored like old wood, or dead leaves, or a pale green, depending somewhat on the environmental conditions. There are two broods of

The Caterpillar of Papilio cresphontes on its food plant, the three-leaved hop tree. Its protective form and markings are well shown. Photograph by Dr. James Walker.

larvæ each year, the second broods being found in Michigan in the latter part of August and early September. The familiar adult butterfly is one of the handsomest species of the swallow-tails. In the south, where this large and beautiful butterfly is common, its larvæ ravage the orange groves. Here the peculiar appellation "orange-puppy" is given to it, perhaps from a fanciful resemblance to a young canine.

The Curious Puss–Moth Caterpillar

ONE August evening, as my lantern light flashed among some willow bushes, I interrupted a feast which the puss caterpillar was enjoying on one of the leaves. By referring to the two photographic illustrations one may get a very good conception of this green caterpillar. When touched on its back it is found to be highly sensitive. The excitement of such treatment is sufficient to cause both ends of its body to curve outwards in a very curious manner, at the same time presenting a singular display of its ability to protect itself in the following manner: There are two tail-like appendages at the end of the body which are extended straight out behind when feeding, as shown in the initial figure; but under excitement the appendages separate and are quickly jerked upwards, each one protruding an orange-colored lash-like thread, as shown on page 155.

The caterpillar is portrayed on the willow in two attitudes. The first shows its ordinary resting position after feeding; the second, the insect under a moderate degree of excitement with the whip lashes thrust out. The function of these organs is considered useful in temporarily arresting the attacks of small Hymenoptera. Under stress of being attacked by these dreaded enemies, it has another means of defence which is perhaps more effective than the whip organs when its deadly power is considered. On the underside of the neck of our species there is a sacculated depression, opening externally by a transverse slit which, in a moment of excitement, exposes the opening of two little tubes. These tubes eject a yellowish spray, which is evidently poisonous. This fluid, in species of similar habits found in England, was examined by Poulton and found to be formic acid. It is quite probable that even birds would not relish such a bombardment and the Hymenoptera attacking the caterpillar appear to have a poor chance of escaping such a deadly shower bath.

I do not recall any record of an observer having seen this device in actual operation against an enemy in our American species. I once saw a small winged parasite run the gauntlet, taking the larva unawares, and in spite of this protective device it succeeded in depositing its egg upon Cerura s skin.

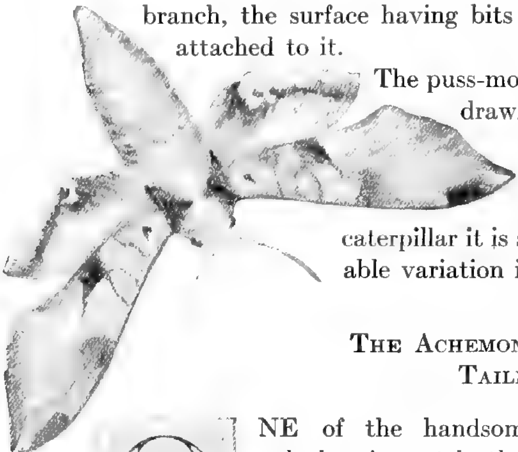
The puss larva is light green, the head is dark purplish, and a triangular marking appears behind the head. About eight or nine small spots decorate the sides of its body. The dorsal area above is provided with a peculiar dark marking of lilac brown, commencing forward on the fourth segment and extending backward to the tail. The widened portion of the forward marking is more or less sprinkled with a lighter color. Underneath the body, just behind the back legs, is a pair of large spots. The lilac-brown patches of color on the greenish yellow body of this caterpillar resemble the leaves perfectly, the former color simulating the seared and withered brown edge of the willow leaves.

After two days of feeding on the willow leaves indoors the larva became restless and refused to eat, and then a change came over it. Instead of the pure green, the body became somewhat brownish, and the appendages seemed to lose their function, becoming reduced in size to mere shrivelled filaments. It travelled over the stems and down on the floor of the breeding vivarium, back and forth, when finally it settled on a piece of newspaper. It then began to spin a rather loose, gauzy web forward around its head, which it attached here and there to the paper on the ground. The weaving continued farther and farther backward to about the middle of the body, when the

The Puss Caterpillar (Cerura multiscripta) on a willow leaf, in a state of excitement, displaying the whip-lashes at the end of the body. The lower figure is the moth of this species.

caterpillar gradually turned around within its narrow quarters, doubling up its body to do so. All this time its head was kept busily in motion attaching silken strands, and giving its attention to the unfinished open portion. In the course of four hours the nearly completed cocoon had attained sufficient parchment-like density to obscure the larva within.

I have seen the cocoon of one of these larvæ fastened to a branch, the surface having bits of bark and wood attached to it.



The puss-moth, as shown in our drawing with the second photographic illustration, appears in June. Like the caterpillar it is subject to considerable variation in markings.

The Achemon Sphinx and Its Tailed Larva

ONE of the handsomest moths found during August is the Achemon sphinx, shown in the initial illustration. Linnæus is said to have long ago applied the name Sphinx to this type of moths from a fanciful resemblance of the caterpillar to the Egyptian sphinx. The caterpillar of the Sphingidæ behaves in a peculiar manner. On the approach of danger they assume the so-called sphinx attitude, and if seized or touched, they forcibly throw themselves from one side to the other, seemingly attempting to terrify their enemy. The Achemon caterpillar in the accompanying plate illustration shows this singular attitude. The first three segments are retracted within the fourth segment, and in this position they remain immovable for hours at a time. It was found on the leaf stem of the Virginia creeper, close to the ground.

This species also feeds on the wild grape. Its color is a pinkish brown above, shading into a rich russet below, and is speckled with minute light spots. A row of six large oblique

The Sphinx Caterpillar (Pholus achemon) on Virginia creeper leaf. This larva has white spots on a rich pink-brown background.

white stripes decorates the sides, these being supplemented with a small one at each extremity of the body. At the end of the body there is a burnished black eye-like spot, which is encircled with white. This spot marks the situation of all that remains of a slender recurved tail, which is present in the young larva but disappears after the first or second moult. Sometimes these larvæ are pale green, but they are usually flesh-brown in color, as I have already described. At the expiration of their period of feeding in August, they excavate a hole in the ground and there transform into a reddish brown pupa. It is not until the following June or July that the exquisite moth emerges. It is about three to four inches in the expanse of its wings. The initial illustration shows the disposition of the markings on a ground color of reddish ash. The thorax bears two triangular patches of rich chestnut-brown. The front wings have two squarish markings, while the hind wings have a pinkish hue shading into a red spot near the middle, and the margin is ash colored behind.

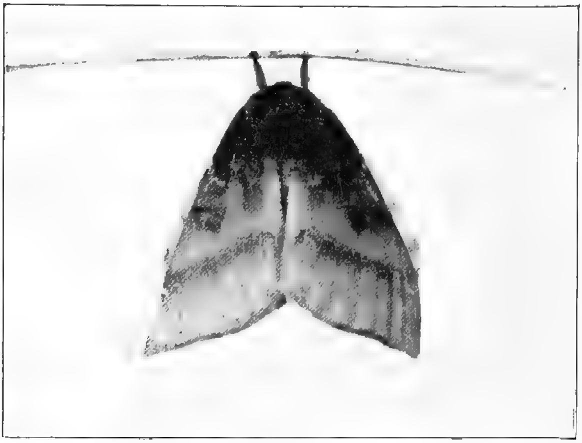
Of all the data furnished by the developmental history of the sphinx moth larvæ, Weismann [1] says that three kinds of markings occur. They are divided into longitudinal lines, oblique stripes, and spots, the lines being the oldest. The first rudiments of striping must have been useful since they broke up the large surface of the body of the caterpillar into several portions, and thus rendered it less conspicuous to its enemies. Various facts tend to show that the oblique stripes appear later than the longitudinal stripes in the ontogeny of certain species. In following out this development in the larvæ it is found that characters vanish from a stage in the same order as they were acquired in their evolution. The oldest sphinx larvæ were apparently without markings; they were supposed to be protected only by adaptive coloring and a large horn at the end of the body, and by being armed with bristles. Their successors became longitudinally striped, acquiring a sub-dorsal line extending from the horn to the head, as well as a spiracular, and sometimes also a dorsal line. At a later period oblique stripes were added, generally slanting across the seven hindmost segments from the back towards the front

[1] "Studies in the Theory of Descent."

in the direction of the caudal horn. The oblique stripes became lengthened toward the back, the longitudinal lines disappeared since they injured the deceptive effect of the stripes. In many species there were also formed dark or variegated colored edges to the oblique stripes, in imitation of the shadow lines cast by the leaf ribs. Still others, of the longitudinally striped species, became developed in another manner.

The first ring-spots probably arose on the next to the last segment and after a time became repeated on the other segments, advancing from the hind segments toward the front ones. If a caterpillar fed on plants containing acrid juices which rendered it repulsive to other animals, the ring-spots commencing to appear would furnish an easy means for natural selection to adorn the species with brilliant colors, which would protect it from attack by acting as signals of distastefulness. But if the dark spots stood on a light ground, they would present the appearance of eyes and cause their possessors to appear alarming to smaller foes. Weismann believes that in the case of the three chief elements of the markings in the sphinx-moths, the initial stages, as well as their ultimate perfection, are of decided advantage to their possessors, and that they can be traced to the action of natural selection, and from the fact of their evolution these changes were not without exerting a certain action on other parts or an innate law of growth, which Darwin called correlation.

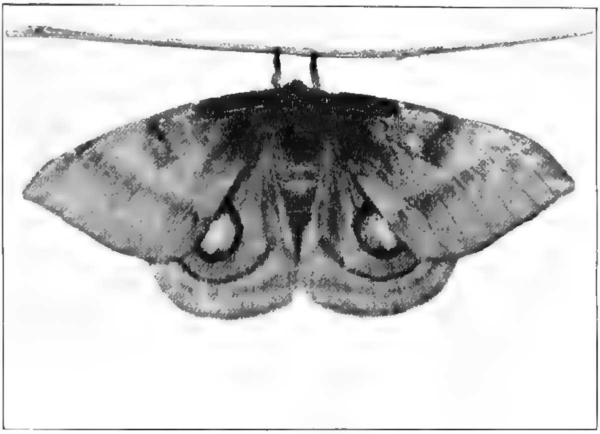
Is it Protective Resemblance and Mimicry Combined in Automeris Io?



MOST insects possess some defensive, aggressive, or protective structures which are effective against the attacks of their enemies. I have given a number of examples in the foregoing chapters. The possession of a sting, scent glands, or poisonous hairs may each play a part in the protection of their lives. Another means of safeguarding life is the possession of some color pattern of a particular kind. Again, there are markings that afford protection to the individual by setting up a supposed warning or illusion in the eyes of its enemies. This illusion may be attained either by general simulation of color markings to the surrounding environment, or the illusion may be excited by an arrangement of markings of such disposition as to resemble some insect better protected, or the imitation of some flower or bird droppings, or it may even extend to mimicking a different order of animals. Here we are concerned with a discussion of some observations of one of our common moths, *Automeris io.*

On a cloudy day in June, I found one of these moths in a beech wood very near to the ground. It was suspended from a dead twig by the front and middle pairs of legs. As shown in the initial illustration, its wings were nearly closed, and its beautiful dark, rosaceous, and purplish colors blended with the background of dead leaves which had accumulated on the forest bed from past years, and were of the same color as the moth.

When I discovered this moth the first question was: Why does this moth hang in the forest in a spot so wisely chosen? Is this peculiar attitude of benefit in concealing its body from the eye of some animal? These questions would perhaps be the first ones asked. But let us examine a little further. At rest, the moth may be mistaken for a dead leaf, but aside from



The Automeris io Moth with spread wings, exhibiting the large eye-like spots on the lower wings when disturbed.

this protective resemblance there is another feature relative to the coloring, which is exposed only on molesting the insect. In the position above described the insect acted quite indifferent to my approach; in fact appeared rather sluggish. The upper wings overlapped the underwings, almost completely covering the latter. The insect hung motionless or moved only as the wind swayed it back and forth.

But now came a revelation. A touch of my fingers was sufficient to cause its upper wings to spread slowly apart, exposing a most conspicuous and beautiful pair of large eye-like spots, one on each side of the underwings. These large spots are ringed with black; they are blue within and each one bears a whitish pupillary line, or white streak. Around the eye-spots is an area of contrasting bright yellow, and outside there is a marginal black line, a yellow band, and a rosaceous shading toward the edge that gives them the appearance of staring eyes.

The under side of this moth, as is well known, is plainly marked when at rest, presenting only a small whitish spot on each side of the underwings. The behavior of this insect was certainly interesting. Instead of flying away, it made a display of these beautiful markings.

To come back to an explantion of the phenomenon witnessed. First, it will be seen that these elaborate eye-spots shown here are effectual only against animals with vision of a high order, and capable of appreciating color values, as well as form, on a gross scale. No animal but a vertebrate could possibly come under this distinctive class, and of these, white-footed mice, bats, squirrels, birds, reptiles, and tree-toads could be considered. For these were the animals found in the forest where my observations were made. If any of these animals prey upon the moths, one might conceive of the explanation of the display of eye-like spots as follows: These moths conceal themselves by day but fly at dusk and night. It is not likely that these conspicuous eye-spots which are displayed only when excited and during flight would be signals of distastefulness at night. It seems much more probable that they are alarm markings serving to terrify or at least bewilder its smaller foes. It is, however, barely possible, if they are attacked by birds, that these spots would be pierced and thereby prevent the destruction of the vital parts, as maintained by Darwin.

In the same woods referred to, on different occasions, I found the wings of these moths which had been severed from the body, and sometimes they were badly mutilated by some animal. Though I made a continued search to find out this particular enemy, I was unable to determine the cause of these depredations. It might possibly have been done by either owls, bats, or flying squirrels, living in the woods.

So much for the moth state, but in spite of some protection afforded the moth, the larvæ are often sacrificed in great numbers by the ichneumon wasps on the one hand, while its eggs are preyed upon by the parasitic species of Eupelmus. These latter enemies come under the class that are not capable of influence by any large color scheme. The larva of this moth is provided with branching spines which have the property of stinging like nettles when handled. These stinging spines are doubtless effectual in warding off attacks by birds and mammals. The larva is green in color, with an ornamental lateral stripe of pink and creamy white, which are probably warning colors.

A Hymenopterous Parasite attacking a Sphinx Caterpillar.

Summing up the matter, it seems remarkable that nature has not perfected some device in these moths to immunize them against Hymenoptera, when they are seemingly so well protected otherwise. Perhaps the Hymenoptera are too recent in their origin and in their destructive influence to have yet brought about adaptive barriers to arrest their attacks. The perfection of color patterns and their arrangement for illusionary purposes are seemingly comparatively recent, and have developed, hand in hand, with the perfection of stinging hairs.

Automeris io is distributed from Mexico and Texas on the south and southwest, ranging northward into Canada. The caterpillars feed on a variety of trees and shrubs. The fact that this insect covers such a wide range of territory and possesses diverse feeding habits is, without doubt, instrumental in the preservation of its life. It seems that these factors, coupled with great fertility, protective resemblance, alarm or signal markings, and poison hairs, combine to outweigh the destructive attacks made by the ichneumon wasps, parasitic Hymenoptera, and other unknown enemies.

VI. ANIMAL BEHAVIOR, WITH EXAMPLES

VI. ANIMAL BEHAVIOR, WITH EXAMPLES

THE activities of animals can be classified into two groups, namely: those of instinct, and those of intelligence. Romanes[1] believed that there is ample evidence to show that instincts may arise, either by natural selection fixing on purposeless habits which chance to be profitable, so converting these habits into instincts without intelligence being even concerned in the process; or by habits, originally intelligent, becoming automatic by repetition. These principles, when working in coöperation, have greater influence in evolving instincts than either of them can have when working alone.

Reason[1] is defined as "the faculty which is concerned in the intentional adaptation of means to ends. It, therefore, implies the conscious knowledge of the relation between means employed and ends attained, and may be exercised in adaptation to circumstances, novel alike to the experience of the individual and to that of the species. In other words, it implies the power of perceiving analogies or ratios, and is in this sense equivalent to the term 'ratiocination,' or the faculty of deducing inferences from perceived equivalency of relations."

Instincts are usually complex acts performed previous to experience and in a similar manner by all members of the same sex and race. For example, in the case of the Golden Sphex wasp, instincts are shown in the behavior of stinging, the taking of particular kinds of prey, the method of attacking, capturing, and carrying its prey, and the making of the nest.

Jennings believes that in the lowest organism, the Amoeba, the behavior is not as a rule on the tropism plan[2] — or a set, forced method of reaction to each particular agent — but

[1] "Mental Evolution in Animals," p. 267.

[2] Tropism is a belief that all vital phenomena will in last analysis prove to be the same forces and activities already known to us in the inorganic world.

takes place in a much more flexible and less directly machine-like way, by the method of trial and error. This method involves many of the fundamental qualities which we find in the behavior of higher animals, yet with the simplest possible basis in ways of action; a great portion of the behavior consisting often of but one or two definite movements — movements that are stereotyped when considered by themselves, but not stereotyped in their relation to the environment.[1]

To account for the behavior of the greater number of animals from the protozoa up to the insects, Bohn [2] has recently expressed his opinion that their actions may be accounted for partly by mechanical reflexes, partly by certain vital rhythms, and by sensation, which may be described as differential sensibility. With the development of the special sense organs, especially the eyes, there is a coincident development of a certain degree of mentality. It is a complicated functioning of the nervous system and not of a kind that recognizes a dual conception of mind and body. In the behavior of these animals, there is exercised association of sensations in addition to tropismic responses. Following upon this stage of life in the animals above the insects, or vertebrates, the dawn of intelligence appears. The association of sensations now dominates over the lower mechanical reflexes and tropisms.

The special sense organs in the lower vertebrate animals are, comparatively considered, of the same kind as our own, though varying in the grade of perception of vibrations of light and sound. It is in dealing with the invertebrate animals that we may have difficulty in understanding their impressions of the world about them, especially inasmuch as the disposition of their sense organs, so far as demonstrated, is often in very different parts of the body as compared to that of the vertebrates. It will do here to cite the case of the organs of olfaction, or smell, in the insects. They are situated in the joints of the antennæ. Again we have the organ of hearing situated in the basal joint of the abdomen in the grasshopper.

[1] Those interested in animal behavior will find their time most interestingly spent by keeping insects and other animals indoors to study. The plant house furnishes a desirable place to rear or breed them.

[2] "*La Naissance de l'Intelligence.*"

The nervous system being the mechanism by which the actions or behavior of animals are directed, it is the special sense organs that are the windows through which the outer world is perceived. I give here, in diagrammatic form, these organs in insects and their anatomic disposition as they are at present interpreted:

PARTS OF THE INSECT'S BODY

Head

Eyes.....Simple, with single lens (ocellus).
Compound or facetted eye.

Antennæ. Olfactory (smell) organs with pore canal, having a sunken or free hair-like structure attached to a slender nerve fibre, and connected with many nucleated ganglion cells; or often presenting a tooth-like projection filled with serous fluid. Antennal auditory hairs also appear.

Mouth....Within, or immediately surrounding it, bearing organs of taste: (*a*) proboscis or tongue. Taste (distinguished with difficulty from olfactory). The tip of proboscis; the epipharynx in nearly all insects have taste buds; the maxillæ of wasps have taste cones. (*b*) Clypeus. At front edge bear taste buds in Orthoptera.

Thorax...At base of wings of many insects club-shaped rods appear, supposed to be auditory organs, also perception of movement of haltcrers in Diptera.

Legs .....Tibia of grasshoppers, bearing chordotonal organs, also in ants, Perlidæ, etc.

Abdomen..Basal joint, on each side, just behind spiracle. Organ of hearing, connecting with the third thoracic ganglia. Common in Orthoptera.
Cerci (at the end of the abdomen) hearing organs (Packard).

In a former chapter, under Evolution and Instinct, the subjects of reflex action, instinct, and reason have already been discussed. Habit, as ordinarily supposed, is a voluntary action repeated until it becomes reflex. It is essentially like instinct in all of its manifestations, but instinct is inherited habit. The sensorium is offered a choice of responses. To choose one and reject the others is the function of intellect or reason. But granting these distinctions, instinct and reason are not sharply defined.

The Assassins in Lace

THE delicate white lace and peculiarly strong fragrance of the wild carrot blossoms are a great attraction to many insects. When viewing these exquisite blossoms, who would think that a strange association of assassins were harbored therein. Yet here they live, ambush bug and spider, each awaiting his turn to destroy the insect frequenters that chance to visit these inviting blossoms. The flowers, supported on long stems, present a beautiful appearance in the open field. The old blossoms are quite easily distinguished from the younger ones by the manner in which the former are drawn together to form little "bird-nests," while the younger ones are flat on top. On nearer approach, it is found that flies and small bees, drawn hither by the scent, are nervously ravaging the sweets.

At times it is at great cost of insect life that these sweets are secured; not that the flowers have structures that would harm the insects, but because of the presence of the assassins hiding within. Close examination of these lace-like flowers will almost invariably bring to light the deadly ambush bug. (See photographic illustration.) Here he lies quietly in wait, ready to seize the unsuspecting insect that alights on the flower. At first the only evidence of his predatory instincts that appears is the dead flies or bees, of various species, that lie upon the surface of the flower. Or, perhaps, this bizarre assassin may be found partly hidden in the margin of the flower, in the very act of sucking the juices from one of his recent captives. His sharp proboscis is used in penetrating the soft tissues of insects between the head and thorax. One may see him choose a point in his attack underneath the insect's body, between the second and third articulations of the legs.

I once found a dead bumblebee hanging from the underside of a bergamot flower. On investigation, a concealed ambush bug, covered by the flower, was holding the Bombus by his

The Wild Carrot (Daucus carota), showing an Ambush Bug (Phymata wolffii) near the middle of the flower with a captured fly. The color of the bug makes it almost invisible, yet it may be seen on close inspection.

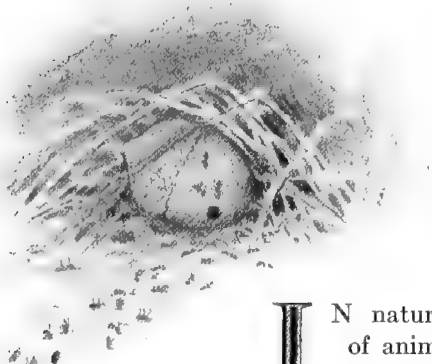
tongue and mouth parts. The bug had his suctorial beak inserted into his captive's throat. Likewise, I have seen this harlequin bug masquerading in the yellow blossoms of the goldenrod, hidden most perfectly by his harmonious colors.

The disregard with which this deadly bug is held by the guests of the flowers is a singular fact. Upon examination into the cause of this seeming recklessness of its prey, it may be explained from the fact that the grotesque form of the ambush bug makes him appear more like a harmless floral structure than an insect enemy. Moreover, the peculiar coloring of his body, both above and below, simulates the flower coloring in a way to make him perfectly protected. Underneath the body of our common species, *Phymata wolffii*, shown in the plate illustration, the color is pale green, the abdomen being edged with green and bearing a dark spot on each side. The colors above are even more deceptive, as will be seen in the photographic view.

If the ambush bug fails to find sufficient victims on one flower, one may not be surprised to see him suddenly take wing and fly with great agility to another one. He is equally at home on many kinds of flowers, but he has a certain predilection for the goldenrod and wild carrot. There is a stage in the life of the wild carrot blossom, marking the beginning of senescence, in which it draws together toward the middle, giving it a cup-like appearance. It is these older flowers that are more frequently chosen by the ambush bug, and on these more often will be found the dead victims of this insect. But further search makes it plain that not all these apparent victims can be laid at the door of this bug. Alongside of the ambush bug, living in the lace-like folds of the wild carrot, one may often find a second assassin, known as the crab-spider.

I have mentioned him in a subsequent chapter entitled "The Evening Primrose Spider Trap." There, it will be seen, he is a yellow spider, but in his existence on the wild carrot his color is white, and his behavior somewhat different from that noted hereafter. The two assassins are not companionable, though they may be seen side by side on separate blossoms of the same plant. In exceptional cases the ambush bug turns upon his spider associate and captures and kills the spider with as much unconcern as he would a fly.

In early August, the whitish crab-spiders of various sizes and ages take certain prey according to their dimensions. One day I found one in the centre of the cup-shaped depression of a wild carrot flower, with his dark, caliper-shaped legs spread wide apart. It was here seen how quickly he could distinguish between an enemy and his prey. A small black wasp alighted on his adopted claim, and instantly the spider slipped out of sight under a little bower of overhanging petals. It was well that he did slip out of sight, for this wasp often captures spiders to store in her underground nest. He kept quiet, but watchful, and as soon as the wasp retired he came back again to his exposed quarters. When the larger flies and bees appeared, this veritable insect "trap" moved a little nervously, but did not attack them. It is obvious that he is obliged to be careful in the selection of his victims, for if the mistake were made of attacking too large a fly or bee the shy spider might be either stung or carried off his estate. With patient discretion he waited until a desired fly appeared, when from the lace folds he sprang forth, closing his front legs on his victim like a flash. Were the ambush bug the only enemy of the insect visitors the mortality in insectdom would be considerably circumscribed. But when this assassin's work is added to that of its distrustful neighbor, the almost invisible crab-spider, I know not the great number of deaths assignable to the combined attacks of these disguised foes.

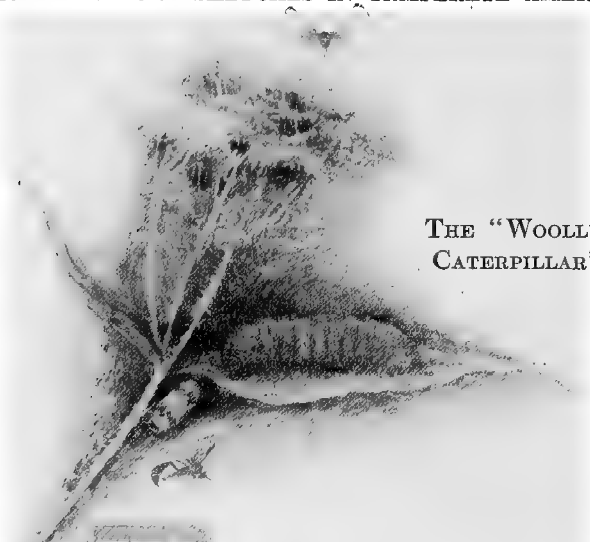


The Tenants of an Acorn

In nature, many incidents of animal behavior escape the observer, unless one's eyes are kept constantly watching. One day I was surprised to find, on the ground under a large oak tree, an acorn which was harboring a swarm of small, brown ants. Unfortunately, I picked up the nut from the ground before realizing what it contained. On breaking it open the ants emerged from the cracks and climbed out over my fingers, rushing in frantic haste to escape. On laying the nut down the numerous members of this ant colony ran into the grass. They went here and there, some having sufficient presence of mind to pick up the suddenly exposed whitish pupæ, while others appeared to act in a distracted manner. In less than ten minutes from the time when the nut was laid down all the ants had left, some escaping into underground retreats, taking all the pupæ with them.

I now found that this little emptied acorn house originally had but one small hole or doorway through which the ants entered and passed out. This hole was not made by the mechanical skill of the present occupants at all, but was the work of a former dweller, the larva of the acorn weevil, *Balaninus nasicus.* The weevil larva had lived there in the early grub state, and just before its transformation into the weevil it had gnawed the round hole in order to desert this place for a future habitation in the ground. Following on the heels of the weevil larva, another tenant of an entirely different species came into possession. This time it was the acorn moth, *Holcocera glandulella.* She found the interior of the acorn a suitable place to rear her grub, so she merely deposited her egg in the hole. For a time the grub, upon hatching from the egg, fed upon the remnants of the meal left by the weevil. Finally, the ants moved in and were content to live among the powdered *débris* left by the moth larva. It is clear then that three distinct species of insects had each in their turn lived in the acorn quarters.

After learning these facts, I made further search among the acorns under the same tree, with the result that I found a number of other similar ant colonies which had likewise chosen infested nuts in which to establish their homes. Whether this is a habit confined to ants in this immediate locality, or a habit common to the species generally, has not been fully determined. When one remembers that squirrels and the red-headed woodpecker will often avoid molesting infested nuts, it will be seen that the quarters chosen by the weevil, moth, and ant tenant are apparently quite safe from the attacks of these larger enemies.

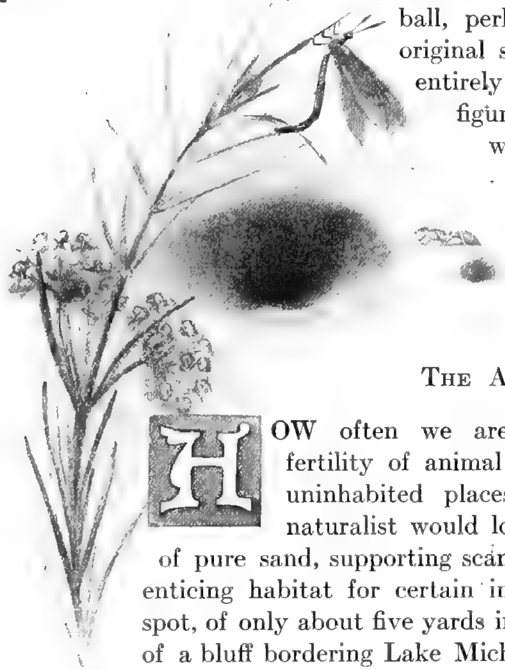


The "Woolly Bear" Caterpillar's Fate

WHILE walking along the roadside one August day I found a "woolly bear" caterpillar, about an inch in length, on a leaf of the boneset. I had no sooner picked the stem of the plant for nearer inspection than I discovered a soft, shapeless grub commencing to emerge from the side of the caterpillar's body. Judging from the size of the whitish grub, it must have filled the greater part of the interior of its victim's body. It presently came completely out and crawled to the underside of the leaf stem. After resting a few minutes it began to spin a cocoon with its mouth, attaching itself to the leaf. Strands of fine silk continued to pour out, and as fast as formed they were thrown or looped back and forth, and worked backwards by a worm-like movement of the body. Finally, as these numerous threads were added from before, backwards, little by little, the cocoon of quite firm texture was formed, such as shown in the initial drawing. When finished, it was scarcely more than a quarter of an inch in length having dark, band-like mottlings near each bluntly rounded extremity. This little piece of architecture was preserved in a box, and at the end of ten days there emerged from it a most delicate, mature hymenopterous insect.

This specimen was sent to Ashmead for identification, and in his reply he said; "The hymenopterous parasite bred by you from a lepidopterous larva came a couple of days ago and I have examined it with much interest. It falls into the tribe, Campoplegini, and into Foster's genus, Anephares. *No species is yet known in the North American fauna and you will be safe in describing it as new.* Of course it might be described under the genus Limneria (now Limnerium) somewhere, but I know most of the species described in this genus in our fauna, and all are quite different from your specimen."

This new species, which I will now call by its new scientific name, *Anephares rufipes*, or the red-legged Anephares, is three-eighths of an inch in length. Its body is black; its legs and ovipositor being reddish brown. The caterpillar from which the grub emerged showed signs of life for several hours after the parasite had left its body, and gradually shrank into a hairy ball, perhaps one-third its original size, before life was entirely extinct. I have figured the caterpillar, with the new species and its cocoon, in the initial illustrations.



THE ANT-LION

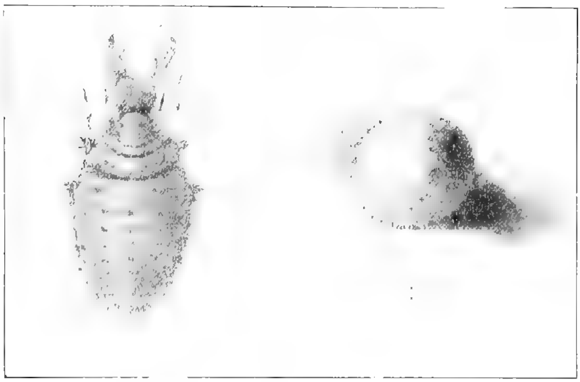
HOW often we are surprised at the fertility of animal life in supposedly uninhabited places! Who but the naturalist would look to a small area of pure sand, supporting scant vegetation, as an enticing habitat for certain insects! To such a spot, of only about five yards in extent, on the top of a bluff bordering Lake Michigan, I have often made visits to view the performances of the ant-lions. When the sun shone brightly for a day or two during the heat of summer this place was always an interesting point of study. At such times the pits of the ant-lions were found rather plentifully strewn about in the sand with most of them freshly cleaned out. These pits at one time or other contain either ants, weevils, or other insects, not excepting even such prey as small robber-flies.

After a rain, all is quiet at these ant-lion lairs. The pattering drops on the ground bring about perfect quietude, and little by little the sand is splashed down the sides of the pits until they are more or less filled up. In the meantime, the occupants keep quietly secreted, holding their peace until the sun again comes out and dries the ground. This may consume a day or more, according to the humidity or temperature. Then, the insects commence their excavations again, preparing the pitfalls for their prey. Ant burrows were also seen dotting the ground here and there, and their occupants were often found to be actively engaged in carrying out grains of sand from the underground passageways, or going on long excursions over the waste of sand. One soon became impressed with the seemingly oblivious manner in which these wandering ants unwittingly tumbled into the pitfalls of the ant-lions.

An ant would come along, slide down the incline of the pit, and in attempting to escape, displace the sand under his feet, finally tumbling down to the bottom. If he is not summarily seized by a pair of jaws lying in waiting at the bottom of the pitfall, he may now become greatly excited, and again make a frantic attempt to get out, sometimes circling around or trying to climb directly to the top on the level plane outside. At this moment, however, the ant-lion sends up a shower of sand from the pit, which, in falling, strikes the victim back into the centre again. Then the widely opened jaws of the ant-lion close on the ant's body and the struggle which ensues is ended by the ant-lion dragging the ant back into the sand. In other pitfalls this same tragedy is repeated again and again, though the victims are not always the same kind of insects.

The ant-lion usually waxes fat on these sumptuous meals, his body being kept well nourished. It is not uncommon for him to take long fasts, and he can go a great length of time without taking water. At all times he is concealed from view, being disinclined to show his soft body for fear of attack. I once exposed an individual by quickly pulling on a beetle larva it had just captured, when, rather than sacrifice its prey, it suffered itself to be drawn out of its lair. At other times I have drawn them out by practising a little trick with a straw, carefully imitating an insect sliding into the pit. If the ant-lion is very hungry he will seize the end between his jaws and in this way he can be drawn out.

One not familiar with the appearance of the ant-lion might imagine from the scientific name that it has some allusion to the beast of prey. He certainly does not share the slightest resemblance, but possesses unique characters quite his own,



An Ant-lion and its cocoon.

as the drawing illustrations show. Its body in the larva state, such as is found in the pits, is admirably adapted for digging in the sand. It is depressed, somewhat stout, and presents a formidable looking head, bearing long, flattened forceps or jaws with three teeth on each side, in the species figured here. The jaws are also provided with bristles, which act as a brush. The legs are slender, and a remarkable hinge exists between the first and second thoracic joints. The latter mechanism is used in jerking the sand out of the pits. Appreciation of this fact may be gained by taking a recently killed ant-lion between the finger and thumb and slightly compressing the abdomen, when the muscular action, such as is witnessed in life when throwing the sand out of the pit, will be repeated.

When the ant-lion is dug out of its pit, it may easily escape one's attention, for its color exactly imitates that of the sand. It will often allow itself to be tossed on the ground without so much as a protest, and often simulates death. On taking it up in one's hands it may still act the part of death, but when dropped back on the sand again it almost at once attempts to bury itself by a succession of peculiar, backward, wedging motions of the body. After covering itself from view with the sand it will remain content and quiet. In a few hours' intermission, when the shyness has entirely disappeared, it may again make a new pitfall.

The first evidence of this procedure is a little shower of sand shot into the air to clear his head of the overlying particles. With the aid of his active legs, the loose sand or other particles coming in the way are piled on his powerful head and again it is jerked into the air. In this performance he further proceeds in a circular groove, jerking out the sand as he goes, narrowing the circle each time like a spiral. At the end of his work he is found at the point, in the bottom of a deep, funnel-shaped pit, with sloping sides. In his industry he clears the hole of many little obstacles, such as shells, stones, or other particles. Finally at the last moment we are treated to a strange spectacle. Now that the last headful of sand has been cleared out, he settles down to one side at the bottom, where he sets his jaws wide apart, and there remains waiting for the next intrepid insect prey that happens to come that way. If the expected prey is not soon forthcoming, he does not remain quiet long, for neat housekeeping is the ant-lion's hobby. This, too, is necessitated by the wind-blown sand falling into the pit, and then comes the interruption of his leisure by a pouring rain which, as I have already mentioned, may so damage the pit as to require its complete renewal when the ground is dry again. After each feast the unedible portions of the ant-lion's meals are jerked out of the pit and a general cleaning up is done to prepare the way for the next comer.

The pitfalls vary in size in different species, the larger ones being three inches across and from one to one and a half inches deep. They are so placed that they are fully exposed to the warm sunshine. I have found them on the tops of bluffs and on the sides of sandy banks. There were almost always numbers of them in a group, but solitary ones were also found. After a time the ant-lion finally retires from his housekeeping and spins a cocoon of silk in the sand (see figure). This usually occurs in the fall of the year, and the winter is spent in this snug abode.

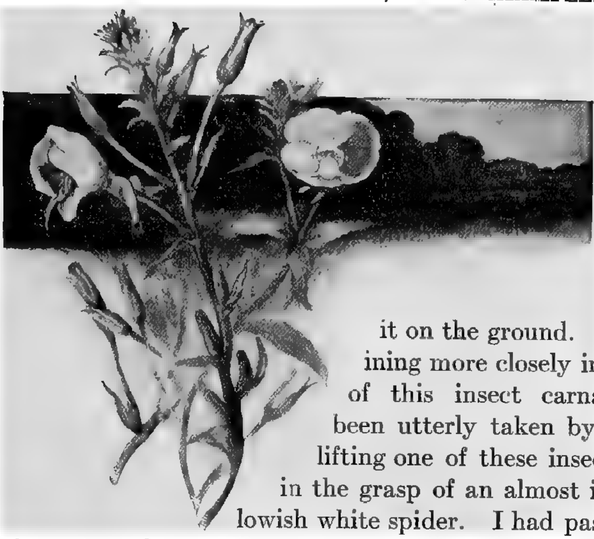
In the next season the winged insect, shown here on a twig of milkweed, emerges into the outer world. It has four dainty, lace-like wings and the head bears a pair of short, club-shaped antennæ, which distinguish it at once from small dragon-flies with which it might be confused. At a suitable time the female deposits her eggs in the sand, one at a time, and from these eggs hatch the remarkable ant-lion larvæ which form the theme of this sketch.

In another chapter on the Habitat of the Orthoptera, the landscape photograph there presented also shows to the left the place where I made the observations of the ant-lions. It may be seen here as a light, sandy area. This species frequented this spot year after year, though not, of course, the same individuals.

The Evening Primrose Spider Trap

WHAT a poetical mood nature was in when she evolved the evening primrose with its dainty yellow blossoms, that forecast the night by opening just before sundown! If it were not for the opening of these flowers toward sunset, there would not be accommodation for the night-flying moths, which depend upon such flowers for their honey. And were it not for these flowers, what would become of the yellow and rose-colored moth which frequents the half-open blossoms in daytime for the protection it there enjoys by its harmonious coloring? Again, how little do these insect guests of the evening primrose suspect that within the delicate flower petals an invisible animated trap sometimes awaits their coming, which in a twinkling and without warning literally catches them in the jaws of death. Evidence of this secret trap may not be found in every evening primrose. In fact, I examined many of the flowers of these plants before discovering the remarkable secret trap referred to.

Those who have not witnessed it certainly have something interesting in store for them. In the wild sandy meadow where the primrose plants are abundant, I have seen a dead moth, a fly, or perhaps a bee lying on the open flower, or below



it on the ground. When examining more closely into the cause of this insect carnage, I have been utterly taken by surprise on lifting one of these insects to find it in the grasp of an almost invisible, yellowish white spider. I had passed the dead insects on the flowers many times before I had seen the spider. What wonder is it, then, that I had not seen her before.

She has elongated front legs, and a peculiar inclination to walk sideways or backwards with equal facility, and through this resemblance to a crab's gait she is sometimes called the crab-spider, *Misumena vatia*. Having become familiar with her appearance, her attainments are more readily understood. In the early part of September, one was detected in a flower of the evening primrose, in the attitude ready to seize her prey. Her appearance was of such a curious character that I have endeavored to depict her in my drawings. Here she rested with her small, atrophied, third pair of legs touching the stamen-cross on each side, while the first and second pairs of legs were widely spread apart, ready for instant action when the time came. I watched her at intervals, but saw only an occasional insect flying in the vicinity, as the flower did not happen to be in the most favorable location. She stayed here at her station all night and into the next day without capturing a victim.

When the bright sunlight came out and the blossoms began to fade, she changed her position, as shown in the left flower of the second illustration. It was interesting to see her hanging her legs out over the edge of the petals. Later, I saw her slyly walk out of the now fast-wilting flower. Then she climbed up the stem to the summit, where the new yellow petals were just peeping out at the top. She stopped there, placing her yellowish abdomen as near as possible to the slightly exposed portions of the flower bud which bore the same color. At the top of the plant there were six buds in various processes of development, but the spider directly selected the very one which showed promise of opening when evening dawned. All day she sat patiently waiting, as if conscious that the new flower would, when spreading its petals, attract food within reach. When the petals finally unfolded she walked from the underneath surface to the upper part of the flower near the stamens, at the centre, and stealthily arranged her body into a living trap. She is shown in our second drawing crouched in the flower at the right-hand side.

After this period of long waiting the reward finally came. First, a light spotted flower beetle flew near and made an aerial descent on the flower. But evidently it was not fitting food, for I was surprised to see it ignored. A moment later, however, she fully awakened when a fly came to the flower and she immediately seized it, using her long legs in the operation of clasping it. After bringing the fly to her mandibles she let go and continued her meal by holding it with her mouth parts, at the same time again spreading her legs wide apart.

Another observation, which directs our attention to the instincts of this spider, was made one late afternoon. I saw another spider of this species on the blosssoms of one of the primrose plants. The following early morning she had changed over to another flower on the same plant, having been driven out by the collapsing petals, as previously described. The following evening the spider was in the newly opened flower, but on the third morning she had left, leaving a dead bee as the remnant of her repast.

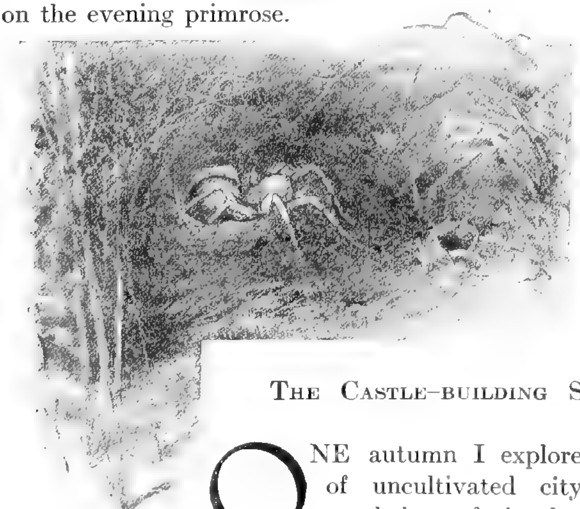
But why did she leave? What unerring instinct was exercised in telling her that the succession of flowers was at an end? For it afterwards developed that the flowers had ceased blossoming. In a certain light, I caught sight of a number of her spun threads connecting the tops of the different flowers. Here lay tell-tale evidence, for the spider had the habit of spinning out and leaving a web behind her. These

The Evening Primrose, showing the pretty pink and yellow moth, Rhodophora florida, which frequents the flowers in daytime for protection.

threads marked perfectly the course of her movements in my absence.

A little study of the various strands revealed the fact that she had examined critically the tops of the buds and had discovered in some way the failing nutrition of the flowers. She had shown evidence of deliberation and had gone to and fro in her travels over the bud tops, as was indicated by the various threads.

I have witnessed this spider change color occasionally from white to yellow, during one of its moults. Packard[1] has intimated that this change of color is for the purpose of more perfectly adapting the spider to the flowers of the goldenrod, and other yellow flowers that appear later in the season. From what I have seen in nature, there is evidence that this spider has the power of changing color when visiting different flowers. In the chapter on "The Assassins in Lace," I have described the behavior of this species in her white attire. Her habits on this plant are somewhat different from those while she is on the evening primrose.



THE CASTLE-BUILDING SPIDER

ONE autumn I explored a number of uncultivated city lots where weeds in profusion had unbounded sway.[2] Patches of high grass, shepherd's purse, peppergrass, sedges, and ragweeds made the

[1] *Journal of the New York Entomological Society.*
[2] Observations taken in Chicago.

open waste a paradise for running Lycosid spiders. In one particular, these areas were uninviting spots, owing to the preponderance of cenchrus burrs. Yet, from the naturalist's point of view, they proved to yield rich material for study. It was here that I made my first intimate acquaintance with the castle-building spider and her various accomplishments. I found, after some observation, that this spider is equally expert whether engaged as a carpenter, weaver, mason, or digger. All of these attributes she brings to bear during the construction of her underground tube and the exquisite castle or turret which often surmounts the opening.

In the fall of the year, building operations are most active, for it is then that young and old individuals alike engage in preparing their burrows, with a view to hibernating through the winter. Whenever possible, this spider either hides her burrow and castle in a recess of overhanging dried grasses, or places it so that the castle blends perfectly with the surroundings. On this account it is often difficult to locate their nests. The first evidence that may attract one's attention is the new, lighter colored sand or dirt which the occupant has thrown out in the form of pellets when she excavates the tube to reach a lower depth. In building her nest, the castle builder does not arrange the material pentagonally, as her near relatives are known to do. Oftentimes her castle is situated beside a half-buried piece of old branch, a site which aids in the deception I have suggested. The little seedlings and mosses growing around it, which spring from the superficial deposit of vegetable mould, give to the surroundings the effect of a small imaginative garden colored with sienna and green.

The nest, or turret proper, projecting above ground, is quite round, forming a hollow ring. It is commonly composed of fragments of peppergrass, bark, and rootlets, woven together with silk, while to one side a dried leaf of ragweed may be æsthetically curved around and attached. Other bits of leaves are incorporated into its margin with good effect. Again, grass leaves may be brought down from a standing plant near by and festooned to the sides, the finishing touch being a dagger-pointed burr poised on the margin. What could be more replete in architectural design? Actual measurements of the larger turrets give a height of five-eighths of an inch, and an inside diameter of little more than half an inch. Looking down into the opening nothing but mysterious darkness appears in the burrow below.

This description does not by any means cover all the castles of this ingenious artisan. Various combinations of material are shown in the drawing illustrations, which were made directly from the nest. By the time several nests are examined, one finds evidence of the most whimsical tastes in the selection of nesting material. An enumeration of these substances was gathered one day, which showed the following assortment: green and dried grass leaves, dried fine sedges, spikes and leaves of the fox-tail grass, pepperweed, fibrous roots, ragweed leaves curved by drying, spikes and burrs of cenchrus, wing of beetle, weatherbeaten white paper, piece of brown string, twigs of various kinds in bits, dark bark, seeds of weeds, sand made into pellets, and small gravel from the soil — for variety, quite a favorable comparison in this feature with some of the birds' nests.

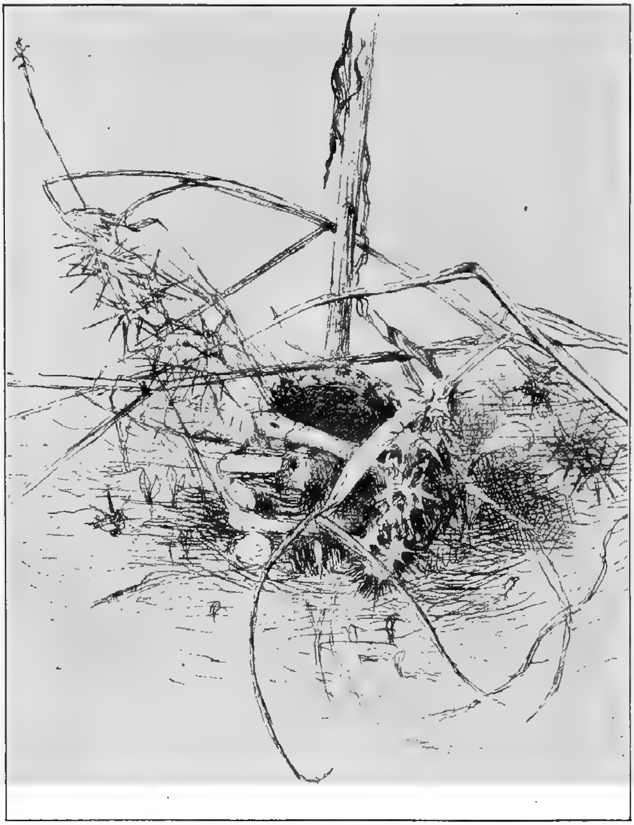
If the day is warm and the castles are approached cautiously, it is quite possible to find the spider peacefully sunning herself on the top of her home. Or if she descends below into her retreat and a doubt exists as to her presence, she may be discovered by lightly exploring the tube with a long grass stem. Our curiosity may be even carried further by digging a hole down at one side with a table knife, to avoid injuring the castle, then making an undercut below extending to the tube. The excavation may be carried on to the bottom where the spider rests.

She is a fairly fleshy spider and presents a dark brown dress of velvet (see illustration). Usually she is quite reluctant to leave her tube, even after such an exposure, and when the earth is carefully replaced she will soon repair the damaged tube. In the event of taking her up for more minute examination, under the excitement she may make a display by raising her two front pairs of legs high in the air, thus showing the contrasting rich black below on the outer three joints. On removing her to new, favorable quarters, after a time she may attempt to get below the ground by constructing a new home. This affords one an opportunity to study her interesting behavior.

In setting out to make the tube, she proceeds, with some variations, in the following way: Standing on tiptoe she moves her abdomen around almost in a circle between her legs, touching the ground here and there with the spinnerets at the end of the body. The silk, pouring out, catches fast in the soil, and in a moment an adherent round mat, three-eighths of an inch across, is formed. Then she turns about, digging up the little silk mat entangled with sand, and in a twinkling she has made it into a parcel which is laid to one side. Again she spins out silk over the same spot and dexterously lifts up the mass with her mouth parts and lays the pellet thus formed beside the preceding one. By such repetitions she soon temporarily encircles the newly made pit with her internal diggings. As the hole is deepened, oftentimes she stands head down in the hole and pats down the new-formed opening with her abdomen. Within an hour she may be down the depth of her body and the hole excavated sufficiently large to turn around in. Then each parcel of sand, after being made and brought up to the entrance, is snapped away from her mandibles with a sudden motion of her palpi. As she progresses, she frequently pauses to line the tube inside with silk, or may often reinforce the surface already covered to prevent the caving in of the earth. When about ten inches of excavation is accomplished she usually ceases her labors, for the tube is now practically completed.

The Castle-building Spider (Lycosa domifex) in the bottom of her burrow.

The operation just witnessed is often performed in the daylight, but the castle, which forms an after addition, is rarely constructed excepting at night. To see her manœuvres during the latter work, one will be more successful in making observations by artificial light. I found that in the vivarium some materials, such as I have seen entering into the composition



The castle of the spider is often made of various small stones, bits of bark, and covered with Cencrus burrs.

of nests afield, could be supplied by scattering them over the ground close to the entrance to the newly-made tube. She willingly adapted them to her nest, as I will presently describe.

One adult female which I had under observation came out of her tube and selecting a prickly sphere of burr grass, she carried it to her burrow where she adjusted it to the border of the opening. She then spent a few moments inside her tube, and when she again appeared, this time took from the ground a second and a third burr, placing each to form a partial border. From the interior of the tube she brought up sand pellets, which she used to fill the intervening spaces between the burrs. Satisfied now with this foundation of burrs, she walked over from the opening to a grass stem, which she picked up and carried back to the edge. Then letting down the fragment, she turned her body about after getting within the tube, and in this way attached it at the middle with multiple strands of silk. Another grass stem was next used, which she laid crossing the first on top of the now half-buried burrs. Then her attention was attracted to some weed stems which she seized in her mandibles and disposed of in a similar manner, but alternating with a silken sand pellet. In their turns she selected a piece of red paper, which I had thrown in her way, and a straw, and to these she added several more sand bundles. All of these articles she utilized, one by one, with the same scrupulous neatness. Similarly, a bit of white paper was also drawn to the side and fastened, and lastly, another piece of blue paper, the whole forming a curious embellishment to the little towering castle which was now finished, and nearly an inch in height. The colors in the paper seemed to be disregarded by the spider in the use to which she put them.

Young spiders, even down to the smallest, exhibit the same inherent instincts for castle building possessed by the adults, though their work may be of a more dainty character. Between these extreme ages the nests may present the widest diversity of material used in their construction. One scarcely can believe, on parting the ragweeds aside, that the perfect little tower at our feet, built almost entirely of stones, is the work of the young artisan. Yet such is the case. As I observe the compact little edifice, three-eighths of an inch high, made up of nine little particles, I wonder where this instinctive versatility will end. This masonry, cemented together with silk, is exquisitely put up, every stone in the round house bearing out true proportions even to the central opening which was only a little less in diameter than the height.

The time of year, as I have hinted, has its effect upon the whole of spiderdom, for activity is now expressed on every side. The little yellow sand pellets encircling the openings tell plainly that the spider year is nearing a close. How clearly they are forewarned of the coming winter is evidenced by the deepening of their retreats to get below the freezing line. But this is not confined to spiderdom, for it is interesting to observe that the neighboring beetles and other insects with one accord churn up the soil by their burrow construction. In another week the vernal spell is changed by lowering temperature, and now inactivity reigns upon the scene. On viewing the spiders' castles, some have been sealed up with a silken screen just inside the doorway, quite an effective barrier against the first falling snow, spreading its white mantle over the still landscape. Our Lycosid castle builders, one and all, have gone to sleep, not to awaken until the sunshine carries warmth again to their underground habitations.[1]

The Behavior of a Jumping Spider

One July day a neighbor brought me an interesting nest of one of the jumping spiders. This nest of *Phidippus morsitans* was made of white flossy silk, as shown in our accompanying photographic illustration. It was built within a large maple leaf, which had turned brown by exposure to the weather. The edges of this leaf were drawn together with a thick mesh of silken threads and in the hollow recess thus formed she surrounded her mass of eggs with a white flossy covering. A hole, serving as a door remained open at one side, through which the spider, who was still in her house, could pass in or out at will. When this little leaf nest was found, it was located close to the ground and attached to a number of green leaves and sedges. I brought the nest into my study, leaving it on the table, where the spider could enjoy a certain amount of liberty. It was not long before she came out to make slight repairs on

[1] Abstract of article from *Entomological News* by the present author. According to Chamberlain, this species of spider is *Lycosa fatifer* Hentz, see "Proceedings Acad. Nat. Sciences," LX, 1908, pp. 241–243. My name, *Lycosa domifex*, is said to be a synonyme, but there is some question on this point, as my species is colored differently and the epiginum of the female differs from *fatifera*.

the nest, and then go foraging about. In these expeditions she was very inquisitive examining nearly everything on the table, and occasionally seizing small insects that I had caught for her.

The Jumping Spider (Phidippus morsitans) with a captured Datana Moth. Its nest of flossy silk is shown above in the centre of the dried leaf. The ball of eggs is stored inside, and a hole serving as a doorway is placed at one side.

But it was on the third day that I was introduced to the pugnacity possessed by this small nest guardian. In the forenoon I had incidentally brought in three live Datana moths, which were quietly resting on the upper surface of some leaves of black raspberry. This small branch containing the moths was inadvertently left on the table in a vase of water, about a foot away from the nest of the spider. I left the room for about half an hour at noon, never thinking of the spider. When I returned I found that all three of the moths were missing, but I soon found one of them on the table near the spider's nest, with the spider complacently feasting on it, just as I have depicted her in the photographic illustration. The other two moths, which had evidently been frightened by the spider, were afterwards found unharmed in other parts of the room. That there had been a struggle by the captive moth was shown by the numerous moth scales strewn over the top of the table. When it is remembered that the Datana moth is so much larger than the spider, the fearlessness of this spider is better appreciated.

In order to reach the moth the spider was obliged to crawl up the side of a small glass vase containing water and the plants. She then could easily jump on the stem and crawl out to the leaves of the raspberry. Either the spider saw the nearest moth from the table below, a distance of at least eight or nine inches, or else she made a foraging trip on the plants without first observing the moth from the table. In the latter case, she accidentally discovered the moths after crawling out on the leaves.

In an interesting article by the Peckhams on "The Sense of Sight in Spiders," they arrived at the conclusion, after experiments on these Attids, that they see their insect prey when it is motionless up to a distance of five inches; that they see insects in motion at much greater distances; and that they see each other distinctly up to at least twelve inches. It will be borne in mind that the Datana moths I have referred to were quiet, and it is much more probable that they were detected by the spider from below the table top.

Numerous species of these spiders frequent our fields and forests. The part they play in the struggle for existence among the insect life living in the same environment is but little known. Yet, who can doubt that these fearless little predaceous tigers are an important factor in the control of insect life, and that they exert an influence on the population of many of these life forms.

The Golden Sphex as the Grasshopper's Enemy

IN our casual observations of the life of insects, how seldom their real enemies are given due consideration. I have in mind at this moment the part played by the wasps in limiting the number of grasshoppers. I have witnessed the destruction of the eggs of the green meadow grasshopper, Orchelimum, by a parasitic species Macroteleira, but I am now about to relate my observations on the large golden digger wasp, *Sphex ichneumonea.* She stores her underground nest with grasshoppers which she captures by paralyzing them with a sting from her ovipositor.

On September eleventh I came upon a freshly made burrow of the golden Sphex wasp, situated only a few yards from the back door of our cottage. Thereafter I kept constant watch with the expectation of discovering the owner of the burrow. Three days later a little pile of dirt close to the entrance indicated that fresh excavation had been in progress which caused me to renew my vigilance. On the fourteenth, near the noon hour, I was surprised by the appearance of the owner, a large orange-colored Sphex wasp. She had made her way along the ground unobserved and at first halted about three inches from the opening of the burrow. She was in this position when I first caught sight of her. At the same time she dropped a robust, green, meadow grasshopper, which she had been dragging along the ground. After discharging her burden she flew up a little way above the ground, making a loud buzzing sound with her wings. She then turned about to examine the surroundings and eyed me intently. Then alighting on the ground again she went into the burrow. There she remained only long enough to make a hasty inspection of her underground nest, and presumably to see that everything was in readiness for the further task she was about to perform. It seemed but a few seconds before she backed out of the burrow. Then turning around, she seized the grasshopper

The Golden Wasp (Sphex ichneumonea) dragging its prey into the burrow. In this instance it is a green meadow grasshopper which has been captured.

by the antennæ close to the head, and dragged it into the hole, backing down with her charge (see text illustration). In half a minute she again came out of the burrow, carrying a parcel of earth which she scattered behind her. After repeating this manœuvre several times she flew away.

It was nearly an hour before this wasp returned again, bringing another grasshopper, seemingly the counterpart of the first. On leaving the spot for several minutes, I found on my return that she had filled up the burrow to the level of the ground and was busily putting on the finishing touches. The latter procedure seemed to be the most interesting part of her performance. While I was viewing her she seized a bit of old wood, about a third of an inch in length, and carrying it three inches to the place where the entrance formerly lay she leaned strongly forward on it, almost standing on her head, while she pressed the object against the ground. A rusty iron shingle nail happened to lie conveniently within reach, which was next seized with her mandibles and forcibly pressed on the ground beside the wood. Notwithstanding that the nail was an inch long and of considerable weight, she lifted it up and down and planted it several times with considerable ease.

Again I saw her busily turn her attention first to bits of twigs, then to little uneven places in the earth, which she dispersed back of her by a rapid scratching motion of her feet. Finally she varied these performances by twice going to small green leaves of a creeping spurge plant, which she cut off very cleanly with her mandibles and laid directly over the former doorway. No one could doubt that these actions were done with a view to conceal perfectly all traces of her precious hidden treasure. After these final actions and as she was seemingly ready to depart, I seized her in an insect net for identification.[1] Upon this point I will have something more to add in the sequence.

At this time I had gleaned but a partial knowledge of the contents of the Sphex's nest. Upon carefully digging down beside the burrow with a trowel and table knife, I found that by cutting the ground away at the side, the course of the nest could be determined by the dry powdered condition of the recently filled-in dirt. As a result of this search I found the tube was made to incline obliquely downward, five inches. Then the burrow suddenly enlarged at the bottom into a pocket which was compactly stored with three female and one male green meadow grasshopper. All of these insects had their heads directed the same way, looking forward, their legs collectively pointing backwards into the burrow. They were, moreover, practically all lying horizontally on their sides. Each one exhibited signs of life by rhythmical movements of the abdomen, though entirely quiescent in their other organs. The top grasshopper, which would seem to be the last one taken into the burrow, had the wasp's egg attached to the ventral

[1] This insect was identified as *Sphex ichneumonea* by the late Dr. William H. Ashmead.

side of the thorax, lying obliquely between the basal coxæ of the first and second pairs of legs. I kept the grasshoppers buried in the damp ground, but they lived only three days. At the expiration of this time the wasp's egg had disappeared and a mould began to form on the discolored, darkened specimens.

The Peckhams[1] give an account of a golden Sphex wasp carrying a single green grasshopper into her nest, after which she at once threw in earth as if about to close the burrow. At this juncture they frightened away their wasp, and after digging out the nest shortly after, they found that she had laid her egg as usual on the under surface of the thorax of the grasshopper. From these observations it would seem that this Sphex lays her egg on a single grasshopper, and that is the first one. From what I have observed I have reason to believe that the Peckhams may have interrupted the work of their insect before she had completed the storage of the full complement of grasshoppers.

One forenoon[2] as I was walking along the roadside, a golden Sphex passed directly in front of me carrying a cone-head grasshopper through the air. She flew in a slanting direction, carrying her burden with considerable ease, until she alighted among some red-top grass, and finally on the ground. After a short rest she carried her prey up to the top of a tall grass blade, where she started off, flying with it about ten inches and landing in front of the opening of her burrow. Then deliberately arranging the head to point toward the hole she left the paralyzed grasshopper. She then proceeded down into her burrow to get it in readiness for her insect prey. In about a minute she suddenly appeared again, and seizing the grasshopper by the head she dragged it down into the burrow.

The golden digger has remarkable dexterity and tremendous strength. This is shown in her power to capture Orchelimum, and then carry her prey bodily or drag it against all kinds of obstacles to her nest. Her ability to destroy the green grasshopper, Orchelimum, is all the more remarkable when we consider that the latter are somewhat cannibalistic and aggressive

[1] "Insects and Habits of Solitary Wasps."

[2] At Lakeside, July 30, Michigan, 1909.

antagonists. They often show a disposition to prey on other insects; their jaws are very powerful and they are always ready to defend themselves. But even though provided with such powerful weapons these grasshoppers are evidently not equal to the attacks made by the possessor of the deadly hypodermic instrument used by Sphex.

Fabre[1] tells us of a species of Sphex observed by him in Europe that stores her burrow with crickets. When she captures her prey the insect is thrown on its back and the last segment of the abdomen is firmly seized and fastened down with her mandibles, while her feet clasp the sides, holding down the body of the cricket. The wasp's front feet hold down the long hind legs of her prey while her hind feet hold back the mandibles to prevent these from biting and at the same time making tense the membraneous junction of the head and body. In this attitude the Sphex darts her sting successively into three nerve centres: first, into the one below the neck which she has stretched back for the purpose; next, into the space behind the prothorax, and lastly, into the one lower down. The cricket thus paralyzed will live for six weeks or more.

The wasp is so much smaller than its grasshopper prey, and there is such a difference in actual weight between them, that the wasp's bravery is all the more noteworthy.

I have taken the opportunity of weighing both the wasp and grasshoppers when fresh, with the following result: weight of wasp, five grains; male meadow grasshopper, seven grains; three female meadow grasshoppers, ten, eleven, and ten grains respectively. It will be seen by these figures, first, that the Sphex is able to carry a weight equal to twice that of her own bodily weight; second, that the material supplied for her growing grub, after hatching from the egg, amounts in all to thirty-eight grains, or more than seven times the weight of the female parent. How much of this food supply is actually available to the grub is not precisely known. The subtraction of the weight of the chitinous material which is not edible would give us only a rough estimate, as only the soft parts are eaten.

In August of the following year, I studied the behavior of several more of these wasps, one of which had stored three

[1] "Souvenirs Entomologiques," 1879 and 1883.

different species of grasshoppers in her nest. The species included a male, slender cone-head, one common green meadow grasshopper, and a female green grasshopper, *Orchelimum delicatum.* Still another of these wasps made two nests in succession near together. She commenced the first nest in the late afternoon, and after storing five grasshoppers, she closed it at 6 P.M. on the following day. The second nest was started at six o'clock in the evening and finished two days later. Into this nest she dragged four grasshoppers before she finally closed it up completely two days later near five o'clock in the afternoon. On excavating the two last-mentioned nests, some interesting new facts came to light.

The first burrow was made to go down at a slight angle from the vertical, at the top cutting through the sod roots a distance of an inch and a half, and then into the dry, sandy earth. The length of the tube was six inches, and it ended in a cavernous pocket. This was stored with a male and female cone-head grasshopper, *Conocephalus attenuatus.* Just above the bottom cavern, and separated from it by a partition, was a second room in which were stored one female meadow grasshopper, *Orchelimum vulgare,* and two green cone-heads, *Conocephalus attenuatus.* I next came upon a wholly unexpected find in the lower pocket, as I lifted the grasshoppers out of their confined quarters. Here were a surprising number, something like thirty whitish grubs, which were about a quarter of an inch in length. The grubs afterward thrived on the decomposing grasshoppers. These fly larvæ developed rapidly until August twenty-third, when a large share of them were transformed into pupæ. In order to lay her eggs, the fly must have gone into the open burrow of the wasp. This was probably accomplished during the wasp's absence.

The second nest was more slanting in its downward course. It, too, was made up of two compartments at the bottom. The length of the tube to the bottom of the lower room was six and a quarter inches. Within the lower pocket were stored a green male and a yellowish brown female of the green cone-head grasshopper. In the second pocket above, the larder comprised two males of the same species, one colored brown and the other green. Only one wasp egg had evidently been deposited in this nest; it was found in its usual situation, laid under the front of the thorax of one of the male cone-heads, and probably the last grasshopper stored. Summarizing the facts above given, the wasp just referred to had stored five grasshoppers in its first nest and four in the next, using, in all, nine victims for her larder.

The Habits of the Green Meadow Grasshopper

In the early part of September, I caught several pairs of the green meadow grasshopper, *Orchelimum glaberrimum*, in a meadow among some coarse plants. After keeping them alive under observation for several days in a large vivarium jar, they were allowed the freedom of flowers on the centre table in my room. I found these insects very wild at first, but they afterwards became tamed and quite adjusted to the indoor surroundings. The means used in taming them were gentle treatment, an occasional supply of water for drinking, and plenty of picked plants in blossom for foraging. The latter were often replenished and kept fresh and green. On September sixth, a female was noticed exhibiting rather restless actions among the loosely spread stems of one of the bouquets of flowers supplied her and soon afterward I found her ovipositing in a stem of the burr marigold. The method of laying her eggs was thereafter studied and found to be of such peculiar interest that a detailed account is here offered.

Before selecting the marigold as the proper plant for her immediate needs, Orchelimum tested a number of different kinds of plants by biting the stems. It was curious to see how quickly a decision was arrived at when she was engaged in the search. Grass, for instance, or other kinds of plants distasteful to her, were either ignored entirely or else subjected to a brief testing with the mouth. After jumping from plant to plant and going up and down in the quest, the coveted stem was found. She then started very vigorous biting, moving her head from side to side in an endeavor to get a stronger hold with her jaws. A gash into the outer layer of the stem was soon made, about an eighth of an inch in length, the insect finally going back over the course of the incision with the evident purpose of more deeply penetrating to the pith. During the first stage of the process the female stands with her head directed downwards, but as soon as the spot is prepared with the mouth, she reverses her body preparatory to the act of oviposition. Firmly grasping the plant stem with her feet, she curves the

A Green Meadow Grasshopper (Orchelimum glaberrimum), laying her eggs in the stem of the burr marigold.

abdomen underneath, at the same time bringing the pointed extremity of the ovipositor into the breach made in the stem above described. Now she stands with her ovipositor under the abdomen with the blades slightly imbedded, but gradually as it is worked within the stem she almost imperceptibly moves forward, a little at a time.

Finally, when the ovipositor is buried to its utmost length, it is directed backwards, as shown in the photographic text figure. We can now appreciate how well adapted the curve of the organ is for this purpose. A moment later the blades are spread apart, allowing the elongated egg to be lodged within the centre of the pith, the latter having been pressed to either side for the accommodation of the egg. During this process the female is very quiet, the only noticeable movement being an occasional quiver of the abdomen. As soon as the first egg is laid, she withdraws the ovipositor and immediately turning around she again bites the same spot, spending several minutes chewing the fibres and pinching the sides together with her powerful jaws. This is done in order to use the same opening to deposit the second egg, as about to be described.

She next moves a little way down the stem, but this time her head is directed downwards so that she may insert her ovipositor in the same hole, but deposit the second egg in a position reverse to that of the first. No sooner is this second egg laid and her ovipositor removed than she turns about and treats the spot for the last time to the same manœuvring of biting and pressing the sides together as before witnessed. The two eggs thus far laid have their anterior poles directed end to end with a slight distance between them. When the third and fourth eggs are about to be deposited, she moves down the stem to a new site about half an inch away, varying the distance, and the process with its several stages is repeated. The interior of the stem is finally filled for a considerable distance with eggs, about ten minutes being consumed in the deposition of each egg.

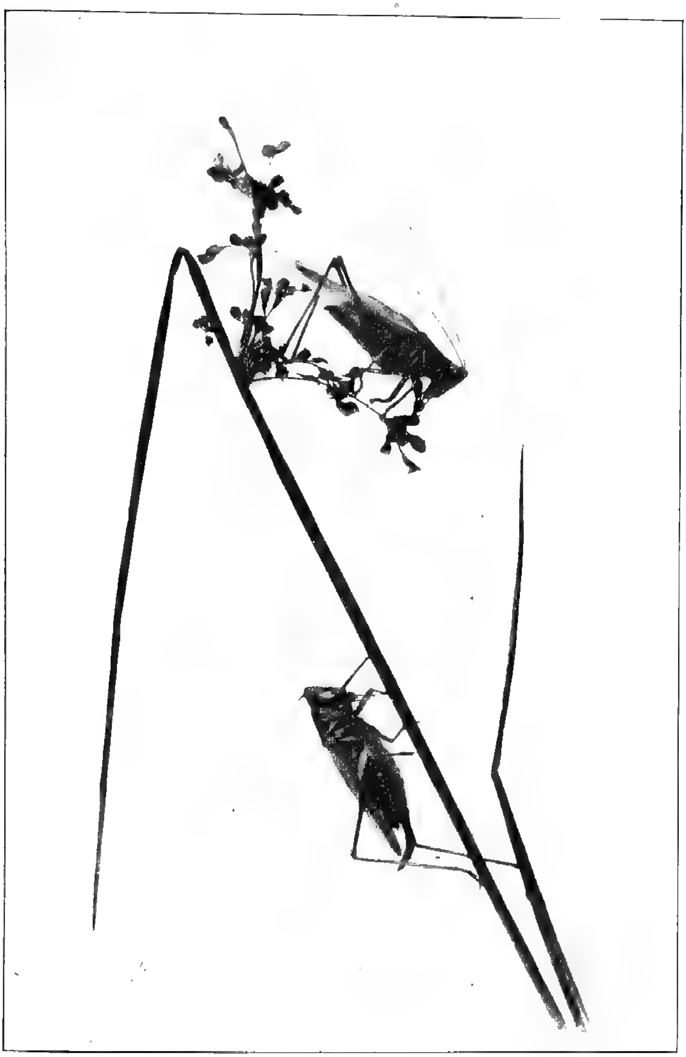
It was during the critical moment when an egg was being deposited that I seized upon the opportunity of photographing the female in life as shown in the accompanying illustration. She had made nine incisions up to this time and was in the act of laying the eighteenth egg. Some of these incisions are easily seen in the illustration. When the eggs hatch, doubtless two young escape from each of the scarified points. On removing one side of the stem containing the eggs, in a longitudinal direction, they were found to lie with their corresponding poles nearest together throughout.

The eggs are slender and beautiful flesh-colored objects when freshly laid; they are nearly straight, about six mm. long and seven-tenths mm. in width. The anterior pole is very slightly tapered, with a bluntly rounded apex; the posterior pole is more distinctly reduced and the apex narrowly rounded. Usually the eggs are skilfully guided to their destined places within the pith, but that they sometimes meet with accidents I can attest from observation. Occasionally, through defective working of the mechanism, I have noted temporary arrest of oviposition, due to the egg sticking between the blades. When this happens the ovipositor is withdrawn, and turning up the tip underneath the body in a forward direction, the female deliberately spreads the blades apart with her mouth and seizing the offending egg she immediately devours it. An egg which I took away from the female just as she was going through this performance was compressed transversely and somewhat distorted. This seemed to show that the excessive lateral pressure brought to bear by the blades had caused the failure of the egg to be deposited.[1]

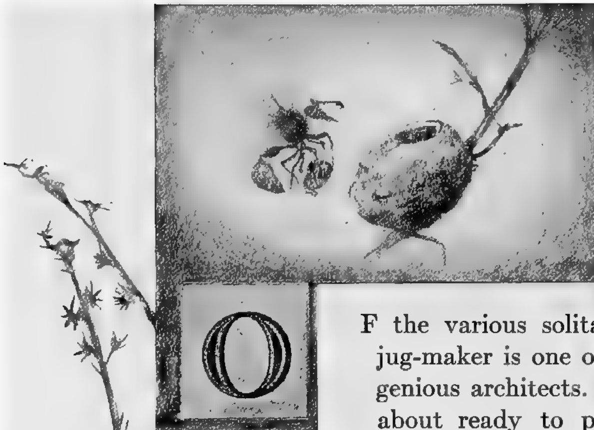
It may be of interest to note that Riley[2] mentions that this species oviposits in the stems of various pithy plants, and especially in the tassel stem of Indian corn. In the photographic plate is shown a pair of the closely allied species, the common green meadow grasshopper, *Orchelimum vulgare*. The habits of these insects are similar to those I have described in my sketch.

[1] The above article, by the author, appeared in *Psyche*, August, 1904.

[2] Standard Natural History, Vol. II, p. 187.



A pair of the Green Meadow Grasshoppers (Orchelimum vulgare) on a sedge. Upper figure male; lower figure female. This species is often captured by the large golden wasp (Sphex ichneumonea), and stored in her underground burrow for her developing grub to feed on.



THE JUG-MAKING WASP

OF the various solitary wasps the jug-maker is one of the most ingenious architects. When she is about ready to perpetuate her species, she selects a small branch of willow, beech, or perhaps a weed, and thereupon sets to work, building a little nest of mud and sand, which, when completed, presents the form of a miniature water-jug. In this jug she stores one or more green caterpillars which she has previously paralyzed by a sting from her ovipositor. She then lays her egg on one of the caterpillars, which furnishes nourishment for the developing larva after it hatches. The period of nest building, in those I have observed, is in the latter part of July.

One day a partly constructed nest of this wasp was found on the flower stem of a dried heath plant. When first visited in the forenoon, the wasp had about two-thirds of the structure completed. The incomplete nest had a hole of considerable size left open at the top. Some hours after, it was found that in the meantime the wasp had finished the nest; the opening having been narrowed into a neck and completed with a circular projecting edge. (See photographic illustration.) Through the small round opening inside a green caterpillar could be seen. On the outside of this nest were a number of protruding nodes, of the same material forming the nest. The significance of this ornamentation is not altogether clear. The first row of these small nodes encompasses the forward third of the globular nest, more or less regularly disposed, while about seven more are

The completed nest of the Jug-making Wasp (Eumenes fraternus). As many as three mud nests are sometimes saddled on a twig. In each jug green caterpillars are stored as food for the grub that hatches from the egg the wasp deposits before finally sealing the opening.

irregularly arranged around the back portion. These little protuberances are fashioned when the clay is soft.

I once saw three nests of this interesting wasp on a twig of a beech tree. They were compactly built in a row, firmly saddled on the beech twig, the middle one being closely wedged and cemented between the other two. All the openings of the jugs were perfectly sealed with smoothed-off mud. Probably all of the nests were made by the same mother insect. After keeping the nests indoors for six days, I found two of the slender-waisted wasps on the windows inside our house. This was the first intimation that the jug-makers had made their exit from their confined cells. Sure enough, an examination of the nests revealed that all three of the occupants had gone. They had not, however, pushed out the little plugs in departing, but instead, each one of the nests presented a little hole in the side, of ample size, through which the wasp's body could pass. It would appear from these holes that the wasps had gnawed their way out with their powerful mandibles. Gibson relates in "Sharp Eyes" that the plug to the jug is pushed out by the chrysalis when it appears as a full-grown wasp. But the writer's observations, as shown above, do not coincide with this view, for all the wasps kept under observation broke out through the side of the nest.

The mason-wasps are rather small in size and are identified by the characteristic form of the abdomen. The latter is attached to the thorax by a slender peduncle, which is slightly swollen backwards. The next segment of the abdomen adjoining the peduncle is globular, the remaining ones forming a tapering point. Again Gibson writes that when this wasp completes her jug-nest, "The wasp lays an egg within it, and then proceeds to pack it full of tiny green caterpillars, each of which she has paralyzed but not killed, by a stab of her sting. The opening to the vase is then plugged up with a mud cork. Presently the egg hatches into a little grub, that feeds for the rest of its days on the living store of food." There are doubtless individual differences in the habits of the jug-maker, and much is to be learned about them by painstaking observations. It is well to mention here that Walsh reared a parasite *Chrysis cœrulans* from the cells of this potter wasp, and it would be of interest to know the whole story of the relations of these two insects.

The Habits of the White-Footed Mud-Dauber and its Allies

WHILE the jug-making wasp, which I have described in the preceding part, may be the most artistic in the jug design of her nest, yet the white-footed wasp may justly claim an architectural skill of an equally high order. Between the nineteenth and twenty-third of July, I studied a white-footed mud-dauber while she was building her nest. When she first started her work on the vertical surface of a rafter under the roof of our porch, she brought pellets of clay and made a rather rough layer of them. These pellets were uncertainly cemented to the wood in the commencing process, though, little by little, there was an increasing evidence of her dexterity and that she had seemingly from the start a definite design in view. From this foundation, she built up the sides and roof of the tube and gradually extended it. When it was finished it was almost straight, two and three-quarters inches in length, and made up of three separate compartments, or cells, with a partition separating each of them. (See plate illustration.)

The wasp only worked on the nest during hot, sunny days. Then she was kept busy bringing soft little pellets of clay which she carried between her feet. These were deposited later on in the construction, and when occasion required, above the opening of the tube, and with the aid of her mouth and legs, she worked this soft, plastic material into a thin, lengthened-out strip. This little roll of clay was firmly pressed against the border as it was strung out, and cemented by its own adhesiveness. If it failed to go completely around the side, she patched out the deficient space with another pellet at a subsequent visit. The opposite side was similarly treated, and the roof was formed by the strips slightly overlapping or joining at the top. Some of these drawn-out pellets, of which the nest is composed, can be traced in the photographic illustration of this nest. This clay tube was built in a slanting direction on the rafter, with the entrance pointing obliquely downward.

The outside of the nest presented a rough appearance, but the wasp took great pains in smoothing off the interior surface with her wings while the clay was still soft. While engaged in this performance I could hear the musical hum of her wings several yards away, as these rapidly vibrating structures brushed and smoothed off the inside wall. It not infrequently happens that the ends of the wings are seriously worn or mutilated in this way. I have witnessed what I took to be an accident of this kind, and also one in which the wings were stuck together by the adhesiveness of the clay. In the latter case, it disabled the wasp from further duty and she left a nearly completed nest, which was never closed, as the male made no attempt to finish the work.

After the first section of the tube was quite deep and completed, the male appeared on the scene, and during a brief period of courtship he entered the nest with his mate. She now went out foraging for spiders, among the herbage or about the recesses of houses. One by one, she captured and brought these stung victims in and stored them until the cell was closely packed full. In the meantime, as the female went away, I saw the male watch her and on her departure he backed into the tube, remaining there until her return. Whether this was simply a retreat for him, or whether he was there to guard the nest, I do not know. After she came back with the last spider and deposited it, she laid her elongated egg on its back, as shown in the lowest spider in the illustration. The wasp then

The White-footed Mud-dauber (Trypoxylon albitarse) and her Nest. The last cell is broken open to show the stored live spiders. The egg of the wasp is shown attached to the lowest spider of the group.

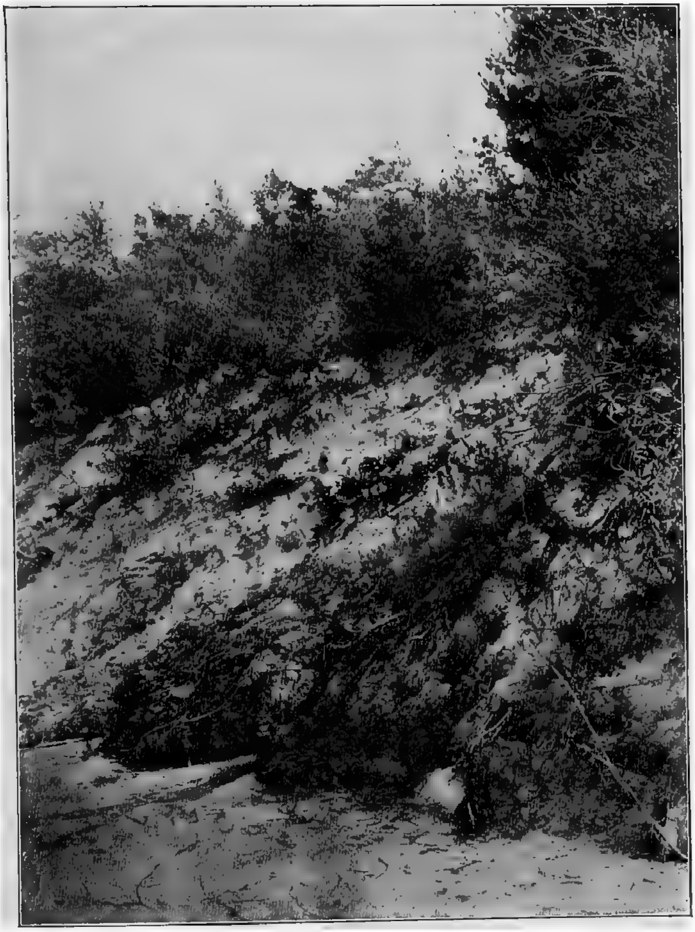
erected a wall of clay pellets, dividing this first cell from the remainder of the tube which was afterwards added. After the second and third cells were constructed and each in its turn filled with spiders, the final action of sealing up the last section occurred.

Usually, in the course of a few days, the egg in each compartment hatches into a grub which commences at once to eat and "wax fat" on the rich store of live, paralyzed spiders. By the time the last spider is consumed, the grubs transform into pupæ. This mud-dauber, or one that was supposed to be the same individual, afterwards made a second nest by the side of the first tube, which was essentially like the first. I have seen as many as seven nests built in succession side by side on the same rafter or beam, but probably some of these were made by different individuals.

It is remarkable the great amount of space travelled during the time this wasp was constructing her tube. In an attempt to gain some information of this kind, I tracked her with considerable difficulty to the source of supply for her pellets. This I soon found was a wet clay bank on the shore of Lake Michigan, thirty-five yards distant from her nest. This bank, showing an outcropping of wet clay, is reproduced in the plate illustration. Not only the present species obtained her supply of clay here, but several other species of mud-daubers, including all those species known in the neighborhood, came to this point of wet clay for this purpose. I once saw as many as seven individuals gathered here at one time, including Pelopæus and Eumenes. The clay part of the bank is shown at the lower part of the picture as a triangular, darker area.

I also made an estimate that at least one hundred and fifty pellets were used in nest construction, including an occasional one dropped by the wasp and not recovered. This would give nearly six miles travelled by the wasp in these operations, to say nothing of the distance covered by her foraging expeditions after spiders, which I could not estimate. The white-footed wasp is rarer than Pelopæus, but enjoys a wider distribution, ranging from Canada into South America.

The observations here related on the nest-making attributes of the white-footed mud-dauber, *Trypoxylon albitarse*, are of

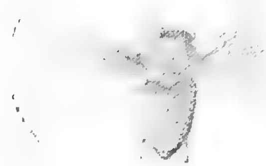


View of bluff on the shore of Lake Michigan, depicting an out-cropping of wet clay where the white-footed mud-dauber wasp (Trypoxylon albitarse) and several other species of mud-daubers obtained the plastic mud for their nests.

particular interest, inasmuch as most all of the members of this genus and its close allies are parasites, using the burrows of other insects. Not infrequently they store their insect prey in the deserted cells of a mud-dauber. Howard[1] relates that there is a curious confusion sometimes in an Odynerus wasp's cell, for a Trypoxylon wasp will enter one, carrying its own store of food with it, and closing the entrance against the return of the female wasp Odynerus; then comes along another wasp, Crysis, and lays an egg, from which hatches a larva which devours the stores of the wasp, Trypoxylon.

In the present species, as I have shown, it has not become parasitic like some of the allied species, but is a true nest builder like Pelopæus.

On August first, I found another mud-dauber's nest of a distinct species cemented to the eaves of a house. I have made an initial drawing of it, showing the underside of the cells, which are stored with spiders. In breaking the nest apart, the large white grub, with only two remaining spiders, fell out. The grub was just about ready to pupate This nest contained seven cells.



The Tabanid Fly as an Aerial Performer

WHEN passing near a grove of trees one evening in August, I heard the humming sound of some insect. I saw the winged minstrel hovering, about the height of my head, in one spot in mid-air. He remained suspended for a moment, then darted off after a companion which was similarly playing in the air. But back again he came after each chase, as if this particular spot had some special attraction for him. I cautiously approached near enough to identify him as a species of large Tabanid fly, *Tabanus giganteus.*

[1] "Insect Book," p. 32.

In flight, this insect, like others of this interesting group, has a singular habit of hanging the hind tarsi out behind its body, in the manner I have depicted him. Like many insects of rapid flight, the extreme vibrations of the wings cause them to appear like a haze on either side of the body. I have attempted to give this in my drawing. With marvellous agility he uses the wings much as a large bumblebee would, though his flight has much more speed and is under better control. We are all familiar with the manœuvres of the large, black horse-fly, *Tabanus atratus*, that can outstrip the speediest animals.

The present species is nearly as large as the horse-fly, and his strong wings give him the power to turn about in the air with great celerity. There is a striking contrast between him and his more delicate, day-flying relatives, the Syrphus flies, some of which are of diminutive size. These flies may often be seen hovering in the air, in their haunts in the shade of trees or among shrubs and flowers. They are so tame that with slight tact I have often tempted them to alight on the tips of my fingers held up quietly toward them. But the Tabanid fly is exceedingly alert.

Some of our readers may have witnessed the aerial performances of this species, and, if so, may be able to tell us whether it is one connected with their sexual dances, or merely one of play. The humming sounds of some male flies have been observed to win the females by their music. One of a species known as Eristalis has been seen by Müller courting a female by hovering above her and flying from side to side, making a high humming sound at the same time.

The Hunted Cicada

The drumming notes of the cicada, or dog-day harvest-fly, are heard for the first time about the latter part of July, though the time varies somewhat in different years. I heard one, in the afternoon of July 20, 1905, trying its long-drawn-out song, but it seemed to be unable to carry out the full continuous drumming. It may be that this was the first trial after emergence from the pupa, for I had not heard many calls before. From this time on, trillings were heard for weeks afterwards, especially in the heat of the noon hours. Graber tells us these shrill, piercing notes issue from a pair of organs situated on the underside of the base of the abdomen of the male, these acting somewhat as two kettle-drums, the membrane covering the depressions being rapidly vibrated.

The dog-day harvest-fly is surrounded by many enemies, and perhaps the most active of these is the kingbird. On several occasions I have seen this bird catch and devour them. One day, in the last of July, I saw a kingbird that could not swallow one after capturing it. It seized the cicada and, taking it to a dead limb of a willow, tried its utmost to swallow it, without being able to do so. This bird finally carried the insect away in its mouth, probably to its young. During my walks afield I have often found scattered about the wings of the dog-day harvest-fly which had been torn by some enemy, but whether this was the work of the kingbird alone I never discovered.

Herrick [1] records having seen one of these insects fed by a cedar bird to its nestlings. He says: "The staple article of food was grasshoppers and I have seen the large cicada or harvest-fly brought to the nest, but never dragon-flies, butterflies, or moths. The cicada made a lively struggle for a few minutes; it was placed in one open throat after another and withdrawn eight different times before a gullet was found capable of the proper reaction time." Again he says: "Exciting scenes usually follow at the nest of the kingbird when a large dragon-fly, cicada, or grampus is brought to the family circle. The insect often struggles hard, but escape is out of the question, especially with both birds at the nest, who at once begin to rend and crush it with their bills."

One of the most formidable enemies of the cicada is the large digger wasp, *Sphecius speciosus*. It is commonly called the cicada-killer, and makes its appearance about the time its prey becomes common. The wasp sometimes springs upon its victim while it is singing in the trees, and when it does so, it generally paralyzes the cicada with one deadly stab of its sting. Both insects then often drop to the ground. Soon after, however, the wasp starts back, carrying its prey up the

[1] "Home Life of Wild Birds."

The Dog-day Harvest-fly, Cicada, or Lyreman (Cicada tibicen), just emerged from the pupa, seen below. The shrill piercing notes are produced by the rapid vibrations of a pair of membraneous coverings of two kettle-drums on the underside of the base of the abdomen.

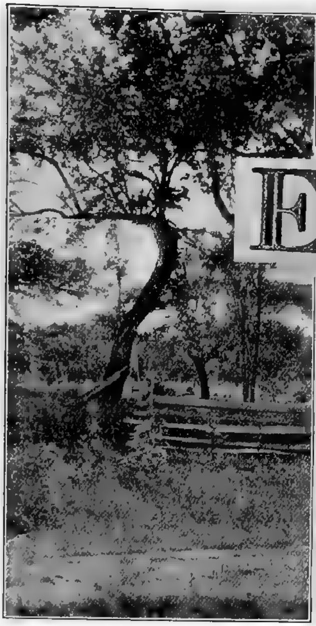
tree trunk, to get to some elevated point from where it can spring off into the air and fly slantingly down near its burrow in the ground.

The cicada-killer digs a burrow from a foot to two feet long, often inclining it, and sometimes making branches. At the end of the burrow and of each branch, a cell of about an inch and a half in diameter is formed. Into these cells the cicada is stored, to serve as food for the larva as soon as it hatches from the egg. The latter is laid usually on the thorax under the middle leg. The wasp may be recognized by its large size, being about one and a quarter inches in length; and it is black with the abdomen banded with yellow.

In a beech forest, August twenty-fourth, I observed some cicadids emerging from the pupa cases, and as these were quite typical of this change I will describe the process. After the insects issued from the ground at night, they climbed up the trunk of a tree, or large twig, and turned brownish in color. When up about three or five feet, this distance varying, they stopped and took a firm hold on the bark with their legs. The claws being large and sharp, there is no danger of slipping. After a while the body of the insect within the pupa case underwent expansive movements forward, in such a way as to cause the skin to burst along the back, over the head and thorax, in a longitudinal direction. Then, very slowly, the exposed back of the greenish adult pushed its way through the opening, spreading the sides apart, until the pale, blue-green wings, body, and finally the legs were almost withdrawn. The position of the newly escaping insect is now quite peculiar, the insect often leaning out at a strong angle from the pupa case. Lastly, the insect works its body loose by grabbing hold of the bark and slowly crawling above a little distance away, leaving the case behind. In one or two hours the wings become sufficiently dried and hardened, so that flight is undertaken in safety. I have shown in the plate photographic illustration this insect in one of the positions described.

A Wild Rose with Rose-Bugs
(*Macrodactylus subspinosus*)

This insect has become a common pest on cultivated roses, grapes, and fruit trees, as noted in the text. The body is densely clothed with minute scale-like hairs.
From a photograph

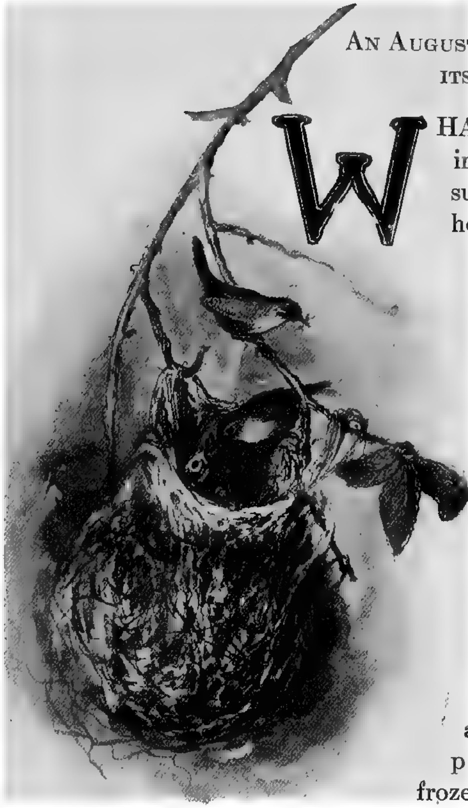


The Rose-Chafer

EVERY year seems to have its prevailing insect pests. Excessive numbers of certain species often appear as the result of a lack of the natural enemies that exercise a checking influence over them. In Michigan, I found the rose-bug especially abundant in June, 1906. Originally, it was doubtless a frequenter of the wild rose, but owing, in some degree at least, to the cultivation of the ground and the consequent spreading of domestic plants, it has so multiplied and changed its habits that few orchard trees escape its depredations. Its feeding habits also cause it to attack the grape and forest trees, as well as a number of shrubs. I have found it especially troublesome to grapes from the fact that it feeds on the blossoms. Similarly, in the year mentioned above, the young peaches were attacked, matcrially affecting this crop of fruit.

In the accompanying photographic plate, I have portrayed the rose-chafers in various positions on the wild rose. After feeding a few days on the plants they are capable of eating the blossoms and riddling the leaves with holes. One would think that the sassafras, with its aromatic juices, might be immune from the rose-bug's attacks, but I found the luscious green leaves, upon which the insects gathered in pairs or gregarious colonies, honeycombed, as the result of their voracious appetites. We have noted in another chapter how the large robber-fly attacks the rose-bug and in this way is of great importance in keeping down excessive numbers of these insects.

Harris says that "the rose-bugs come forth from the ground during the second week in June (Massachusetts), or about the time of the blossoming of the damask rose, and remain from thirty to forty days. At the end of this period the males become exhausted, fall to the ground and perish, while the females enter the earth, lay their eggs, return to the surface, and, after lingering a few days, also die." Harris further wrote that the eggs laid by each female are about thirty in number, and are deposited from one to four inches beneath the surface of the soil and hatched twenty days after they are laid. Should the reader care to learn more detailed facts of the habits of these interesting insects, he is referred to "Insects Injurious to Vegetation," by the classical writer above cited. The rose-bug, or rose-chafer, is known to the naturalist by the name, *Macrodactylus subspinosus.*



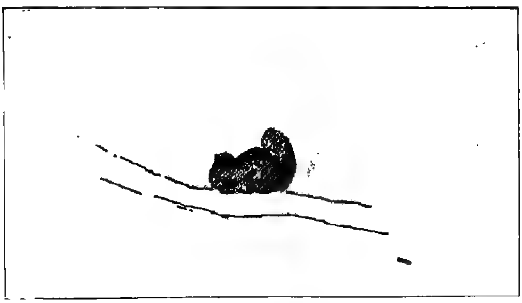
An August Hailstorm, with its Sequence

WHAT can be more impressive than a sudden storm in the heat of an August day! One afternoon as a storm arose, the southwest wind blew with terrific force through the nearby groves and orchards; and before long the wind storm was followed by rain. Every moment the large drops of water came faster and faster, here and there accompanied by little frozen messengers from the sky, the first warning of danger that was in store for our field and forest neighbors. The hail, having now taken the place of rain, fell rapidly and the earth was treated to a prolonged roll-call. The icy masses, which were often half the size of hens' eggs, bounded from the ground; with the hail also descended many leaves which had been torn from the branches of the trees.

Standing under the trees, one could watch the lull, and then the final clearing of the skies. How refreshing these sterile icy masses tasted as they were allowed to dissolve in the mouth and the cold liquid quench one's thirst! Now that the storm was over, it was time to visit the orchards to note any mishaps that possibly might have occurred to the birds. On entering the orchard, the injury occasioned by the storm was conspicuously shown by the bushels of luscious apples which lay on the ground under the trees. But what was my surprise the next morning while passing under the branches of a pear tree in the orchard to hear the smothered cries of baby birds! Looking down upon the ground near my feet, I located the nest of a Baltimore oriole which had been knocked down and flattened out by the force of the hailstorm of the previous evening.

On picking up the nest a putrefactive odor was detected emanating from it, which caused me to surmise that it came from a dead bird inside. In the meantime, there flew about me, in an apple tree, two house wrens that kept up distressing cries. Then I saw that these were the same birds that had appropriated the unused oriole's nest which had formerly hung near the top of the pear tree. This was the wren's second brood, for I recognized this same pair as having reared a family in the eaves of an outhouse. The opening in the top of the present oriole nest was very small, as the wrens had lined the interior with soft chicken feathers and twigs. These were quickly removed and the hole made large enough so that I could see within. One of the young birds was found to be dead, but the four remaining ones were alive and cried vigorously. After taking out the dead bird and rearranging the nest, it was placed in the same pear tree and tied to the trunk with a string. A careful watch had been kept on my movements by the parent birds, and as soon as I retired the mother bird hastily made a visit to the nest. With evident excitement she hurriedly examined it and then she flew to a woodpile about fifteen yards away. She nervously searched the spaces here between the sticks of wood, going in and out, gathering insects and spiders as she proceeded on her way. The male, in the meantime, seemed also to be cognizant of the situation, and he, too, was soon in search of food. At last, after going the rounds, he flew to the woodpile, and, meeting his mate, with trembling wings he passed the gathered morsels over to her from his loaded bill. In a moment more, she flew to the nest with the extra spread and fed the little crying babies, which were almost famished. The parents then alternated in their visits with food to the young, keeping up a constant feeding thereafter. The various activities of the wrens, their greetings, and chattering performances, indicated the great delight they experienced at again having their little family to care for.

This narrative would not be complete without mentioning that, in the midst of one of these bird reunions, one of the wrens paused sufficiently long to administer a scolding to a young red squirrel that impudently came to a neighboring apple tree. There was something in the wren's scolding that meant determination, for the squirrel understood and immediately vanished in the tree tops.



The Maryland Yellow-Throat

BE-WITH-YOU — be-with-you — be with-you!" comes the Maryland yellow-throat's notes as we tread along the pasture. We are led by the bewitching song that seems to come from the grove of willows in the swampy hollow. At last we locate him in the low button bushes, seeking the winged insect morsels as they fly among the leaves. What an inviting home he lives in! The air is made fragrant with the perfume from the sun-burst blossoms, which have drawn multitudes of bees and butterflies. His home is like a charmed world where these innumerable flower suns with their halos are so many little bodies of irresistible attraction. Nearly every orb has its own inhabitants and visitors from without. Besides, the buttonbush and willows, whose poetical leaves are like light dashes of the painter's brush, afford a dreamy nook for the hiding place of this warbler. The ground all around is covered with dewberries, forming a mat upon the earth. Blue flag and sedges, boneset and grasses, each have a place in this enchanted home. First one bird, then another, sings his cheery song, and we wonder that our presence is not an intrusion. Leading us unto this beautiful spot, we soon find that the birds have seemed to escape by the back trail, for now the distant note seems still to say, "Be-with-you—be-with-you—be-with-you!" But the birds have played their parts of ventriloquists so well that they have had time to disappear altogether.

As late as 7.20 P.M., one evening, I heard the Maryland yellow-throat singing beside the country road. At the same time the chimney-swift was also seen flitting high in space. The voices of the birds were quieting down before the advent of night, but still I could hear the mournful coo of the dove. These notes in the quiet of the evening, when the afterglow is lighting the landscape, are most enjoyable. A robin seems to want his voice heard, and stationed on a fence post he gives out a varied song as late as half-past seven. Even the barn swallow is making his last rapid flight through space. Then, finally, the Maryland yellow-throat comes forth again with the last song of the parting day, mounts into the air almost perpendicularly for about a hundred feet, then as suddenly drops toward the earth. As he takes his farewell evening flight, he has not lost the opportunity to assert his last cheery song, "Be-with-you — be-with-you — be-with-you!" [1]

[1] In the illustration I have figured a pair of Maryland yellow-throats with a nest, which I found at Riverdale, Illinois, on July 17, 1889. It was built at the border of the Calumet River, in tall grasses a foot from the ground. Three young birds just hatched and one egg were the contents of the nest at the time I found it.

The Morning Troubadour

STROLLING along the country road about seven o'clock one July morning, I was held spellbound by some bird music which seemed to come from several directions at the same time. Beside the road on one side was a grove of high trees; on the other, an apple orchard. The music did not seem to come from either side. Finally I perceived the author of the pretty strains almost overhead, circling far above, with quivering wings, seeming to mount higher and higher with each musical inspiration. In that lofty altitude, free from the cares of the world, the varied song seemed to indicate a jovial outpouring of sentiment rare even among the feathered ones.

After I had peered aloft at this master of exquisite song for several moments, I discovered, as the bird descended in looping flights, that it was a goldfinch. I had seen birds of this species nesting some distance away, but I little suspected that the male took singing tours and went so far away from his loved ones at home, even to make a temporary circuit above the woods and orchards. It is worth a whole day's travel to hear and view the goldfinch in one of these wild aerial manœuvres, and catch the echoing strains which may be more or less modulated by the currents of air. I have read the poet's tributes to the skylark, and have seen the beautiful painting, "The Song of the Lark," by Jules Breton, but to come really in touch with one of the loveliest sentiments in nature, one must seek out our native troubadour when he is scaling the heights of heaven.

While most birds have departed, or are making serious preparations for fall migration, the goldfinch is still attending to housekeeping. I recall having seen one of these birds nesting as late as the middle of September. It was on the tenth of the month that I made the first discovery of this nest, and as I approached the nesting site, the mother bird flew to a dead branch of an oak tree near at hand and watched me attentively, incessantly changing her attitude. In the course of five minutes she flew away, keeping rather low to the ground, and giving out her characteristic call notes while flying. Here she joined company with her mate, who was perched on the

The Goldfinch giving forth his morning song.

top of a thistle at the border of the woods. This was my opportunity to examine the nest more closely. Their nest was located about four and a half feet from the ground in a small burr-oak tree, about six feet tall, growing in a slightly elevated portion of a field. The tree referred to was provided with dense foliage. The nest was placed in the depression formed by a three-branched crotch, surrounded with many leaves. In these surroundings the nest was perfectly secreted.

It was a neat, compact structure, composed of dried weed fibres on the outside, and lined in the interior with soft whitish plant down. In this beautifully protected bed, I found, on this first inspection, three bluish white eggs. I had tarried some ten minutes, and when I had gone about a hundred feet the mother bird came back, bringing her golden mate with her. They both alighted in the small tree containing the nest, as I have endeavored to portray in the initial illustration, and after considerable conversation between them they quieted down and took up the duties of housekeeping again.

In the course of twelve days I again visited the goldfinch's nest. A hot, withering September wind from the southwest was blowing at the time, following upon a cool period. This brought back to activity the life in the meadows, which were richly covered with the flowers of aster and goldenrod. At this time I again found the female goldfinch on her nest. Her greenish coloring harmonized with the surroundings so well that I could hardly see her, but she eyed me with suspicion. Her head was partly in shadow above, adding to the deception, and the recess in which she was enclosed by leaves afforded an ideal home. After a few moments of tolerance she flew off the nest from the opposite side, and alighting on another low tree she chirped in a distressed way as she watched me.

On this second inspection the nest contained three very small pinkish red young, which evidently had been hatched but a short time. One of the eggs still remained unhatched. The young lay flat on their sides, appearing motionless at first, but in a moment or two they stretched out their little ungainly heads, lifting them up with unsteady effort, as if desiring food. I then left them, realizing the possible distress occasioned the mother by my presence. She must have sat very closely on her eggs, for during the long interval since I had last visited the nest there were a number of cold and rainy days, the temperature one night having fallen so low as to produce slight frost. On the afternoon of the twenty-third, while in this meadow in the vicinity of the nest, the wind suddenly changed around to the north, blowing very strongly, and during this gale I visited the goldfinch's nest. I found the mother bird faithfully sitting, while the small tree bearing her home was rudely shaken by the blasts of the winds. At times it seemed as though the nest would be destroyed, but she stuck to her task of covering and protecting her little ones. Here, indeed, the compact nest with its downy lining proved of great utility in protecting the young. I did not, on this occasion, frighten her from her home.

It was four days later when my final visit was made to the goldfinch's nest. True to her instincts, she was harboring her young, and after she had viewed me several minutes, she took to her wings. On inspection of the nest's interior, four young birds squirmed about, and soon raised their little awkward heads, widely opening their vivid crimson mouths, presenting a curious sight and reminding me of the mouths of certain snakes. Is this color for protection? The unhatched egg, previously mentioned in my last visit, was now hatched, the young forming the fourth I was viewing. With this parting glance I left the home of the goldfinch family, thoroughly convinced that these birds have such human attributes as loving disposition and faithfulness.

Birds and Blue Racers

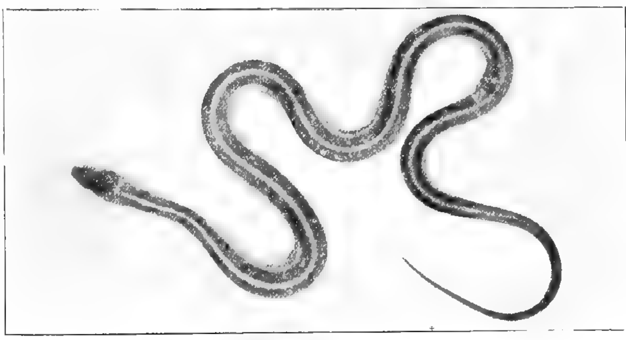
BY an early hour one morning in July, I observed a number of birds gathered on a barb-wire fence at the side of the road. There were five of these songsters grouped between the posts, somewhat as follows: a brown thrasher about midway on the top wire, a male orchard oriole and chipping sparrow on the second, while on the third wire nearest the ground sat two excited catbirds. From the clucking sounds of the catbirds and intense stare into the long grass on the opposite side of the fence, I surmised at once the object of this curious congregation of birds. Every action evidenced an excited interest in some object located in the grass. As I walked quite near, the brown thrasher flew away, soon followed by the oriole and chipping sparrow. Finally, but reluctantly, the catbirds departed into the orchard nearby, giving me an opportunity to make an investigation. On the grassy ground I found a full-grown blue racer in the attitude I have drawn him in the illustration. He had been the cause of all the commotion among the birds. There was plainly a community of interest exhibited here against a common enemy. It is interesting to note that the brown thrasher had not been seen thereabouts before, though I had taken careful observations of birds, covering a period of three weeks, in the neighborhood. Only such an exciting event as that above related brought him into the foreground.

The blue racer allowed me to approach quite near, scarcely displaying the slightest alarm at my presence. In trying to catch him he dodged repeatedly, making several gymnastic turns as he went between my legs. Finally he glided off gracefully into some dense vines of bittersweet. It is almost needless to state that this species is a harmless snake to man. Old individuals can outrun an ordinary man for a short distance. I once observed a large blue racer at Dune Park, Indiana, which was sinuously stealing its way near a fledgling song sparrow in some low bushes. As I came near the scene of action, the bird was found so paralyzed by fright that it was "glued" to the branch on which it was perched. The snake had its head elevated about eight inches above the ground and was within striking distance of the bird when I discovered the latter's predicament and came to its rescue.

Here again the snake was so intently preoccupied that it was but little frightened at my approach and lingered thereabouts for some time after I had removed the bird to a place of safety. I have never seen the blue racer actually devour a bird, but I have seen young snakes catch frogs. On one occasion when coming along a main wagon road [1] I saw ahead of me a frog jumping rapidly across the road, raising the dust as it went. Closely pursuing it was a half-grown blue racer, which seized it in its jaws just as the frog had reached the other side of the roadway. Then, getting a second hold on its prey, the snake, raising its victim about six inches from the ground, started back across the road, finally seeking the cover of the herbage.

[1] Millers, Indiana, September 21, 1905.

The instinctive dread and curiosity displayed by birds toward snakes is very deeply rooted, and it is even shown in our domestic chickens, some of which rarely or never see snakes. One day I saw some half-grown fowls in our yard gathered together in a comical semicircle with their necks craned, staring intently at some object on the ground. When I went to inquire as to the cause of their curious attitudes, I found them viewing a moderate sized garter snake which was coiled up in the grass, apparently more frightened than the chickens. After this experience I could always tell when a snake had been discovered by the chickens, as a silent conference by them always took place at the sight of a snake. That this apparent hatred for snakes is not confined to birds, but extends to the human species as well, was shown when I caught the innocent garter snake above referred to. Two persons who were standing by demanded that it be killed at once, without a thought of its possible usefulness on the grounds. It is needless to say



that I let it have its liberty. I have given a picture of this much maligned but innocent snake, that a better acquaintance with it may be had by the reader. The birds may have at times a real grievance against the blue racer, but it, too, is a harmless species, and is very useful to the farmer because it is destructive to mice and other rodents. I trust that with a more intimate knowledge of all our common snakes the deeply rooted superstition which seems to be almost general among human beings will be largely dispelled. Harmless snakes generally seem to be as much despised as the birds are loved, even in this day of enlightenment.

THE PHŒBE'S BIOGRAPHY

IN June, 1906, I found a phœbe had made her nest on a beam of a shaded porch of an unoccupied cottage near our quarters. The mother bird had laid two eggs by June fifteenth, and all was contentment until two human occupants came to the dwelling referred to. From now on the birds had a serious time, as they were kept in constant anxiety. But in spite of this the mother bird laid a third egg later. I viewed the nest cautiously in an opportune moment, by means of a small hand mirror held above the nest. A day or two later the persons living in the cottage fired a gun from the porch, which was more than the phœbes could stand. On June twentieth they gave up visiting the nest, and one morning it was completely demolished, together with its eggs, supposedly by a red squirrel.

Our cottage was about thirty yards distant from where the phœbes had their first nest, and it was provided with a porch in front. One morning I was pleased at finding the same female phœbe carrying building material in her mouth and depositing it on the beam under the porch roof almost in front of our door. The nest was worked upon day after day until completed. By July seventh she had laid three eggs and this was the full complement. The interval between the laying of eggs and the hatching, which occurred on July twenty-third, was another restless siege for the birds. Notwithstanding we were very careful not to disturb our little feathered family, the opening and closing of the doors of the cottage, which was only about six feet away, were a constant annoyance to her.

Whenever she was sitting on her eggs and some one entered or came out, she would fly away for a short time and show great nervousness. These manœuvres were kept up so frequently that I wondered if she could possibly succeed in hatching her eggs. During the night hours, from 6.30 to about 5 A.M. she was able to sit continuously on her nest. After night was fully established, she could not be induced to leave it, though she was ever so timid in the daytime.

The three young phœbes required an immense amount of food, both parents being kept busy foraging for insects. The latter consisted of almost every kind the parents could catch. One day I found a small gray robber-fly, which was dropped by one of the parents, below the nest on the porch. The insect's head was missing, so I kept watch to see if the birds always practised decapitation before feeding them to the young. A short time afterward I found a nearly full-grown but mutilated mole cricket, which was inadvertently dropped by one of the phœbes. It proved on inspection also to be without a head. This was all the evidence I gathered on this point, but I think, perhaps, it may be a common practice with phœbe to decapitate her captive insects.

It was interesting to note the instinctive dread exhibited by the young towards a person's hand. When the ground was jarred, or at the sound of a slamming door, they would open their mouths quite freely, as when the parent birds came to the nest, but when one of us put our hands near the young they shrank back into the nest with abject fear and silence, at the same instant almost closing their eyes.

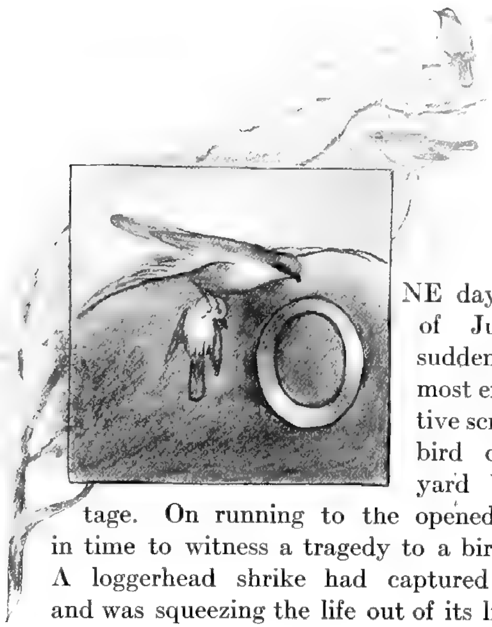
One of the young which I took out of the nest was at first quite reluctant about feeding. After twenty-four hours, however, it took insects from the tips of forceps or from my fingers. The nest is kept clean by the mother bird, the excrement being taken in her bill at the moment it is expelled and carried some distance away and dropped. The droppings of the little birds reflexly pass out the instant it swallows its food, so the parent can attend to it immediately.

The young bird which I took from the nest was afterwards restored to it, and on August seventh all three of the young left their nest simultaneously when I was making an inspection.

Two of the birds flew off slantingly to the ground, while a third flew to the branches of a walnut tree about forty feet away. They used their wings surprisingly well, considering the little exercise they had had. The latter consisted in occasional wanderings along the beam a foot or two from the nest, and these ventures occurred only two or three days before the final flight.

These little birds were pressed to leave their nest also by the parasites infesting them. These mite pests were so numerous that once when I removed one of the young birds for examination my hands and shirt were covered with mites. They were gotten rid of only by strenuous brushing with a broom. When they get on the human skin they give rise to a distinct irritation. It is, in fact, remarkable that the young birds can tolerate such hordes of mites infesting their bodies. On placing one of the young birds on a smooth table, the mites fairly swarmed off its body on to the varnished flat surface, where they were easily observed. This little bird that I took indoors became very tame and learned to alight on my fingers for food. It ate small grasshoppers, after they were first killed and stripped of their legs and wings. This diet, when crushed and mixed with mocking-bird food, became the staple article of nourishment, but the bird occasionally ate young, green walking-sticks and small, smooth caterpillars and moths that I captured for it. The bird had no trouble in swallowing these tit-bits. On feeding the phœbe a full-grown walking-stick in two pieces, it soon disgorged it. Evidently the walking-stick presents some unpalatable features to young birds, or perhaps its lengthened body was a mechanical impediment to digestion. I kept the tamed phœbe until the fifteenth of September, when it was allowed to join the migrating throng.

THE DEATH OF THE YELLOW WARBLER



ONE day in the early part of June, I was very suddenly startled by the most extraordinary plaintive screams of some little bird coming from the yard back of our cottage. On running to the opened door, I was just in time to witness a tragedy to a bird on a brush pile. A loggerhead shrike had captured a yellow warbler and was squeezing the life out of its little body. When the shrike saw me it flew away with its victim in its feet to another brush pile in the shade of the peach orchard fifty yards away. It had hardly alighted when a stick which I had thrown in an attempt to rescue the warbler struck dangerously near the shrike's body. This act of mine so startled the loggerhead that, in his haste to depart, the yellow warbler was left behind hanging in a mat of branches. A hasty examination of the little victim showed that it was almost dead, and a moment more a slight quiver evidenced the last life struggle.

The shrike was one of a pair that were nesting in the vicinity; while the yellow warbler that was killed was a bright-plumaged male, also one of a pair that had established their home nearby and made frequent visits to the apple trees about our dwelling. The shrikes stayed about all the remainder of the summer, but I rarely afterwards saw them attempting to destroy birds. At another time, however, one of these birds came near a Baltimore oriole's nest in a young maple tree. It was the signal for a general uprising among the bird colony. The male oriole flew at the shrike with great vengeance, in defence of his young, and the two locked in a fierce battle. Finally the oriole, which was seemingly getting the worst of the fight, attracted his mate by his screams and with her aid the shrike was soon forced to retreat. In the meantime, some catbirds and robins had heard the commotion and they joined in with their scolding cries.

The shrikes often appeared on the apple trees, perching on the topmost branches, where they could look off into the open distance. From these perches they would fly down to the ground to catch insects. Their presence was generally sufficient cause for the robin to set up a cry, which in turn aroused the orioles to action.

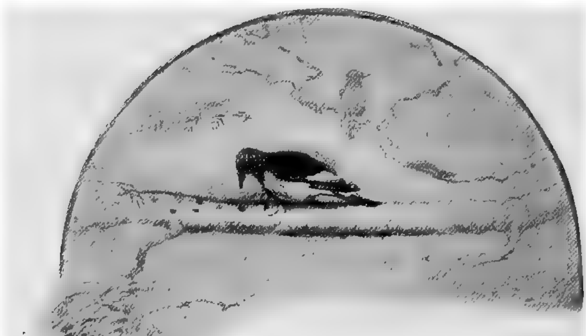
The Red Squirrel's Frolics

THE artist who thinks he can stroll in the woods with a view to depicting nature without eye witnesses, often deceives himself. To be sure he may be free from human critics, but the squirrels are sure to discover the loiterer, especially if he sits down beneath some forest trees where the bushy-tailed inhabitants abound. At least this was my experience not long since when attempting to sketch an interior view of an inviting piece of woodland. With paper in hand I had fairly got seated when a perfect storm of protest was expressed by the red squirrels. Barking, whistling, and drumming, they pursued me. Down the trunk of a tall beech one came, then, sounding his roll call, he awakened his companions to action. He then frolicked along a branch to make nearer inspection and greater demands. There he paused, looking down constantly and staring me out of countenance. But even then he was not satisfied with his vantage-ground and ran along the branches, now and then almost sailing, until he secured a lower position directly over my head.

If one were to doubt this little tyrant's motive, the question would soon be settled, for he sent down a tantalizing rain of bits of beech nuts, shells, and meats, all of which fell upon my drawing paper. After satisfying his squirrelship that he could not dislodge me, he came still nearer, running out about four feet from the main trunk onto another larger branch. Here he repeatedly peeked and squeaked, until he suddenly became alarmed by an unexpected arrival. A loud *c-a-w* from a crow a short distance away was the signal for his departure to the upper loft, where he scampered into an opening in the bark ready to receive him. Upon reflection, what a curious performer is the red squirrel! His first squeak sent the tail back; the second sent it forward, and with each sound he jerks his tail with a rhythmic exactness of motion that is not only highly ludicrous but is also expressive of every emotion.

In this manner of addressing, he is at his best when trying to impress upon the stranger that trespassing by human beings is not desirable within his domain. I have mentioned, in the chapter on the Birds' Assemblage Grounds, the red squirrel's taste for mulberries. He is equally fond of walnuts, butternuts, and beechnuts, but his diet is by no means confined to this limited bill of fare, as may be gleaned from a visit to the apple orchard. Here several times on the threshold of the orchard I had observed an unusual number of large sweet apples on the ground under a particularly fine tree. I had supposed at first glance that they were windfalls, and paid but passing attention to them. But one morning a number of apples, which seemed to be without a blemish, lay conspicuously in my path and called for an explanation. Why should these luscious specimens fall when practically no wind had been blowing? Furthermore, there was not the slightest trace about the body or stem of the fruit to indicate insect attacks. Here was a subject for investigation, but it escaped attention until a day or two following, when in the forenoon I again visited the place to find an unexpected answer to my inquiry.

A young squirrel was found up in the tree at the end of a bough with a large apple tightly grasped in his forepaws. He was eating the fruit with great relish when suddenly, through a momentary relaxation of his paws, it dropped to the ground. With a look of mixed disappointment and surprise, he peeked over the side of the branch and watched its descent to the ground. Then, jumping to a higher bough, he sought another apple, but it also fell almost as soon as it was touched. Retiring to another limb and seeming to think the matter over, he climbed to a point where he could seize a third apple. Taking a good hold with his mouth he quickly pulled it off and carried it along the limb to a crotch which formed a little platform. Here he quietly finished the remainder of his meal. I waited until he had dropped the half-eaten apple and scampered away to a neighboring tree, where he entered a hole leading into the vacated nest of a bluebird.



Some Visitors to the Walnut Tree

THERE was a half-dead walnut tree standing alone near our home where many birds congregated during the summer. In July I often saw nut-hatches, downy, hairy, and red-headed woodpeckers, who made frequent excursions on the bark. The latter species was especially delighted after discovering some corn which I threw into a cavernous opening low down in the trunk of a tree. The corn was thrust into the hole more with a view to feeding and taming some young red squirrels that played about the grounds, than to feed the birds. It was something of a surprise one day when I found the red-headed woodpecker a more persistent visitor to the hole in the tree than the chickarees.[1] I not only learned by this that yellow field corn was a choice diet for these woodpeckers, but I also acquired a knowledge of its feeding habits, that gave me much pleasure to observe.

On a large, outstretched, dead branch free from bark, near the top of the tree, the woodpeckers found a suitable spot to rest. Here the parent birds came to feed two almost fully grown young in July. As I remember the young, they differed from the parents principally in that their heads were dark instead of red, and were thus easily distinguished. One of the parent birds would fly down to the hole, step inside, and seize a kernel of corn in its bill, then, flying to the dead branch, as I have depicted in the illustration on the foregoing page, it placed the kernel in a little hollow pit. Then the bird would drive the corn into the bottom with several determined strokes of its bill. There were several of these pits which the birds used as mortars. The corn, on being placed in the bottom of them, was then cracked into bits with the chisel-like tip of the bird's beak. Then, removing the pieces they had thus made, piecemeal, they were fed one fragment at a time into the opened mouths of the young, who had, in the meantime, expectantly awaited the parent's action. These young birds would always stand by watching their parents during the process of breaking the corn within the pits, and they often fought each other for positions of advantage.

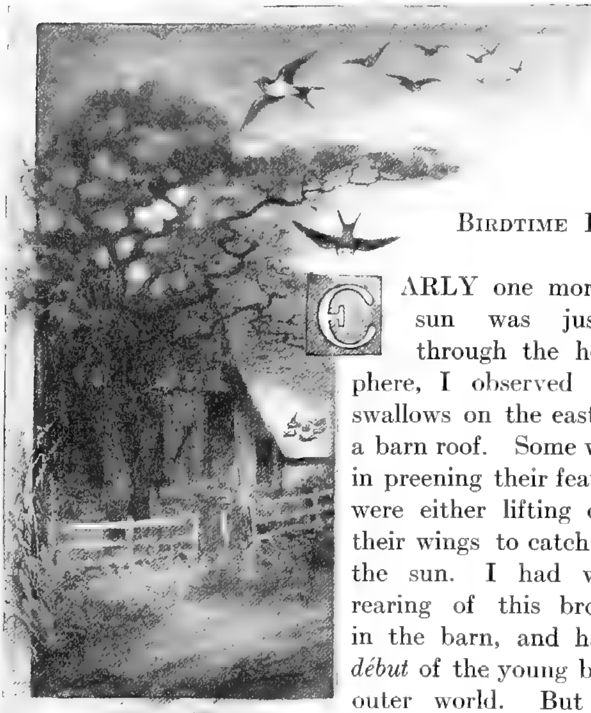
It is not sure that the mortars referred to were made especially for the purpose of cracking the corn. In fact, one might be inclined to the theory that possibly these pits were originally produced during the habit of rapping, or in the attempt to make the well-known drumming sound of the males. The holes were mostly placed on the upper side of this particular branch, where I had often seen the male rapping loudly on the limb. That the young birds soon learned to use these pits was evident later, and at the same time they gave a display of the agile manner with which the young redhead can snap up insects on the wing.

[1] A name commonly applied to the red squirrel.

I had an oblong-wing katydid which I kept indoors for a number of days to study. Finally, it was thought best to liberate it, so, stepping to the door, I tossed it aloft in the open air. The katydid flew off some yards, when, hardly before I could realize what had happened, a young redhead swooped down on the katydid, seizing it while on the wing, and carried it to the dead limb of the walnut tree. Here the bird placed it in one of the pits in the same manner as I had seen the old birds treat the corn. Soon the katydid was reduced to tit-bits. These the bird then devoured while its hungry companion looked on enviously.

The red-headed woodpeckers and chickarees were not the only visitors to the corn, for I frequently saw the chipmunk race over the intervening grassy ground which separated the bush-covered lakeshore bluff from the tree. Quicker than I can describe it he made his way up the trunk and disappeared within the hole. Later I saw his little head at the opening, with his cheeks suspiciously protruding as though afflicted with the mumps. As everything seemed quiet to him, he dropped back again within the darkened chamber. Whether from curiosity or not, I do not know, but no sooner had the chipmunk gone inside than a bluebird suddenly halted her flight in mid-air before the hole, and, making a hasty inspection, immediately flew away again. Several moments afterwards the chipmunk appeared again at the entrance with his cheek pouches charged to the utmost. He wasted no time in descending the trunk and soon scampered over the intervening space to the bank, finally seeking shelter in the underbrush. Some smaller dead limbs of the walnut tree were occupied almost constantly by phœbes which had their nest on the protected beam under our front porch. Were I to mention all the birds that I have seen in this walnut tree during the summer, nearly all the smaller singing birds resident in the locality would be included in the enumeration.

On August thirteenth, just before sunset, when the golden rays lighted up the tree tops, and here and there the streamers found their way through the foliage and fell upon the trunks, I saw in the blue canopy of sky above, phœbes and kingbirds playing, and chasing many little insects in mid-air. An unusual flight of small neuropterous insects furnished abundant food for the birds. On the walnut tree the dead branches served as perching spots for the birds, and the old birds were ever on the watch. The phœbes would rapidly fly into the air, then abruptly slow their flight while seizing the insects that were now becoming almost invisible to one's eyes. As they came back, the greedy young were awaiting their supper. In one of the sudden aerial turns in the air, a kingbird startled a downy woodpecker which had gone out foraging on a horizontal limb of the walnut tree, and he suddenly dived to the underside, keeping his eye carefully on the kingbird, which, of course, did not harm him. This was a busy hour for bird life; every second counted, for the sun was fast going down behind the distant horizon over the lake, and many little bird stomachs must be filled to last over night. With scarcely a moment's rest the parent birds worked until finally they all quieted down to sleep. Then from the edge of the woods came the parting call, *pee-wee,* and the walnut tree visitors departed for the night.



Birdtime Reflections

EARLY one morning, as the sun was just breaking through the heavy atmosphere, I observed a family of swallows on the eastern slope of a barn roof. Some were engaged in preening their feathers; others were either lifting or spreading their wings to catch the rays of the sun. I had watched the rearing of this brood of birds in the barn, and had seen the *début* of the young birds into the outer world. But now I was treated to a most unexpected surprise. As I stood viewing the birds from the roadside, the male head of the family poured out his musical subdued warble. This song was repeated at frequent intervals, nearly always ending in a pleasing low chatter. During these expressions of sweet cadences all the other birds seemed to enjoy the music. I have always cherished the memory of that morning's observations, for it was my first experience hearing the barn swallow's song. Before this time I had never considered this bird in the light of a songster.

The Baltimore orioles are not often seen in July; having reared their brood earlier in the season, they now keep slyly hidden in the shadow of the foliage of the trees. A beautiful example of one of their nests hung pendent from one of the upper branches of a tall pear tree. On August sixth I had about decided to cut off for preservation the branch bearing the oriole's nest. To sever the limb I had devised a wooden pole with a small hand scroll saw fastened to the end. When about to start the sawing, I noticed a house wren fly to the opening of the nest, carrying some moths in her bill. A moment later she disappeared within the nest, where she undoubtedly emptied the tit-bits into some little upturned mouths, for she soon emerged with no trace of the moths in her mouth. I saw both parents repeat these visits several times and I became satisfied that the wrens had adopted the oriole's nest as their own home. In another chapter, entitled "An August Hailstorm and Its Sequence," I have given a further account of these birds.

A nest of the mourning dove, which had seemingly been entirely vacated by the owners, was singled out to be taken for a friend who had a hobby for nest collecting, but through a change of plan the empty nest, which was built in an apple tree, was left unmolested. Later, while incidentally making observations, the mother was found to have again returned to the nest and had laid two eggs. What a lesson is taught here! It is from such facts as these that I have learned never to appropriate seemingly abandoned nests when they could possibly be used again by their owner or by some other bird or mammal as a home.

As I visit the nesting birds the time seems to fly only too swiftly. A day or two ago I observed eggs in the nests of the catbird, song sparrow, and indigo bird. Now I view the curious little worm-like new-born young instead of the eggs in the nests. How rapidly they lose their downy coats! In another few days the little wings will be arrayed with quills, and before one realizes it the birds will be nearly ready to fly, or perhaps they will have gone from their nests before our next belated visit to their homes.

Many birds are exceedingly sensitive to any human intrusion, as I found to my sorrow one day. A pair of field sparrows had built a nest in a bush along a fence row. Almost immediately after the nest was completed, a cowbird deposited one of her eggs in it. I left this egg and watched developments. The field sparrow seemed to pay but little attention to this parasite's egg and went on laying her own full set of four. Now, with a view to giving the eggs the full benefit of the mother's care, I carefully removed the cowbird's egg. But shortly after, on her return, the keen-eyed mother discovered the change and after deliberation with her mate they flew away together, never to return to the nest.

A red-eyed vireo's nest which I found in the orchard attached to a branch of an apple tree is shown in the illustration. The birds left this nest on July twenty-fifth. What remembrances of summer it recalls! Now, as I look upon the treasure, it brings to mind the bird period full of cares, transformations,

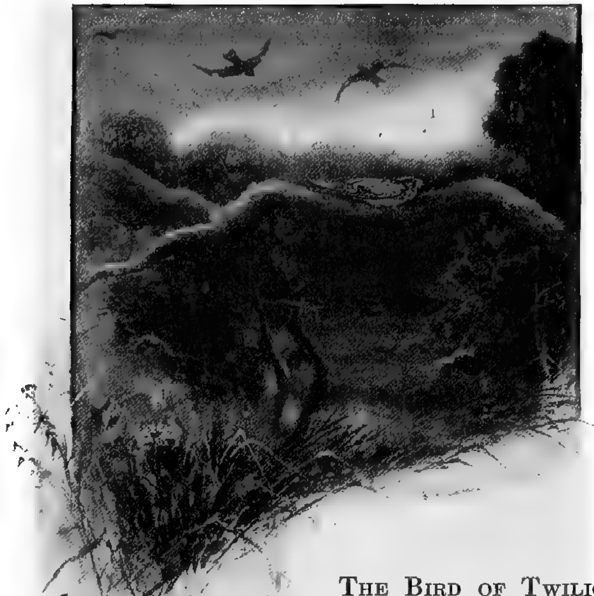
The nest of the Red-eyed Vireo, showing superb bird architecture.

perilous risks, and sweet songs, that join to form part of the bird's life. And tenderly do I cherish the recollection of the little red-eyed vireo's family in their orchard home.

During the cold Spring of 1907, the delayed appearance of the leaves caused many of the small birds to be unusually exposed to the attacks of hawks. An incident of this kind which I noticed comes vividly to mind. One morning I was commenting on a male brown thrasher, which was singing one of its glorious songs on a tree just opposite the doorway of our quarters, when suddenly its song ceased and instead a series of distressing screams rang out from the same direction. Not a moment did I lose in an effort to find out the cause. A sharp-shinned hawk was seen bearing the bird off slantingly into the country roadway. When I rushed up to rescue the songster, the hawk, which was now on the ground with its prey and about ready to despatch it, reluctantly released its hold and flew away. The brown thrasher, in the meantime, suddenly recovered itself and flew off to the lower limb of an apple tree, somewhat injured from the loss of feathers, but it finally recovered completely from what came near being a tragedy.

During this same spring many birds, for want of other foliaceous covering, built in evergreen trees, so that I often witnessed social groups made up of several different species of birds occupying the same tree. In some of these cedar trees I not infrequently found the catbird, robin, field sparrow, and mourning dove, each with its own nest, but enjoying each others' society in common; while, on the other hand, I found birds like the brown thrasher, which ordinarily build in bushes, nesting on the ground, one such nest being surrounded by some weeds on the back of our grounds. The mourning doves, which usually build in apple trees, were similarly inclined to nest on the ground, several being seen in such a situation.

The Red-eyed Vireo



The Bird of Twilight

WHO has not associated his boyhood days with the bird of twilight! Sailing here or abruptly tumbling in the air, the strange-winged form appears as a seeming spectre before our eyes. In the fall of the year we are forewarned of the first mysterious flight of the night hawk by the straggling advanced sentinel's rasping *ze-e-e-e-t*, as the sound comes in at the open window. The popular name of night hawk given to this twilight visitor is a misnomer. No bird with which we are familiar is farther removed from the hawk group. Then, too, the name bull-bat, which some of the Southern boys would have us call him, is fully as misleading. For the reasons I have stated I have christened him the bird of twilight.

On the long route of migration, insects are gracefully eaten in mid-air by this bird. They are swept into the cavernous bewhiskered mouth during the flight. Frequent stops by day are made in the open woods, but a practised eye is necessary to detect their resting spots. I recall, when once making an excursion into the woods, noticing what appeared to be an ordinary knot protruding slightly from the horizontal limb of an oak tree. It would have been passed by without another thought had not the knot suddenly evolved wings and taken a zig-zag flight through the open woods. The cause of my astonishment was soon explained when I saw it was a night hawk, for this bird rests with its body parallel to the top of the limb, unlike other birds. Moreover, his color matched the bark so well that it was next to impossible to distinguish him from some excrescence on the tree.

On the last day of August, 1902, at about five o'clock P.M., I noticed a flight of night hawks going south. From the porch of our home in Chicago I watched their flight as they came scattered along restlessly pursuing their way. The open view from where I stood would allow a vision of about a one-mile stretch, looking east. At 5.26 P.M. I took note with watch in hand and counted all the individual twilight birds that passed the line of vision. In four minutes one hundred had passed the line, the time then being five-thirty. In another three and a half minutes one hundred more passed; the time now being five thirty-three and a half. Still continuing counting, another hundred birds passed just at 5.37½ P.M., or in four minutes. If this was a fair computation, one thousand five hundred birds would pass in an hour. Allowing only six miles as the width of the city, nine thousand birds would pass over the line drawn across the city at a given point in an hour. As a matter of fact, the birds fly in scattered flocks over a large area, and while these flocks come periodically, lasting into the night, there are quiescent spells when almost no birds are seen in the sky for a space of a minute to several minutes at a time. A fair estimate would indicate that eighteen thousand birds pass over the city in a single night in this migration the last of August. The birds seemed much more plentiful fifteen years ago, when similar timing gave a larger percentage during these migrations.

The night hawk may be readily distinguished from its allied neighbor, the whip-poor-will, while on the wing, by the presence of a white spot conspicuously displayed on each wing. I remember one spring finding the nest of the whip-poor-will on the leaf-covered ground in a wet woods near Grand Crossing, Illinois. The bird, while setting on her eggs, was well protected by the beautiful mottled brown and gray markings on her back against the leafy background. As I approached nearer to the bird, she tried her utmost to decoy me away from the spot by feigning injury to her wing. The two eggs were quite inconspicuous also, being nearly white, marked by lilac tracings and brownish splashes, which helped them to blend with the surrounding. In contrast with the whip-poor-will, our other bird of twilight deposits her eggs in an open meadow or field.

The House Wren's nest in the woods, occupied by the White-footed Mouse.

A Tragedy in the Dunes

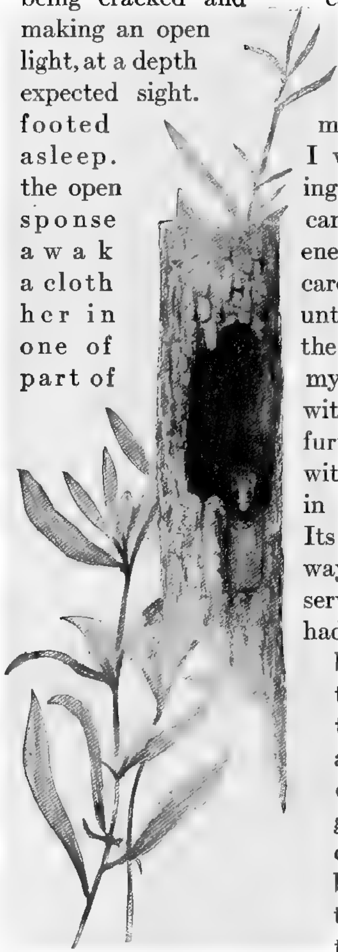
One forenoon in May I strolled to the top of a moderate sized sand ridge among the Indiana dunes, taking in the sights of nature about me. The sandy waste of ground supported a few pines and a rather thick growth of small black oak, which, under the warmth of the spring weather, were just leafing out in a blaze of red. The birds were abundant and active after a period of slow migration. Among these arrivals my attention was particularly drawn to a house wren, by his gushing, overflowing song. At first he was detected among the top branches of an oak tree, restlessly moving from one place to another. Then he suddenly took a longer flight to a tree at the base of the sloping dune, flitted about nervously, and passed from one twig to another in a downward course, gradually approaching the ground. These actions, perhaps, would not be worthy of record had they not in the end led up to an unexpected sequence.

The wren, after reaching the ground, occasionally repeated his beautiful song. Then I noticed him pick up a small piece of twig in his bill, but seemingly in a doubtful mood, for he soon dropped it. The next instant he again picked up another twig, treating it in the same manner as the preceding. During the next few moments he spent his time among the branches in a certain dead tree having a hole in the trunk, which I will have occasion to refer to again. Finally he flew away through the woods, disappearing entirely from view.

I had now turned my attention to the flora covering the sand all about. Here were the new shoots of the oak, with their pretty magenta-colored leaves; the false solomon's seal, the thickly clustered blossoms of the blueberries, the little white four-petalled blossoms of *Arabis lyrata*, the æsthetic and biological features of which are treated in a further chapter on "An Illusive Butterfly and its Flower Protector." An hour, perhaps, had been spent in this immediate neighborhood, when suddenly a wren appeared which seemed to be unmistakably the same one I have mentioned. It alighted on the same dead oak tree. Moreover, he again flew to the ground and feigned picking up sticks, at the same time pouring forth his interludes of song. On going closer I saw him flitting back and forth before the hole leading into the hollow tree and situated four feet from the ground. As I approached nearer, he again would sing, drop to the ground, pretending to pick up small twigs, then finally flit away from the scene.

The construction one should place on these manœuvres was very puzzling. Naturally, the first thought was that the bird had a nest in the hollow tree, but why did he always drop the twigs, and never attempt to carry them to the opening. Investigation was the only hope of satisfying my mind. On looking into the dark hole of the tree, I could not discover anything.

Examining the bark, I found the tree a mere shell, the bark being cracked and easily removed with my fingers. On making an opening sufficiently large to admit the light, at a depth of six inches there appeared an unexpected sight. There lay a fat-looking, white-footed mouse, curled up and apparently fast asleep. I ventured putting my fingers into the opening and touched the mouse. No response came from her at first, but she soon awakened from her slumbers. I then stuffed a cloth carefully in the opening and held her in until I finally persuaded her to enter one of the small round cages which formed a part of my field equipment. Placing the cage with its treasure within my satchel for further study, I next examined the nest with care. To my surprise, I found in the bottom a dead house wren. Its body was curled around in such a way that it lay perfectly flat and served as a bed upon which the mouse had rested. On removing the bird's body to the light, it was found that nearly half of the skull was detached and completely cleaned of all flesh. There were incriminating evidences of mice teeth having gnawed the bones of the skull. No other part of the bird's anatomy had been eaten, and the flesh was so fresh that it had not yet undergone putrefaction. Not until the night of the same day was there indication of this change. The idea gained from these facts was that the bird had been killed quite recently. Underneath the bird's body and occupying the bottom layer, a number of coarse, short twigs had been deposited by the bird, which were doubtless only the beginning of her nest.



The White-Footed Mouse in the Wren's nest as she appeared after removing the bark.

Now let us go back to the male wren's performances and the full realization of the meaning of his actions will be at once understood. Here, indeed, I had witnessed a pathetic state of affairs. He probably had been thrown into a condition of dismay by his mate's absence, but did he know the cause of her disappearance? He must have seen the mouse in his home and must have had a suspicion of what had happened. He appealed to her with his song, coming near the doorway of the little house where he had last seen her enter. Then again he brought such means to his aid as would attract her attention, but alas, without avail. In a few minutes the male again made his appearance. This time he made a short stay in the old locality, surveying it hurriedly. I next saw him flying to a distant tree. Without ado, he started in most industriously to pick out the decayed pulp at the top of a broken-off tree. Did he do this from nervous excitement, or was he starting in housekeeping anew?

The narration of these observations would not be complete unless I mentioned that the white-footed mouse was observed in her roomy cage the next morning lapping a little red object. Close examination revealed the fact that it was a new-born baby mouse. The mother tried soon afterwards to hide it under her body in an attempt to conceal it from my scrutiny. But I relieved her anxiety at once by supplying some wool, which she quickly used in making a cozy nest. Afterwards, in succession, one hour apart, six young mice were born. Many hours afterwards were spent in observing the attentive mother rear her pretty little family. The final question may be raised: Did the mouse accidentally stray into the wren's nest to give birth to her coming progeny? Or, are we to interpret the tragedy in the wren household to the wilful plot of the mouse to attack and eat the wren? The most we can do is to give the facts for the kindly consideration of our readers.[1]

[1] Since these lines were in type I am informed by C. F. Castle that he had two wren boxes on his premises having holes only three-quarters of an inch in diameter or just large enough for the wrens to enter. Two pairs of wrens established their homes in these boxes, but both pairs soon afterwards suddenly disappeared. On investigation of the interior of the boxes he found in one the nest of a white-footed mouse, in the other the remains of a dead wren, showing unmistakable evidence that the wren had been killed by one of these mice, probably at night.

Strange Mishaps to Birds

IF all the various mishaps that befall birds during their life struggles were recorded, what a collection of tragical incidents such a voluminous record would contain! One day in July, I discovered a beautiful nest of the Baltimore oriole swaying in the air from one of the terminal branches of a large beech tree. The family of orioles occupying it had left some time before. For a week afterwards I passed the locality of the nest without observing anything unusual about it. Of course there was no expectation of seeing the artisans that had built the superb architectural structure, for orioles usually leave their nests in June in this latitude, being much earlier than most birds. Later, while on a strolling tour of inspection one morning, after a strong northeast wind, accompanied with rain, a dark object was seen hanging suspended below the oriole's nest, dangling by a thread. At the first glance I surmised that it was a dead leaf, but after again noticing the object I concluded that it was a dead bird which had been entrapped by a string composing the nest. I set out to investigate the matter more fully, despite the height of the nest, which was about twenty-five feet above the ground. To carry out my project I used a long pole, at the end of which was fastened a pocket knife securely tied with wire, leaving the blade open at an angle of thirty degrees. With this improvised implement I managed to cut off the branch bearing the nest. In the photographic illustration, I have shown the nest and the weather-beaten mummy of a young oriole just as they appeared. The latter was evidently nearly full fledged at the time of its death. There was every evidence to show that the bird had met death by being caught by a thread from its own cradle. The feet of the little victim were tied as tightly together as though it had been done by human hands.

The fate of a young Baltimore Oriole hung by a thread of the nest.

The body originally hung head downwards and the accidental resemblance it bore to a leaf at so great a height was increased by the attitude of the wings, which had become mummified in an outstretched position. Many twists, perhaps aided by the wind, occurred in the thread that held the bird a prisoner. On the other hand the entanglement suggested how the young victim had struggled during life to release itself.

Were I to propose an explanation of the tragedy, the inference drawn is that on the advent of the young getting its feathers the inspiration to leave seized the bird, and it attempted to crawl up the inside of the nest to the opening. Young orioles are possessed of good climbing powers. After reaching this point its feet probably got caught in one of the many loops of soft silky strings of which the nest was constructed. Then getting out on the edge of the cradle, carrying the thread along and feeling its feet entangled, it attempted to extricate itself by jumping and fluttering, thereby hopelessly hanging itself. The bird's continued struggle under these peculiar conditions must have favored the twisting and tightening of the string about both legs. One side of the loop being weaker had broken away, leaving the other end fastened securely to the nest. The photographic illustration conveys a better conception of this tragedy of bird life than a word description.

The nest was a typical one, made of a multitude of exquisitely woven, light, flossy fibres, derived from the bittersweet. It was lined inside with a few rootlets and black horse hairs. After the bittersweet dies, the exposed bark peels away easily into thin, thread-like strands. By the second year the birds find the weather-beaten strings of this vine very well adapted for nesting material, though occasionally one may act as a snare, causing the death of one of the precious progeny.

Bowdish has recorded in "Bird Lore" a somewhat similar accident to a Baltimore oriole. He found a nearly completed nest from which hung the dead body of the female bird. A horse hair used in the construction had become twisted about the neck and she had been strangled to death.

In the Fall of 1906, I found a burdock plant which had captured the golden-crowned kinglet, shown in the plate photographic illustration. I found these specimens at the border of an open field along the roadside in Chicago. The mummified bird showed evident signs of having been exposed to the action of the weather some time before I found it. Numerous feathers

A Golden-crowned Kinglet captured and killed by the burrs of a burdock. Found at the border of an open field.

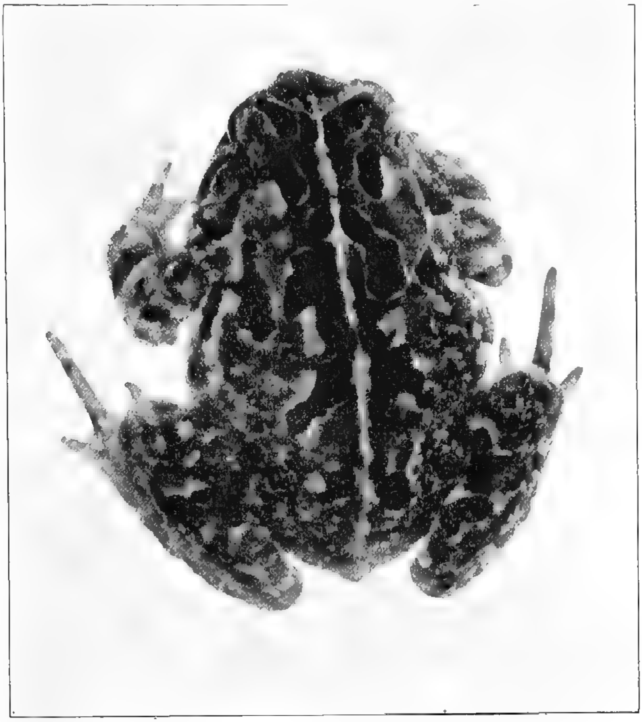
were entangled in the upper cluster of burrs, showing that possibly in the first struggle of the bird for its liberty it suffered severe contact there, stripping off many of its feathers. It finally fell victim to the lower bunch of the inextricable hooks and perished from fright and starvation.

Goldfinches not infrequently fall victims to the burdock traps. Mr. Bowdish, in the article before cited, mentions that young barn swallows not infrequently become entangled in the horse hairs of the nest lining and break a leg or are choked to death. Doubtless some of our readers will be able to recall mishaps to birds from their personal experience, for there must be many of such happening in nature.

The Toad's Social Life

ROASTED insect morsels are not often to be had, and whether thoroughly cooked, or not, seem equally satisfactory to the toad's palate. A number of toads made regular night visits to the base of a large beech tree under the bright gasolene flame used to illuminate the yard in front of a neighbor's farmhouse. Occasionally, moths and beetles came flying pell-mell into the flame, singeing their wings and precipitating them helplessly to the ground.

One night I saw one of these toads sitting motionless, with its head rather high, watching intently for the insects when they struck the ground. If some distance away from the fallen insect he made several hops and soon snapped up his prey with a precision of his tongue which was interesting to observe. The size of its intended victim seemed to offer no objection toward trying to swallow it. Once a large beetle, such as I have shown in the initial illustration, was thus seized and was of such a size that it stuck in Bufo's throat. Several attempts were made to swallow it and after going through some comical gestures of winking and blinking its eyes and pawing its mouth with its front feet, the object was finally swallowed. After the second night a number of other toads came to partici-



Fowler's Toad (Bufo fowleri). It is distinguished from the American toad by its silvery white iris and less conspicuous warts.

pate in the feast, so that for some time after, the night socials of these banqueters became a familiar feature of the place.

On July twelfth, after a rainstorm, I nearly stepped on a toad which made a sudden jump on the ground in the grass. Almost immediately afterwards a second one was seen. After some study I found that these individuals belonged to the species known as Fowler's toad. They were bright and vari-colored, the markings showing up well after their refreshing bath in the rain. The beautiful black dorsal spots were noticed to assume the form of three conspicuous pairs, while again they appeared so distorted and differently arranged in the second individual, as compared to that of the first, that the law of definite pattern seemed to have been set at defiance. The lower surfaces of this species are unspotted, as shown in the tailpiece photographic illustration. The young subject of this picture very amiably allowed me to turn him over on his back, and there he remained until I had obtained his picture.

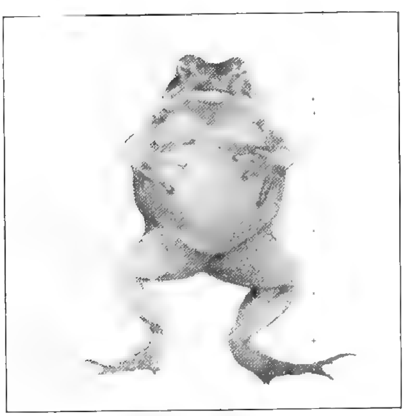
The text photograph illustration of a Fowler's toad was made from an individual which frequented the open grassy ground near my summer quarters. This species proved to be almost as common as the ordinary toad, *Bufo americanus*, and equally effective as insect destroyers, foraging for the latter over a wide extent of the open country. I found multitudes of the eggs of the Fowler's toad in June, 1907, in the temporary small ponds, formed by recent rains along the roadside. These egg masses were easily recognized by their resemblance to long strings. In the latter part of June the tadpoles were very numerous.

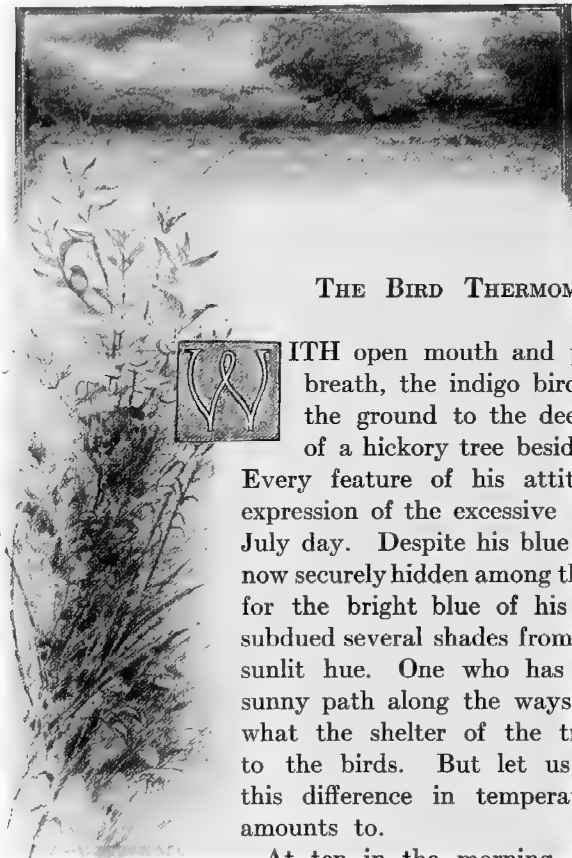
As the range of Fowler's toad has heretofore been recorded only from the New England States, it is interesting to note that Allard, in a recent number of *Science*, has described this toad as occurring in Georgia. He describes its notes as a "brief, penetrating droning scream." Science is indebted to Dickerson for presenting an excellent account of this species, as well as the common form, in her "Frog Book."

That the common toad is well protected from the attacks of birds is quite evident. A tame red-shouldered hawk on our grounds, which was nearly full grown, had never seen a toad before, so I placed a full-grown toad in the hawk's cage to determine what action, if any, he might take. The toad jumped out of my hands only to be at once seized by the hawk. The attitude of the toad was of particular interest, because of its complete submission to the hawk's attack. It immediately quieted down — its body being perfectly motionless — in apparent fear, closing its eyes half-way. The hawk picked at one side of its body behind the foreleg but twice. Then, seeming to be seized with a disagreeable taste in its mouth, it stopped further attack. The hawk then stepped aside, away from the toad on the ground, and flew to a perch above. In the meantime, he repeatedly shook his head violently and went through the act of swallowing over and over again, as if endeavoring to get rid of some disagreeable taste in his mouth. No inducement could make him show any further interest in the toad.

The toad lay in one position for some minutes after the attack and then jumped away, getting under some herbage; it seemed to be unharmed by the ordeal. This attack on the toad by the hawk showed admirably the defensive nature of a poisonous excretion from some skin glands possessed by the toad. These defensive structures in the toad, together with protective resemblance to its surroundings, go far to aid in the preservation of the species.

A tame crow which I raised from a nestling during the year 1909 exhibited a great liking for very young toads which were from a half inch to an inch in length. They were not usually eaten at once, but were picked up in his bill and repeatedly pressed before he swallowed them. Later on in the season, when the toads became larger, the crow showed the same desire to capture them, but was more reluctant about eating them. In almost every case then he would hide them, tucking them out of sight under grass or stones. I never saw him touch a full-grown toad. It is possible that the secretion of the skin of young toads is less distasteful than in the adults.





The Bird Thermometer

WITH open mouth and panting for breath, the indigo bird flies from the ground to the deep shadows of a hickory tree beside the road. Every feature of his attitude is an expression of the excessive heat of the July day. Despite his blue coat, he is now securely hidden among the shadows, for the bright blue of his feathers is subdued several shades from his former sunlit hue. One who has taken the sunny path along the wayside realizes what the shelter of the trees means to the birds. But let us see what this difference in temperature really amounts to.

At ten in the morning, beside the shaded door of the house, the thermometer registered eighty-three degrees, but see how rapidly the mercury ascends as the thermometer is changed. In the course of a number of minutes the mercury runs up to one hundred and sixteen degrees when the instrument is placed on the ground. Then, fixing the instrument in mid-air so that the air circulates about it in the sunlight, it soon drops to one hundred and three degrees Fahrenheit. These are the actual varied conditions that caused the indigo bird to seek cover. How much this change of temperature at different points affects the animal inhabitants I have noted on every hand.

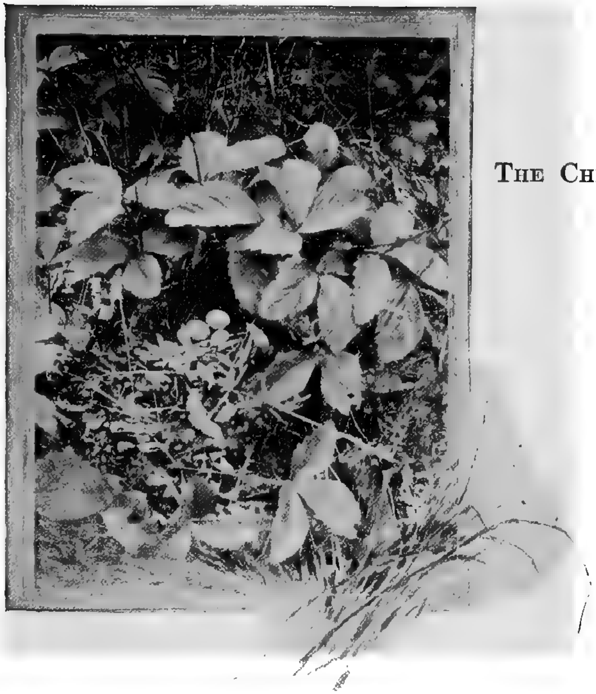
The quail, which are ordinarily so fond of the open fields, now seek the border of the woods, where I have startled them in my walks afield. But here they fly through the woods to the marginal underbrush, like the ruffed grouse, for better

Indigo Bird on her nest in dogwood bush.

protection from the heat. In the orchard the waxwing fledglings, in order to keep from perishing, are sitting bolt upright far apart, like little wooden images on the edge of their nest. Two young wood pewees in the beeches have similarly separated to take positions on opposite margins of their nest, to avoid as much as possible, not only the atmospheric heat, but that emanating from their own bodies as well.

Again, in an apple tree, I have just witnessed the mother robin standing over her nest brooding the tiny newly hatched young. The nest is so situated on an outstretched bough that it is in full exposure to the direct rays of the sun. Unless this wise precaution of brooding were taken by the parent birds, the young would undoubtedly perish. But this hot spell is the delight of the Ajax butterfly. He comes down near the ground in the openings in the woods to imbibe the heated exhalations from the earth, and also to dip into the sweets of the white clover. Among the recesses of the forest trees, the Turnus butterfly is engaged in spasmodic flights, darting here and there, but rarely satisfied to alight. His exit from the wood is as rapid as his coming, and in the next instant he is lost to view. He flies too high now for any one but an expert lepidopterist to identify him with certainty, from the instantaneous impression one gains of his wing stripes.

The behavior of the indigo bird and insect life show the effect of solar heat on animal life. Little do we realize the great influence the heat exercises during the short period of tropical heat in our mid-summer, yet it doubtless is one of the greatest factors in stimulating changes in the various forms of life. To view the effects of the weather, one's time may be profitably spent in the woods and waysides of nature, where these lessons are readily at hand.



The Chewink

NO bird with which I am familiar heralds the coming morning with sweeter notes than the chewink. It runs, as Chapman expresses it, "Sweet bird, sing," which is frequently repeated with short intervals between. He is the cheeriest bird on the premises, singing fully as contentedly before the coming of the storms as in bright sunshine. Now, while the sky is fully overcast with clouds (on July twenty-ninth) and the wind of considerable velocity blows off the lake, one still hears him singing in the sumachs. Almost any time of the day one may find him in the beech woods, and here I have often surprised him in his favorite occupation of scratching over the dried leaves of the forest bed. In the next moment he is likely to be found in the open, within sight of some thicket.

Some years ago I found a pair having their nest on the ground in a neighbor's strawberry patch skirting the woods. I deemed this little home of sufficient interest to present it here in the photographic illustration at the beginning of this sketch. Only three eggs were laid when the mother bird decided to set on them. They were white and lightly speckled with reddish brown over the surface. Three young, which left on July fourteenth, were successfully reared from this nest. During the past season another pair had their nest on the ground among the leaves in the woods near the lakeshore bluff. This nest also contained three eggs. After two of the eggs had hatched, one of the young, on the third day, was destroyed by some animal, so the only remaining young, after living a precarious life, was finally ushered away to safe quarters. The handsome chewinks are early arrivals in the spring and they remain throughout the summer, having two broods, the birds leaving about the last of October.

Male Chewink or Towhee (Pipilo erythrophthalmus).

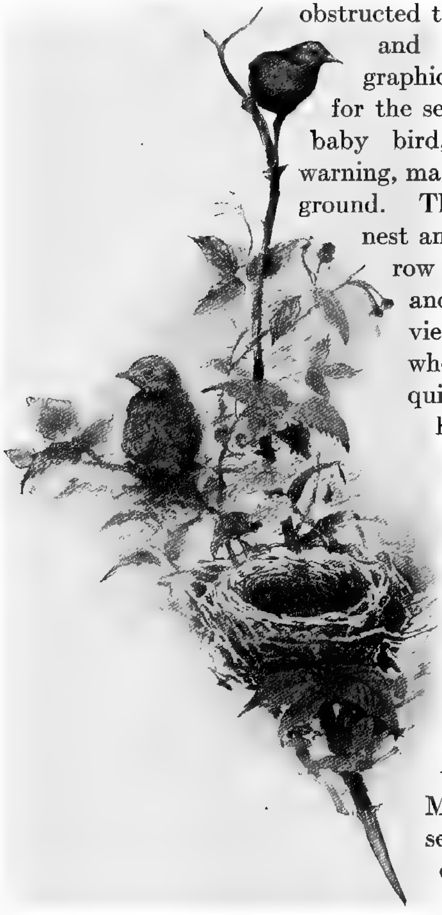
TAKING SPIZELLA'S PORTRAIT

VARIOUS species of young birds are leaving their nests in the beginning of August, and if one desires to record their portraits this is the last opportunity of the nesting season. This was the conclusion I came to as I started out in the bright sunlight one afternoon, with a view to photographing a nest of a field sparrow. The nest which I had in mind was near the top of a black raspberry bush and it had been examined and found to contain three nestlings.

At the last inspection I noticed that their bodies were nearly naked and that the feathers of the wings were in the form of quills, not yet spreading into feathers. After two days of absence I found on arriving at the nesting site that the young had acquired a complete covering of feathers. Who could have believed that in such a short time the development of plumage could be so rapid? Yet there were two sprightly little ones, with short tails and brownish suits, whose precociousness led them to stand triumphantly on the branches. How unconcerned they appeared as I viewed them; their inconspicuous bodies showed scarcely any signs of animation.

But from another quarter I was being intently watched. In an instant more the mother bird, which had been perched upon a bare twig some distance away, now suddenly appeared.

Flying down, fluttering along near the ground, she artfully feigned being injured in an attempt to attract and divert my attention. I cut away carefully some of the branches which obstructed the view of the little ones, and then made one photographic exposure. On preparing for the second picture, the topmost baby bird, without the slightest warning, made a headlong dive to the ground. The bush containing the nest and birds was one of a long row of black raspberry shrubs and they obstructed the view on the opposite side where the bird fell. As quickly as possible I made haste to recover the little adventurer.



Field Sparrow with nest and young bird.

This attempt was not a moment too soon, for, to my amazement, two large chickens, which had noticed the helpless bird, rushed at it and viciously picked at the tiny waif which by this time was crying loudly. My endeavor at rescue seemed only to annoy one of the fowls which, having grown bold, dashed in ahead of me, and having picked up the defenceless bird in its bill, started off on a run with it. By this time a well-aimed throw of my hat, which landed broadside near the chicken, frightened it so that it dropped its prey. The little bird was found practically uninjured, though had it remained much longer in sight of these ravenous fowls it would undoubtedly have been killed and eaten by them. As a rule, young birds, after leaving the nest, never return to it, so I tried placing this young bird near the nest again, but it showed dissatisfaction at once and jumped to the ground. The other two young birds had, in the meantime, lost self-control, and they, too, dropped to the ground. After catching the birds several times and restoring them to the nest, they showed the same antipathy toward it, each time immediately leaving the site. I had not intended to disperse the little family in the raspberry bush, but doubtless they would have soon left of their own volition.

During these manœuvrings, the parent birds continually manifested anxiety. They would repeatedly fall to the ground as if stunned, then, recovering themselves, they hopped toward me as if pleading for mercy. In the next moment, perhaps, they would fly very near to me, chirping incessantly, but keeping a safe distance near the top of a leafless twig. I had no sooner departed a safe distance than the parents followed the little ones into the grass, each one apportioning off its charges, which they carefully cared for. As the commotion finally died away, the photographer retired from the scene with the mixed feelings of pain and pleasure,—pain at the thought of the suffering fright caused the field sparrows' family by my intrusion, and pleasure that I had at least obtained photographs from which the drawing could be made, that Spizella's portrait may be handed down to posterity.

VII. GENERAL OBSERVATIONS AND SKETCHES AFIELD, WITH EXAMPLES

VII. GENERAL OBSERVATIONS AND SKETCHES AFIELD, WITH EXAMPLES

DURING walks afield something will always be found of interest to study and ponder over, and on these occasions it may be the means of directing the thoughts into new channels of interpretation of nature. The contact with nature should elicit a study of the behavior as well as the structure of plants and animals. It seems to me better to train one's eyes to know one department of plant or animal life accurately before generalizing on many groups.

The pleasures of life are greatly increased even to be able to recognize the kinds of insects, birds, and other animals and plants, and these pleasures are still more enhanced by knowing their behavior, or habits. This knowledge is a stepping stone to the understanding of evolution. It is generally conceded that the natural way to a knowledge of nature is to come in touch with the common live objects about us. This must be gained by actually viewing them in their natural surroundings, in all kinds of weather, whether in the pasture, meadow, swamp, brook, or forest. Here the organism with its responses to the environment can be better understood.

Morgan [1] affirms: "That interest in collecting and recording the results of observations, and in the artistic side of nature, is much more widespread than interest in the study of problems, or, if the interest is not lacking, the will to take the initiative in the formulation and solution of problems seems to be less cultivated in the biological sciences than the power to observe and to describe."

The many nature books now existing for the easy determination of plants and animals are a great help to the nature lover, but it must be remembered that the identification of animals and plants is but a superficial knowledge; the real object of the

[1] "Experimental Zoölogy."

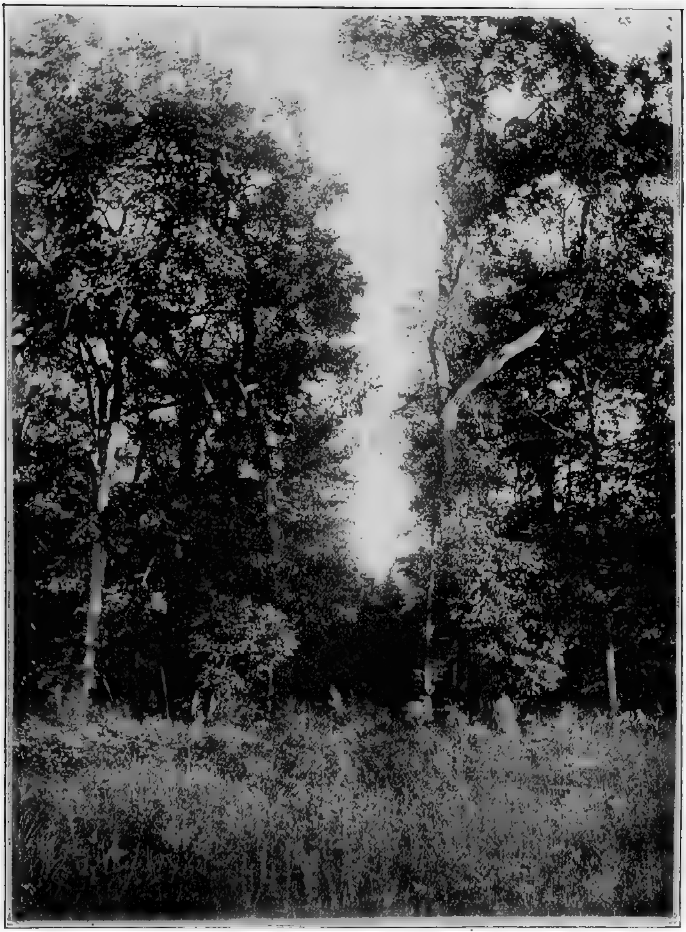
study of nature being not only the development of the observational powers, but to arouse interest in the philosophy of life. While a great deal is learned from observational study of nature afield, there is a growing interest in experimental work supplementing field study. It is well known, for instance, that the so-called seasonal dimorphism in butterflies — that is, difference in color in the summer and winter broods — is mainly due to the influence of temperature. By subjecting the pupæ to high or low temperature one or the other type of coloring can be produced in the laboratory at will. Breeding experiments are also of great importance in the study of evolution.

The best of all experiments in evolution, says Clements,[1] "are those that are constantly being made in nature. Such experiments are readily discovered and studied in the case of origin by adaptation. Variants (which are new forms resulting from variation) present greater difficulties; while mutants (which are sudden changes) are very rare under natural conditions."

It is well to note here that some forested tracts should be set aside as natural preserves for the benefit of the general nature-loving public. Some of the pleasures one may enjoy by contact with nature are set forth in these sketches. Such a forest as is pictured on the opposite page[2] is both an inspiration and delight to the nature lover. Some of these tracts of wild lands still abound, and should be preserved before it is too late. The present movement for the conservation of these beautiful wooded areas is most timely and imperative. Their preservation is due our future generations. This conservation should also include tracts of wild accessible land not necessarily forested, having its natural fauna and flora undisturbed, yet should contain diverse topographical features. These parks should furnish the necessary grounds for that growing population who desire to make field trips whether it be for recreation, nature study, or the searching into the deeper problems of biological science.

[1] "Research Methods in Ecology."

[2] At Kenilworth, Illinois.

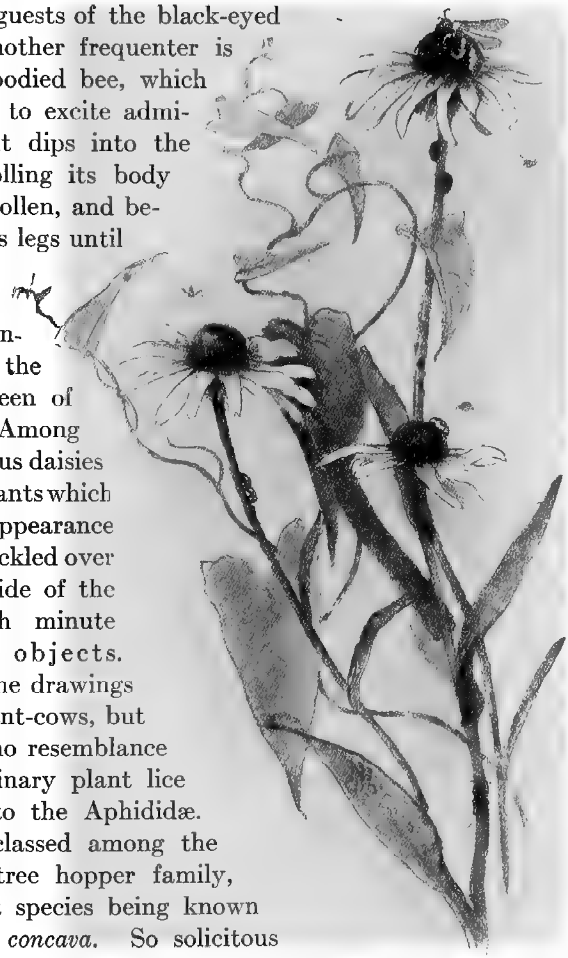


A View at the Edge of an Oak Forest in Late Summer. This landscape is replete in interest for the artist, nature lover, or the thoughtful biologist.

Meadow Echoes

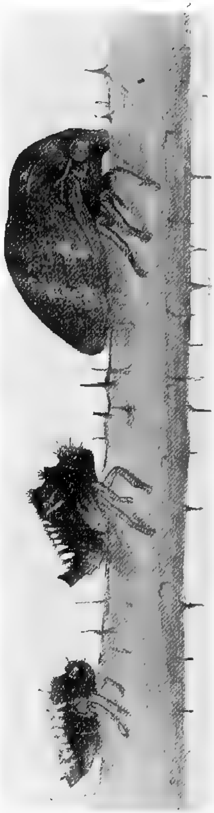
AFTER the night's shower, what a freshness comes over the uncultivated meadow! It is the time of year in early July when all nature is putting forward her greatest efforts. The grasses and other flowering plants are of sufficient growth to afford protection to the young locusts and the grasshoppers now so plentiful; also allowing the small garter snakes to easily escape unobserved. The rasping call note of the meadow lark, constantly repeated, hints of bird nesting, while every now and then moths fly up disturbed at our tramping footsteps. The black-eyed susans are gathered in clusters, which, viewed at a distance, appear as if the ground had been splashed here and there with yellow amid the verdant green.

If one comes cautiously upon the black-eyed susan, he may see a little frequenter of its blossoms, but one has to be very quiet in making its acquaintance. As soon as this small striped beetle is aware of danger, it takes a headlong tumble into the grasses below, in this way concealing itself from its enemies. I have endeavored in the illustration of the black-eyed susan to show this insect in the act of feeding among the tiny florets adorning the central disc of the flower. It is but one of a number of guests of the black-eyed susan. Another frequenter is the green-bodied bee, which cannot fail to excite admiration as it dips into the blossom, rolling its body in yellow pollen, and besmearing its legs until the golden hue of the pollen contrasts with the metallic green of its body. Among the numerous daisies one finds plants which have the appearance of being speckled over the underside of the leaves with minute brownish objects. These, as the drawings show, are ant-cows, but they bear no resemblance to the ordinary plant lice belonging to the Aphididæ. They are classed among the grotesque tree hopper family, the present species being known as *Publilia concava.* So solicitous are the attending ants regarding the welfare of these numerous small larval insects that they will rush to their rescue when the slightest danger threatens.



The Black-eyed Susan with its insect guests.

If the plants are rustled and one watches closely, the ants may be seen tenderly picking up these tree hoppers in their mandibles and carrying them to a point of safety. On arriving at maturity these ant-cow larvæ transform into little dark objects appearing like excrescences, feeding on the juice of the flower stems, and then the ants no longer attend them. At this late period in their life history, the full-grown ant-cows have gained jumping powers which they are quick to exercise when disturbed. Two stages of the larvæ and one of the humped-back adults, greatly magnified, are depicted in the illustration.



The Tree Hoppers (Publilia concava); larva, pupa, and adult insects, living on the stems of the black-eyed susan.

Peeping up almost everywhere, the small pale violet-colored blossoms of pennyroyal are the most evident representative of the mint family. It makes up for its small size in the great numbers present and its odorous scent. Here the little tubular flowers bearing a three-lobed underlip are visited by honey bees, while the larger bumble bees do not disdain taking their sip of honey. The daisy fleabane finds little opportunity to crowd its multitude and thickly set neighbors, and only occasionally it shows its white-fringed, yellow-centred blossoms.

On a previous visit to the meadow in May, I noticed a small open space on the ground about eight feet across, which was covered with a rich carpet of moss. Now it has become completely transformed. The surrounding ground which formerly supported few plants that were more than two inches in height is now covered with tall rank growth. The mossy spot has been closed over by the false buckwheat entwining itself in pretty festoons and forming a bower.

In the meadow one may find that the rain has replenished the water in the small pond beyond the copse. At the margin, set off by a surrounding group of Sagittaria, a pair of spotted sandpipers are spending their moments. In the small stream emptying into the pond the thirsty snails have been saved from utter extermination by the recent rain. Throwing over the old logs one finds crayfish hidden from the warm rays of the sun, while simultaneously the roofs of many spiders' homes have also been dishevelled by our rashness, displaying certain species of running spiders, Lycosidæ, that bear a spherical egg-sac attached to the end of the body. In some instances the eggs are hatched and the mother is harboring a thick mat of her numerous young on the back of her abdomen.

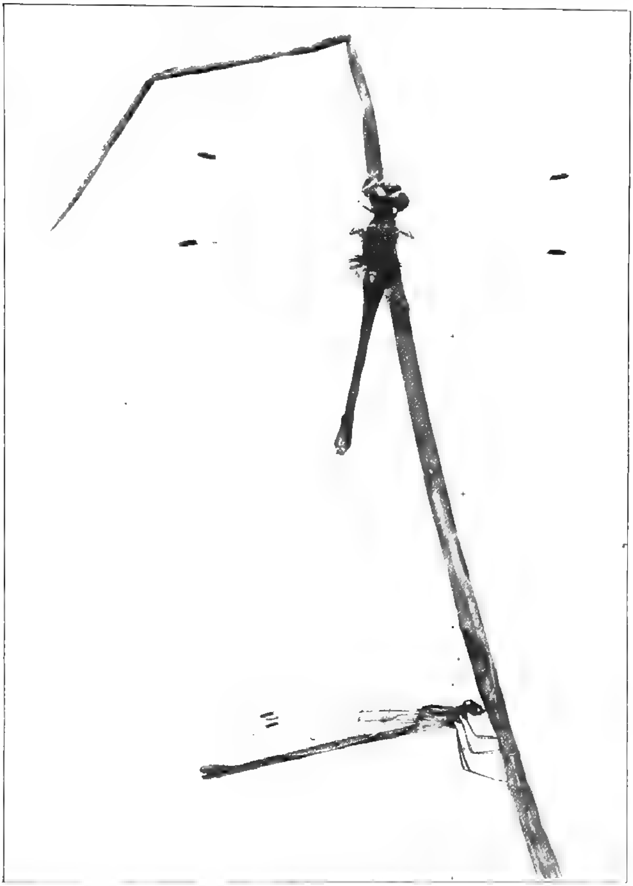
Such a sketch as I have just chronicled may enliven interest in the midsummer meadow where legions of incidents are passing each year. As one recalls the stroll over the meadow there comes to mind the fact that the grasses and flowering plants with their associated animal life have a certain relation to each other. The meadow often connects with the pond or swamp, on the one hand, or with a forest on the other. Or, farther on, one may find a pasture drier than a meadow. Each of these have their respective plants and animal societies. Further on, in the chapter on the Pasture Locust, will be found a description of the adaptation of an insect to the plant societies of the pasture. The plants are dependent on the physical properties of the soil, chief among these being the amount of water the latter contains. According to whether these groups of plants inhabit water or soil of various degrees of moisture, naturalists designate them by different names. Those plant societies living in water, such as are found in swamps and ponds, are called hydrophytic; those plants living under drier conditions on land and under normal conditions, as the meadows, pastures, and woods, are called mesophytic societies.

The Pond

BESIDE the open woods in the meadow we have paused at the pond to witness the myriads of aquatic plants and animals. How much is suggested in that swampy odor exhaling from the decaying lemna in the heat of the July day! Venturing out from under the shade of the trees, one finds the alert dragon-flies are sweeping here and there over this haven of life. On watching them intently, one sees that this apparently aimless flight is for the purpose of catching the small winged insects, which are either instantly devoured or carried to the dragon-fly posts at the tops of the last year's dead reed stalks that here and there have weathered the elements. Or, perchance, one of these insects has sped down to the water's surface, where she has momentarily dipped her body to release an egg.

What country boy is not familiar with the flying monarch, Anax, or the "snake doctor," which goes to and fro in mid-air with glimmering wings, at one moment playing hide-and-seek above the herbage at the border of the pond, and in the next moment swinging out over the open surface.

The timid boy who has superstitions respecting these harmless aviators in the sunshine may have lost heart; but the one more courageous is often invited to a merry chase by a bold dash near his head of one of the less wary. He must



The upper Dragon-fly (Sympetrum vicinum) has just captured an insect and is feeding on it. The lower figure is a species of Argia resting on the reed. These insects frequent the shores of rivers and ponds.

be quick, for while making up his mind to accept the challenge with the net, the opportunity is past, and perhaps the brilliant sunlight has temporarily blurred his vision.

Nowhere do we find brighter coloring than among these graceful pond frequenters. Here is presented a green-bodied species with transparent wings, while a moment later another comes with its body bathed in vivid carmine. Contrasts in the color pattern occur which show a representative with blue body and emerald eyes. In the torrid summer heat one may not be surprised to see a suggestion of winter by a coating resembling white frost on the body and wings of *Libellula pulchella*, one of our commonest species. This insect is, moreover, exquisitely dressed in bluish drab, with two splashes of yellow on the sides of the dark thorax, besides having three broad smoky blotches on the transparent wings. In this assemblage, low among the Sagittaria, the paired damsel flies, Lestes, are stealing lightly about, the female forming a graceful arch as she adroitly places her numerous eggs, one at a time, in the plant stems.

The curious empty dragon-flies' nymphs, with their vacant stare, are seen grasping the iris and water dock close by. A hollow mockery are the gaping skins, for sometimes, until one has examined them carefully, the secret of the escape of their occupants into the new winged realm of life is not divulged.

Skirting the margin of the pond, the white blossoms of the water hemlock are found attracting the nine-spotted ladybird beetles. This is the opportunity to become familiar with these insects, for they are so industriously engaged delving in the sweets that they have scarcely moved. Yet a false footstep would cause them to drop to the wet ground for concealment. How delicate the lace-like flower clusters lie in their broad stretches, touched here and there with small hemispherical red beetles! One must stand some distance away to see this æsthetic floral display at its fullest beauty. This plant is also known as the spotted cowbane and is very poisonous to the taste. Across the pond a dull crimson pink color enlivens the perspective, and as one approaches the spot the individual flowers of the swamp milkweed delight the senses. The

The upper Dragon-fly figure is Anax junius, male; the lower figure Aeschna constricta, male. These insects frequent the sun-exposed borders of ponds.

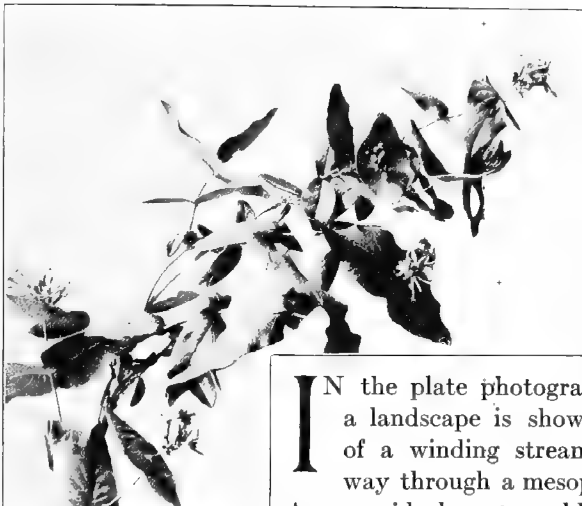
flowering button bushes which have taken root in the bottom of the pond attract many insects to their blossoms. Then there are the tall sedges which have pushed their way along the margin with the army of other species of plants, each kind crowding the other, while the detritus falling to the earth contributes

Dragon-flies at the border of the pond.

as a land maker. The decaying pond weed vegetation and legions of dying aquatic animal life are forming sediment which is gradually filling in the pond.

From an earlier reed swamp we now view the pond, the reeds and bulrushes standing out in the deeper water. Then follows the reed grass, and toward the shore the cat-tails. This is the pioneer arrangement of plant societies around which the sediment collects about their roots, causing the water to become more and more shallow. Later comes the pond weed societies I have described above. Year by year the filling-in process proceeds while the borders have contracted. Finally, where the pond formerly stood, one finds the land reclaimed, and converted into a part of the wet meadow. So that by the time the present generation of youth has matured, perhaps the pond of one's childhood, with its many former life attractions, will exist only as a cherished memory.

THE BROOK INHABITANTS



IN the plate photographic view of a landscape is shown a glimpse of a winding stream cutting its way through a mesophytic forest. A more ideal spot could scarcely be found for certain biological studies. The edge of the bank on the right is covered with grasses, and back of this there is an abruptly sloping bank, upon which the yellow ladies' slipper and wild honeysuckle find a footing. Still farther back, the May-flower, Podophyllum, populates the open woods. In this stream little fishes, such as darters, stickle-backs, small suckers, and red-bellied minnows, seek the shadowy recesses cut by the water into the overhanging earthen ledges. Or, now and then, one sees them gliding out from the algæ-covered boulders into the glimmering light of the swiftly moving water. The silty bottom affords shelter for many nymphs of dragon-flies, midges, May flies, and other aquatic insects that preyed upon their neighbors. Regarding this stream, Needham says:

"The pools are the home of the Cordulegaster nymphs (*C. obliquus*). They lie on the bottom covered with silt. They do not burrow, but descend into the silt by raking it out from beneath with their legs. Then, when deep enough, they kick it up over their backs and hide themselves absolutely against observation, having only the sharp, upper angles of the eyes, the sensitive antennæ and frontal fringe, and the respiratory aperture at the top of the abdomen exposed. Thus they lie in ambush, wholly inactive, unless the wandering near of some May fly nymph (here *Leptophebia parpedita Etn.*) or gnat larva invites a thrust of the enormous, grasping labium. They have competition for their food, also dwelling in the pools, chiefly the red-bellied minnow and black-nosed dace."

The active red-bellied minnows, *Chrosomus erythrogaster*, make very good aquarium objects for study. On the day mentioned above, I obtained several individuals of this species, which lived in an ordinary aquarium in my home for a period of a year. After five years one of these minnows is still alive. The rest of them, at different times since first confined, jumped out of their small quarters onto the floor during my absence. This species of minnow is more or less of a vegetable feeder, consuming green algæ in quantities, its choice of these plants being Spirogyra, which is abundant in almost all our ponds and streams. In situations of the brook, such as I have shown, earth worms and midges, the latter in either larva or adult stages, also form a large proportion of their food.

If any of our readers desire a handsome species for stocking a pond, or for aquarium objects, this is certainly a most desirable native species to cultivate. In the spring at the time of mating, the males undergo a change of color of a secondary sexual character. The sides of the abdomen, which are ordinarily silvery white with a dark stripe, become suffused behind the gills backwards, with an exquisite, brilliant red.

Nature's Laboratory

The great laboratory of nature is always open to the interested observer. On the one hand, we see the effect on animal and

A brook, the habitat of the Red-bellied Minnow (Chrosomus erythrogaster) and the Black-nosed Dace (Netropis megalops).

plant life from the downpouring rain in summer, the effect of hail, wind, sudden lowering or elevation of temperature, and finally the effect of sunlight and shadow. On the other hand, these physical forces are seen operating every moment of time over the face of the earth, exercising a powerful influence now, as they doubtless have in the past, over organic life. These facts tell us that the interrelation and interdependence between organic life and the relation to their environment are forever seeking adjustment. We note that the destruction of a large number of one form of life may disarrange the adjustment of the whole interlacing series in a given locality, because of the dependence or predaceousness of one form upon another. The same is true as to the effect of a sudden shower in summer, which may cause the death of thousands of insects, to say nothing of the occasional destruction caused in other groups of animals.

Hinds says, in writing of Thrips, which are minute insects often found on flowers and grasses, that "of all the natural checks none can compare in efficiency with a hard dashing rain." He further notes that these insects are "abundant during hot dry weather, but disappear almost entirely as soon as the heavy showers of midsummer begin, and as long as such showers continue at frequent intervals, the Thrips do not again become abundant." These observations might be multiplied without number, showing the destructive effects of summer showers, while other facts could be adduced to show their beneficial action. Millions of small land animals suffer destruction during every hailstorm in summer, and though these hailstorms are quite local, the effect is nevertheless one that influences the future generations and it may change the whole interrelated system of life adjustments.

The wind as a factor in local and geographical distribution is evident to every observer who goes afield for the valuable information there afforded. Aside from carrying hordes of insect life adrift in the prevailing southwest winds in this temperate latitude to new habitats, other hordes suffer destruction from the fact of not falling in their descent upon the earth into a suitable environment. The seeds of plants profit by the strong wind currents in being distributed into new fields, but many of these fall on sterile ground.

PLANT AND INSECT ASSOCIATION OF THE MEADOW IN SEPTEMBER

A field thistle, Carduus species, with some of its insect visitors, namely: a bug, bumble-bee, and honey bee. From a photograph

I will recall some personal observations bearing on this subject. I once entered an uncultivated meadow [1] to find a strong wind blowing from the southwest, which came in almost steady wilting blasts. It was seed distributing day *par excellence.* The air was flecked with the fluffy seeds of the field thistles, which were accompanied with tops of grasses. These seeds were flying as far as the eye could see and were being distributed broadcast. Many of the flower heads of the thistles in some clumps of these plants were swelling to overflowing with seeds, and the wind was in the act of carrying untold thousands away to distant places.

Again, here in a marshy swale, I also came upon some cat-tails in the act of seed distribution. Stored within the magazines were sufficient seeds to populate the marsh for acres. Simply starting the seeds at one point was sufficient for the wind to release showers of the little parachutes, which sprang into the air and were carried away to distant points.

Who can look upon the seed carriers of the milkweed or dandelion without the thought at once arising of the marvellousness of the physical adaptation for aerial travel displayed? Did it take eons of time to perfect these structures? Or on the basis of some remarkable mutations were these structures hurried along in their evolution? It is obvious that these questions cannot be explained in the indoor laboratory alone. The pollen of many trees, such as the elm, poplar, and some grasses, maize, and hazel, in which the stigmas are small and inconspicuous, is carried by the aid of the wind and they are thus pollinated.

The sudden changes of temperature, as a control over life processes, are all too apparent on every hand to ignore. The destruction of small migratory birds that are caught in the trend of a cold wave in the spring has been noticed from time to time and is now common knowledge. The destruction of insects that appear early in the spring, along with the injury to flower buds by delayed frosts, are some of the physical effects commonly noticed during certain seasons.

Finally, elevation of temperature so as to produce the other extreme of drought is also productive in destruction of many

[1] South of Jackson Park, Chicago, August 21, 1903.

forms of animal life. From the foregoing remarks one may note that the temperature, degree of humidity, and the wind are some of the physical agencies at work exercising an influence over the life of animals and plants, and in other chapters I have shown the reciprocal relation that some of the insects bear to plants. In nature's laboratory will be found an endless chain of circumstances that show the intricate adaptations wrought during the evolution of organic life.

Animal Life in Rainy Weather

WHILE the pouring rain is often destructive to many forms of insect life, on the other hand it is really favorable to the existence of many other animals. For instance, it is the gala time for snails and slugs, as may be found by observation in the woods. On humid days in the beech forest[1] I have noticed that each one of the old stumps has its slow moving inhabitants. In the holes made by the wood-boring insects, a good opportunity is presented of becoming acquainted with the large grayish slug, *Phylomyus carolienensis.* On my approach I found that some of these slugs had drawn themselves up into robust oval bodies and were hiding just within the holes. Others were welcoming the rain and crawl-

[1] Diary Notes, Lakeside, Michigan, August.

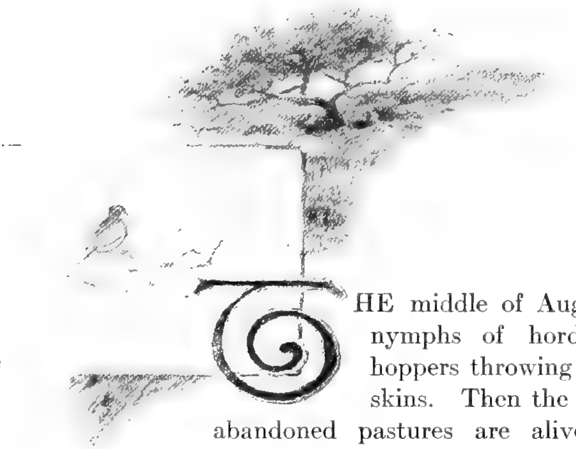
ing about on the old reddish wood. These slugs were very sensitive to the finger touch, and, when disturbed, secreted a milky mucus over their bodies which was probably in self-defence. Not far away other worm-like slugs were taking excursions about; these also thrust out two tentacles on the front of the body, showing at once that they were not real worms, which they quite closely resembled. Furthermore, a little study reveals the presence of a very small rudimentary shell on their backs, identifying them as the slug-like snail, *Agriolimax campestris.* During wet weather these little snails pass up the trunk and branches many yards from the earth. The land snails are everywhere in evidence, from tiny specks to those with circular shells of half an inch in diameter.

The ungainly harvestmen, or daddy-long-legs, are seen travelling about and now and then entering into seeming play. In the wood interior on rainy days I have always found them in great abundance.

In the wind and rain the hickory nuts are falling prematurely and here at my feet I gather some only to find, after sectioning with my pocket knife, that they are infested by the nut weevil, *Balaninus nasicus.* These are so numerous in some years that the crops of sound hickory nuts are appreciably reduced. Here and there on the trunks of the trees, usually only a few feet from the ground, are found the singular empty cases of the cicada that have become a familiar sight. The wet weather has favored the exit of the pupæ from the ground. One before me is just about ready to emerge from the pupa case, while another is in the act of escaping; but I have already treated this subject at some length in another chapter entitled, "The Hunted Cicada." In hollow scars on the beech trunks the tree-toad appears, colored like the surrounding bark. He is especially favored by the wet weather.

Now, turning my footsteps towards the open country, I have come upon an unexpected view. A wire fence behind the farmyard supports an assemblage of barn and eave swallows. About two hundred are lined up on the wire, covering a distance of fifty or more feet. Now and again one leaves his perch to brave the rain, flying into the open meadow, skimming along just over the weed tops. It is needless to say that this is August. All day this colony of swallows played about, sometimes the members dispersing and again assembling; but the next day, the storm having cleared, I discovered that all these birds had left the locality. What a reminder this is of the approaching fall. But only on a rainy day like the one I have described have I had the good fortune to view some of these habits of animal life, stimulated into activity by the humid conditions of the atmosphere.

Pasture and Meadow Insects in August



THE middle of August finds the nymphs of hordes of grasshoppers throwing off their last skins. Then the meadows and abandoned pastures are alive with adult katydids and other forms that enliven the scene. Before us is a grassy pasture, rich in blue lobelia, boneset, sedges, ragweed, vervain, pearly everlasting, and horseweed, to say nothing of the other less conspicuous members of the flowering plants. Bees are busy visiting the blue lobelia blossoms, and the air is scarcely silent for a moment from the humming of their wings. The clattering notes of the varied-winged locusts, *Arphia xanthoptera*, indicate almost in themselves the kind of ground one is visiting. The flashes of red or yellow from this locust's wings when flying are momentary delights. It is now between ten and eleven o'clock in the forenoon, under a hot sun, yet one is well repaid to wind his way leisurely across such a busy spot.

The little white and yellow butterflies are fairly dancing in the air just above the herbage, undecided just where to rest.

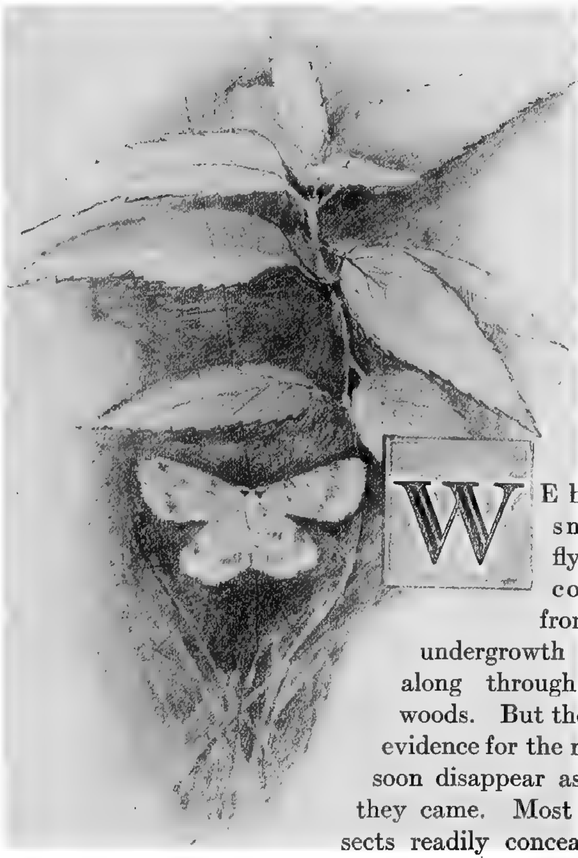
The great army of locusts, Melanopli, the common horde of grasshoppers, shoot up from the earth, scattering before each footfall. In the next moment comes the exquisite Turnus butterfly, not the least in a hurry, for lobelia's blossoms are too much of an inducement to pass over. Few views can compare

The Varied-winged Locust (Arphia xanthoptera). Its clattering notes recall the visits to the pastures and meadows in August.

with this rare scene of vital activity, especially with this yellow and black swallow-tail among a clump of these blue flowers. One is hardly lost in thought before up from the herbage is startled the green Texan katydid. He is one of the commonest species, yet how few of us know him intimately. There he flies with a slight up-and-down motion, keeping just above the tops of the plants, dropping about ten yards away. One finds, on following him, that in his descent he has caught in the leaves of a ragweed. Had I not "marked him down" carefully it would have been difficult to locate his narrow green body again. Against the green background he is perfectly concealed. Like the other members of this group he resembles the green vegetation to a marked degree. He is, moreover, hardly visible on the wing, for his plainly glazed wings are quite inconspicuous in the air. In association with the Texan katydid is a smaller form, the fork-tail species of Scudderia. The latter is, perhaps, a little more sprightly on the wing and considerably smaller than his neighbor above referred to.

In general, the pasture is drier than the meadow, due to a difference in drainage. Here the prevailing plant species are grasses, or the ground is invaded with perennial herbage, such as I have described in the beginning of this article, in which case we have a blending of pasture and meadow. The life I have portrayed above is that living under both pasture and meadow conditions. In another chapter I have described in detail the Pasture Locust, which exemplifies a typical pasture insect living under conditions of restricted plant association.

THE UNDER-LEAF INHABITANTS



WE have seen the small moths flying out quite conspicuously from among the undergrowth as we trod along through the shady woods. But though quite in evidence for the moment, they soon disappear as suddenly as they came. Most of these insects readily conceal themselves under the leaves of plants. Here is one I have just followed to its retreat. Turning the leaf gently over, I find the snow-white form a perfect type of æsthetic beauty. As a rule, I observe that the whiter their color the more seclusive they are in their habits, resorting to the underside of the leaves, generally in the darkest part of the woods. Those having their wings normally spread apart or open are often scalloped at the margins, which is typical of the geometrid moths. Their habits of concealment are of the utmost importance in protecting them from the birds which readily prey upon them.

In a long stroll it is not uncommon to find the fragments of moth wings lying on the surface of leaves, or on old stumps of trees, where they fall after being picked to pieces by a roving fly-catcher, or other birds. I have frequently found their remains in webs spun by spiders. Other moths had been killed by the small jumping spiders. But besides the geometrid moths, countless other insects and spiders resort to the leafy cover for their protection. At the edge of the woods, on the underside of the hairy boneset leaves, I find the harvestmen, or daddy-long-legs, quietly reposing, probably after a foraging expedition after some larvæ. Near the top of this plant, under the leaf shelter, a globose-bodied spider has taken up his residence. The sun's rays, coming down through an opening in the trees, have lured the red-striped cercopid to the upper surface of the elderberry leaves. But on the slightest touch or move, quick as a flash, they run sideways to the margin of the leaves, where they disappear underneath.

Examples of the under-leaf inhabitants might be added to those already given, but these will suffice to show some of those living in our forest interiors.

Branch of the Button-bush

The Sand Dunes

THERE are few places possessing greater attractions for the naturalist than the sand dune region of northern Indiana. Stretching from the shore of Lake Michigan back for a number of miles is a succession of beach, dunes, and fields. Each of these physiographic areas bears its peculiar plant and animal societies. Within the depressions are interior lakes, ponds, marshes, swales, and bogs. The beach nearest the lake is a more or less sandy waste, with scarcely any plants growing upon the sand, and those that do manage to get a footing are mostly bunchgrass and creeping plants. The dunes are made up of great mounds of sand produced by the action of the wind, and are continually shifting their positions. In doing so, the dunes often engulf vegetation, and even large trees that lay to the landward side of them. The few plants that grow on the moving dunes are often buried and if not entirely covered they often develop very large stems in becoming adapted to their peculiar condition.

Farther inward, shrubbery and grasses grow in some luxuriance in the fields, and the older dunes farther in are covered by such trees as pines, oaks, and other mixed forest trees. About the lakes, ponds, and bogs there is often a rich flora. Unless one has visited this interesting region, he can hardly realize what a wild jungle these interior bogs and moors present, with their rank growth of shrubs, cat-tails, and sedges. I recall as I strolled through these places the Maryland yellow-throat warbler, the swamp and song sparrows, peering out from under cover of the bushes as I passed through their domain. The frogs lunge headlong, bending the cat-tails, in their wild leaps, into the splashing water, while back from the edge of the pond in the sand the fragments of white turtle eggs, scattered before the little hollows in the sand, tell of the new progenies that have appeared.

At Miller, Indiana, one day late in summer, I started in the morning to go along the wagon road leading to the old Calumet River and the shore of Lake Michigan. Beside the road my attention was drawn to some yellow primroses.[1] I found

[1] *Onagra rhombipetala.*

on close observation that three daddy-long-legs were dipping down into the centre of the open blossoms of these plants, with their long legs extended in queer attitudes. They were drinking the juices of the flowers and at the same time they were unconsciously acting as pollenizers. With a hand magnifier I found the grains of pollen piled on their backs, eyes, and legs.

In the marsh beside the road were reeds, white pond lilies, Sagittaria, and cat-tails, along with numerous sedges. The button-bush skirted the margin of the marsh and had but few blossoms remaining, the delicate fragrance from these, however, perfumed the air as I passed the shrubs. I have presented at the bottom of page 294 a drawing of one of these beautiful blossoms that it may become familiar to the reader. The white-flowering spurge was met with everywhere in the open woods, their blossoms sometimes covering large areas. There are many species of spurge here, but this one seemed to be the commonest along the roadside.

On visiting some bogs I found, after fighting off a host of mosquitoes, the sundew, *Drosera rotundifolia.* It is this species of plant with which Darwin performed his remarkable experiments, and gave the result in "Insectivorous Plants." These plants capture insects by means of sensitive tentacles disposed on the leaves. When an insect crawls on the leaves, the tentacles grasp its body and carry it to the centre. Here there are absorbing glands which take up nutrition from the dead bodies of the insects. When I found these plants they were closed in by a dense growth of herbage, living in great luxuriance. Here were assembled gelatinous fungi, creeping plants, wintergreen, liverworts and lichens, forming a group replete with forms, well typifying bog societies.

These plants grew on the south side of the bog, the opposite side having a more barren, sandy margin. On the sandy margin in certain spots close beside the water's edge the little blue face of the wandering Jew, Commelina, nestled in among the rich verdure. This plant is easily distinguished from its cultivated relative by its having thinner leaves. Skirting the margins of the bogs for yards at a stretch were the pink flowers of the steeple bush. Again, it was often mixed in here and there with the allied species, the meadowsweet, which

A Pair of Texas Katydids on a Sedge
(*Scudderia texensis*)

The green coloring and graceful form of the body afford these insects excellent protection. Upper figure male; lower figure female. From a photograph

also appeared in abundance. Though late for this species, many blossoms of the meadowsweet were in evidence, but most of them were in a state of senescence.

In the open sandy areas is the mint, *Monarda punctata*. It is extensively distributed here and is an appropriate plant for the roadsides, appearing at first glance as if the whole plant were covered with dust, but in reality it is only a light down. The sage-like odor of this plant is peculiar and leaves a lasting impression on one's mind. The flowers are sprinkled with magenta on the pale ground color, the upper and lower lobes gape widely and present a slight resemblance to a tiger's mouth. This flower is perfectly adapted for bees, which I saw visiting them.

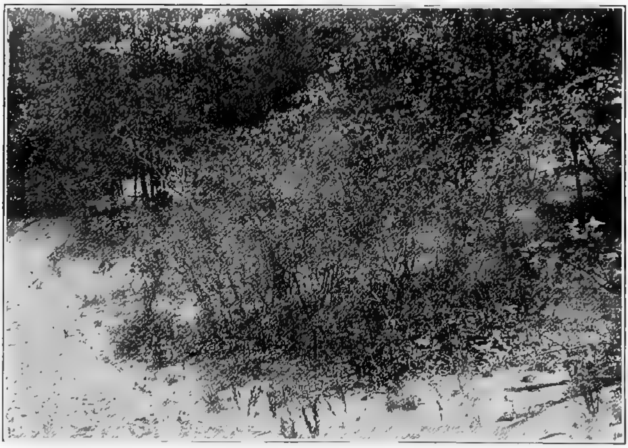
At frequent intervals, both Fowler's and the common toad crossed my path, almost underfoot. While the toads kept to the drier portions of the trail, at the edge of the swale among the cat-tails, blue flag, and reeds I found a short-winged green locust [1] frequenting the leaves and lower herbage, especially the marsh grasses. I have given a separate account of this species further on. In a drier situation, among some dead branches on the ground, fallen from the blackjack oak, I found a number of the sprinkled locusts, *Chœaltis conspersa*. The larger, leather-colored locusts were in many instances seen shedding their last skins before reaching maturity. These insects, in this stage, could be distinguished after recent moulting by their pale color and the perfectly soft condition of the integument. A detailed account of this and the preceding locust will be found further on in this work.

Among the cat-tails, I occasionally saw the bright female of the common yellow and black harvest spider, Argiope, which fared sumptuously on locusts of the genus Melanoplus. The web of one of these spiders was built in the marsh near the shore; her web contained two locusts. The spider was hanging head downward in her usual position. She held one of her captives across her mandibles, intent upon sucking its blood. In the woods I came across a number of sassafras trees with the small green drupes showing among the leaf clusters at the end of the branches. These round drupes containing the seeds

[1] *Dichromorpha viridis.*

on long stems are aromatic in flavor. Late in the season the thickened pedicles are red while the drupes turn blue. On tasting these drupes, one is reminded of cardamom seeds, and they are capable of making the mucous membrane of one's throat somewhat irritated and sore.

A trip to this region would not be complete without viewing the agile, striped lizards common on the sand. One has to be quiet in approaching them, for they easily take alarm and run with great swiftness to their holes, which are often at the roots of bushes. They have certain selected localities where



Landscape in the sand dunes, showing the habitat of the striped lizard. The shrubbery and such plants as puccoon afford cover for them.

they can almost always be found. I present herewith a photographic view of the plant associations which is also the habitat of this striped lizard. It was taken in the spring, May 26, 1908.

Such flowers as lithospermum or puccoon and *Arabis lyrata*, and also oak leaves, sparingly covered the ground. I have known two such localities for a number of years past where lizards remained constantly. I frequently found them here, climbing on the branches of the bushes after insects and running across the sand.

The blow snake is also a common resident here. While walking along near a bog under some trees, I heard a friend some distance away make a noise as if pounding the ground with a cane. I hurriedly went to him and found that he had disabled a large snake, which was partially coiled on the ground. My friend told me that he had flattened its head with blows from his cane. This appearance, however, was due to the habit of this snake, when alarmed, of distending its head and neck laterally into a flat cobra-like appearance, such as is common among certain poisonous snakes. My friend described the sound made by this individual as being not unlike that of the cicada or, perhaps, it is better compared to the noise made by a clock spring when it is running down. These snakes are richly marked behind the head with wedge-shaped black bands. There are three rows of black spots along the back. The middle row is of large size, while the side rows often alternate with the middle row, the spaces between the spots being yellowish. The tail in this species is very short. I have given a photographic portrait of this snake as a tailpiece to this article. It is commonly known by the name of puff-adder, or hog-nose, as well as by its scientific name, *Heterodon platyrhinus.*

Again, on my way I found several species of St. John's wort, though the pretty yellow flowers are somewhat scarce. The various blueberries were abundant on the wooded dunes and were refreshing, at times through the day keeping my throat from being parched by the heat. The smaller wild species, with the bloom on the berries, was soon found to possess the best flavor. The berries without bloom of another species have larger and harder seeds, are blacker, and inferior to the taste. The ever-present boneset was seen at the margins of the bogs. The peculiar leaves of this plant, it will be recalled, are joined at their bases, so that the stems appear as if they perforate the leaves. The sand cherry, *Prunus pumila,* grew at the margin of the Calumet River. The cherries were lusciously ripe, and after eating a few, one is apt to feel a dislike for their pungent flavor.

Perhaps the most æsthetic flower here was the rose pink, *Sabattia calycina.* I have never seen it growing in such abundance as I found it here along the edges of the ponds. The five-petalled pink flowers form in some instances a flat top. Each flower is beset at the centre with a small yellowish green star, which, coupled with its sweet fragrance and square stem, gives this member of the gentian family a distinctive character.

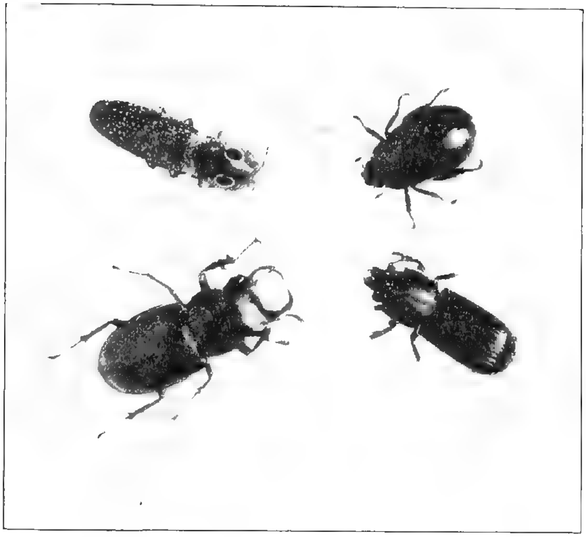
As a parting word with reference to the plants, perhaps I have overlooked in the foregoing remarks an important member of the pea family. It is *Cassia chamaecrista,* abundant on the sand among the open groves of oak. Then, too, this is the country of the prickly pear cactus, *Opunta humifusa,* though it is not quite so abundant here as at Dune Park, five miles east of Miller. To the entomologist this region is a paradise, there being hosts of dragon-flies and other insects about the ponds and along the river. At one place in the woods I saw some large neuropteroid insects on the trunks of the oak trees.

A week later, after spending a rainy day here, I took a winding road beside a pond. I suddenly came upon a large bullfrog, *Rana catisbiana.* It was seated squarely in the middle of the road, and stared intently at me. The size of this frog, which outmeasured any I had ever seen, would indicate that it had doubtless led a life of many years among the seclusion of the dunes. It submitted without much resistance to capture, and became very tame in captivity. After a time it would lower its head at my approach to have its head caressed. But as it failed to take the required amount of food I finally restored it to liberty. Once more its low bellowing notes sounded over the spring pond, while I still retain its photograph, which is presented here in its natural colors for the pleasure of the reader.

The Blow Snake in a sleeping attitude. When threatened it often flattens its body against the ground.

THE GREEN BULL-FROG
(*Rana catisbiani*)

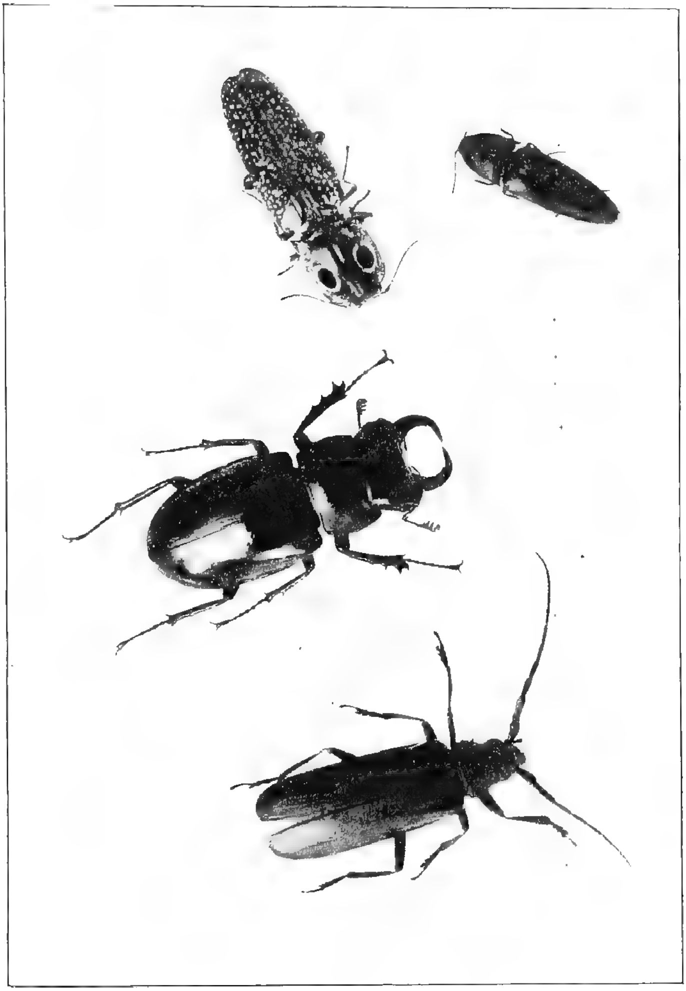
It often changes color, becoming darker when living in deep water of large ponds, but when on land in the warm bright sunlight, becoming a beautiful yellow green.



NIGHT INSECT VISITORS TO OUR DOORWAY

AT night I often set out a kerosene lamp, both as an attraction to the various insects, as well as to divert the attacks of mosquitoes. The insect visitors that were in this way drawn to our doorway were often made up of the most unexpected species. Each night seemed to have its peculiar arrivals. Sometimes it was moth night, again it was beetle night, and on several occasions even the strange long-legged harmless flies, known as Tipulas, were found among the assemblage of those that sought to become light-hypnotized. In fact, from the daintiest minute moths to the formidable stag beetle, there were always enough comers on hot summer nights to satisfy our keenest entomological enthusiasm. Perhaps the most weird insect among these visitors was the eyed-elater, or click beetle, as he is more often called. I have pictured him herewith in company with his associates. He is possessed of two eye-like spots on the thorax, which are velvety black, surrounded by a light ring. They are not real eyes, the true optics being quite small and situated, one on each side of the head, near the base of the antennæ. When these insects are touched they snap up from the ground as if provided with a spring.

Again, with a loud buzzing sound, the stag beetle comes into our midst, closely followed by the antelope species. Not the least interesting was the spotted Pelidnota, which fell in readily with the procession. Springing out of the darkness into the light with great suddenness, this attractive lot of insects kept us well supplied with biological material. I must recall some of the interesting sights dating from the first week to August sixteenth. At this time the long-winged forms of crickets which live in the nearby fields begin their flights. Sometimes one, or as many as two or three at a time, would come to the light, and at the end of twenty minutes as many as thirteen were counted. These were of the species known as *Nemobius fasciatus*, shown in the photographic illustration at the end of this article. They came about 7.30 P.M. and were accompanied by the usual moth frequenters. Perhaps the most interesting arrival I have yet recorded was the mole cricket. On the sixteenth we were visited by one of these insects, which was shortly after followed by another. One came down upon the wooden platform with a thud and flew almost under my hands, as I was catching one of the small crickets. Finally, a green forked-tail katydid and a single female short-horned green grasshopper came to the footlight, closing the performance for that night.



Beetle visitors to the lantern light. Upper figure to the left is the eyed-elater (Alaus oculatis); the one to the right is also a click beetle. The largest figure in the middle is the stag beetle (Lucanus dama); the lower one is a longicorn beetle.

The Bumblebees' Night Camp

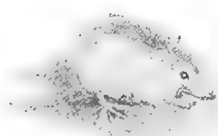
IT is eventide and the busy day is nearly at a close. How majestically the July sun subsides below the horizon as one views it in the open! Nature lapses into a stillness that gradually supersedes the multitude of sounds made by birds and insects. The roseate tints of the sky presage the coming of night. Now turning our footsteps into the wild pasture-land, I find the red, black-spotted milkweed beetle, Tetraopes, still astir on the blossoms of the large milkweed, though the watch indicates seven o'clock. A bumblebee is fumbling among the blossoms, taking such sweets as come easily within reach. Its flight of a few feet, to another plant, is noticeably lazy, the bee not daring to trust itself to take a long journey in the evening twilight. As the moments pass, the insects settle down for the night.

Here is a suggestion as to the bees' night camp. What has become of the army of bees that we saw during the day; for instance, those on the button-bush, the blossoms of which were fairly teeming with them? With this question in mind we pass a few more steps to inspect a rich cluster of bergamot

A Branch of the Button-bush (Cephalanthus occidentalis), showing the flower and visiting bumblebees.

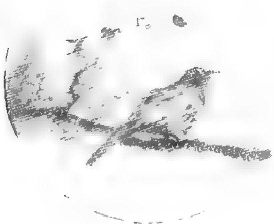
displaying about ninety blossoms. Here, perhaps, we may find an answer to our inquiry. Near the centre of this festive array there are two bees which have retired for the night, not a motion of their bodies being visible. One is *Bombus virginius*, fast asleep, with her body hanging upside down, her feet carelessly grasping the flower bracts just under the flower. The other smaller *Bombus vagans* sleeps with its second pair of legs spread apart, while its body rests upon the upper surface of a blossom. This recalls to mind that but an hour before some of the bees were seen spending their time making their toilets. With dainty combing they got rid of the superfluous pollen and dust from their antennæ and legs preparatory to the night's rest. Further search showed that the few bees we found on the various blossoms at evening are but a small portion of these insects seen during the day. What made them so numerous on the button-bush flowers was simply the allurement of sweets and nectar. Awaken one of the bees from its slumbers and it will respond with a loud buzzing of wings. Perhaps, before quieting down again, the insect will change its position to another flower or stem, but it will not condescend to fly away. At last it may drop to the ground, where it is soon securely hidden among the herbage. Comstock relates that the first broods of Bombus are workers that relieve the queen of her duties, with the one exception of laying her eggs. In the late summer young queens live in the nest with males and females, but in the autumn the colony disbands, and scattering about, finally perishes, leaving only the young queens, which pass the winter by hiding in some out-of-the-way nook.

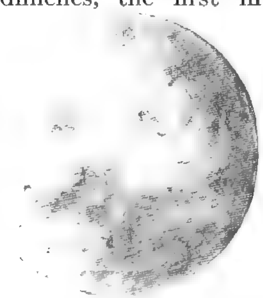
About the time the last bird sounds are dying away, and the bees have gone to rest, the sphinx moth, *Celerio lineata*, comes out from its day hiding-place. It whirls about with rapid flight, dipping here and there into the flowers for nectar. Then come legions of night-flying moths, along with an entirely new animal populace which have shifted places. The nocturnal forms reign now, while the diurnal are asleep. A peep into the deep woods tells us that the little white-footed, and also the jumping mice, *Zappus hudsonius*, have just opened their beaded eyes for an all-night play. Few of us appreciate this magnificent procession of life, much less grasp its meaning. One who will take to the wild pasture land at eventide, relying on the native flora and fauna as companions, will find demonstrations of the many secret problems in the adaptation of life.



The Birds and Squirrels' Assemblage Ground

If one were to ask what tree was the most attractive to birds, almost the first thought is the mulberry tree. Aside from the apple orchard, the presence of one or more of these valuable trees is a great invitation in fruiting time to the birds and squirrels. One summer a kingbird passed back and forth before our veranda, making constant visits to the mulberry tree. Here was often gathered an assemblage of birds from every quarter of the grounds. The branches were fairly weighed down by the avian visitors as they got out on the small branches to pick the luscious berries from the stems. To enumerate the species witnessed one day: Besides the kingbird above mentioned, there were four goldfinches, the first in point of numbers; two robins, three catbirds, and two waxwings. The kingbird remained long enough to partake of a few berries to satisfy his hunger, then, selecting a choice one in his bill, he flew to his nest in a nearby elm tree to feed his young. The bluebirds were also seen feeding on these berries, and a pair on our grounds made frequent journeys to one of these trees, carrying





the berries off to their young, who lived in a box provided for them.

In the last of June and early July, the little red squirrels made the mulberry tree their favorite resort. If the red squirrels are not found in their highways, frolicking and playing hide-and-seek over the outstretching limbs of the beeches, or bounding over the adjacent oak boughs, one will very likely find his majesty saddling a crotch in the mulberry tree, with a berry in his forepaws, contentedly enjoying his usual meal of mulberries. He paid no attention to me when I quietly stole up near the tree for better observation, having become accustomed to my presence, but let a mischievous dog or a stranger come near and instantly his curiosity is aroused. His black eyes are ever on the alert to detect an enemy. At once his little energetic body becomes aggressive, expressing his dislike by scolding, barking, and whistling, and often emphasizing his emotions by vibrating his tail and body. A moment later and he has disappeared into the thick tangle of the branches of a cedar, where he finally subsides.

While the cherries are ripe, the almost undivided attention of the birds is taken up with them. But a little later the fruit of the mulberry tree begins to ripen. From this period on, for a week or more, the succession of maturing berries is most prolific, and, as above suggested, offers a tempting diet to the winged and bushy-tailed inhabitants. By planting a mulberry tree near cherry trees which ripen at the same time, the usual attacks on the cherries by birds will be very much reduced, as most birds prefer the mulberries.

Besides the mulberry tree, strawberries are considered luscious morsels by the Baltimore oriole. There is no sight more beautiful to the eyes than the brilliant orange-colored male oriole with a crimson strawberry in his mouth, passing in mid-air, back and forth from the berry patch to his exquisite hanging nest. The bird lover may well sacrifice some of these berries for the privilege of viewing this beautiful sight.

Certain preferred localities are often chosen by birds because of their close proximity to good feeding grounds. I met with an incident in the summer of 1904 that shows the preference for certain surroundings chosen by the field sparrow in which to build her nest. In passing along between the rows of some black raspberry bushes, I discovered two nests of this species. In the first nest there were three young birds nearly full fledged. One of the little birds had enough self-possession to stand upright on the edge of the nest and eye me attentively. The other two, evidently not so strong, lay in the bottom of the nest. The second nest also contained three, which opened their mouths as I came near the structure to part the branches. I had seen this second brood on the first of August just out of the egg shells.

The raspberry bushes, while offering a suitable nesting site for the field sparrow, also tempt them with the berries. The parent birds were occasionally seen painting their bills by plunging them into the juicy berries. This action is more for the bird's own refreshment, for their young are fed various insects as well. On the raspberry bushes the kingbird contests the right of ownership of the patch with the field sparrow. I saw him snapping off a berry from a branch, while he was on the wing, with as much skill as a smaller flycatcher catching a winged insect. In this performance the kingbird presents a pretty sight as he flutters and spreads his wings and tail. I saw the bird referred to chase a robin that came near, preferring to enjoy himself in this way rather than eat his meal. He suddenly started in pursuit, keeping close behind the robin, darting in and out among the apple trees, until pursuer and pursued disappeared in the distance.

Assembled on our grounds one may often see a variety of summer residents. During last summer a pair of flickers built their nest in the hollow limb of an old apple tree. The birds were a constant source of enjoyment during their nesting time. I frequently saw them foraging in the woods along the bluff near the lake shore. Here they hunted over the decayed stumps and trunks of trees for ants. The initial letter illustration shows a pair of robins. These birds built their nest on an apple tree on our grounds. The ruby-throated hummingbird and brown thrasher, whose portraits are also presented herewith, formed part of the notable bird assemblage that delighted one's senses throughout the summer.

The Hermit Thrush as a Selective Factor

The food habits of migratory birds, and their bearing as a factor in the control of other organisms, especially insects, form an interesting theme. Until these habits are thoroughly known, we cannot hope to elucidate some of the fundamental problems of evolution in insect forms. That birds exercise a selective power and that this unconscious selection is a factor in the modification of insects has long been maintained. Taking one common bird like the hermit thrush, we find that it consumes a great number of insects.

This thrush is a very common migrant in Michigan and Illinois. It has the same general habits as the Swainson thrush, with the exception that it is not so shy. It may be seen silently moving about in the woods among the underbrush, and when startled it has a tendency to fly straight until it nearly reaches its selected branch, when it gives a sudden sideways swoop and alights. Then, gently raising and lowering its tail, one is treated to the low uttered "chuck." It rarely sings during migration.

In the spring it arrives between April twelfth and the middle of May. On the return migration in the fall, it remains only from the middle to the last of October. This species, like many other migrants, is influenced somewhat in its time of arrival and departure by the condition of the weather. It usually comes in great abundance.

Forbes, in writing of the hermit thrush, says: "Considering the fact that all these birds travel slowly the whole length of the State, merely keeping pace with the advancing and retreating seasons, and also that the species is a very abundant one at the period of migrations, it will be seen that its food has great economical significance. There is reason to suppose that these migrants, in passing north and south, follow year by year about the same route; do not vary, that is, far to the east or west. Consequently, occupying, as we do, a State that lies in five and a half degrees of latitude, we can do much to protect this species in its wanderings, or can, if we choose, almost entirely eliminate the part of it passing over our territory (Illinois). Twenty-one hermit thrushes were taken during the year, two in October and the remainder during the spring migration. All but five of these birds were shot in extreme northern Illinois, at Waukegan, Evanston, and Blue Island. Eighty-four per cent of the food consisted of insects, four per cent of spiders, and twelve per cent of thousand-legs; ants amounted to fifteen per cent, butterflies and moths nineteen per cent, and Diptera only to three. Beetles make thirty per cent of the food, four per cent are water beetles, five per cent scavenger beetles, two per cent weevils, and two per cent plant beetles. Leaf chafers and spring beetles amount to one per cent each — the latter chiefly of the genus Melanotus. Eight per cent of the food was bugs, nearly all of which were predaceous. Grasshoppers (Tettix and Tettigidea) make seven per cent of the food."

"Respecting the number of beetles eaten by this bird, we have to remember that it passes us at the time of that great outpouring of insect life connected with the pairing of the spring beetles which we have already seen to have a very significant relation to the food of birds. It rides northwards, in fact, on the crest of this beetle wave, and we find the same excess of predaceous beetles in its food which occurs in the food of the other thrushes at the same season. Concerning the two October specimens taken in northern Illinois, I need only say that they had eaten ants, caterpillars, ground beetles, weevils, burrowing bugs, and grasshoppers, spiders, Iulidæ, and larvæ of March flies. The habits of this bird suggest that the principal drain on the number of predaceous beetles may be due to the depredations of the migrants at the season of the greatest exposure to these insects; and that the complete destruction of resident birds would affect the number of these carnivorous insects much less than would at first seem likely."

After reviewing this array of insect food consumed by one species of bird, it is readily conceived what a pronounced effect the combined action of many species would have in controlling the number of insects. Especially is this factor of insect control an important one in the spring, when it is remembered that many of these hibernating insects are the sole survivors of many that have perished through the cold winter.

Other birds have been studied in relation to their food supply

The Hermit Thrush, a migrant in this region. Its food supply consists of a great variety of insects, and on this account it is an important biological factor.

by Forbes. Those especially interested in this subject will also find much of great value in the researches carried on by the staff of the Department of Agriculture at Washington, concerning the hawks and owls by Fisher, the woodpeckers, the meadow lark, and the Baltimore oriole by Beal, and the common crow by Barrows and Schwarz.

VIII. ECOLOGY — INTERPRETATION OF ENVIRONMENT AS EXEMPLIFIED IN THE ORTHOPTERA

VIII. ECOLOGY — INTERPRETATION OF ENVIRONMENT AS EXEMPLIFIED IN THE ORTHOPTERA

Sources of Life after Glaciation

At the time of the glaciation of North America, the lower Lake Michigan region, with which we are here interested, was submerged in an ice sheet. (See map,[1] page 319.) The lake formerly extended over a much wider area than it does at the present time. All the life now occupying this region has become established here since the decline of the glacial ice sheet. Whence comes the source of life found here at the present time is not fully determined. But much thought has been expended on the general subject of post-glacial dispersal of North American animals and plants by workers in this field. Especially notable are the researches carried on by the United States Biological Survey. Adams[2] and others have given special attention to this most interesting subject, and the reader is referred to their published papers. In general, it may be said that the fauna and flora of the northern United States, east of the Great Plains, are geographically related to those of the southeast. In other words, from the southeastern part of the United States we have derived a great part of our fauna and flora, except in the case of some species which are supposed to have their origin in the north.

Other species are also known to have come from the arid, southwestern part of the United States. The Mississippi Valley has been an important highway for the dispersal of forms from the southeast. The study of the local flora and fauna over great areas will ultimately throw much light on

[1] See Leverett's published map in one of the Bulletins of the Geological and Natural History Survey of Illinois, published by the Chicago Academy of Science.

[2] *Biological Bulletin*, Vol. IX, 1905, and others.

the source and dispersal of species. There are many observed ways by which plants and animals are disseminated. For instance, in plants, the wind is perhaps the most important means of scattering seeds and fruits. Examples of this method are shown in the winged fruit of the maple, and the fluffy seeds of the milkweed and thistle. Water, also, has been another factor of great importance, as well as snow and the wind combined.

Animals aid the dispersal of fruits and seeds by eating the fleshy, edible kinds, such as the cherry, bittersweet, raspberry, and the poison ivy; the undigested seeds being dropped in the excreta. There are also explosive fruits and seeds that possess a peculiar mechanism for shooting the seeds some distance away from the place of growth, while still others are provided with creeping mechanisms. Lastly, man has inadvertently scattered many weed species which were contained in adulterated clover and other crop seed. Free-moving animals, through migration, become widely dispersed, the wind here, as in the case of seeds, aiding them in these movements into new fields. Young mollusks which frequent ponds are often carried on the feet of water birds and thereby transported to new and similar habitats where they may start a new colony.

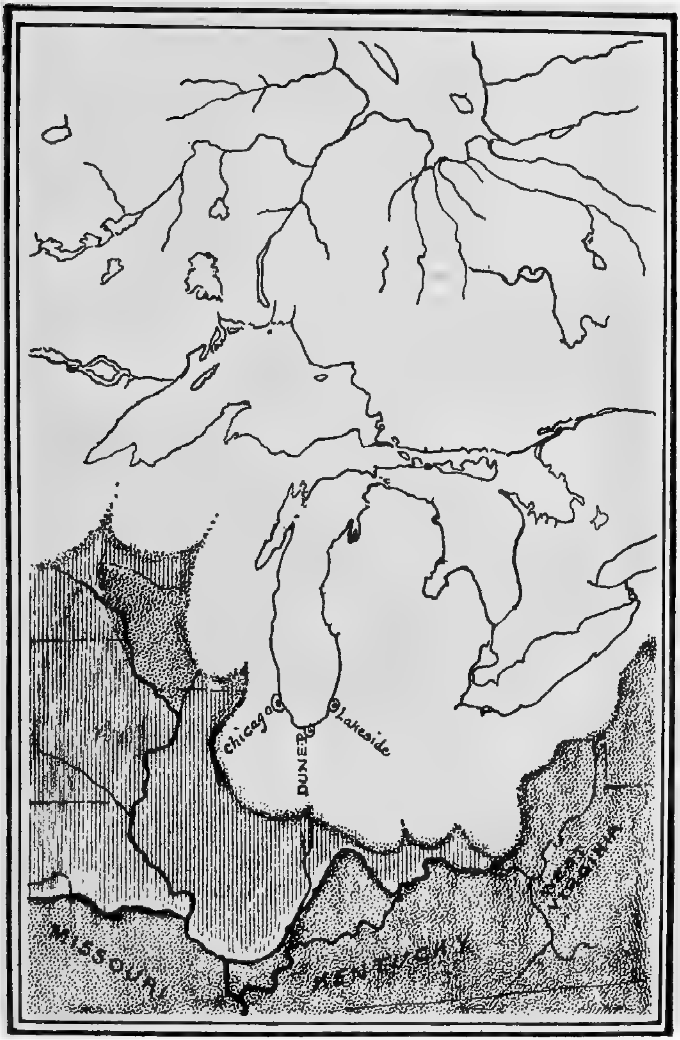
Habitats of Plants and Animals

Merriam and Allen, as well as others, believe that definable life zones are apparent over different regions of North America. The dependencies upon the habitat of free-moving animals, however, are not often clearly perceptible. These relations of the environment are generally not so evident, for instance, as the physical effect that water or light exerts upon fixed plants. But in some special cases they are quite marked. The physiographic features in the landscape doubtless have a great deal to do with determining the habitat of animals and plants. The real habitat of an animal is determined by the place in which it habitually breeds.[1]

Woodworth,[2] in an article on "The Relation between Base

[1] See classified habitats at the end of this book.

[2] *American Geologist*, XIV, 1894.



Map of the Great Lakes Region, showing the former glaciated area. White portion indicates ice sheet; the fine vertical lines, older drift; fine dots, driftless area. Chicago, Dune Park, and Lakeside, Michigan, noted.

Levelling and Organic Evolution," has shown that base levelling processes influence the evolution of a species by erecting new and destroying old barriers. In this way there is caused isolation, or intervention of crossing between a separated section of a species or kind on the one hand, and intermingling of species on the other. Clements[1] remarks that the beginning of all the primary and many secondary successions of plant life is to be sought in physiographic processes which produce

A view on the Des Plaines River. At the edge of the stream aquatic plants such as Sagittaria and reeds abound, affording a perfect habitat for dragon-flies and diptera. The shores are skirted with these hydrophytic plants, and farther back are shrubs and tree societies.

new habitats or modify old ones. On the other hand, most of the reactions which continue successions exert a direct influence upon the form of land. Along this line, Cowles[2] has recently asserted that, according to well-defined laws governing topographic geography, namely, the action of water in producing denudation and deposition and ultimate base levelling, there occurs at the same time a succession of plant societies which, after a time, reach a climax stage. As years pass by,

[1] "Research Methods in Ecology."
[2] *Botanical Gazette,* 1901.

one plant society must necessarily be supplanted by another, though the one passes into the other by imperceptible gradations. This implies that environmental influences are cumulative, that is — a plant society is not a product of present conditions alone, but the past is involved as well.

Great emphasis is placed upon border lines or zones of tension, for here, rather than at the centre of the society, one can interpret the changes that are taking place. The various plant societies pass in a series of successive types, from the original hydrophytic condition through the xerophytic, to a final mesophytic forest, the latter being regarded as a climax, or culminating type. The trees making up this kind of forest are often able to propagate from seeds within their own shade. Sometimes, however, this order is not the one followed, as retrogressive steps away from the mesophytic condition toward the hydrophytic, or xerophytic, phase occur. Moreover, "Changes may take place in plant societies more rapidly than in the topography." On this assumption Cowles maintains that in this region, as well as in the extensive area of the United States east of the Mississippi, such forest trees as the beech and maple have better chances ultimately in the contest for space and time.

In this case, societies of the small field daisy or thistle, which are higher in the scale of evolution, will give way to tree forests. Here we are reminded of Clodd's[1] remarks about the daisy, and he might have added the thistle: "Its position among plants corresponds to man's position among animals. As man, in virtue of being the most complex and highly specialized, is at their head, albeit many exceed him in bulk and strength, so is the daisy with its allies, for like reasons, above the giants of the forest."

Clements, in the work previously cited, remarks in regard to the dependencies and habitat of animals: "Vegetation indeed, as the source of food and protection, plays a more obvious, if not more important part. This is especially true of anthophilous insects, that is, those that visit flowers, but it also holds for all herbivorous animals and through them for carnivorous ones. The animal ecology of a particular region can only be properly investigated after the habitats and plant formations

[1] "Primer of Evolution," 1895, pp. 55, 56.

have been carefully studied. A great deal can be done in the way of listing the fauna, or studying the life habits of its species, without any knowledge of plant ecology, but an adequate study must be based upon a knowledge of the vegetation. Although animal formations are often poorly defined, there can be no doubt of their existence. Frequently they coincide with plant formations, and then have very definite limits. They exhibit both development and structure, and are subject to laws of invasion, succession, zonation, and alteration, though these are not altogether similar to those known for plants, a fact really explained by the motility of animals. Considered from the above point of view, zoö-geography is a virgin field, and it promises great things to the student who approaches it with the proper training.[1]

Nature's Reclamation of Sterile Ground

When a portion of the surface of the earth is denuded, that is, all the vegetation has been removed, the new area becomes inhabited by plant life of a pioneer type. When this ground is not shifting by action of the wind, certain algæ, fungi, composites, grasses, or weeds initiate a formation. As time goes on, this new formation of vegetation may be succeeded or supplemented by another or secondary vegetation, having migrated from the adjacent areas.

The ordinary sequence of vegetation forms in succession is; first: algæ, fungi, and mosses; second: annuals and biennials; third: perennial herbs; fourth: bushes and shrubs; fifth and lastly: trees. The stages or formations of a succession are distinguished as initial, intermediate, and ultimate; the number of species occupying a denuded area is small in the initial stages, becomes large in the intermediate, and again decreases in the ultimate formation because of the dominance of a few species supposed to be created by competition. There is a universal tendency to stabilization in vegetation, grass being the ultimate stage of succession for prairie lands, while forest is the last stage for mesophytic midlands and lowlands of the temperate region.

[1] Bailey Willis has treated this subject in a recent interesting article entitled "Paleogeography," in *Science*, Vol. XXXI, p. 251.

The competition which takes place has been well described by Clements, who says: "Competition is a question of the reaction of a plant upon the physical factors which encompass it, and of the effect of those modified factors upon the adjacent plants. In an exact sense, two plants do not compete with each other as long as the water-content and nutrition, the heat and light, are in excess of the needs of both. The moment, however, that the roots of one enter the area from which the other draws its water supply, or the foliage of one begins to overshade the leaves of the other, the reaction of the former modifies unfavorably the factors controlling the latter, and the competition is at once initiated. The same relation exists throughout the process; the stronger, taller, and more branched, or the better rooted plant reacts upon the habitat, and the latter immediately exerts an unfavorable effect upon the weaker, shorter, less branched, or more poorly rooted plant. This action of plant upon habitat, and of habitat upon plant, is cumulative, however. An increase in the leaf surface of a plant not only reduces the amount of light and heat available for the plant near or beneath it, but it also renders necessary the absorption of more water and other nutritive material and correspondingly decreases the amount available.

"In the competition between parents and offspring of the same perennial species, the former usually have so much the advantage that the younger plants are often unable to thrive, or even germinate, and they disappear, leaving a free space beneath and about the stronger parents. This illustrates the primary law of competition, *viz.:* that this is closest where individuals are most similar."

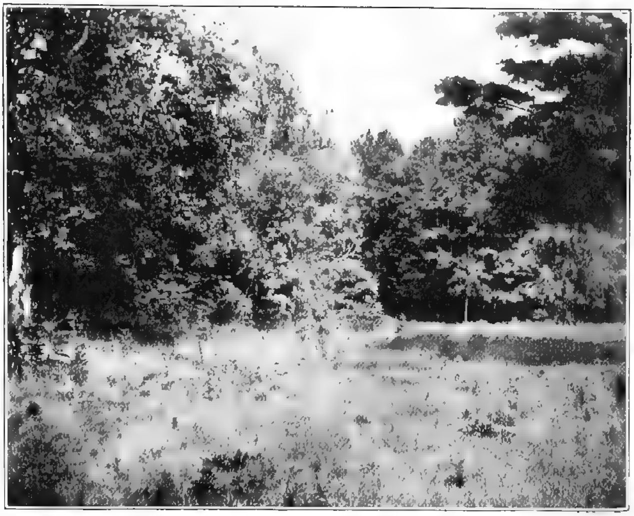
The effect of distance, or the interval between individuals, upon competition is fundamental. The competition increases as the interval diminishes, and the reverse. Masses of vegetation are commonly thought to force the weaker species towards the edge, thus initiating an outward or forward pressure, but in all probability competition is purely physical in nature. The movement outward that does occur is due to simple migration, followed by the germination and establishment of invaders, taking an indeterminate course in their operation of competition.

Two common plant associations occurring in the sand areas of this region are the prairie and the forest formation. In the former it is characterized by bunchgrass, the blow-sand and blowout associations. In the forest formation the common one is the black-jack oak association. These sand areas, notwithstanding their sterility, offer favorable habitats for many species of insects and plants. The animals frequenting them can, in some cases, be separated into biological groups. On these barren areas I have found insects and spiders enjoying a life of busy activity. The predaceous tiger-beetles, robber-flies, bembecid wasps, jumping and tube-constructing spiders, as well as various locusts are seen in considerable numbers, the latter flying about or living on the bare sand. It is in the richer vegetation and older formations among the middle and culminating formations, that is, where the water-content is greater in the soil, we find a corresponding fertility in animal and plant life. In the next chapter I have given a more detailed account of the various species of Orthoptera, or locusts and grasshoppers, as related to their habitats.

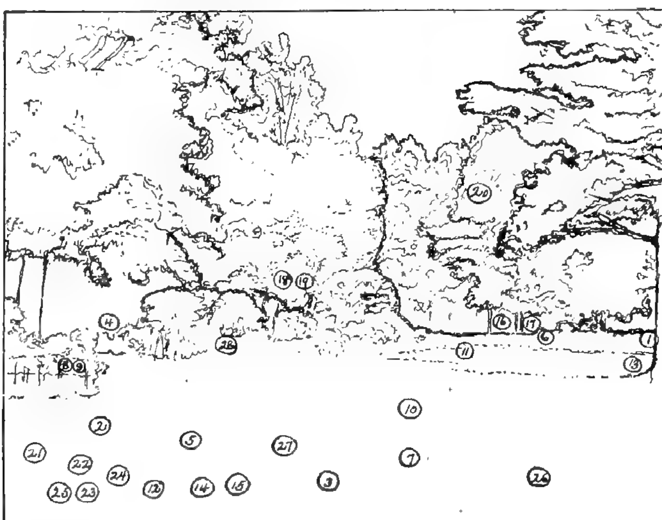
The Habitat of the Orthoptera

Few of us realize how perfectly adapted the Orthoptera, or grasshoppers, are to their habitat. Locally, they are often associated, like plants, into groups, and show a predilection for soils possessing various degrees of humidity. This class of ground-loving individuals are characterized as geodytes. Other forms, like the katydids and tree crickets, prefer living on trees, shrubs, or herbaceous plants, and these are characterized as phytodytes, in contradistinction to the first-named class. The various subdivisions of habitats are defined at the end of this section. I present herewith a photographic reproduction of an August landscape which is rich in Orthopteran life. It is noteworthy from the fact that it shows a variety of "habitat zones," or areas inhabited by grasshoppers. It presents a deciduous forest in the background, with a sandy foreground, over which mesophytic plant societies have become established.[1] I will presently show the relation of these plant societies to

[1] Mesophytes make up the common vegetation in temperate regions where the soil is rich in humus, with a medium amount of moisture present.



A landscape view showing the habitat of Orthopteran life. Here is shown a deciduous forest in the background and mesophytic plant societies in the foreground. Taken at top of bluff near the shore of Lake Michigan. The numbers in the tracing below show habitat of each species.



Outline tracing to show the habitat of the various species of grasshoppers mentioned in the text. The numbers in the circles correspond to the species given in the text, commencing with the walking-stick, No. 1, and ending with the four-spotted tree cricket, No. 28. Only those Orthoptera actually seen are included here.

Orthoptera, first enumerating the species of these insects that I found in August, as follows:

1. The walking-stick (*Diapheromera femorata*).
2. Clear-wing locust (*Camnula pellucida*).
3. Short-wing brown locust (*Stenobothrus curtipennis*).
4. Yellow-wing locust (*Arphia sulphurea*).
5. Varied-wing locust (*Arphia xanthoptera*).
6. Sprinkled locust (*Chlœaltis conspersa*).
7. Carolina locust (*Dissosteira carolina*).
8. Maritime locust (*Trimerotropis maritima*).
9. Mottled sand locust (*Spharagemon wyomingianum*).
10. Lubberly locust (*Melanoplus differentialis*).
11. Two-striped locust (*Melanoplus bivittatus*).
12. Lurid locust (*Melanoplus luridus*).
13. Grizzly locust (*Melanoplus punctulatus*).
14. Narrow-wing locust (*Melanoplus angustipennis*).
15. Red-legged locust (*Melanoplus femur-rubrum*).
16. Blatchley's locust (*Melanoplus blatchleyi*).
17. Green-legged locust (*Melanoplus viridipes*).
18. Texan katydid (*Scudderia texensis*).
19. Fork-tail katydid (*Scudderia furcata*).
20. Arboreal katydid (*Cyrtophyllum perspicillatus*).
21. Short-wing green grasshopper (*Xiphidium brevipenne*).
22. Striped green grasshopper (*Xiphidium fasciatum*).
23. Dorsal-striped grasshopper (*Xiphidium strictum*).
24. Smooth meadow grasshopper (*Orchelimum glaberrimum*).
25. Common meadow grasshopper (*Orchelimum vulgare*).
26. Common field cricket (*Gryllus abbreviatus*).
27. Pennsylvania field cricket (*Gryllus pennsylvanicus*).
28. Four-spotted tree cricket (*Oecanthus quadripunctatus*).

In the extreme left of the landscape view is a sycamore tree, the light bark of the trunk showing quite plainly. In the extreme right the dark masses of foliage and branches are those of a pine, the shadow of the tree being seen on the ground. In the background is a glimpse of a dense woods consisting of maple, oak, some hickory, and beech, but the maples show more conspicuously. A small thicket of sumach, sassafras, and an occasional wild black raspberry brier appear at the border of the woods to the left of the middle of the distance. The sweep of open ground bears a profusion of grasses, white clover, wild bergamot, evening primrose, catnip, wild strawberry, and common milkweeds. In this open foreground, which had never been ploughed, I frequently flushed the clear-wing locust, a detailed account of which will be found in another chapter. It was persistent in its preference for a small area of only a few yards in extent, shown on the left-hand side of the view. This is of particular interest because the species was scarce in other localities thereabout.

In the short grass of the near foreground I also met with the short-winged, brown locust, but it was by no means common, and this would not be called a typical habitat for this species. At the border of the woods, especially as seen in the background, the sprinkled locust found its typical home. When the photograph was taken, August third, a number of these insects were found laying their eggs in pieces of old, dead wood, and the detailed observations given further on relate to individuals found there. In the left of the picture, lying in front of the sycamore tree, is a small light-appearing area of white sand. No vegetation was growing upon it, yet it was of unusual interest. Here, in the proper season, the pits of the ant-lion were very numerous. They have already been referred to in the separate chapter which treats of their habits. Here, also, certain digger wasps, as well as the sand-loving fly, *Stichopogon trifasciata*, were seen.

But of particular moment was the fact that the maritime locust lived on this little, circumscribed, barren spot. With it was associated the mottled sand locust, as will be noted farther on. Both of these species, on being disturbed, circled around, and often attempted to come back again, and would ultimately do so if not prevented. As is well known, both of these locusts, owing to their harmonious colors, are very well protected while they rest on the light sand. The sweep of sunny, exposed portions of the foreground also harbored the Carolina, the lubberly, the two-striped, the clear-wing, the lurid, narrow-wing, and the red-legged locusts, respectively, each species having their period of appearance in greater or lesser numbers.

On one occasion I found a female grizzly locust in the shadow of the pine shown at the right of the illustration, which had probably been on the bark. Again, the walking-stick was frequently seen on the trunk of this tree. This insect also often appeared in the woods and thicket shown here. In the seclusion of the deep woods in the background, and sometimes skirting on the border, I found numbers of Blatchley's locust, and also its nearly allied species, the green-legged Melanoplus. These were found several years in succession among the undergrowth, on the thick bed of the forest among the fallen, dried leaves.

The notes of the arboreal katydid were heard at night during the fall in the maple trees shown in the distant middle background. This species was also noted for a number of years in succession here. The growth of low herbage at the left of the middle, bordering the thicket, fostered many four-spotted tree crickets. This species was often a source of pleasure to study by lantern light at night, while the Texan katydid, as well as the fork-tail species, came in for a share of my attention. The common green, meadow grasshopper with its allied form, — the smooth, green grasshopper, were often found among the short herbage in the foreground. They were not as common as the smaller species of Xiphidium. The short-wing and striped species of the latter genus were everywhere present in the short grass. The crickets were represented by the common, field Pennsylvania species, and doubtless this group was represented by more species that had escaped my attention.

In the late fall the varied-wing locust was an occasional visitor, during its whimsical flights of crossing the open, sunny grounds; while in the spring and early summer the ground in the thicket shown to the left was constantly frequented by the yellow-wing locust.

In addition to the foregoing picture showing special habitats, I present herewith, in the second landscape, a view of the rear of our grounds. It was taken on September eighteenth, at the close of summer, but at the height of the grasshopper season. In the foreground the abandoned strawberry patch, which had formerly been under cultivation, is now given over to "weeds," which have developed in profusion. At the right-hand lower corner of the picture is a bunch of pearly everlasting in full blossom. Its white flowers show conspicuously just in front of evening primroses and golden-

THE MALE TEXAS KATYDID
(*Scudderia texensis*)

Besides the Texas Katydid often found on golden rod in the meadows, the ambush bug (Phymata wolffii) lurks in these flowers awaiting an opportunity to seize some small unsuspecting insect. From a photograph

rods. Cultivated and wild blackberries and dewberries occupy the middle portion of the landscape, on the top of a sandy knoll. Among other plants in view of the observer are the knotweed or Polygonium, ragweed, wild lettuce, and grasses. A superficial humus only, covers the surface of the sandy earth.

The largest tree in the distance to the right is a maple, while in the farther distance, willows appear; the remotest distance

Landscape, showing the habitat of Orthoptera in the rear of the author's grounds. See description in the text.

showing a mixed forest of sycamore, tulip, oak, sassafras, poplar, basswood, butternut, walnut, paw paw, hickory, and flowering dogwood. To the left of the middle, young sassafras trees are shown.

As to the Orthoptera here, as I view the landscape in the warmth of the sun, the varied-wing locust flies across my path. The hotter the day, the oftener he indulges in his aerial flights, which are sure to attract attention by the characteristic crackling sound made by his wings. I will not go into further particulars regarding each species of grasshopper that I found here, but will simply give the following enumeration of the common species. These are sufficient to show the general character of the acridian fauna, as I found it, on the day our photograph was taken.

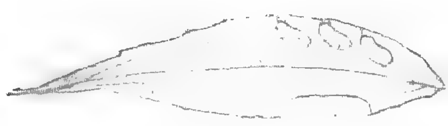
Obscure grouse locust (*Tetrix obscurus*).
Long-winged grouse locust (*Tettigidea pennata*).
Sprinkled locust (*Chlœaltis conspersa*).
Short-winged brown locust (*Stenobothrus curtipennis*).
Varied-wing locust (*Arphia xanthoptera*).
Yellow-winged locust (*Arphia sulphurea*).
Green-striped locust (*Chortophaga viridifasciata*) young.
Carolina locust (*Dissosteira carolina*).
Lubberly locust (*Melanoplus differentialis*).
Mottled sand locust (*Spharagemon wyomingianum*).
Boll's locust (*Spharagemon bolli*).
Leather-colored locust (*Schistocerca alutacea*).
Red-legged locust (*Melanoplus femur-rubrum*).
Narrow-winged locust (*Melanoplus angustipennis*).
Lurid locust (*Melanoplus luridus*).
Lesser locust (*Melanoplus atlanis*).
Small locust (*Melanoplus minor*).
Clouded locust (*Encoptoloplus sordidus*).

THE TEXAN KATYDID

The beautiful, bright green Texan katydid is one of our commonest and yet one of our most interesting species. It may easily be recognized from our plate photographic illustration, which is here reproduced. In the chapter on the Habitat of the Orthoptera, showing a landscape view and the species noted there, I have mentioned the Texan katydid as one of the number represented. It is also referred to under Pasture Insects in August, where I have given a note of its habits. This species frequents damp meadows and pastures, where it lives among such coarse herbage as tall sedges, grasses, lobelia, and goldenrod. When startled, it arises in the air and pursues a noiseless, zig-zag flight just over the tops of the weeds, finally dropping some distance away from the pursuer. At night I have frequently heard its notes along the roadside and located the songster with the aid of my lantern light.

It matures in the early part of August, and then about the middle of the month begins to lay its eggs in the leaves of plants. August thirteenth I found several of these insects in a wet pasture. One of them laid her eggs indoors in a leaf of the goldenrod. She laid them, one at a time, in the edge of a leaf between the two layers of epidermis. She first made a pocket with her blade-like ovipositor, slitting the leaf open at the edge, of sufficient depth to accommodate the egg. Then the thin, flat egg was deposited, and when thus inserted, it caused the spot to appear like a blister slightly raised at this point, and could be easily seen when held against the light, as shown in the tail-piece illustration.

The eggs, which measure about two and one-third mm. wide by five and one-half in length, are laid in an oblique direction, being slightly curved; the posterior pole points in the direction of the base of the leaf. I found that one female laid fifteen eggs up to the time I had last observed her, from one to three eggs being laid in each side of a leaf. They were disposed quite near together, and nearly equal distances apart, when two or more were laid. The leaves drop to the ground in the fall, and the eggs remain there throughout the winter and hatch in the early summer. This species is perpetuated through the winter in the egg state, the young hatching some time in June. The young, which scatter about after hatching, are rarely seen until they attain considerable size, owing to the protection afforded by their harmonious green coloring.



The Home of the Forked-tail Katydid and its Allies

AT the edge of the forest the margin slopes gently to the meadow lands adjoining. Here the masses of foliage are so adjusted that the relations of the leaves to the light are most perfectly displayed. The lofty hard maple, the oak, basswood, and elm would end very abruptly were it not for the natural setting given by smaller trees, which are mingled with black cherry and young butternut. Blending with the latter, but still farther to the outside, are the sassafras and sumach, which grow to tree-like proportions, shown in the landscape view that I have drawn here. Lastly, the sweet-smelling elderberry bushes appear at the outskirts, forming the skirmish line between the straggling flora of meadow and forest.

In July the flowers of these bushes fill the air with an abundance of sweet perfume, attracting myriads of insects for their own selfish needs, while at the same time delighting the æsthetic sense of man. Placed in with exquisite effect, their large white flower heads, together with the red flowers of the sumach, offer a finish which sets all artificial attempts of portrayal at defiance. The open meadow, that I have depicted in the foreground of the landscape drawing, shows the home of the forked-tail katydid. Here too the Texan, round wing, together with the slender meadow grasshoppers, dwell in abundance.

The exquisite forked-tail katydid, shown in the plate photographic illustration, is one of the smallest and daintiest of our species of Scudderia. Its deep green color harmonizes so closely with the background of green foliage that it escapes one's attention as it stealthily moves about or feeds among the bushes at the margins of the woods. It is one of the commonest insects in the damp meadows during the time it arrives at maturity, about the first to the second week in August.

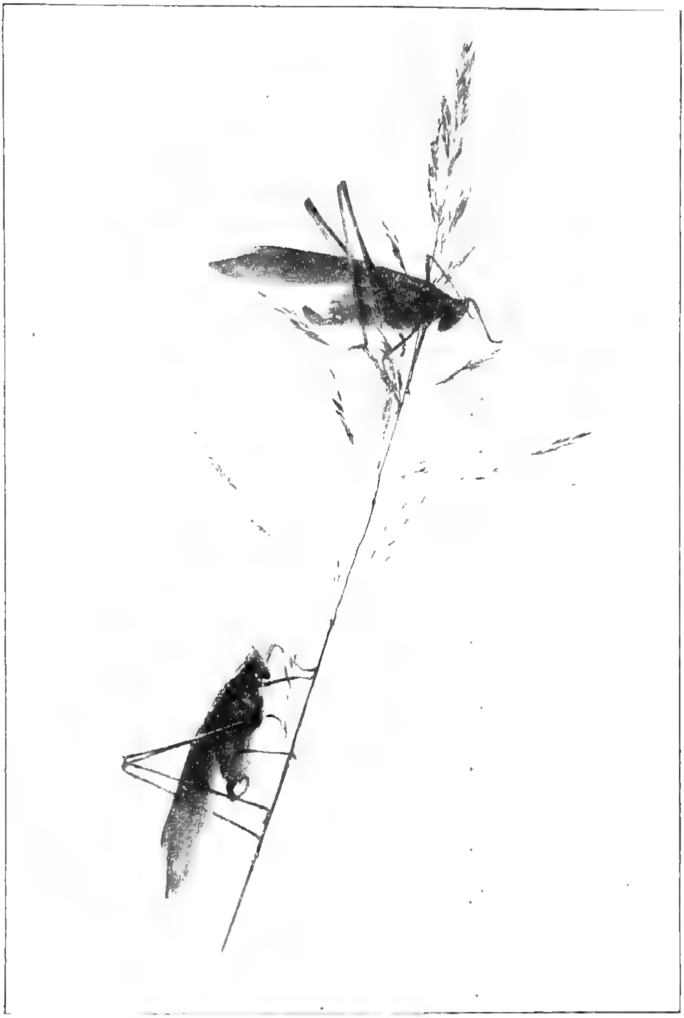
The home of the Katydids. The foreground meadow and shrubbery at the edge of the woods afforded shelter for several species of katydids, including the forked-tailed, Texan, pistillated, and oblong-wing species. Here was also the habitat of the green meadow grasshoppers, crickets, and many locusts.

On August first, I found the first individual, which had just moulted for the last time, and on the fifth another was found undergoing this process. Thereafter adults became quite common. In the meadows it was often associated with the allied Texan and pistillated species. It has a peculiar, wavy flight as it skims quietly over the tops of the herbage some distance away, to alight again, perhaps, upon some weed. In the fall it becomes uneasy, and then is more prone to take longer or shorter aerial migrations at night. At this time they were sometimes attracted to the lantern light left out in front of our door.

Similarly, in searching for insects at night along fence rows, I often came upon individuals of this species on the tall grasses, goldenrods, bushes, and on the tops of fences. Here the males were often heard giving out their musical sounds among the chorus of striped meadow crickets and the oblong-wing species.

Riley says: "The shrill of the male is by no means so loud as that of the oblong-wing katydid, *Amblycorypha oblongifolia*, in which its sound is always drowned in the woods. It consists of a softer *zeep, zeep*, sometimes uttered singly, but generally thrice in succession. The call is occasionally responded to by a faint chirp from the female, produced by stretching out its wings as if for flight, and is as often heard in the day as at night." He further describes this species as laying her eggs as follows: "The female stations herself firmly by the middle and hind legs on twigs or leaves contiguous to the one selected to receive the eggs. This leaf is then grasped by the front feet and held in a vertical position, while the edge is slightly gnawed or pared off by the jaws to facilitate the entrance of the point of the ovipositor. When this is done, the abdomen is curved under and brought forward, and the ovipositor is seized on its convex edge by the mandibles and maxillæ, which, with the aid of the palpi, guide the point to that portion of the leaf prepared to receive it. After gentle, but repeated efforts, the point of the instrument is finally inserted between the tissues of the leaf, and gradually pushed in to more than half its length.

"As soon as the cavity is formed, the egg is extruded, and passed slowly between the semi-transparent blades of the ovipositor.



A pair of Forked-tailed Katydids (Scudderia furcata) on grass plant. The female is shown above, the male below on the stem.

As the egg leaves the ovipositor the latter is gradually withdrawn, while the egg remains in the leaf, retained in place, probably, by a viscid fluid that is exuded with it. As many as five of the eggs are sometimes deposited in one row in the same leaf, but more often they are single."

From the general shape of the ovipositor of the genus Scudderia, it is quite probable that all the members lay their eggs between the epidermis of leaves. The plate photographic illustration accompanying this article was taken from a male and female found at Lakeside, Michigan, in the habitat shown in the view of the landscape in another chapter. Its general range includes the United States and southern Canada, east of the Great Plains.

The slender meadow grasshopper is one of the most interesting as well as exquisite forms of this same group of insects. After the second week in July, scarcely a sweep of the net among the tall grasses and other herbage in the damp meadows would fail to disclose some of these artful little locustids, which had hidden behind some plant stem or grass leaf. Yet, withal, it seemed less wild than some of the allied species. The male, shown in the illustration, on page 333, at the top of a goldenrod and on the same plate with the cone-head grasshoppers, was found by a fence row. Toward the last of July, and later, it often gathered on tall red-top and timothy grasses, as well as on the goldenrod, in association with other locustids and œcanthids.

I have also noted, under the title "Before the August Shower," the habits of this species and its song, which is so faint that it is scarcely audible a few yards away. It was a common frequenter of the weeds and grasses of our grounds, shown in the photographic view of the "Habitat of the Orthoptera." This little locust must have some excellent means of escaping from its enemies and perpetuating its kind, for it is widely distributed, being found from British America to Buenos Ayres, South America.

The Swordbearer

What an opportunity awaits the interested observer in the early days of August! A walk through the nearest meadow can hardly fail to make new acquaintances among the multitude of insect denizens. Though the farmer's mower may have deprived the earth of certain portions of the flora, the undaunted observer finds the low and perpetually wet places, which the scythe has avoided, rich in both floral and faunal treasures. Perhaps in the midst of a field, or at the marshy roadside, the blue flag, or the reeds, and the larger species of Polygonium with pink flowers, along with other plants belonging to a like group, will be found flourishing in luxuriance. Here the green meadow grasshoppers swarm before one's footsteps, jumping in confusion, especially when fording through the high herbage. Beyond, in the vigorously growing timothy grass, a shrill sound is heard from various places almost simultaneously. In the same environment Orchelimum and the crickets are mixed in the medley, which makes their notes at times almost indistinguishable.

On listening carefully, one discerns a continuous, high-pitched *z-e-e — z-i-p*, which is so shrill that it might easily be mistaken for the note of a cricket. If one were fortunate enough to trace the shrilling to its source, the pea-green songster would be found secreted among the grass blades. His color is a becoming shade against the same tinted background. What a picture this cone-head katydid presents during the height of his musical performance! In answering his rivals, his enthusiasm seems to rise to a supreme height, as signified by the energy exercised in rubbing his outer wings together in rapid vibration. Several feet away, a repetition of his orchestration is heard in the grass, and again following the sound to its source, its pretty counterpart is found. This experience may be repeated a number of times, each time resulting in discovering the whereabouts of new individuals.

So thoroughly preoccupied is this second musician that the long grasses may be cautiously parted for nearer inspection without disturbing his stridulation. But what a change takes place in his actions when a moment later he has detected us. He takes an entirely different position. In perfect silence, while clinging to a grass stem, he turns his body promptly around to take a more strategic attitude. He then stretches his slender brownish legs upward, alongside the plant, which they closely resemble. If this bit of artifice is not effective in diverting the attention of his foe, he soon tumbles down into the heart of the grass forest, where he now allows his legs to take an indifferent posture.

A proper conception of the home of the cone-head can only be attained by peering closely into this miniature dense forest of wild timothy. Such perfectly adapted surroundings, full of mysterious shadows and recesses, have many points of interest to insectdom as well as to the naturalist. In the midst of this maze of green and brown stems and leaves, we have come upon the secret of his peculiar, conical-shaped head, which is never fully appreciated morphologically, unless the insect is seen under exactly similar circumstances to those here related.

On careful inspection he may be seen lying immovable, with his pointed head stuck down among the grass roots, causing the body to assume an exact resemblance to a narrow green leaf, while his brownish legs, which are nearly invisible, project in perfect likeness to plant stems. He deftly remains quiet here for several minutes, when, concluding that the danger has passed, he tremblingly stirs his body slightly. If satisfied there is no further danger threatening, he stealthily moves with great caution upward on the grass near to his former perch. Soon afterwards, forgetting the past experience, he again joins in the meadow chorus.

In the same surrounding we may find the cone-head's mate, presenting quite a difference in certain details of the anatomy; notably, she is provided with a long sword at the end of the body, with which she inserts her eggs between the stems of plants. Owing to this peculiarity, this insect sometimes receives the name of swordbearer, but the scientific name, Conocephalus, refers to the cone-shaped head, and is an appropriate appellation. In her sphere of life she does not have occasion to audibly express her desires or sentiments, and by reason of this fact she has no special organs of stridulation. The species forming the subject of our sketch is the slender cone-head, *Conocephalus attenuatus,* or *ensiger* of some authors.

A pair of slender Cone-head Grasshoppers (Conocephalus attenuatus) on goldenrod. Upper figure female, lower figure male. These insects are often captured by the large golden wasp (Sphex ichneumonea), and stored in her underground burrow for her grub to feed on.
See also Colored Plate, facing page 22.

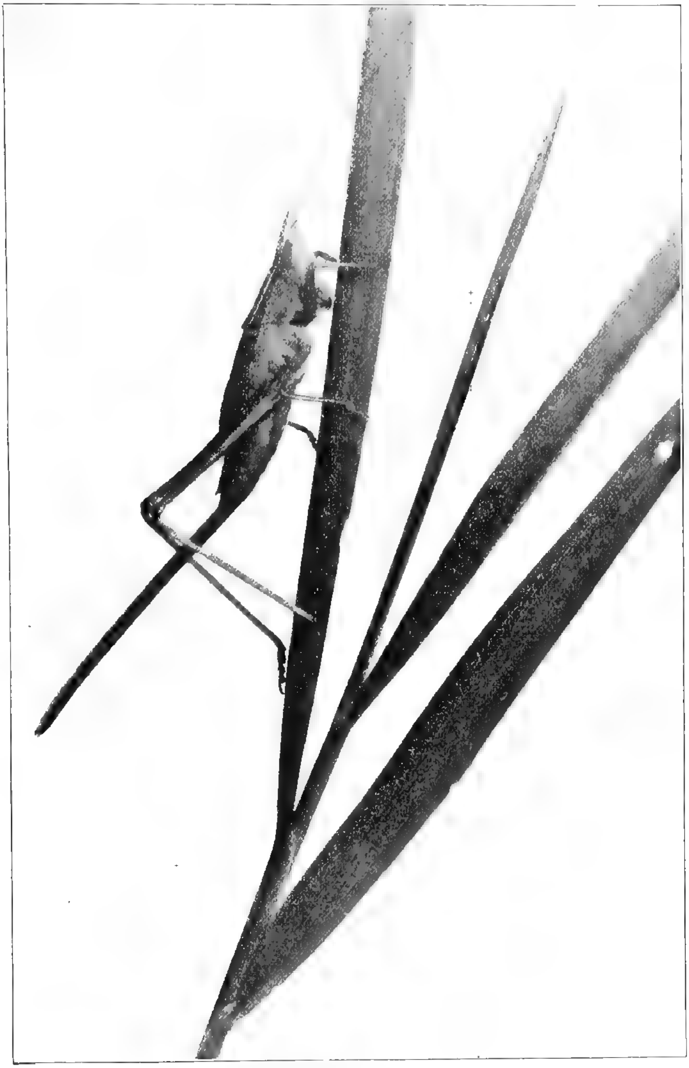
The slender cone-head, like its rarer relative the robust species, stridulates during cloudy weather in August, and the notes are particularly vigorous during the night hours. The notes of the robust cone-head are distinguished from those of the slender species in being much louder. The shrilling is more continuous and is accompanied by a resonant humming at once perceptible as one approaches near the insect, recalling the notes of the cicada.

In the weeded portion of the meadow, the graceful Texan katydid sometimes appears in the same company with the swordbearer. At such times, when the two are approached, the Texan species will more readily take to flight. I have seen them, for instance, fly from the top of the cone flower Rudbeckia, or goldenrod, to a distant point, alighting again on some plant, or they may pitch headlong to the ground. During such flights, the delicate, transparent wings, glimmering in the sunlight, present one of the most æsthetic sights in the meadow.

The Carolina Locust

Among the hordes of grasshoppers that are seen along the roadside and barren fields in midsummer, the Carolina locust is one of the most familiar species. In the open pathway of the observer, either in the city lot, or in the country, one is almost sure to scare up a number of these handsome locusts from the bare ground. When flying, the sombre black wings of this species, which are bordered with light greenish yellow, present a ready mark of recognition. But on the ground, with its wings folded, it is well protected by the various hues on its body of gray, reddish brown, or yellow, which simulate the harmonious background. On a cloudy or rainy day, the same roadsides that are usually favored by so many Carolina locusts often appear uninhabited by them. The locusts under these conditions seek temporary shelter, but they are abroad again as soon as the sun comes out brightly.

When this locust is flushed in the heat of an August day, it starts out with a whirr of the wings, flying with great swiftness in a zig-zag, somewhat choppy flight. In the excitement of rising from the ground, the wings are sometimes caught by

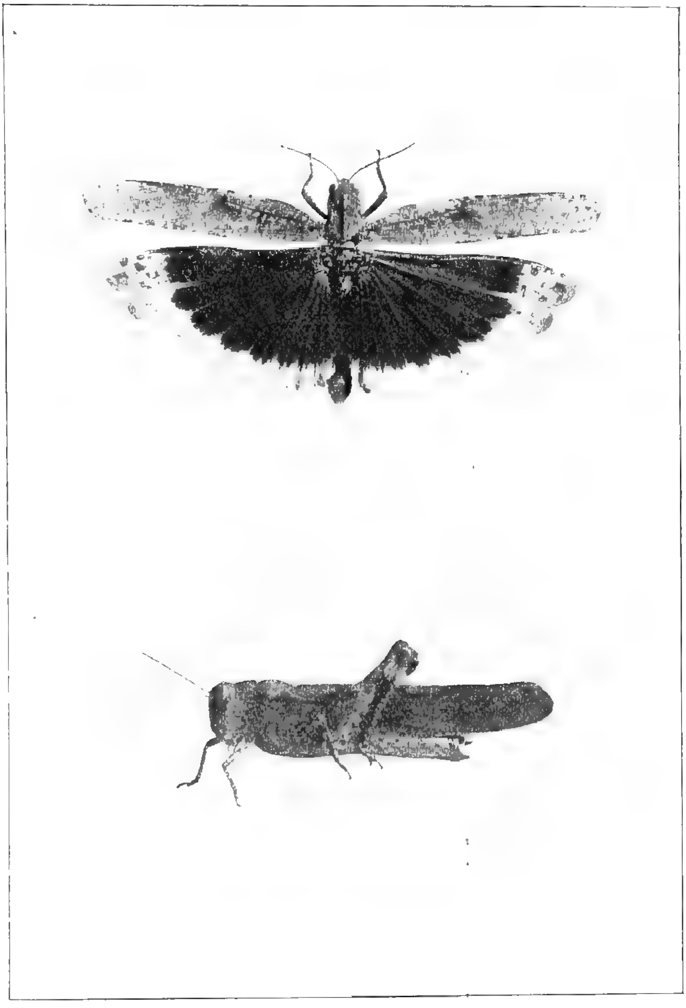


A young (nymph) Cone-head Grasshopper (Conocephalus robustus), showing stage just before the last moult.

the grass or other herbage in the first attempt to spring into the air. At such times I have seen individuals make several attempts at flights, and failing, would then remain quietly on the ground. The bare ground, free from surrounding herbage, is for this reason more often chosen by the locust.

In flight, the female shows the greatest vigor, as she often flies from thirty to fifty feet without stopping. The males, on the other hand, sometimes exhibit a pretty, playful performance, seemingly in an attempt at display before the females. On these occasions he flies into the air from two to four feet above the ground. Then, hovering like a butterfly, he flutters his wings with remarkable rapidity, and finally, tired by his efforts, his wing strokes become appreciably slower, until he finally falls back to the ground. I have often seen the male walking on an old board sidewalk, as well as on the bare ground, looking for the female. When within eight or ten inches of her, he shows great emotion, by moving his hind femora up and down, and in this way producing stridulation to attract her attention. Sometimes a number of males attend the same female, each one trying to outdo the others in his efforts at Orthopteran courtship.

I especially recall some observations made August fifth, in a sun-exposed waste of ground. Here, almost directly in my path, I was presented with some queer performances of the Carolina locust. More like a large moth or butterfly than a grasshopper, a male individual started from the sandy ground, mounting into the air to a height of about three feet. There he balanced himself in mid-air for a period of several seconds. At first his wings vibrated very rapidly, but toward the end of the flight they became slower, and then occurred the final drop to the ground as previously mentioned. While in the air, toward the last, I noticed the dark wings with their light border, and even the rusty hue of the tegmina, or first pair of wings. After this individual dropped to the ground, I found, on careful approach, that two other males were close by. All three were then having an active greeting, each one taking part in stridulating, the queer-looking trio rubbing their thighs up and down against the wing-covers. This enjoyable meeting, which lasted for the greater part of a minute, had the effect of



The Carolina Locust (Dissosteira carolina). Top figure male with spread wings, lower figure female. These insects are common in August and September.

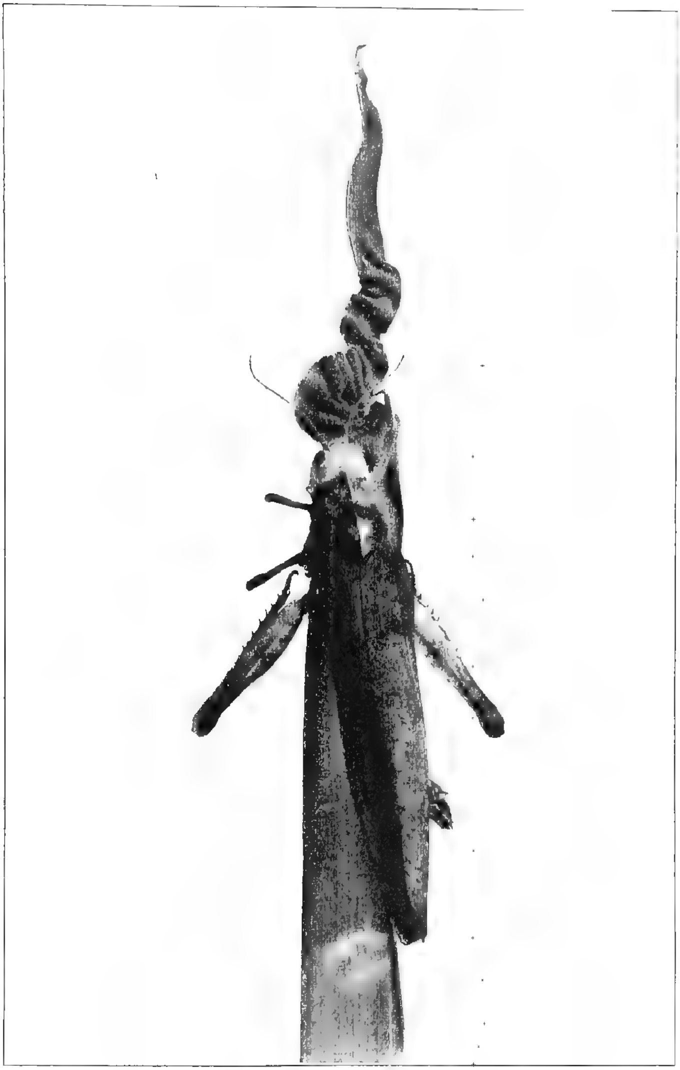
attracting the pretty male of the sprinkled locust, *Chlœaltis conspersa,* and in a moment he also joined in the jollification. I have witnessed many of these manœuvres, where only the males were present, the females taking no part in the play whatever. The performances always occur in the heat of the sun, and the hotter the day, the greater the activity displayed by the locusts. There seems no doubt but that these acridians have a cultivated ear for grasshopper music aside from its mere secondary sexual attraction.

In the plate photographic illustration, the upper figure shows the male with spread wings; the lower figure portraying the female. It will be seen that the coloration of the wings of this locust is quite similar to that in the wings of the butterfly, *Euvanessa antiopa.* It has been suggested that herein lies a case of mimicry; the locust mimicking the butterfly for protection, but I have not been able to trace any connection of this character between these two insects. It is more likely that the similarity in color is a mere coincidence.

The Carolina locust lays her eggs in the ground in September, one to several males often awaiting close by while she is thus occupied. The eggs remain in the ground through the winter, and hatch in the following spring. The young seem to undergo five instars, or moults, before they mature the following summer, in July and August. In an effort to determine whether this locust changes color at the critical stage of the last moult to resemble the ground upon which it lives, I tried a number of experiments. A few of these, with the resulting conclusions, are given herewith:

On July twenty-ninth, I subjected two nymphs, one rust-red, the other gray-speckled over the body, to a residence within a screen-covered vivarium. On the bottom of the enclosure to one side was placed a layer of light sand, and on the other side, separated by a screen partition, was a covering of dark earth. The rust-red form was placed in the side containing the light sand, and the gray-speckled form on the dark earth.

These insects had been confined here but a few hours before they started to moult. At 10.15 A.M., of the same day, the red form, after climbing on the vertical screen partition, commenced to moult, and by 10.45 A.M. had entirely emerged from



A Carolina Locust which has been killed by a fungus disease.

the nymph skin, thereby entering the adult stage. In twenty minutes the body was pigmented with red, the coloration being of the same general character as that of the nymph. The pale, wrinkled wings did not take on the black pigmentation immediately, but after one-half hour they gradually stretched out to full length and dried, so that they were finally brought together like a folding fan, and closed to the side. The tegmina, in the meantime, were stiffening and they were aided to the sides by the hind tibiæ, and pressed together by the femora into their normal straight position.

Shortly after the moulting of the red individual, the gray nymph referred to also underwent ecdysis. When the resulting adult became fully pigmented within an hour afterward, it was gray like the nymph. Though these adult insects assumed the general coloration of the nymphs, they gradually turned darker, so that after a month, August thirtieth, the rust-red individual was deepened into a very dark purplish brown, with a grayish tinge on the upper surface of the body, tegmina and pronotum. After the expiration of a similar period, the grayish individual appeared slightly darker than when it first moulted. It must be remembered that these Orthoptera were left exposed to the full out-door sun and air, and fed on grass and other green herbage. On several occasions when it rained, the vivarium was filled with water, driving the locust to the top of the screen, but the water in each instance was soon emptied out. These locusts were subjected perhaps, on this account, to little more humid conditions than they would probably have experienced if they were allowed to remain free, out on the ground in nature.

I later tried two more nymphs in my tests of this species. They were both light ochre-colored individuals, and they were placed under the same conditions for the experiment. Shortly after moulting, the adults in both cases took on pigmentation, which gave them the same general coloration as that exhibited in the nymphs. They, also, gradually became noticeably darker as time went on. After a month's interval they were decidedly grayish, instead of yellow, and sprinkled with fine dark markings over the whole upper surface of the body. In these experiments, together with others that I have made, the evidence indicates that the Carolina locust does not change abruptly at the critical period during the last ecdysis or moult, from one color to another, but a change takes place in the adult gradually after the last moult. Whether this is in sympathy with the surroundings or not is not definitely proven. But the indication is that the hypodermal cells lying in the integument of the newly moulted adult are very sensitive to light and humidity, and are capable, under the effects of these stimuli, of responding by changing color in accordance with that of the habitat. Further experimentation of this kind is under way, in which various conditions are being studied, with a view to finding out, by breeding, more about the evolution and the origin of the color variation in Orthoptera.

I have frequently found, hanging on the tops of plants, dead specimens of this locust, which had been killed by a fungus disease. The bodies of these insects often present a discolored appearance, and a close examination reveals the fungus, *Empusa grilli*, issuing from various parts. In the second plate illustration is portrayed one of these insects in a characteristic attitude, at the top of a leaf of blue flag.

The Carolina locust, *Dissosteira carolina*, is widely distributed in North America. It ranges throughout all the United States and Canada.

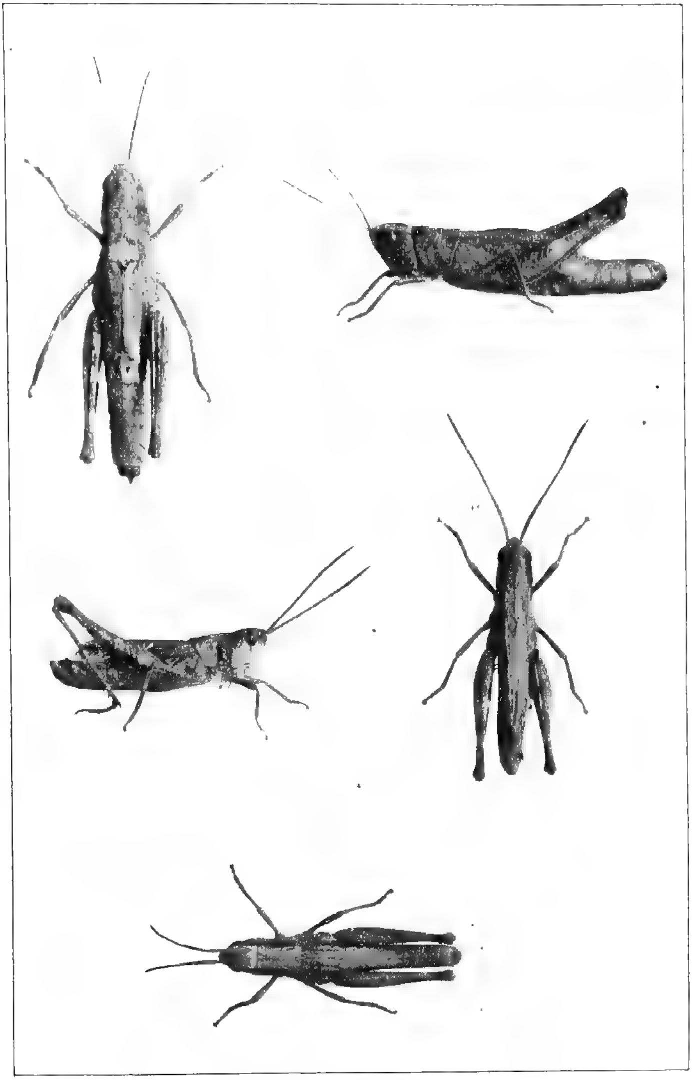
The Sprinkled Locust

In the accompanying plate photographic illustration, I have portrayed the short-winged sprinkled locust, which is doubtless familiar to some of our readers. Perhaps it may be recalled as having been seen along fence rows, in dry pastures bordering woods, or in the thickets. Here among the dead browned leaves it occasionally jumps from its resting place, at the sound of one's footsteps. Until the insect moves, however, the attention is not usually called to it, for among the surroundings, I have noted that its colors blend so perfectly with the background that it is seldom seen.

At four o'clock on the afternoon of August fifteenth, I discovered one of these sprinkled locusts in a curious attitude on the top of an old tree stump. The antennæ were extended forward, near together, and her hind legs were rather widely spread apart. The grayish brown color of the body exactly harmonized with the seasoned surface of the wood on which she was stationed. I soon found that she had her abdomen completely buried in the wood, and was in the position of laying her eggs. In about twenty minutes she withdrew her abdomen part way, and moving about four inches forward, she endeavored to find another spot suitable for ovipositing. The wood being quite hard, she tried various other spots, without being satisfied. I was curious to know whether she had laid her eggs here, and so, with the use of a pocket knife, the decayed wood was cut away at one side of the burrow. What was my surprise to find that the hole made by the locust's ovipositor led into a cavern within the stump, which was filled with small brownish ants. At once they were set in motion, and commenced to swarm out of the opening that I had enlarged with the knife, going here and there, evidencing the greatest excitement. In less than five minutes the whole surface of the large stump was swarming with ants. After they had examined the surroundings, they seemed to realize that the danger to them had passed, and, little by little, they ran back into the hole. These ants had blackish abdomens, which they carried erect at a right angle to the body. They showed great fearlessness.

No one will doubt this was a luckless spot for the sprinkled locust to lay her eggs. That she intended to oviposit in, and was interrupted, was shown from the fact that her body upon dissection was afterwards found to contain sixteen matured eggs. In one instance I observed two at the same time, at work on an old weather-beaten block of pine wood, lying on the ground. A female was busily occupied on each end when I discovered them. One of the locusts tried her ovipositor in at least five places without being satisfied, and finally departed into the grass. The other, working in the shadow, succeeded in finding a suitable wet place on the wood, and made a burrow. This individual, in the operation of boring the wood and laying her eggs, occupied about four hours' time. On cutting away the wood, I found that the hole was on a slight slant away from the insect. It was one inch deep and contained fourteen eggs.

That the time consumed by this species in ovipositing varies



The Sprinkled Locust (Chlœaltis conspersa). Two upper figures females; two middle figures males; lower single figure a nymph.

may be seen by another observation following the one I have just recorded. Three of these insects were found at the same time, on an old oak stump. Two of these kept busy working in the old punk-wood nearly six hours in each instance. In still another piece of broken-off pine, near the stump, which suited all requirements, I found four burrows, the average number of eggs being fifteen in each. I gather from the many observations I have made, that the process of oviposition is accomplished as follows:

The females lay their eggs between the last of July and the last of September. She searches about on the ground, in quest of a site, until she finds an old piece of wood, or stump, but seldom is able to pick out a place, without first making a number of trials with her ovipositor. Often, after boring quite deeply in the wood, she withdraws her abdomen, either from taking fright, or not being satisfied with the physical conditions. She uses her ovipositor by opening and closing the valves, and turning the tip around on the axis of the abdomen, as it is forced in between the fibres of the wood. In this way she consumes hours, if the wood is quite sound. In old decayed wood, where it has become very soft, it is obvious that she accomplishes the boring quite easily. The direction of the hole is slightly inclined backward, and downward, going with the grain of the wood, and extending about an inch in depth. Then the eggs are slowly deposited. The first two eggs are laid side by side in the bottom of the burrow; the third egg, deposited just forward of the first, is slightly elevated. The fourth is laid beside the preceding, but it is still more raised, so that each succeeding egg is alternately raised on a little higher plane than its companion; this process continues until the burrow is filled to near the top with fifteen eggs, more or less. As each egg is deposited, a light frothy secretion is discharged and used in gluing them together. The final process consists in secreting enough of this mucoid substance to fill the remaining part of the opening to the top, but when it hardens it presents an outer concave surface. The alternating elevation of each egg in the burrow is doubtless necessitated by the narrowness of the burrow.

The sprinkled locust, *Chlœaltis conspersa*, is found over the northern United States and Canada, east of the Great Plains. Southward, it extends as far as Arkansas and Indiana. The color of the male is usually light brown; the lateral lobes of the pronotum, or thorax, in this sex generally being black. In the plate photographic illustration I have portrayed, at the top, two views of the female. At the middle, I figure the male in two positions. Below them, in the middle of the plate, is shown a nymph, in which, of course, the wings are not yet developed. In the adult male, the wing covers, or tegmina, often reach nearly to the tip of the abdomen; the same structures in the female only reaching to about the middle, but I have found individuals occasionally possessing fully developed wings. In one male I found that the black on the side was replaced with brown. The males are sprightly little insects in the hot sunlight, and may often be found joining in the stridulating concerts so much enjoyed by acridians in the late summer.

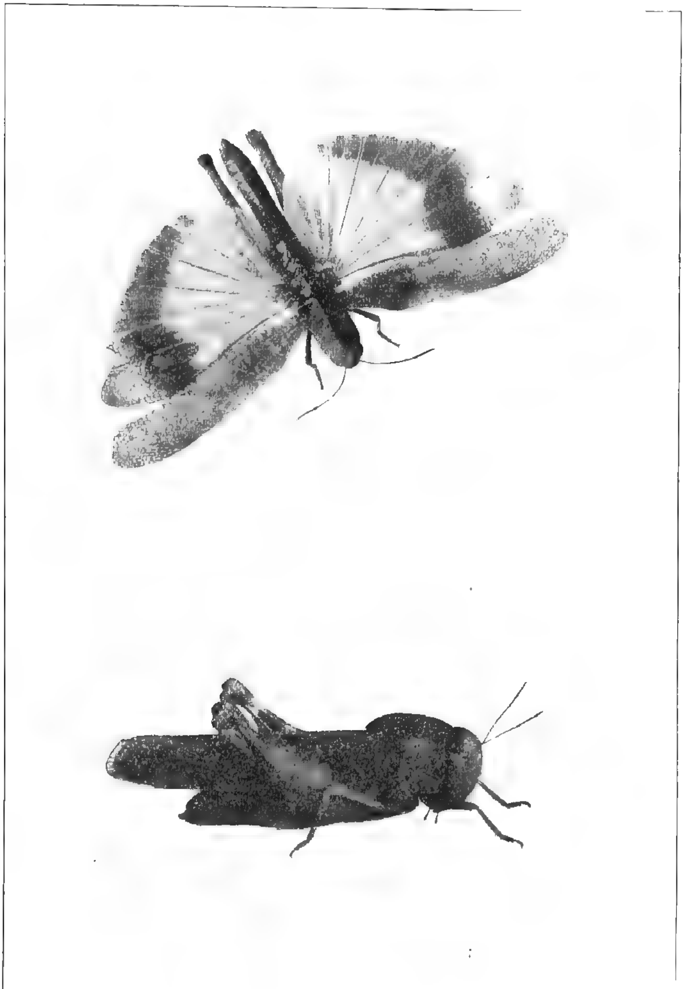
The Varied-wing Locust

Of the many species of locusts, maturing the last of July, the varied-wing Arphia is one of the most active species on the wing. One of its characteristic habits is to take long flights over the sandy wastes. When flying, on a sunny day, the beautiful orange-winged variety of this insect might easily be mistaken for a butterfly, from its habit of frequently fluttering or hovering in the air. The color of the wings in this species varies exceedingly, the yellow forms usually predominating, of which about one-third or less are of different shades of orange. The males of the salmon-colored forms make loud crackling sounds, which they often change into a succession of distinct snapping notes just before alighting. I have figured both male and female in the accompanying illustration.

I have seen the salmon-colored forms chased by the common butterfly, *Anosia plexippus,* while on the wing, in an evident attempt at play. It is possible that the bright color of this locust's wings was the temporary special attraction to the butterfly. On a windy day the varied-wing Arphia may sometimes be seen, about September first, to take flight from the ground and, facing about in the direction of the wind, rise in the air higher and higher to a great altitude, finally becoming a mere speck in the sky. Then they move off in the direction of the wind to some unknown point. I have seen this remarkable migratory movement exhibited only in the fall.

Again, on numerous occasions during short flights, I have observed some small insects darting from the ground into the air, keeping close on the heels of the varied-wing. Sometimes one, or not infrequently two, of these watchful torments would arise into the air at the exact moment this locust would start from the ground. In their pursuit they caught up readily with their selected host, recalling to mind, in miniature form, the kingbird, in his chase after the crows. But we will see, in the sequence, that there is quite a different motive underlying each of these performances. I did not succeed in clearing up the cause of these insect manœuvres until the latter part of August. One day I visited a dry pasture, where the varied-wing was found in abundance. Here I succeeded, after many attempts, in landing in my net a varied-wing along with its much desired pursuer. Here in the white folds of the net, I finally had him, — a rather large-sized, grayish fly. He was identified at once as a Tachina fly. This little pest pursues the locust in order to lay its egg on the neck, or under the wing of the locust. The egg thus placed is out of the way of the host, and it later hatches out in a grub, which eats its way into the fatty parts of the locust's body, thus disabling and finally killing its helpless victim. I have also seen Diptera of this kind following the Carolina locust through the air. These flies pass so swiftly that I had to be on the keenest lookout even to see them. When they catch up with the locusts, they may be seen, under favorable conditions, hovering about its body for the brief space of time they are within view, which sometimes is only for a fraction of a second.

The eggs of the varied-wing hatch in the spring; the young maturing about the middle or the latter part of July. The adults live until the advent of very heavy frosts in the fall. I found them frequenting open dry woodlands, stubble fields, meadows, and pasture lands. About September first, I find that after half-past four o'clock in the afternoon, these locusts,



A pair of Varied-wing Locusts (Arphia xanthoptera). Upper figure, male with spread wings; lower figure, female. The male had yellow, the female salmon-colored wings in life. This species is often parasitized by a gray Tachina fly which deposits its eggs on the living individual while it is in flight. The locusts' eggs are laid in late July and early September.

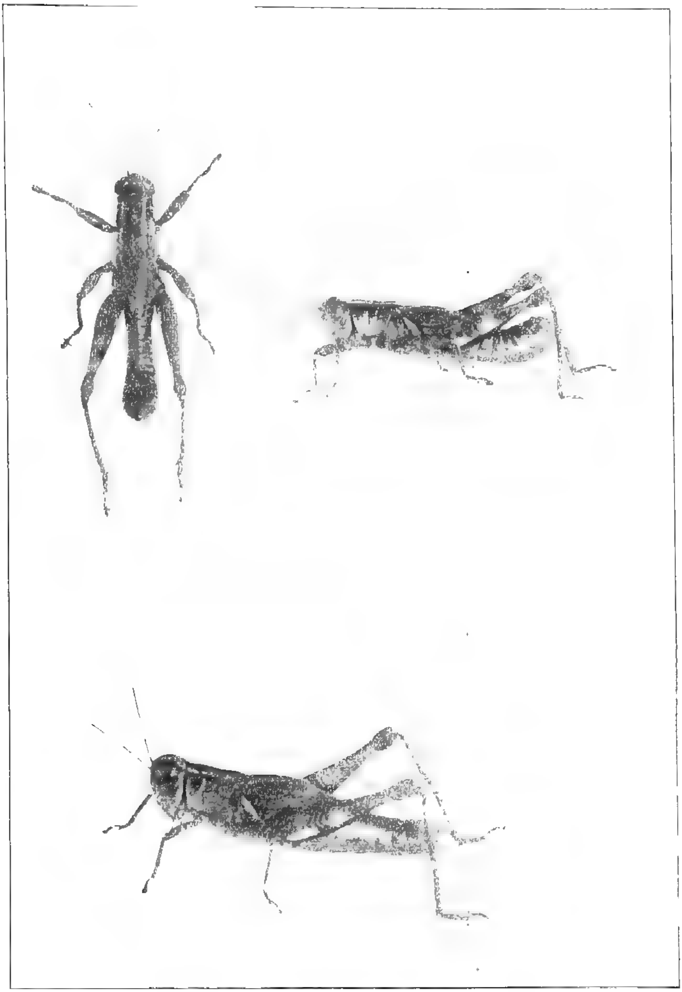
like most of the neighboring Acridians, do not rise so readily from the ground as they do in the middle hours of the day, and after five o'clock they all go to rest for the night. The distribution of this species extends throughout the greater part of the region east of the Rocky Mountains. The scientific name of this locust is *Arphia xanthoptera.*

Blatchley's Locust

In the account of the green-legged locust, I have mentioned finding Blatchley's locust. (See plate photographic illustration.) About the time the short-wing; green-legged locust disappeared, between the first and the twenty-second days of August, this species was gradually supplanted by Blatchley's locust. By the last of August the latter was alone in the possession of the same forest environment. The habitat of both of these insects is shown in the landscape photograph in the chapter on the Habitat of the Orthoptera.

Like the green-legged locusts, the males of the Blatchley's locust are much smaller and more active than the clumsy females. When rustled, the sprightly males made several rapid leaps in succession, to effect escape, but if caught under the insect net they readily hid under the leaves. I found these insects also quite common on the edge of the woods, and it was not an uncommon sight to see them, in the last half of August, scattered in the open fields immediately skirting the woods. I not infrequently saw the females sunning themselves on old pieces of wood, lying on the ground, while the more active males often sought the bark of such trees as the butternut, on which to sun themselves. In these sunbaths, the males often associate with the lubberly locust.

In their foraging excursions, the males more often than the females climb on various shrubs, several feet above the ground, where they feed on the foliage. But both sexes seem to be more common on the interior bed of the forest that I have described above, than elsewhere. The two figures in the upper part of the plate are males; the single figure below is the female. The characters of the species are so well shown in these figures that a detailed description seems superfluous.



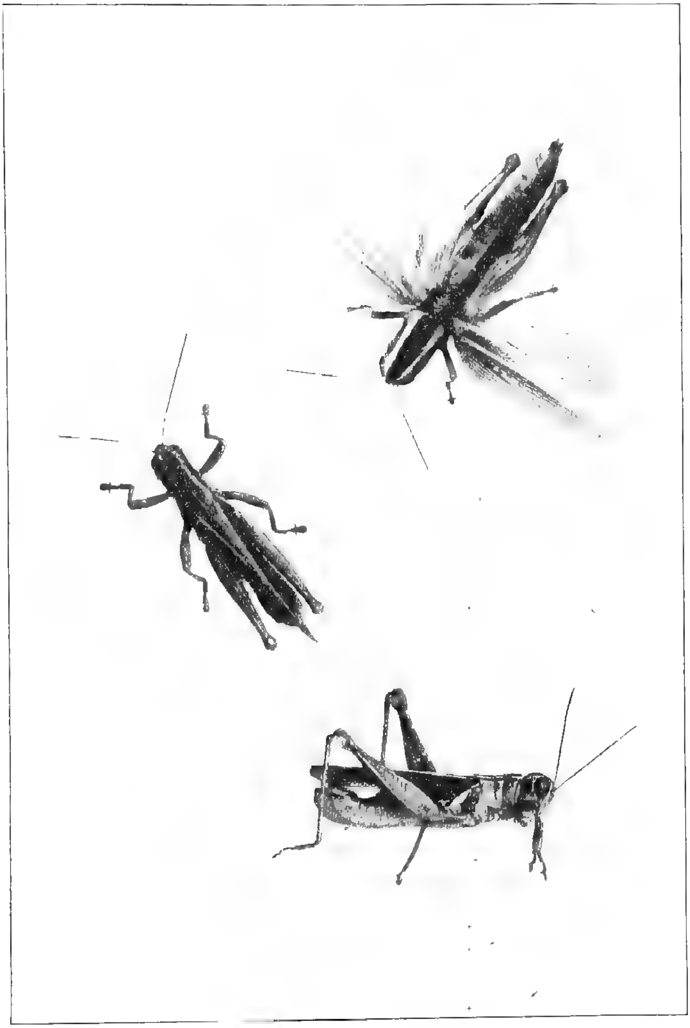
Blatchley's Locust (Melanoplus blatchleyi). The two upper figures are males, the lower figure is a female.

The functionless short wings in Blatchley's locust, as well as the allied green-legged species, prevent their use in flight. The wings have either become diminished in size, or have never become developed, such as occurs in the long-wing species like the Carolina locust. When their habits are taken into consideration, one finds that the short-wing species of locusts almost always live on plants and shrubbery, excepting during the time they lay their eggs in the ground. Carrying the argument still further, Morse observes that short-wing species of acridians generally are much less numerous proportionally in treeless, arid districts than in humid, forested regions, east and west. Every flightless species of locust, excepting the Tettigians, known in the eastern half of the continent, is phytophilous,—plant-feeding, as distinguished from geophilous, — ground-feeding, in habits.

My own conclusions respecting long and short wingedness is simply this: that it is a question of food supply and nutrition derived therefrom. In the case of short-winged forms, they are due to under-development as the result of scant food. Conversely, in the case of the long-winged forms, they are the product of better and more nutritious food supplied during development.

The Two-striped Locust and its Related Species

The common two-striped locust, which I have shown in the photographic illustration, is a member of the genus Melanoplus. The members of this group have semi-transparent wings, as shown in the upper right-hand figure representing these structures spread open. Owing to their clear wings, these insects are quite as inconspicuous when flying as when they are on the ground. Moreover, the species constituting this large genus form the majority of the locusts seen in our fields, roadsides, and meadows, sometimes flying up in swarms, especially during August. At that time, on a sunlit day afield, when one is walking toward the sun, the glimmer of so many wings often dazzles one's eyes. The two-striped and the lubberly locusts are larger than the ordinary forms, and they are often found associated. Neither of these insects is inclined to fly far when



The Two-striped Locust (Melanoplus bivittatus). Upper right-hand figure, female with wings spread; middle and lower figures, males. These insects mature in the early part of July and then appear very commonly.

disturbed, each preferring rather to jump away from his pursuer. In the heat of the day, they are more apt to use their wings than at other times, flying then only a few feet or yards.

The many smaller species of Melanoplus are quite difficult to distinguish off-hand in the field. Especially true is this of the females. The males are determined principally by the differences found in the abdominal appendages, the distinctive features of which can be seen clearly with a hand magnifier. In the late afternoon of August twenty-fifth, I found a great number of the lubberly locusts on some low sassafras shrubs. Here, many had taken up positions on the leaves and stems near the tops of the various branches, where they were quietly settled among the dense foliage. It was half-past four o'clock, yet they had evidently selected their night's roosts, which were in the shade cast by large trees at the edge of the woods. Here and there, also, the two-striped locusts mingled with the lubberly species, enjoying the same sort of protection for the night. This tendency that locusts exhibit to gather on the top of herbage was again shown farther on in my travels, for nearby I saw a number of red-legged grasshoppers enjoying a meal of yellow pollen, while resting on the top of the goldenrod flowers. Other red-legged individuals were sleeping, clinging to the stems near the top of these plants. No eyelids, of course, curtain the eyes of grasshoppers, and as a result they seem sensitive to a high degree to sunlight. The setting, or even lowering of the sun to the horizon, which diminishes the actinic rays, is sufficient to cause the hordes of these grasshoppers to seek their night quarters.

The two-striped locust, *Melanoplus bivittatus* especially, dwells in pastures and meadows, both wet and dry, but one may often find it along the roadsides. It feeds upon all kinds of herbage, and is particularly fond of the various kinds of succulent vegetation. This species matures about June thirtieth, judging from the freshly mottled individuals I have found at this time. They lay their eggs to better advantage after a rain, when the earth is damp and affords better facilities for burrowing in the ground. After a heavy rain, August 24, 1905, I noticed one of these insects at a point where the sandy soil was washed into the roadway. It was a female endeavoring to lay her eggs, and she bored a hole with her ovipositor so that her abdomen was deeply imbedded in the ground. But when I approached, she withdrew her ovipositor. Afterward, her body was found to contain sixty fully developed eggs. She probably would not have laid all these eggs in one burrow.

The Long-horned Locust

This rather slender and inconspicuous locust frequents sandy ground, where there is but scant covering of plant *débris*, and usually but little vegetation. When startled from the ground, in the sunlight, the red-winged individuals show the flash of their pretty wings with considerable vividness. There is also a yellow-winged form of this species, which may quite easily be mistaken for the mottled sand locust, *Spharagemon wyomingianum*, with which it is often associated.

The male of the mottled sand locust and the female of the long-horned species are nearly of the same size, making this liability of confusion all the more likely. At Miller, Indiana, September twenty-first, I found both of these insects beside the main road, half way between the town and Lake Michigan. Both species were seen on the sandy ground, which was more or less mixed with gravel, and covered superficially by fragments of twigs and a few plants, principally the burr grass, *Cenchrus tribuloides*.

The long-horned locust flies but a few feet when disturbed, and then alights again on the ground, where its gray-varied, colored markings are quite protective. I found this species also on the sand about two hundred feet from the lake shore, at Cheltenham, a suburb of Chicago.

The three individuals from Miller, Indiana, shown in the plate photographic illustration, page 361, will render the identification of this interesting species quite easy. Its geographical range is east of the Mississippi River, covering the United States and Canada. Its scientific name is *Psinidia fenestralis*.

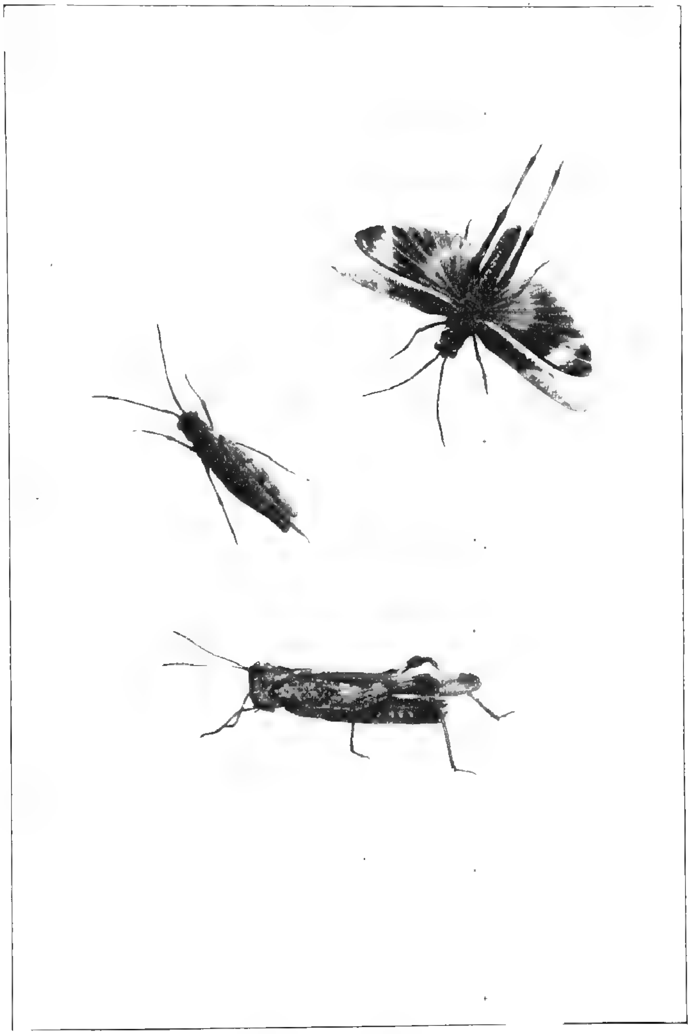
The Mottled Sand Locust

The mottled sand locust will be readily recognized in the plate photographic illustration of three individuals, which shows the external structural characters of this species quite perfectly.[1] It frequented the circumscribed sandy area previously described in the chapter on the habitat of the Orthoptera and the landscape there depicted. Here it was associated with the maritime locust, to which it bears a close resemblance. The upper surface of its body is protectively colored like the sandy ground upon which it lives, and it is not easily detected until flushed from the ground. The males, which are usually quite wild when approached, make a faint crackling sound as they arise in the air from the ground. The females are noiseless, and somewhat less active on the wing, though on hot sunny days they fly a hundred feet or more.

One will often find that this and some allied species are sometimes disinclined to leave a certain favored locality when once they become established. I recall an instance of this kind occurring at Lakeside, Michigan, on July twenty-fourth. I came across an isolated sandy area of about twenty yards in extent near the bluff at the border of Lake Michigan. This area was surrounded by such plants as Equisetum and a long-leaved, sand-binding grass, which was encroaching on its margins. Within this sandy enclosure I found a number of the mottled sand locusts, and its companion species, the maritime. The majority of the individuals seemed to be males, and when they were startled they flew only a few yards. Nearly every one was careful not to leave this area or alight outside of this limited habitat.

I have also found this species inland from Lake Michigan in sandy fields covered with bunchgrass and weeds, and occasionally along railroad embankments. The young appear scattered about on the sand in the early part of the summer and by the last of July have usually reached maturity. Its near congener, the maritime locust, is often found closer the water-line of the lake, on light wind-blown sand, covered here and there by bunchgrass.

[1] See plate on page 363.



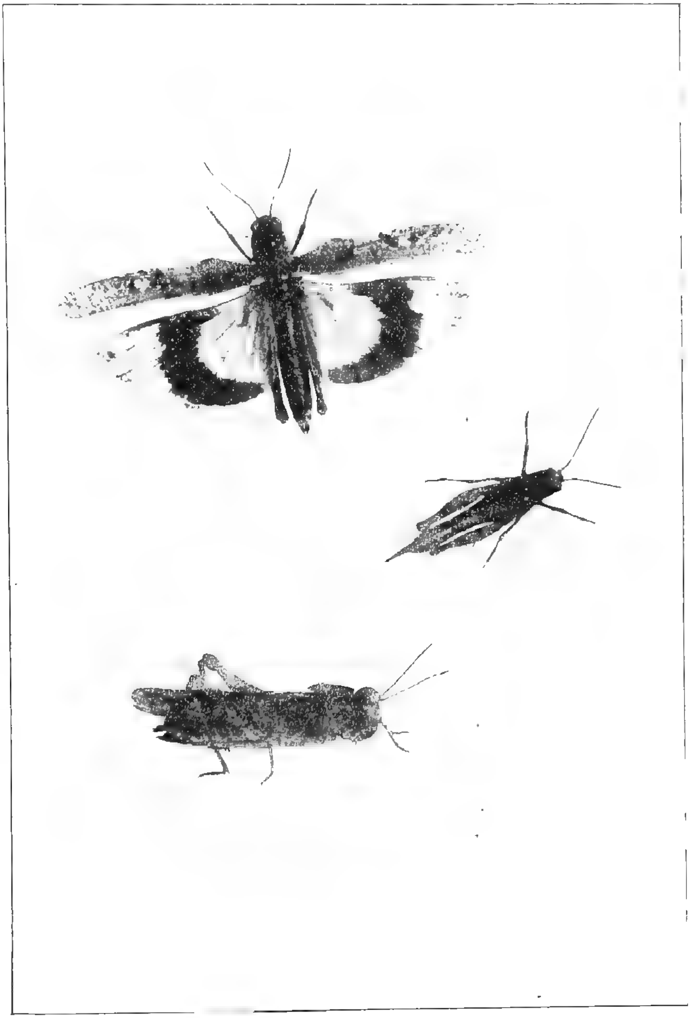
The Long-horned Locust.

At Cheltenham, south of Chicago, on August twelfth, I found the sand locust associations about as follows: At the sandy beach, where there were no grasses or other vegetation, no Orthoptera whatever were found. Stretching backward from the shore line two hundred feet, where the sand-binding grasses and bunchgrass appeared, the maritime, mottled sand, and Carolina locusts lived in company. The latter were for the most part colored like the sand. Still further away from the shore, where there were ragweeds (Ambrosia), horseweed (Leptilon), and grasses (Panicum), I found the long-horned, the lesser, and the lurid Melanoplus, and the sand locust, *Ageneotettix arenosus*. I also found the handsome short-horned locust, *Syrbula admirabilis*, living on burr grass. As I went inland the species changed correspondingly, but I will be content to mention simply the sand-loving species met with at this time.

The inner wings of the mottled sand locust are colored light yellow at the base and a broad curved band occupies the centre area, which is almost black; the apical portion of the wing is transparent. The hind tibiæ are coral-red or pink and somewhat pale at the base, while the spines have the extreme tips black. The range of the mottled locust, as far as known at present, extends from Wyoming on the west, through Nebraska, Iowa, Indiana, and thence southward to North Carolina. The scientific name of this species is *Spharagemon wyomingianum.*

Boll's Locust

In the chapter on the habitat of the Orthoptera I have presented two landscape views. In the dry, sandy area shown in the foreground in the second picture, Boll's locust was a common frequenter. On warm, sunny days in the fall it was often seen exercising its wings in flight. The males make a rustling sound with their wings while hovering in one place in mid-air. This performance is very similar to that displayed by the Carolina locust. In the open woodlands and dry pastures, or on the connecting borders where these two areas meet, Boll's locust was found in the latter part of the summer and fall, but it never occurred in great numbers. At times the mottled sand locust is quite likely to be confused with Boll's locust.



The Mottled Sand Locust (Spharagemon wyomingianum). Top and bottom figures, females; middle figure to right, male.

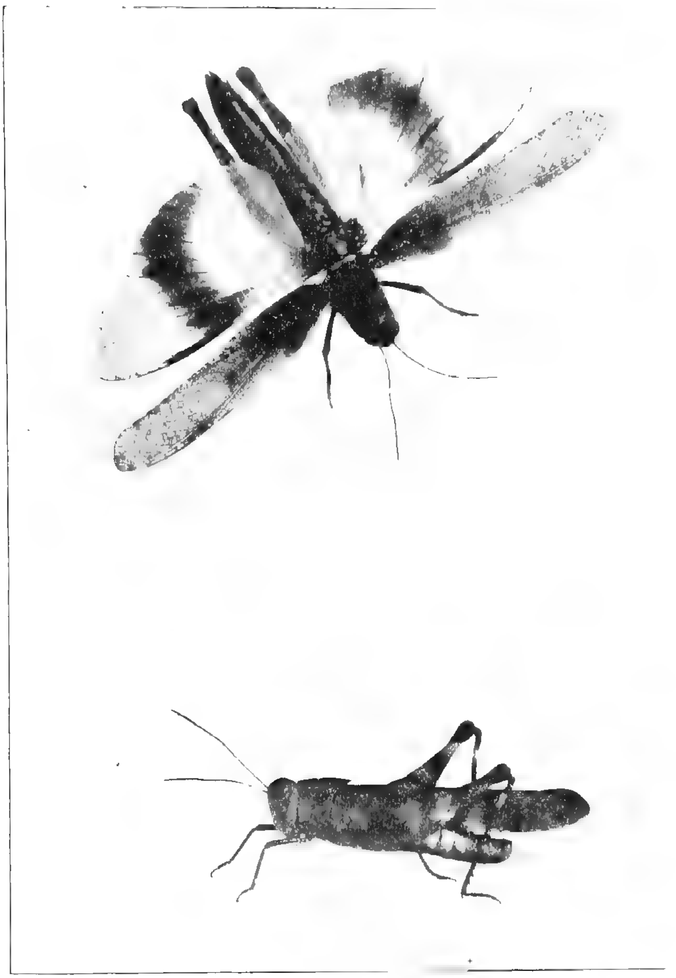
The former can readily be distingushed from its near relative by the plain, coral-red hind tibiæ, which are paler at the base. On the other hand, in Boll's locust these structures have a distinct light ring at the basal third, which is followed by a contrasting black one, and the apical half only is coral-red like the preceding species.

The plate photographic illustration shows two individuals, including the male below and the female above. Identification will be facilitated if this plate is compared with the plate depicting the mottled sand locust. Like many of the allied species of Acridians, this locust, when it remains quiet on the ground, is well protected by its colors, which harmonize with the background of the environment. The color markings are quite variable; the male usually being dark or grayish, the female more often being rusty brown or light dead-leaf color. The wing-covers (tegmina) are sprinkled with minute blackish spots which merge together in the male, forming distinct cross bars, but these are scarcely distinguishable in the female. Similarly, the outer side of the hind femora bears three or four alternating oblique bars of black and dull yellow, which are more vivid on the inner surfaces. This species ranges from Massachusetts to Florida and westward to Nebraska and Texas. The scientific name of this species is *Spharagemon bolli.*

The Clear-wing Locust

The clear-wing locust is an inconspicuous striped species common in certain areas of dry, grassy or weedy lands left in an uncultivated state. It may be easily recognized by the plate photographic illustration showing three individuals. I found this species frequenting a grassy clearing in the woods at the edge of a moderately high bluff at Lakeside, Michigan. On June 19, 1904, nymphs were prevalent here, but three days later, on visiting the spot, they had all moulted and had become adults.

Three years before, the underbrush was cut out in these woods leaving a clearing of about a hundred and fifty feet, and this area became occupied by these locusts. In the last two years the invasion of the new growth of shrubs and other coarse



Boll's Locust (Spharagemon bolli). Upper figure, female; lower figure, male.

vegetation had narrowed the area down to a few yards of grassy exposure, and only a few locusts still occupied this area. When the locusts were disturbed they flew up in short semicircular flights and returned at once within the limits of this environment and hid in the grass. The behavior of these insects was quite different from their actions in the open fields where there is a wider expanse of ground.

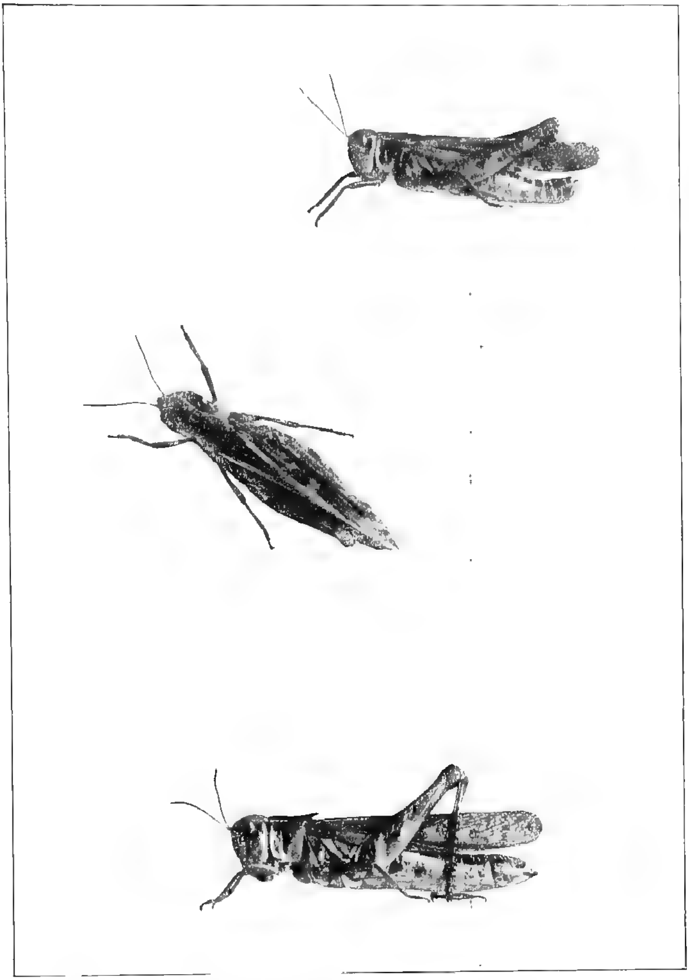
On another occasion, June 21, 1899, I found this species in a mature state in a flat meadow adjoining the bluff near the lake shore at Kenilworth, Illinois. When flushed from the ground its flight was generally noiseless, but sometimes it started off with a slight, rustling sound, flying straight for a number of yards. When alighting, it secreted itself immediately in the grass, where it was afforded perfect protection by reason of its harmonious color markings.

At Evanston, Illinois, I found it during August in an open environment similar to the one I have above described, and the locust's behavior was the same in every particular as that of the Kenilworth individuals.

The clear-wing locust's habitat is shown in another chapter in our landscape depicting the areas inhabited by Orthoptera. It established itself here in the short grassy area to the left of the open stretch of foreground. The ground to the left lay nearest to the edge of the bluff of Lake Michigan. The young, or larvæ, of the clear-wing locust is shown in the photographic plate on which the robber-fly is also depicted. The clear-wing locust is a species of northern distribution, extending entirely over Canada and the United States, from ocean to ocean, and as far south as Indiana, Illinois, New Mexico, and Arizona.

The Leather-colored Locust

From the latter part of August until late frosts, the leather-colored locust was quite numerous in the rear of our grounds. It frequented the taller weeds, dewberries, and cultivated blackberry briers, which appear in the middle distance of our landscape view showing the habitat of the Orthoptera. I often found it abundant in pastures and meadows, where it also showed the same tendency to frequent wild rubus briers. At



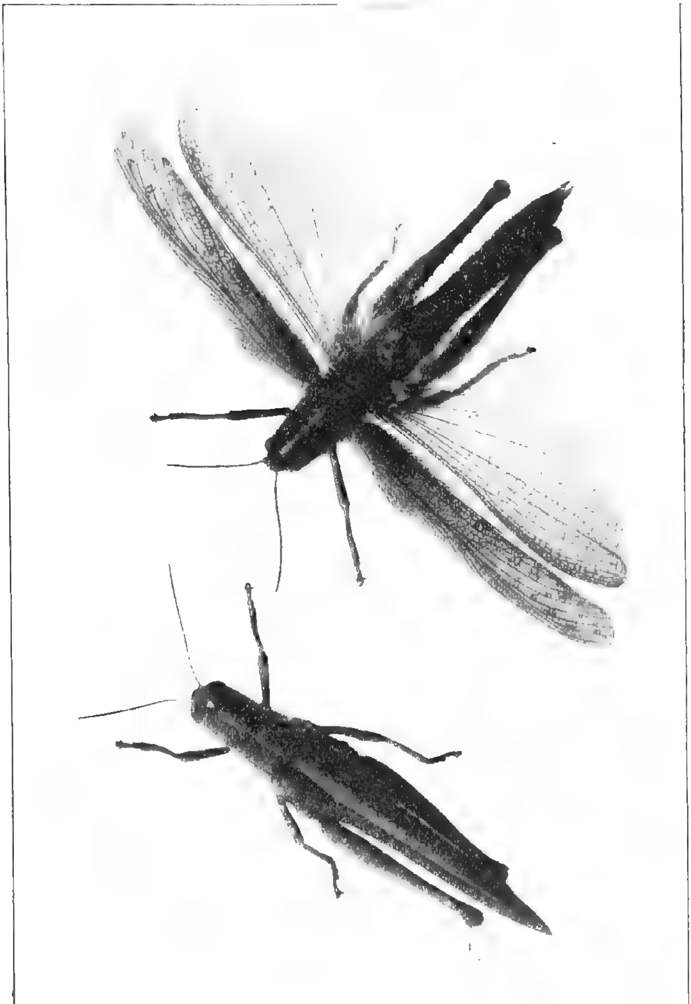
The Clear-wing Locust (Camnula pellucida). Upper figure, male; middle and lower figures, females. The environment of this species is shown in the landscape view given in the chapter on the Habitat of the Orthoptera, page 325.

other times I came upon numbers about coarse grasses and reeds in swampy meadows. Again, on August twenty-sixth, mention is made in my notes of finding this species several miles south of Chicago on an uncultivated sandy ridge. Here the ground was scattered with a dwarf growth of burr-oak, small hazel bushes, and many tall weeds. As I approached, numbers of the leather-colored locusts flew up from the herbage with a whirring sound of their wings, taking different courses from my chosen path. These large locusts presented an interesting picture in the air with their transparent yellowish-tinged wings glimmering in the light. In an area of half an acre there were as many as seventy-five to eighty individuals seen. The males seemed to take fright more readily, and were the first to arise to their wings.

In this assemblage were a number of the allied species, the rusty locust, *Schistocerca rubiginosa.* The two species intermixed freely, and were found mating without distinction as to the color forms. At the end of their long flights these locusts often fall rather clumsily to the ground, where they remain quietly, protected by reason of their harmonious body colors. In one color form there is a conspicuous median yellow stripe on the back along the length of the whole body, which is an excellent aid to concealment when the locusts are on the ground. If further molested, they often attempt concealment by crouching among the grasses or other herbage, making it very difficult to find them.

In their headlong aerial flights these insects not infrequently catch upon a weed with their feet before falling to the earth. In this way they check the progress of their flight. McNeil in "Psyche" has recorded finding a colony that established themselves in a certain point near Colona, Henry County, Illinois, which frequented a patch of Johnson grass, *Sorghum halepense.* That the habits of the leather-colored locusts are quite changeable is shown from the observations of Blatchley, who notes that in Indiana this species is abundant about the marshy meadows, where it makes its home in the rank grasses, weeds, and rushes which grow in such places.

Finally, I find in my notes that I observed a large number of these Orthoptera associated together near the shore of Lake



The Leather-colored Locust (Schistocerca alutacea). Upper figure, female, olive-green in life; lower figure, male, yellowish brown in life.

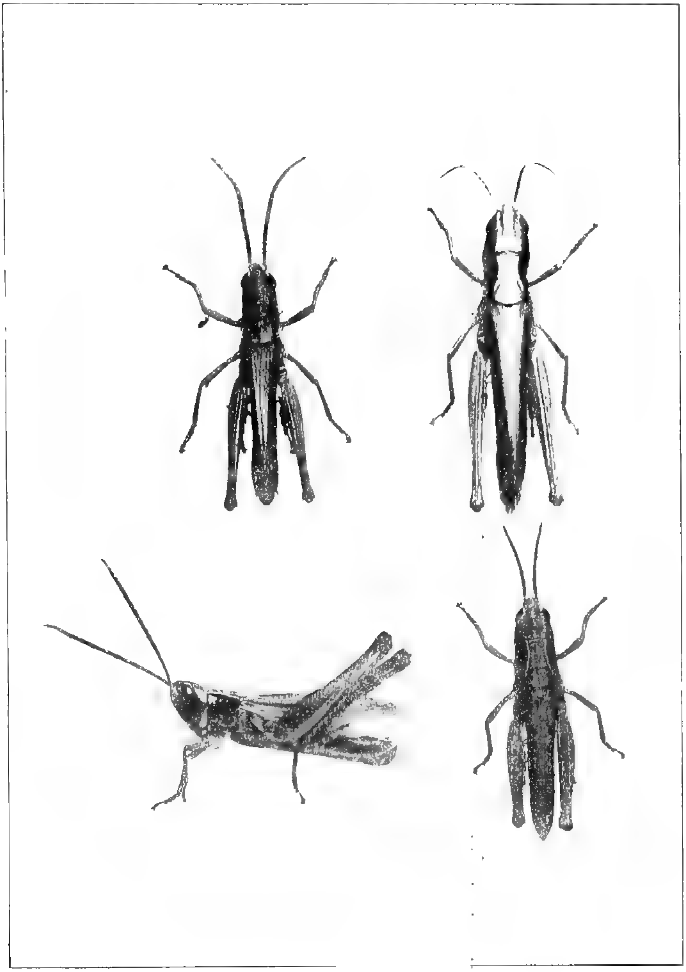
Michigan, at Cheltenham, Chicago. They had gathered in numbers on some sand-binding grasses, weeds of various kinds, and willow shrubs. They would fly wildly when disturbed, the northeast wind which was blowing strongly at the time carrying them inland with great velocity across the stretches of waste ground. The difference in the color varieties was very noticeable here; the majority of the females were plain reddish brown, while the brownish and olive males, which had the distinct median yellow stripe, predominated. As these were brought together indiscriminately while mating, the contrast in coloring was strikingly noticeable. Sexual selection is obviously completely lacking here so far as choice in color-pattern or markings is concerned.

The distribution of this species, according to Scudder, is the eastern United States, east of the Sierra Nevada Mountains, to southern California. The scientific name of this locust is *Schistocerca alutacea.*

The Short-wing Brown Locust

The quick-tumbling antics of the short-wing brown locust are familiar to most of us who have studied insect behavior in the meadows. This sprightly little locust may be found in great numbers among the succulent grasses, sedges, and other wild herbage. Commencing in July and extending through September this locust gradually reaches the climax in point of numbers. In the stretches of wet meadows and swales, it it often forms a large percentage of the assemblage of spiders, moths, flies, grasshoppers, and other insects that one may find by using the sweep-net.

South of Jackson Park, Chicago, I found the short-wing brown locust, on June eighteenth, just reaching maturity; the nymphs and adults were then about equal in numbers. The accompanying photographic figures in the plate were taken from four individuals found at this point. These Acridians did not jump about as actively at this time as they did in the hot days of July and during fall. At Riverside, Illinois, I have observed this species in the grassy openings east of the Des Plaines River as late as October thirteenth,



The Short-wing Brown Locust (Stenobothrus curtipennis). Upper and lower figures to the left, males — the latter individual in the attitude of stridulation; upper figure to the right, female; lower figure to the right, nymph.

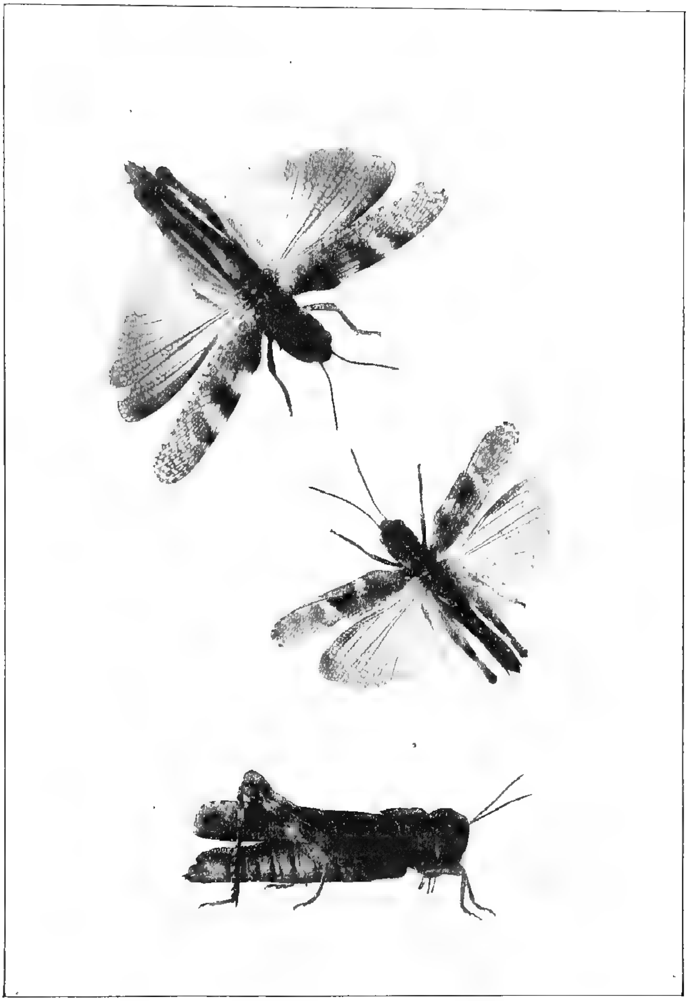
which had survived light frosts. In 1906 it came to maturity about June twenty-third at Lakeside, Michigan, and from that time on it began to be more noticeable in the damp meadows some distance back on our experiment grounds. I found it occasionally appearing on the light sandy earth covered with a light humus and grasses.

This area is shown in the foreground in the view of the habitat of the Orthoptera, though it was not the typical abiding place of this species. On sunny days I often observed the interesting males stridulating. In the lower left-hand figure he is shown in the position assumed during this performance. The very faint sound he makes is made by the friction of the thighs against the outer surface of the wing-covers. This species is distributed over the northern United States and Canada, east of the Sierra Nevada Mountains, or covering the transitional and Canadian zones. Southward, it ranges through Nebraska, Iowa, Indiana, Illinois, to the mountainous regions of North Carolina, the latter locality being recently determined by Morse. The scientific name of this insect is *Stenobothrus curtipennis.*

The Clouded Locust

When looking for the clouded locust it may be sought in dry, grassy pastures and old stubble fields. These places seem to possess the ideal surroundings. It arrives at maturity late in summer, or about the first week in August. This species is very inconspicuous when hiding among the herbage on the ground, or while arising into the air in flight. When it is on the earth its dull rusty mottlings of yellow and dark shades serve most admirably in concealing it, while in flight its glazed smoky wings, which are slightly yellowish and transparent toward the base, do not attract one's attention like the contrasting yellow and black wings of such species as the mottled sand locust.

In his work on "The Orthoptera of Indiana," Blatchley describes the habits of this species as follows: "It frequents only dry upland timothy and clover meadows, blue grass pastures, roadsides, etc. When living in woodland pastures

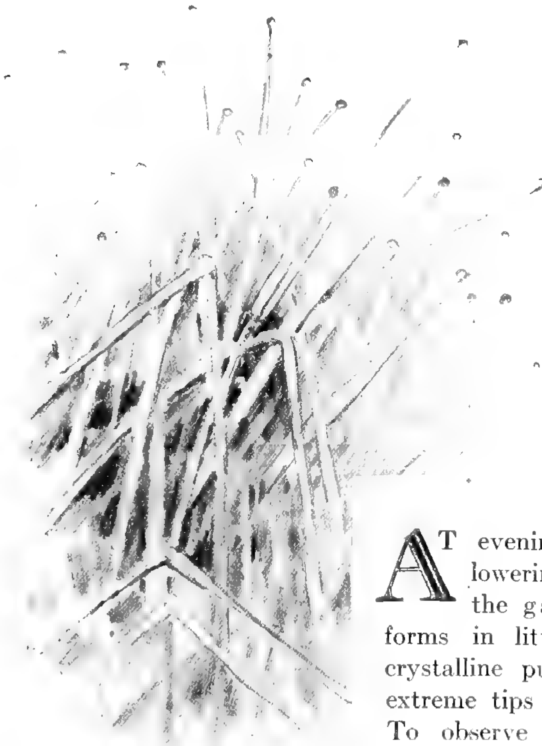


The Clouded Locust (Encoptoloplus sordidus). Upper and lower figures, females; middle figure, male. The habitat of this species is shown in the landscape view depicting the rear of the author's biological experiment grounds. The old weeded strawberry patch in the foreground was frequented by it.

it frequents the sunny spots, seldom alighting in the shade when flushed. The male stridulates on the wing during short flights, but seldom, if ever, in the more prolonged ones, which it makes when frightened. The note is a harsh droning or buzzing sound somewhat resembling that of a bumblebee, but longer. It is begun after the insect has arisen three or four feet from the ground, and is continued until it begins to descend, being kept up continually while it is flying horizontally. The females usually leap for the first two or three times they are disturbed, but if flushed a number of times they use their wings in endeavoring to escape."

The clouded locust was a common frequenter in the late summer within the weeded area of the old strawberry patch, shown in the foreground of the landscape view depicting the back of our grounds. One can hardly fail to identify this species from the plate photographic illustration containing three figures. The upper and lower individuals are females; the middle figure is that of the male.

The clouded locust bears the scientific name, *Encoptoloplus sordidus.* It ranges over the United States and Canada, east of the Great Plains. I have specimens from Kenilworth, Downer's Grove, and Chicago, Illinois; from Oconomowoc, Wisconsin, and from Dune Park and Miller, Indiana. The figures on the plate are from Lakeside, Michigan, and were photographed from living individuals which were posed for the purpose, while in an anæsthetized condition.



The Drink of the Grasshoppers

At evening, after the lowering of the sun, the gathering dew forms in little spheres of crystalline pureness at the extreme tips of the grasses. To observe this beautiful phenomenon, which is common in July, one has but to seek a field where grass, wheat, or rye is growing. Then, getting near to the ground and looking upward toward the west, so that the afterglow of the evening sky will light the tiny water spheres, they are here seen to best advantage.

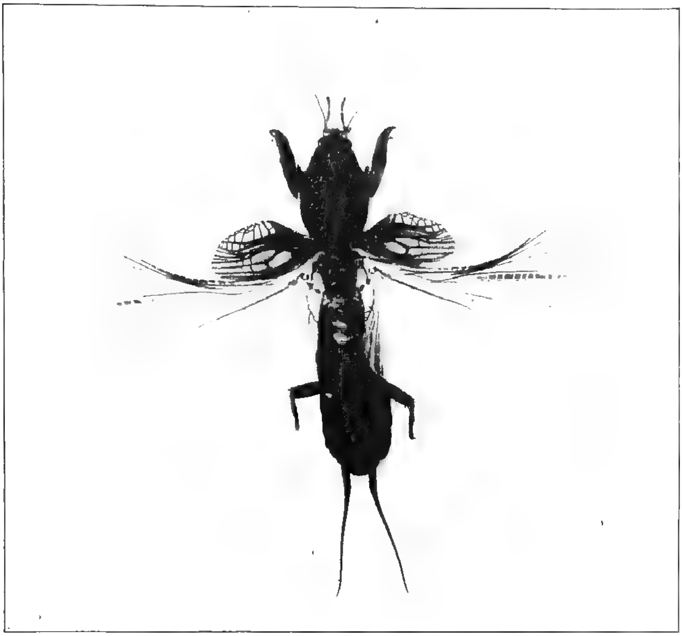
The illustration figures the dew as I witnessed it on July twelfth, at 7.30 P.M. As shown in the drawing it often furnishes drink for insects, especially grasshoppers. The dew is produced by the lowering temperature of the grass blades below that of the dew point in the surrounding air, causing a condensation of moisture on the grass tips. This condition is favored on still nights more than on windy ones, because circulating currents keep the air from arriving at dew point, by bringing variable warmer air in contact with the objects.

Grasshoppers have other resources in obtaining water. I have often seen such species as Tetrix apply their mouths directly to the damp earth in hot weather and suck up the water till their thirst was satisfied. Other species derive moisture from biting into the stems and leaves of succulent vegetation.

The Mole Cricket

Under date of August first, I find recorded in my diary the following notes: Within the last few days, especially around the noon hours, the cicada has been practising his long-drawn-out notes in the trees, prognosticating the advent of August. So, too, the oblong-wing katydid's *z-i-p*, often three times repeated, is now beginning to be heard in the evening, in the low herbage and shrubbery along the waysides. The crickets also join the fiddlers' concert, so that at dusk is heard a grand, shrilling accompaniment, taken up just as the bird music has quieted for the day. Each of these sounds is quite distinctive and no one can mistake the low *g-r-ü*, *g-r-ü*, of the mole cricket. He is a perfect ventriloquist, throwing his notes out from his underground home in a way that makes it almost impossible to locate him.

Scudder says, "Our common mole cricket usually begins its daily chirp at about four o'clock in the afternoon, but stridulates most actively at about dusk. On a cloudy day, however, it may be heard as early as two or three o'clock; this recognition of the weather is rather remarkable in a burrowing insect, and the more so as it does not appear to come to the surface to stridulate, but remains in its burrow, usually an inch below the surface of the ground. Its chirp is a guttural sort of sound, like *g-r-ü* or *g-r-e-ü*, repeated in a trill indefinitely, but seldom for more than two or three minutes, and often for less at a time. It is pitched at two octaves above middle C, and the notes are usually repeated at the rate of about 130 or 135 per minute, sometimes, when many are singing, as rapidly as 150 per minute. Often when it first begins to chirp, it gives a single prolonged trill of more slowly repeated notes, when the composite character of the chirp is much more readily detected, and afterwards is quiet for a long time. When



The Mole Cricket (Gryllotalpa borealis), long-wing form. This species was attracted to our lamp-light. See chapter on "Night Insect Visitors to Our Doorway" (page 301). The notes "grü grü," many times repeated, were heard on August nights.

most actively chirping, however, the beginning of a strain is less vigorous than its full swell, and the notes are then repeated at the rate of about 120 per minute; it steadily gains its normal velocity and sounds not unlike a feeble distinct croak of toads at spawning time."

I found the mole crickets, about half grown, quite numerous on the sandy borders of ponds, where their intricate tunnelling, just under the surface of the ground, gave evidence of their presence. They were not easily found in these burrows, even after the most exacting search for them. I sometimes found adults crossing elevated, dry, sandy roadways between wet meadows. Here they were retarded and exhausted in their efforts to cross from one side to the other. Again, they were occasionally surprised in their retreats under old pieces of wood, in their accustomed haunts.

The two individuals figured in the photographic illustration belong to the long-wing variety. They were quite welcome visitors to our lamp-light at night on August sixteenth. At this time we sometimes found specimens washed up on the beach by the waves at the shore of Lake Michigan. They, doubtless, had been carried out into the lake by the winds. The scientific name of the mole cricket is *Gryllotalpa borealis.*

THE HABITS OF THE STRIPED MEADOW CRICKETS

IN uncultivated wastes, the common horseweed, *Leptilon canadense*, often takes possession of the soil and flourishes most luxuriantly. Owing to its rapid growth, it not infrequently overshadows the neighboring clover, wormwood, knotweed, daisy fleabane, and other forms of plants which happen to live where its society conflicts. There are many interesting features in the miniature forests of weeds, not the least of which is the insect life they harbor. In the last of August the weed first mentioned commonly attains in sandy soil a height of from four to six feet, and it is at this period that it seemingly furnishes an ideal environment for the striped meadow cricket, *Oecanthus fasciatus*.

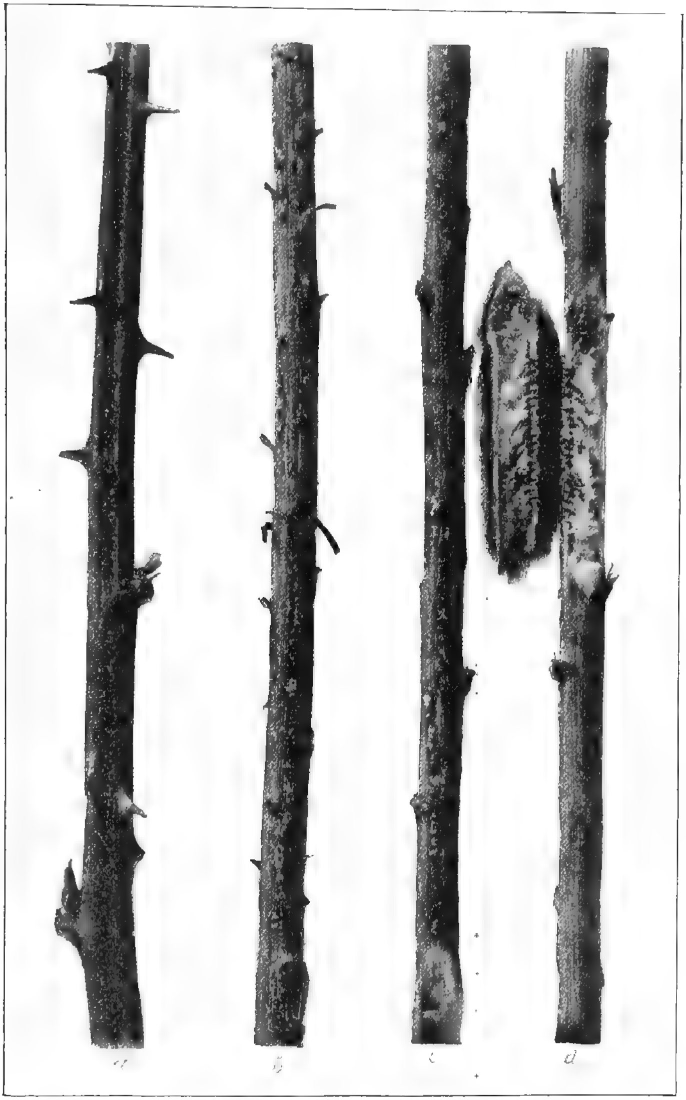
This insect has been termed a tree cricket by some writers, from the occasional habit of living on trees. Inasmuch as it is more often found laying its eggs in the stems of meadow weeds and shrubbery I have preferred calling it a meadow cricket, the real habitat of an insect being determined by the place in which it breeds.

My experience with this cricket is principally drawn from observations made at Lakeside, Michigan, during the month of August, the last day of September, and the first two days of October, 1904. Further studies of its habits were carried out on numerous live individuals which I transported to my home in Chicago.

I have found this insect living singly, or from one to four together, upon the horseweed, the females predominating during August. It is found more often on the main central stem, from eighteen inches to two and a half feet from the top, attracted there doubtless for the purpose of courtship and laying eggs. Here it exhibits exquisite protective resemblance. The body of the insect is colored pale green, but the legs, antennæ, maxillary palpi, head, thorax, cerci, ovipositor, and the under aspect of the thorax and abdomen are very dark, though the color is somewhat variable. It is a delicate soft-bodied insect with exceptionally long antennæ. One of its favorite habits is to grasp the green main stem of its chosen plant with its body resting close to the stem, head downwards. When disturbed, its first impulse usually is to jump to the ground, where its black legs, blending with the background of earth, are invisible, while the green top of the body now appears from above like a small blade of grass. If the insect is again molested while on the ground, it jumps quickly here and there in a spasmodic manner, then catching hold of some herbage, climbs upon it. After waiting sufficiently long for danger to pass, the cricket eventually springs from one small plant to another until it again finds the main stem of the horseweed. It then climbs up to take a position similar to that which it had formerly occupied. One may often find it at rest, with its legs extended nearly straight out behind the body; or it may appear on the flowers feeding.

After a period of dry weather in August the older weeds, often selected as a residence by the crickets, present a series of dead, brownish leaves below, that extends from the ground a third or more the length of the plants upward. Because of the existence of these dead leaves and shadows, the darker parts as well as the light coloring of these insects serve as excellent protection. Moreover, as they rest on the main stem among the maze of leaves, they enjoy complete immunity from their grosser enemies.

Later in the season the habits undergo some modification incident to the change in the vegetation. For instance, on September thirtieth, I visited the horseweed patch which furnished the theme of the above remarks, to find that many of the weeds, while still standing, had turned brown and were dead. There were very few crickets to be found at the point



Stems of blackberry (a), the horsewood (b), and goldenrod (c) and (d), stripped of their leaves to show the holes made by the striped meadow cricket (Oecanthus fasciatus) during oviposition. In the last stem (d), where a piece has been removed, the eggs are shown in their natural position.

where they had been so common before. After a long search, a number were located in quarters somewhat different from those in which I had previously found them. They had taken up positions near the ground. To enumerate, I discovered one female hiding ten inches above the earth within the folded dead leaf of a ground cherry. Close by was a male on a green leaf of the same plant. Immediately afterwards I found two more males and a female on the light yellowish green leaves of another of these plants. Similarly, a pair which were almost invisible were crouched among the leaves and seed receptacles of a species of cinquefoil.

On October first, among some wild blackberry bushes, I noted a number of these crickets of both sexes walking about on the upper surface of the leaves. The slightest motion on my part caused them to seek safety by darting around the side margins of the leaves, disappearing underneath, or they would jump below. Here I found two females together, clinging on upside down, each hiding within a curled leaflet of the blackberry. In the stem of the blackberry and other plants there was evidence that they had laid their eggs.

A stem of one of these plants which I found here, shown in the reproduced photograph at *a*, shows ten punctures made by the ovipositor of Fasciatus. The scarring of the plant in this way did not appreciably affect the health of the branch, the leaves of which were fresh and green. The same day I located a number of rather large plants of the goldenrod, the stems of which were used by this œcanthid for depositing her eggs. The points selected for this purpose were often situated half way down the main stem. Here the darkened scar areas can be recognized on the green stems, where a number may be found lying in close proximity. The holes, which are near together, take the form of vertical continuous lines of varying length, or they appear dotting the surface irregularly, as shown at *b* and *c*. A broken longitudinal section of the goldenrod at the scarred places will show the eggs disposed in the manner represented at *d*. Or sometimes the eggs will be found missing and instead of them there will be encountered a white larva which destroys the eggs. This grub tunnels through the central pith, feeding upon it and leaving the stem hollow.

Near the noon hour on the morning of September thirtieth, as the sun became overcast by clouds, I was treated to a pretty serenade by a host of males. Hidden in a dense thicket of weeds, they started up their shrilling orchestration which they continued at intervals. Beyond this spot their shrilling was again heard in the open field planted with clover, but grown over with a mixed wild herbage. After a little experience one is quite easily led into the presence of these crickets by their song, as the following incident will prove. At two-thirty in the afternoon of October first, during the bright warm sunlight, I heard what seemed to be a chorus of this species emanating from a point quite a distance off. From the open field where I stood I gradually traced the trills to a corner of an adjoining unmowed field where the crickets appeared in abundance in a small wild blackberry patch. On near approach some of the songs ceased, but they soon commenced again when I stood perfectly quiet.

After nightfall, as well as in daytime, the high-pitched notes of this cricket are uttered at regular intervals, sounding not unlike the croaking of a frog, or a sparrow's notes when heard at a distance. They are not so monotonous as those of the large familiar black cricket, or so resonant as the notes of the mole cricket. The concerts accompanying their social gatherings may well be placed among the choicest of insect orchestration.

The male of this œcanthid possesses a remarkable mechanism for alluring the female during the period of courtship. He not only uses the pretty modified forewings, or tegmina, as an artifice in attracting her, but he also brings into operation a most peculiar device on the thorax between the wings. In order to attract the female, the male, having approached within her sight, commences his advances by elevating his transparent wing-covers to a nearly vertical position. Then, separating them so that their surfaces shuffle together in and out, he produces a high-pitched shrilling for the female's benefit. She in turn, being readily attracted by these notes, moves towards him and, climbing on his back, goes sufficiently far forward that her attention is further drawn to the little odd-shaped glandular cup on the back of the thorax between the wings.[1] Here she at once inserts her mouth to find a delicious potion secreted for her special needs, and which she devours ravenously, as depicted in our illustration. The male, in the meantime, may or may not cease his singing, but while she is availing herself of the curious plasmatic drink, his tegmina are continually elevated and his wings, which are folded at his sides, undergo a slight rhythmical motion in and out, lasting during the five to ten minutes she is usually content to stay. When she moves away he backs toward her, again elevating his tegmina and repeating his song. Similarly affected by his overtures, and remembering the reward of sweets awaiting her return, she again mounts his body and proceeds to partake from his loving cup. These curious executions are often repeated several times as a preliminary to their nuptial union. During the mating of meadow crickets a sperm sac is fastened by the male below the base of the female ovipositor, and from this sac the sperm is supposed to enter the oviduct. This sperm sac is carried about for a short time only, being finally devoured by the female.

The stridulating organs of this species, as well as the secreting compound gland on the back of the thorax, furnish an excellent case of secondary sexual organs. It is in such organs as these that sexual selection is supposed to operate in their production. Even opponents of the theory of sexual selection, like Weismann, believed that the stridulating organs in the Orthoptera are thus accounted for.

We have frequently observed the males in active combat over the possession of the female. As a result of these struggles later on in the season the males become decidedly dilapidated in appearance, the legs and wings having suffered more or less destruction as the result of the many contests for supremacy.

The method employed in laying their eggs is most interesting.

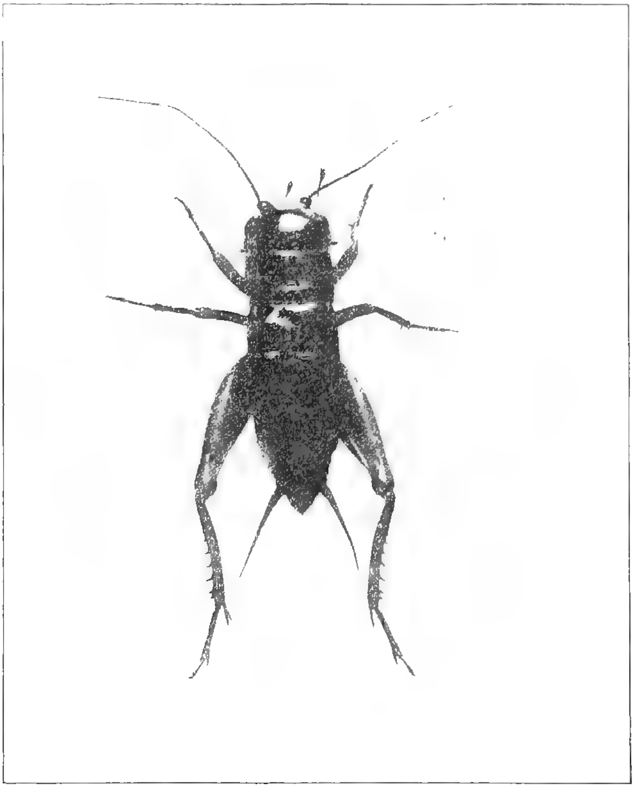
[1] This is an abstract of an article by the author appearing in the *American Naturalist*, January, 1905. Researches on the anatomical structure of this compound gland are in preparation and will be published in a technical journal. Briefly stated, this peculiar secretion is supplied by a series of glands in the hypodermal cells which find exit through a series of hairs or setæ and have no connection with the true sexual organs, yet acting as secondary sexual organs.

On October first I examined a large number of the horseweed and goldenrod afield, which showed the scars where the crickets had oviposited. The fact was developed that the eggs of this species were always deposited on the sunny south exposure of the main stem of the plants. This is obviously an advantage in furnishing the necessary heat in hatching the eggs and aids the delicate young when they first emerge. In Fig. 1 the serial sub-figures represent the stems of the blackberry, horseweed, and goldenrod, all shorn of leaves to demonstrate the scars or holes, as well as the eggs in position. I witnessed the act of oviposition for the first time on the afternoon of September twelfth, and thereafter observed it on a number of occasions. In brief, the process is as follows: The female, coming to a suitable spot on the stem, prepares it by first biting it with her jaws, spending scarcely a minute in doing so. Then, moving her ovipositor under her body at nearly a right angle, she places the tip in this superficial abrasion in the stem and immediately proceeds to drill a hole. The drilling is accomplished by rotating the ovipositor while keeping the end, which is provided with a dentate rasp, firmly pressed against the stem. The abdomen, which she turns from side to side, takes an active part in this procedure, acting as upon a pivot, and at times covering about forty degrees in these movements. The ovipositor is soon passed through the tough external covering, finally penetrating deeper and deeper into the pith. In the beginning the course of the hole takes a right angle, but as she proceeds its direction is changed, taking a curved inclination backwards, as depicted in the plate photographic illustration, Fig. *d*.

When the female has bored into the pith as far as the ovipositor can go, she then discharges the slightly curved egg very slowly. Then, after withdrawing the organ, she finishes the process by chewing the stem at the point of puncture as she did in the beginning of the operation. The anterior, whitish-tipped end of the egg usually lies within a millimeter of the opening. This is shown in the specimen of goldenrod (Fig. 1*d*) laid open for inspection. Some of the eggs here show the whitish micropilar extremity quite clearly. I did not see the female use the same hole for the deposition of more than one egg. It is at one end that the eggs are fertilized before they are laid, the sperm cell passing into the egg through a microscopic opening called the micropile.

Some Habits of Field Crickets

In the first week in June, one begins to hear the notes of the field crickets, and from that time on until autumn frosts



The Pennsylvania Field Cricket (Gryllus pennsylvanicus). Its notes are often heard in early June.

appear, their songs emanate from the pastures and roadsides. One of the common members of this group of early songsters is the Pennsylvania field cricket, *Gryllus pennsylvanicus*. Most of the crickets are excellent ventriloquists, making it very difficult to locate the deceptive males by their songs. Occasionally, though, led by their notes, one may succeed in finding this species, under stones and *débris*. One such case which I now recall is the male figured in the text photographic illustration. It was heard on June eighteenth, singing under a stone in an uncultivated meadow, south of Jackson Park, Chicago. Here he was found as the solitary occupant. But I have met with this species in various localities. In the landscape view given in the chapter on the Habitat of the Orthoptera, at Lakeside, Michigan, this species was a common frequenter of the grassy retreats, often hiding under collections of leaves or old chunks of wood.

The crickets have not yet been studied as carefully as these interesting insects deserve, possibly because no one but an expert can identify some of them. The resemblances of certain different species are so close that naturalists have often ignored their distinguishing characters. In Blatchley's work on "The Orthoptera of Indiana" will be found the most reliable information regarding our species. Some crickets are said to be cannibalistic, and will not hesitate to devour members of their own species.

I once found evidence of the ravenous appetites of crickets during an excursion afield. I came upon a dead shrew-mole, during September, lying on the ground, which had evidently been killed but a short time previously. Four or five large black crickets, *Gryllus abbreviatus*, were eating voraciously from the shoulder and abdomen of this little mammal. Upon close examination, I found a fresh cavity in the side of the body, from which the flesh had been cleanly eaten from the scapula and vertebræ between the shoulders. I surmised that possibly the crickets were responsible for the death of the mole.

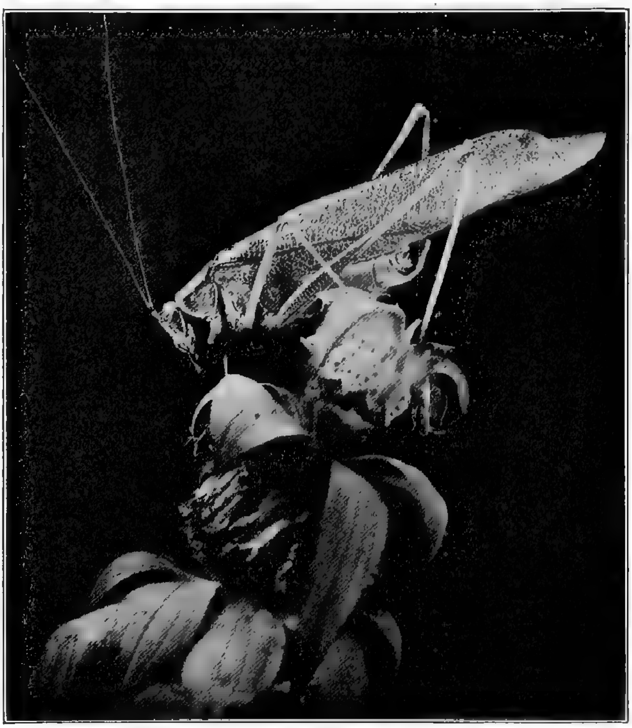
KATYDIDS IN THEIR NIGHT RESORTS

WITH the light of my lantern, I frequently found katydids in the taller herbage along roadsides and fence rows. No one can imagine, without personal experience, the beauty of the view presented as the lantern light fell upon the profusion of green herbage. Here and there, for instance, the view may be enlivened by either the little slender green grasshoppers, Xiphidium, on the very summit of a head of timothy, or the presence of a cone-head, or the exquisite oblong-winged katydid perched on the goldenrod. After a little attention is given to the notes of the males, the various species can be distinguished, and then one may trace them to each of the musicians. One night, near the last of July, I started upon a katydid excursion along a narrow lane. A farmer had mowed down the plants along the line of the path, but leaving at the fence row, on one side only, a margin of native wild plants. I cautiously lighted my way and had proceeded but a few minutes, when I heard the high shrilling of a cone-head. In a few moments more he was in the full glare of my lantern. Though I had made some commotion in getting to the spot, he continued

The Female Oblong-winged Katydid (Amblycorypha oblongifolia) on dandelion. On account of the insect being newly moulted it was a very pale green in color. I found this species at night often frequenting the tops of the goldenrod along the roadsides and fence rows, as described in the text.

his shrilling uninterruptedly, entirely unconcerned at my approach. After a distance of three hundred yards had been covered by my walk, my list of cone-heads seen consisted of five males and three females, each one suggesting some new feature of their habits.

On this night, I also occasionally came across the pupæ and adults of the oblong-winged katydids. To those who love



Texan Katydid as viewed at night on flower of horse mint.

the katydids and outdoor life, there is great joy in standing quietly and listening to the night sounds. First one hears the cone-head, then the oblong-wing, then a mingling of the striped meadow cricket with that of the slender green grasshoppers. As a base accompaniment, one is also treated to the *grü-grü-grü* of the mole cricket, which comes from somewhere within the hidden underground burrows. The various

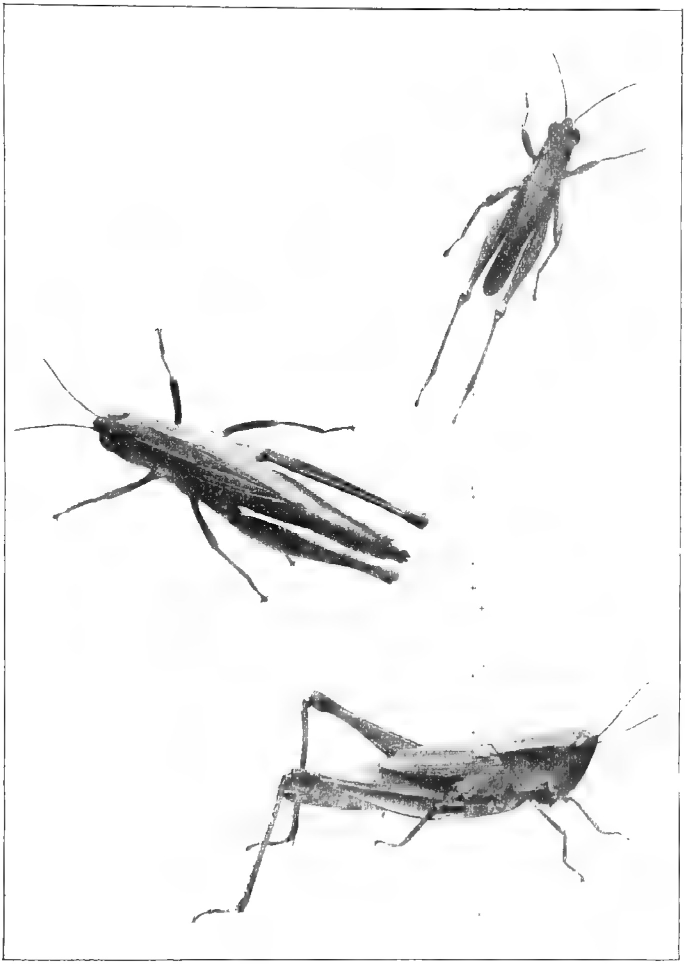
A pair of Oblong-winged Katydids (Amblycorypha oblongifolia) on the Monkey Flower (Mimulus rigens). Upper figure, female; lower figure, male.

sounds from all these Orthopteran denizens seem to arise from every quarter of the compass.

Nearly a month later, or on the night of August twenty-fifth, I found the day-loving locusts of the genus Melanoplus at the roadsides in great numbers, asleep on the stems and flowers of the herbage. Again, I heard the shrilling notes of the multitudes of grasshoppers, as convincing evidence that abundant life was astir in the night hours. New notes, too, were now in evidence. On the goldenrod flowers, for instance, the four-spotted tree crickets were rejoicingly active in their calls. Near them were many more striped meadow crickets than I had hitherto seen or heard. Some were engaged in courtship, others were satisfying their appetites on the golden pollen. The beautiful Texan katydid was now perched upon a leaf, and paying little heed to the flash of the lantern rays as they illumined the surroundings and brought him into full view. A little further on I found myself again listening to the high-pitched shrilling of the ever-present cone-head. This time he made me wonder at his ability at instrumentation, his slender body fairly shaking from the vibrations of his wings. Finally the view is repeated again, the little green grasshoppers keeping up their fiddling, while on a stalk of tall grass; each scene urging us on in the search. Even though there is a lingering memory of the mosquito pests, which annoyed me during the katydid excursions, I look back with pleasure to the acquaintances made by lamp-light at the fence row.

The Short-winged Green Locust

The landscape illustration on page 394 is that of a view near Miller, Indiana. It shows, in the wet grassy foreground, the typical habitat of the short-winged green locust, *Dichromorpha viridus.* The three individuals of this species, which are represented in the plate photographic illustration, were found here September twenty-first. This locust usually takes on the bright green color of the herbage among which it lives. It shows very little activity when approached. It either tries to hide in the grass, or perhaps jumps away to avoid its enemies. The wings have become atrophied, and they are short and not



The Short-winged Green Locust (Dichromorpha viridus). Upper figure, male; middle and lower figures, females. The habitat of this insect is shown in the landscape view on the next page.

used in flight. The long-winged forms of this species are seldom found.

I have found the short-winged green locust on various occasions at the point above mentioned, and in September and October it was mating. At this time also, in the fall, it was accompanied by several species of the green grasshoppers of the genus Xiphidium. As will be seen in the plate illustration bearing three figures of this insect, there is a great discrepancy between the size of the male and the female. The

Landscape view showing the habitat of the short-winged green locust.

males are so much smaller than the females that they might be taken at first glance for a different species. While the female is usually green, an occasional brown individual occurs. In the green form, a narrow dark line extends backwards behind the eye, and over the lateral lobes of the thorax, or pronotum. The green-backed male is dull brown, excepting the bright green coloring covering the top of the head, disk of the pronotum, and the dorsal, or upper surface of the tegmina; or sometimes this part of the wing-covers is brown. I have called attention to this locust in another chapter, "Among the Sand Dunes in Late Summer," also noting its habitat.

The Quaker Locust

Few insects are better protected in their natural habitat than the ground-inhabiting grasshoppers. Because of this inconspicuousness, but little attention is usually paid to the habits of these sun-loving insects of our fields and forest. Having startled a yellow-winged Arphia or "Quaker" to its wings, one July day, I followed it for several yards in the open woods, where it alighted on the ground, on some curled dead leaves. This individual was colored yellowish sienna-brown on the upper surface of the body, in exact simulation of the background of dead leaves and bleached grasses. There were some green grasses and green leaves of wild strawberry also surrounding the spot, but this vegetation was avoided by the locust, in a preference for the dried leaves. Though I walked toward the insect, it refused to fly again, even refusing to do so when I shuffled my feet and stirred the leaves in the near vicinity.

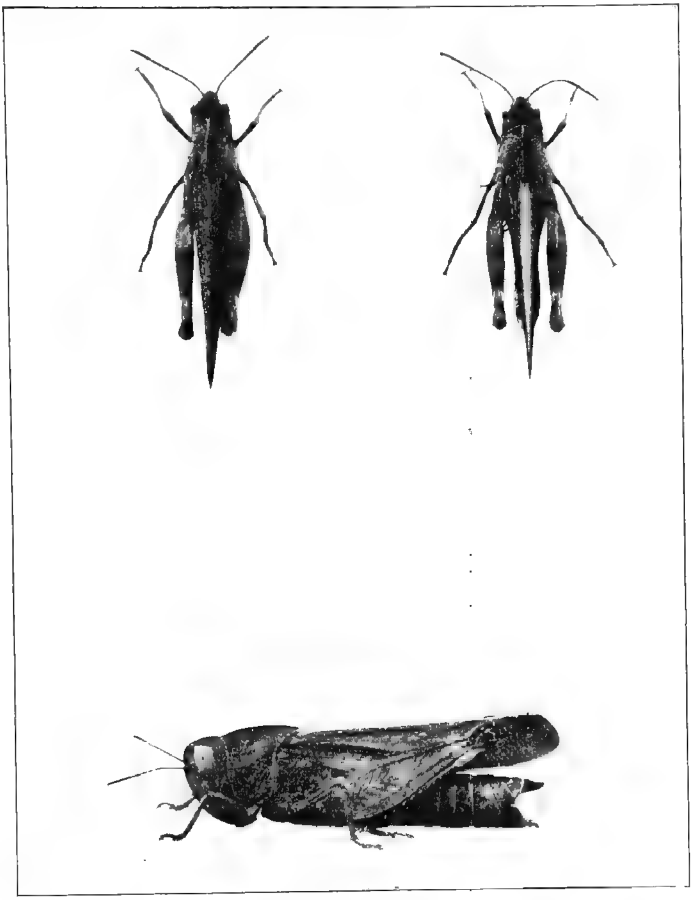
After I had kept quiet for about three minutes, the locust, evidently supposing danger had passed, began leisurely cleaning its antennæ with its front legs, and soon moved its body around to expose its back to the warm sun rays.

Not far from this site, a few minutes afterward, I started up another locust of this species under very similar circumstances. Both of these insects were females. The second locust was considerably darker in color, yet she, too, matched the background of dead leaves. Her actions were identical with those of the former locust, in the behavior of refusing to fly the second time, and in keeping very quiet on the ground. I soon discovered the fact that both color forms of this insect corresponded to two general types of coloring found among dead leaves. The first type is shown in the leaves with a distinct yellowish-sienna cast to them, fallen during the past season. The second type is more brownish, appearing on older leaves that have laid for more than one season. Leaves of the latter character possess gradations of darker hues, until they assume the very dark color of humus. The russet-colored leaves were well represented by the sycamore, examples of which were scattered over the ground by the wind.

The smaller bodied male flies much farther than the female, usually when frightened from the ground. The faint familiar crackling sound made by his wings while flying in a still atmosphere is quite a reminder of hot sunny days in spring and early summer. He is often stimulated by the warmth of the sun into greater activity. He starts up occasionally in short flights, from a few feet to several yards, finally ending them by dropping back to the ground again. On windy days the crackling of his wings, over which he seems to have some control, may be scarcely audible to one's ears even at a short distance away. The appellation "Quaker," given to this species, is in allusion to the crackling sound made by these Orthopterans. It was first described by Fabricius, in 1781, under the caption of "Gryllus," which is the name retained for our crickets now.

This species ranges throughout that portion of the United States and Canada east of the Rocky Mountains. I have found it moderately common in such uncultivated places as I have described, in the northern part of Illinois, Indiana, and the southern part of Michigan. It matures early in the spring; adults being found at Dune Park, Indiana, as early as May ninth. It is often found in the larva and pupa stages hibernating through the winter, under various kinds of *débris*, old wood, and stumps. With them are associated the young of the green-striped locust, *Chortophaga viridisfasciata*. On June fifth I found adults at Miller, Indiana, in a variety of places among the sand dunes. At one point it frequented the sandy ground in the open woods, among such plants as lupine, but selected a habitat covered with dried oak leaves. At another locality it chose the border of a pond, where blue flag and a sprinkling of dead leaves furnished the surroundings. On this occasion females appeared very scarce, there being about one individual to each dozen males examined during the day's journey. It is barely possible the females kept hidden by refusing to fly on account of being burdened by the eggs contained in their bodies.

A pale yellowish brown female, together with two males, showing varieties, are shown in the photographic illustration. The figure to the right shows a color form, which presents



The Quaker or Sulphur-winged Locust (Arphia sulphurea). The two upper figures, males, the one to the right showing a light median stripe on the upper part of the wing-covers; the lower figure, female.

a light median dorsal stripe on the tegmina of the male. This marking is obviously for protection. Finally, besides the variations of coloring above mentioned, I have found very dark brown, or even black varieties, and females have been taken which were sprinkled with minute dark brown spots on a lighter ground. I found these colors so perfectly simulated the background that it was always very difficult to locate these insects.

The landscape view presented in the photographic illustration is a typical habitat of this species. It was taken May 26,

Landscape view in the dune region showing typical habitat of the quaker locust, Arphia sulphurea. Among the cactus and blossoming lupine it was well protected on the leafy ground.

1908, at Miller, Indiana, solely with the view to showing the natural environment of this locust. In the foreground, where I flushed these insects, may be seen blossoming lupine *Lupinus perennis*, cactus *Opuntia humifusa*, and moss. Here are also shown some young willows, and scattered about on the ground are leaves and *débris*, among which the locusts could easily secrete themselves.

The Pasture Locust

The landscape herewith shown of an open sweep of pasture is notable as being a typical habitat of one of our small inconspicuous locusts. In the short green grass of the foreground I found the pasture locust, *Orphuella speciosa*, quite common. In the first few days of August, 1905, these locusts were nearly all mature, but an occasional retarded nymph, or young, like the one I have portrayed in the group illustration, was found accompanying the adults. I found this species quite common

A view showing the habitat of the pasture locust, Orphuella speciosa, found among closely cropped grasses.

in pastures generally, on the superficial loam where grazing cows and horses had kept the grass closely cropped. Its small size and protective coloring make it a very difficult insect to discover, even after one knows its habits. It has two phases of color pattern — green and brown; the green coloring often being confined to the head and dorsal surface of the body and wings.

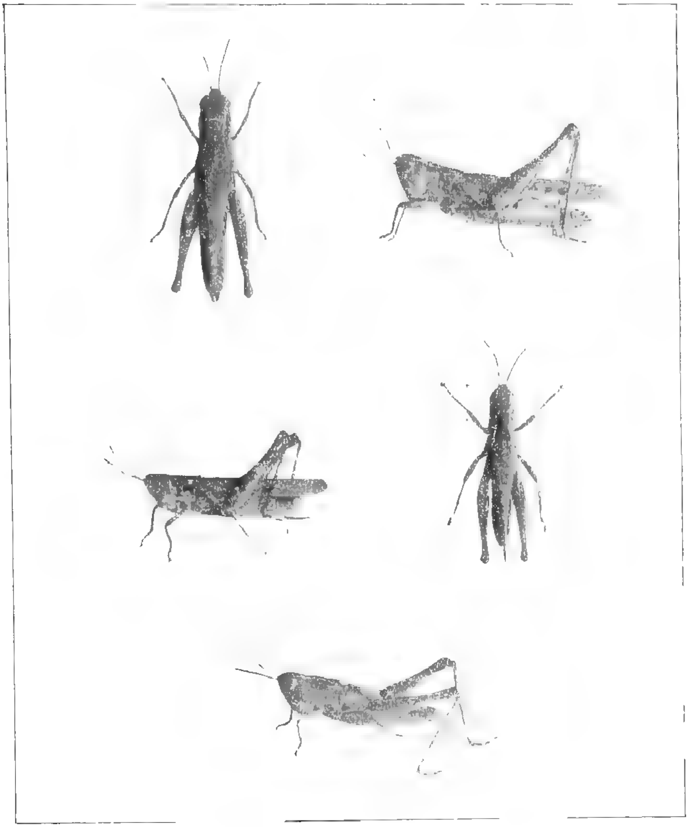
When occasion arises, this locust jumps or flies only a few feet. In either case, owing to its protective coloring and transparent wings, it is almost invisible, either in the air, or when it alights again in the grass. Here, as in many other similar instances among the Acridians, I have observed a notable advantage to the species possessing two or more color phases coexisting in individuals of the same species. In this case it is obvious that its vertebrate enemies such as birds, snakes, toads, and perhaps gophers are much less apt to discover them, because the deception practised is probably more efficient than in monochromatic, or one-colored insects, under the same conditions, especially when these colors are in harmony with the surroundings.

It is a noteworthy fact that the grasses among which these Orthoptera live are subject to frequent fluctations in color, from green to ochreous brown, depending on humid conditions or drought. Both color patterns are always present in different individuals during their life period in summer.

The legends under the illustrations describe the color phases of this species, so that with these descriptions, it is hoped the reader will have little difficulty in familiarizing himself with these insects. In the chapter on "Meadow Echoes" I have considered the subject of the relation of plants to the physical conditions of the soil; the pasture differing from the meadow in being drier, and its prevailing plants consisting of grasses. In the sketch given above, the pasture locust is a well-marked example of the adaptation of an insect to the plant societies of the pasture.

The Short-horned Locust

To understand insect life, one must study a species in its natural environment. Here one learns certain facts pertaining to their behavior, and elicits from nature the important circumstances bearing on their life relations. I have shown in another chapter how thoroughly adapted some of the Orthoptera have become to their habitat. Some of these insects are so well adapted to a special kind of plant group that they fail to exist elsewhere. I refer here to the short-horned locust, known as *Tryxalis brevicornis*. As will be seen, its interrelation to its surroundings is of a very exacting kind. In the plate photographic illustration, I have depicted this handsome species by four figures. This insect presents a graceful form, having a produced conical head. From an economical standpoint



The Pasture Locust (Orphuella speciosa). The two upper figures are adult females, the one to the left during life was green on the dorsum; the two middle figures are males, the one at the left was brown, the one to the right was greenish brown; the lower figure is a pupa, which was light green in life. They are from the grassy pasture shown in the landscape view.

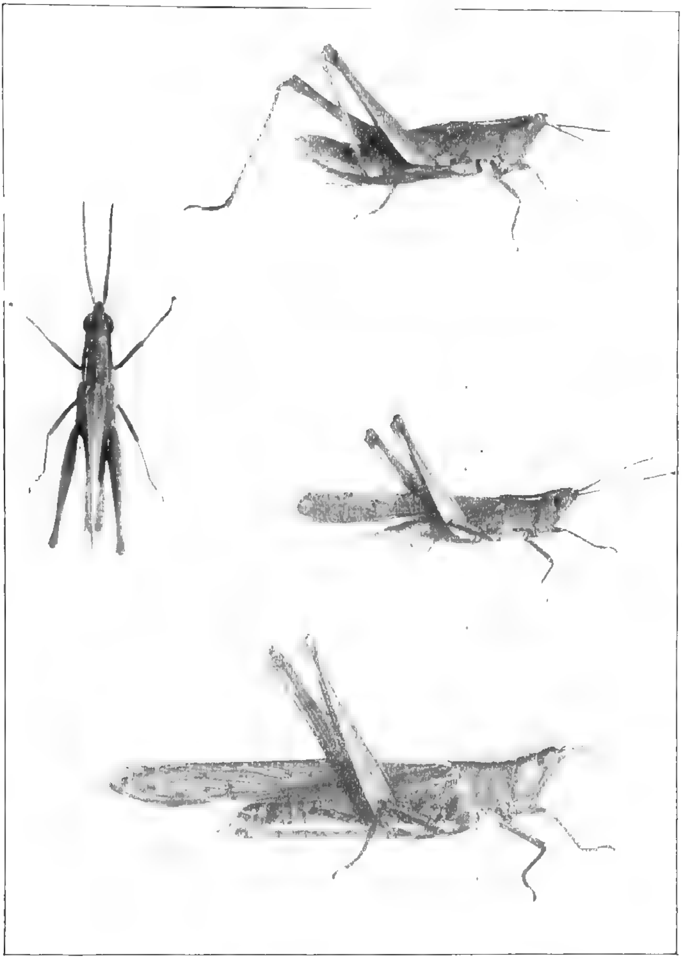
it is a harmless species to cultivated crops. But from a biological point of view it is of particular interest. The form of this locust, as well as the body color patterns, are seemingly of use in protecting its life from predaceous animals. It is a variable species, presenting three types of color markings in the male, and at least two types of coloring in the female. These color forms may be represented as follows:

MALE Very much smaller than female	*1st form.* Dorsum, face, and middle legs green, contrasting with dark brown of the remaining portions of the body.
	2nd form. Light straw color replaces the green, and in other respects similarly colored.
	3rd form. Body wholly green with the exception of eyes and antennæ, which are pale brown.
FEMALE	*1st form.* Pale green dotted with brown on the wing-covers (tegmina).
	2nd form. Body wholly brown.

The landscape view of a creek bottom, shown in the accompanying plate, shows the habitat of this locust. In the open foreground, the greater part of the vegetation consists of lizard's tail, blue flag, and sedges, springing from the perpetually wet sandy creek bottom. Water plantain and marsh grasses are also represented, but not conspicuously showing in the view.

This vegetation, together with the wet ground, is the ideal home of the short-horned locust. As these insects perched on the leaves, or stems of these plants, the colors of the insect were remarkably beautiful, yet very inconspicuous against the green background. These locusts often hid behind the stems of the leaves, in which case their slender bodies proved to be exquisitely adapted for concealment.

On August sixth and seventh I found that some of the nymphs of these insects had just undergone the last moult, having just arrived at maturity. At the same time I found many of the larvæ in the wet marsh grass in various stages of development. The morning dew was still on the vegetation when I visited this locality on the seventh. Then I found that the males, which are much smaller than the females, were quite sluggish, and they generally chose to perch on the upper surface of the leaves of the lizard's tail. They often flew but a few feet when disturbed, and their transparent wings would fail to attract attention to them.

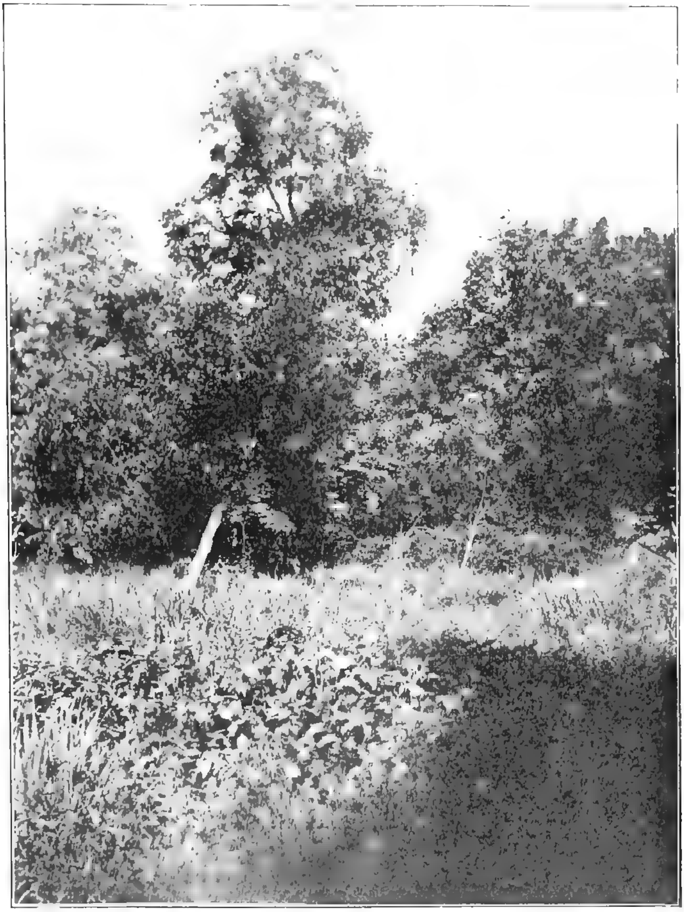


The Short-horned Locust (Tryxalis brevicornis). The top figure is a young (nymph) female; the left figure shows the dorsal view of an adult male; the middle and lower figures to the right are profile views of the adult male above and the female below.

On the twentieth, while the wind was blowing strongly, I found their behavior quite different from that which I have just described. At this time they were wary, being ready at the slightest provocation to take to their wings. When so startled they flew but a few yards, but they always showed an indisposition to leave the immediate locality, which I show in my landscape view. On one occasion I found many of the adult males assembled on the ground at a certain point among the short marsh grass. Then, after further investigation, I commenced finding females congregated, to the extent of five or six in number. I had not noticed the latter at first, owing to their harmonious coloring exactly simulating the grasses. So inactive were the females here, that I picked them up with my fingers with little difficulty.

Associated with the short-horned locust on the lizard's-tail leaves and blue flag were a number of lubberly and two-striped Melanoplus, which are found widely distributed. The frogs and the garter snakes were quite numerous here. One garter snake climbed to the top of the herbage, and there seemed content to spread its coils out to get the full rays of the sun. I wondered, while viewing this sight, if these frequenters were not a factor in reducing the numbers of these grasshoppers, yet I did not see them feeding on insects.

At a certain period in the late summer, the short-horned locust finally becomes discontented with its exclusive home among the lizard's tail, and sets out on a migratory expedition, never to return again to the place of its birth. The first evidence of this was found on the night of August sixteenth, when one of these insects, attracted by the bright light of a lantern, came flying down at our doorway. I assured myself that this was a migration, for the natural dwelling place of these short-horned locusts was not less than several hundred yards away. Afterward, I found other specimens of this species, washed up on the beach at the shore of Lake Michigan, which seemed convincing proof of the truth of my deductions. The short-horned locust has a southern distribution; only once has it been found as far north as Ontario. The short-horned locust well illustrates the adaptation of an insect to hydrophytic plant societies.



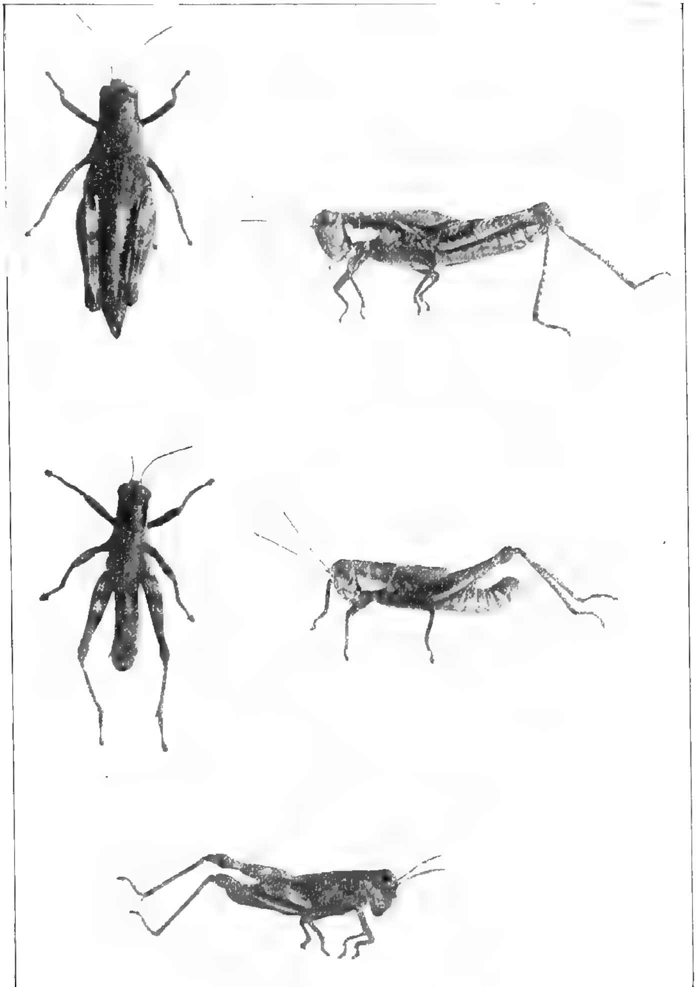
The home of the Short-horned Locust (Tryxalis brevicornis). In the foreground is shown the lizard's tail (Saururus cernuus), blue flag, grasses, and sedges. The locusts frequent the leaves of these plants and on the wet ground deposit their eggs. The right hand foreground is in deep shadow, produced by a large tree not in the picture.

The Green-legged Locust

In another chapter on the Habitat of the Orthoptera, I have given a view of a landscape, showing the environment of locusts, and also giving a list of the Orthoptera found within the area shown. The green-legged locust, *Melanoplus viridipes*, shown in the plate illustration, prefers the seclusion of the forest, living on the shadowy ground among the fallen dried leaves, such as the beech, hard maple, lime, and hickory. The dense undergrowth toward the edge of the woods, interior consisted principally of spice brush, elderberry, nettle, sumach, poison ivy, sarsaparilla, and a scattering growth of wild blackberry brambles. In this dense undergrowth on the ground, there were small areas of leaf-covered humus, free from vegetation, which were exposed to view. It was in these situations, covering about an acre of ground, that the short-winged green locust gathered in little scattered communities of three to half a dozen individuals. This species was not alone here, for it was sometimes accompanied by another short-winged species, the sprinkled locust, which is described at length in another chapter.

The green-legged species is very inconspicuous, living almost entirely on the ground; occasionally, however, I found one perched on the green leaves of the low herbage, where it feeds on the leaves. They were not easily detected among the fallen leaves, owing to the harmony of their colors with the background, and sometimes I recognized their presence only when the herbage near the ground was suddenly shaken by the contact of the male and as it jumped swiftly to escape. The female is more clumsy than the male; the latter often makes a succession of rapid jumps on the bed of the forest, covering a distance of a yard or two. If pursued further, it not infrequently hides under the leaves.

This species was found between the middle of June and the middle of August in the woods mentioned, but after the latter date, it was replaced by Blatchley's locust, a closely allied species. On August fourth a number of nymphs were found, which were about to become mature. The life history of this species, like many of our locusts, is still unknown. At one time, July thirteenth, I found a female on a rotten stump and possibly it was laying its eggs there.

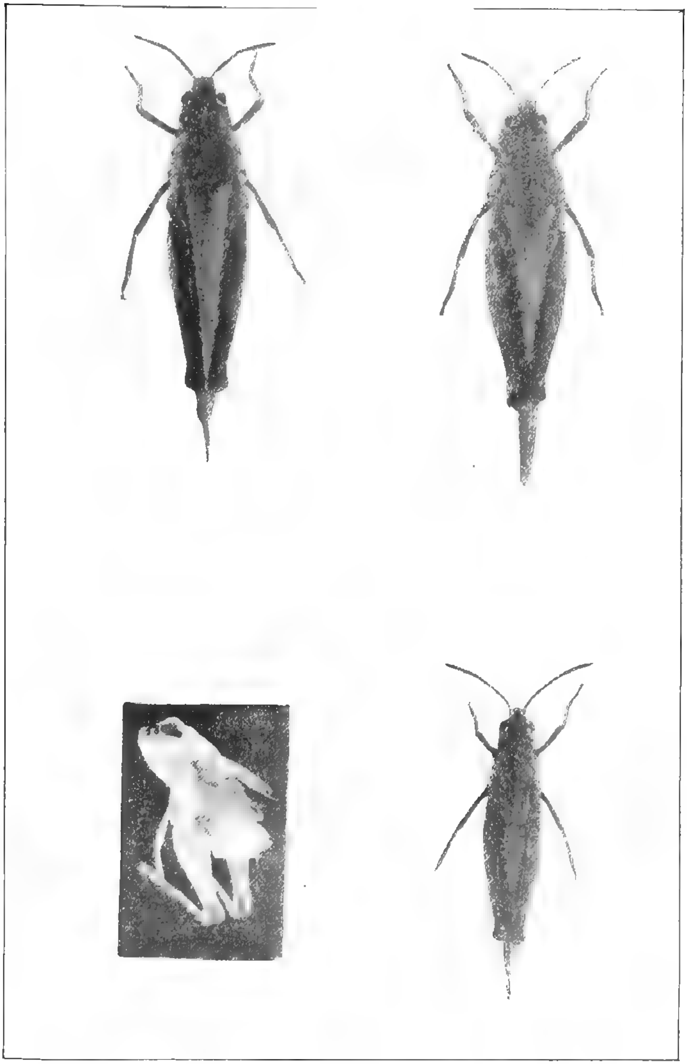


Green-legged Locust (Melanoplus viridipes). Upper two figures, females; the two middle figures, males; the lower single figure, a nymph — last larval stage. This species prefers the seclusion of the forest, living among the fallen dried leaves on the ground, but is occasionally found at the edge of the woods on shrubbery.

The Green-striped Locust

Only a few of our locusts hibernate in the immature stage, most of the species passing the winter in the egg. The green-striped locust, *Chortophaga viridifasciata*, is one of the first to mature in the spring from the nymph that has passed through this cold period. It is a great delight to visit the haunts of this locust. At the border of an oak copse, after the snows have just melted, one finds him in a fresh dress of vivid green. Even as early as March the nymphs of this species may be found on a sunny day in company with the quaker and the small grouse locusts that have also weathered the winter. The green-striped locust is trichromatic in color pattern, that is, it presents a green and a brown form, and in addition a mixed type occurs which seems to be a hybrid of the two former varieties. In the green form, shown in the plate photographic illustration in the upper left-hand figure, it is tinged with a beautiful pinkish purple on the antennæ, lower face, under surface of the body, fore and middle legs, the hind tibiæ and median carina of the pronotum. The wing-covers when closed are marked by a dorsal stripe of ash brown.

On May seventh I found these insects abundant in a blue grass meadow east of the Des Plaines River, at Riverside, Illinois. On flushing the locusts from the ground here, they usually arose with a rapid, noiseless flight, keeping low to the earth. They often flew in a slightly curved course before they finally dropped into the grass, a distance of from five to seven yards away. The male sometimes gave out a faintly audible rustling sound only when his wings were thoroughly dry. Being much smaller than his mate he was less conspicuous on the wing, and appeared somewhat erratic in the zig-zag flight he pursued. During the warm sunlight, if these locusts were repeatedly followed, they generally arose a number of times from the grass. But instead of always hiding so, they would sometimes prefer to vary their behavior by hiding in the dead bleached grass which lay flat among the standing green herbage. In this case, either of the color varieties I have described was equally effective in concealment of the body. In the meadow habitat I have above mentioned more



The Green-striped Locust (Chortophaga viridifasciata). The upper two figures, females, the one to the right is the brown form, the one to the left is the green variety; the lower figure to the right is the brown male; the lower left figure is a cuticle or exuvia, shed from the body by the female above when it changed to maturity.

than a hundred of these locusts were seen. Of this number twenty-seven were swept into my net at random, with a view to examination. A census of this series showed the following ratio of color varieties: out of nineteen females seven were green and twelve were brown (like the upper right-hand figure of the plate illustration), while out of eight males all were brown (like the lower right-hand figure in the same plate).

In April the nymphs are found more than the adults. In the lower left-hand corner of the plate illustration I have shown a pale nymph cuticle against a dark background. This exuvia or skin was shed by the adult female shown immediately above it on the same plate but a few minutes before I pictured it. On April 22, 1906, I found three nymphs in the southern part of Chicago at the border of an oak copse. Here they enjoyed a life among the *débris* resulting from the decayed leaves, and stems of herbage. A few days later these nymphs moulted in my vivarium at home. In this region adults reach maturity from about the last of April to the second week in May.

At Miller, Indiana, June fifth, I found a female laying her eggs in damp sand at the border of a pond. When I approached she had her abdomen buried quite deeply. After I waited about fifteen minutes she finally moved away from the place. I proceeded very carefully to dig the earth away to one side of the burrow and then it was found to be twenty-seven millimetres deep and at the bottom the eggs, twenty-five in number, were laid in a compactly cemented mass. They were bound together with a whitish mucus and there was quite an amount of this substance lying above the eggs in the burrow. The smaller poles or ends of the eggs were directed upwards, as is usual with the Acridians. The eggs measured four and one half millimetres in length and about one millimetre in width, and they were slightly curved in their long axes. Both ends were rounded, but the cephalic or head end was slightly smaller than the opposite one and further distinguished in the fresh eggs by the very small, densely opaque, cap-like structure occupying the extreme tip. There is but one brood of these insects, the young hatching from these eggs passing the winter in the nymph state.

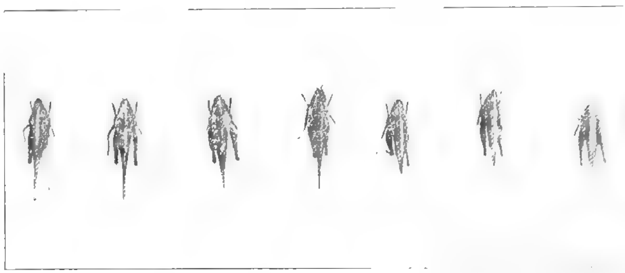
In reference to the color varieties, McNeil mentions in "Psyche" that the brown form "is the common one in the early spring, and while green males are very rare at this season, green females are common; later the green form predominates and the brown form is the one of exceptional occurrence, but the males are less common than the females." These insects are found throughout the summer in suitable localities.

View of a landscape in the dune region in April, showing the habitat of the granulated grouse locust (Tetrix granulata).

The Grouse Locusts

The grouse locusts are the smallest Acridians, and they will be easily recognized from the photographic illustrations. They are often found in marshy swales in early spring, such as I have depicted in the typical landscape illustration on this page. This particular view was taken at Dune Park, Indiana, in April, and at the time I visited the spot the area shown in the foreground was frequented by hundreds of granulated grouse locusts, *Tetrix granulata*. These insects were sunning themselves on the ground among the fragments of dead, bleached bunchgrass and sedges. This part of the ground, which was now dried out, had evidently been under water but a short time previously. The row of granulated grouse locusts presented in our second illustration shows seven individuals which bear a light median stripe along the back. This form of coloring is perfectly protective when the insects are in their natural environment.

In this species the color markings, or patterns, are quite variable; though these variations are not nearly so numerous as those exhibited in the following ornate grouse locust, given



A row of Granulated Grouse Locusts (Tetrix granulata), showing the median striped form. These insects are well protected in their natural surroundings.

in the third photographic illustration. Notwithstanding the extraordinary variety of color patterns of these Acridians, they harmonize in every instance with the soil, making it difficult to locate them. This protective resemblance is heightened

A row of the Ornate Grouse Locusts (Tetrix ornata), showing many color forms and hybrids.

by the little insects living on the soil scattered with *débris* faded out by the sun. The lights and shadows in whatever way they play are copied exactly. No shade, color, or arrangement of markings seems impossible of simulation, and every individual is a study of color harmony. It is in the ornate grouse locust that is found the greatest amount of variability, and in this species the individual color varieties interbreed freely. According to experiments in breeding made by Nabours, some of the color forms I have noted are hybrids. These nine examples were found associated together on a light loam in an open meadow, within an area of a few square yards, at Kenilworth, Illinois, on July eleventh. I have borrowed this illustration from my published work entitled "Tettigidea of North America," and also some of the facts given in this sketch.

The jump of the grouse locusts is peculiar, in that it is quick and inconspicuous, and it alights almost invariably on the ground. The young of the larger Orthoptera usually alight on grasses or stems of plants, dodging behind them for protection. These insects often hibernate in the nymph and adult state during the winter. Like the quaker and green-striped locusts, described in another chapter of this book, they appear very early in the spring and at times all three may be found associated together. Before the grouse locusts hibernate they have the habit of secreting themselves under dead leaves, mosses, grasses, old wood, logs, and bark at the base of trees, and in the little crevices in the earth where they happen to be in the late fall of the year. All of the species live on the ground.

Those in this region belong to either of the following four genera: Nomotettix, Tetrix, Paratettix, and Tettigidea. They usually live near water, either in boggy places, along the shores of lakes, the banks of streams, swamps, in woods, or, more rarely, on dry upland ground. They feed on vegetable mould, or decomposing soil, and are quite fond of algæ, lichens, mosses, tender sprouting grasses, sedges, and germinating seeds of plants found in damp situations.

In the middle of May the first eggs are laid in the ground, the female accomplishing this act by making a shallow burrow with her ovipositor. The young larvæ hatched from this brood mature by fall, passing the following winter in the adult state. The broods hatched in late June or early July are often immature by the time winter arrives, and one finds them hibernating in the pupa state. Thus it is that the grouse locusts are about the earliest insects to be found in the spring, appearing as early as March, and rarely, in winter when the sun's rays thaw the ground. The time of incubation varies with the temperature, the early broods of the ornate grouse locust hatching in twenty-three days; but as the days become warmer this period is shortened to about sixteen days. The number of the eggs of the grouse locust varies considerably; in the genera Tetrix and Paratettix they often consist of ten, thirteen, or sixteen in each burrow. In the genus Tettigidea they more often range from twelve to twenty-six in number. The eggs are laid at the bottom of the rather shallow burrow. They are deposited one by one, side by side, on the same level, and when all are laid they form a pear-shaped mass. In Tetrix the eggs are covered up with minute fragments which the mother scrapes off the ground with her hind feet. During the life of these little Tettigians they are more or less constantly in danger of enemies among the spiders, insects, birds, toads, and other animals. The larva of a red mite is one of the most frequent sources of annoyance. Acting as a parasite, this Trombidian larva clings to the body and attaches itself out of reach of its victims. It is found on many species. Among insect pests, ants and bugs are sometimes deadly to them. In June in a wet ditch I found a number of small dark brown ants dragging along the ground a female *Tetrix ornatus* which had just been killed by them. When endeavoring to capture some Tetrix at the same place, my attention was drawn to a colony of these ants acting excitedly. Further investigation showed that the ants had darted upon the insect I was pursuing, tumbling it over and biting it savagely about the neck. The little locust finally escaped by a vigorous jump.

The bug known as *Galgulus oculatus* captures many Tetrix. It suddenly leaps on the grouse locust, and embracing it between its front femora and tibiæ, sucks out the locust's vital juices. I have frequently seen these curious bugs with prominent eyes in numbers in the same habitat with these little locusts. Toads, fishes, and birds devour these insects and help to swell the mortality among them. The hermit thrush, as I have noted in another chapter, during its spring migration consumes Tetrix and Tettigidea to the extent of seven per cent of its entire food. Nabours informs me that he found several species of spiders preying on these insects in the South, especially in Louisiana.

The Lesser Locust

The lesser locust is one of our commonest species, beginning to mature about the first of June in northern Illinois and at Lakeside, Michigan. It is found in waste places almost everywhere, along weeded roadsides, in meadows, and even making cultivated fields and lawns its abode. I found this species in an open meadow south of Jackson Park, Chicago, June 18, 1905. A great number of young Orthoptera were seen here, including Melanoplids, Tryxalids, and Edipodids, but the only mature species were the lesser locust, the quaker, and the green-striped locust, all of which I have described in other chapters. The lesser locust was the prevailing species, and it jumped up very often before my footsteps. Many of the individuals had just moulted, as instanced by their pale color and the soft condition of the body. The average adult flew only a yard or two when disturbed, and then it sought cover among the verdure of the grasses, poison ivy, the low hop clover, white clover, sheep sorrel, wild strawberry plants, swamp rose, beach pea, potentilla, bed straws, and other plants too numerous to include here.

The lesser locust will be quite easily recognized from the photographic illustration of the female above and the male below. In the latter the abdominal appendages are quite characteristic, the cerci are about twice as long as broad, the apex rounded, and the apical half is turned upwards.

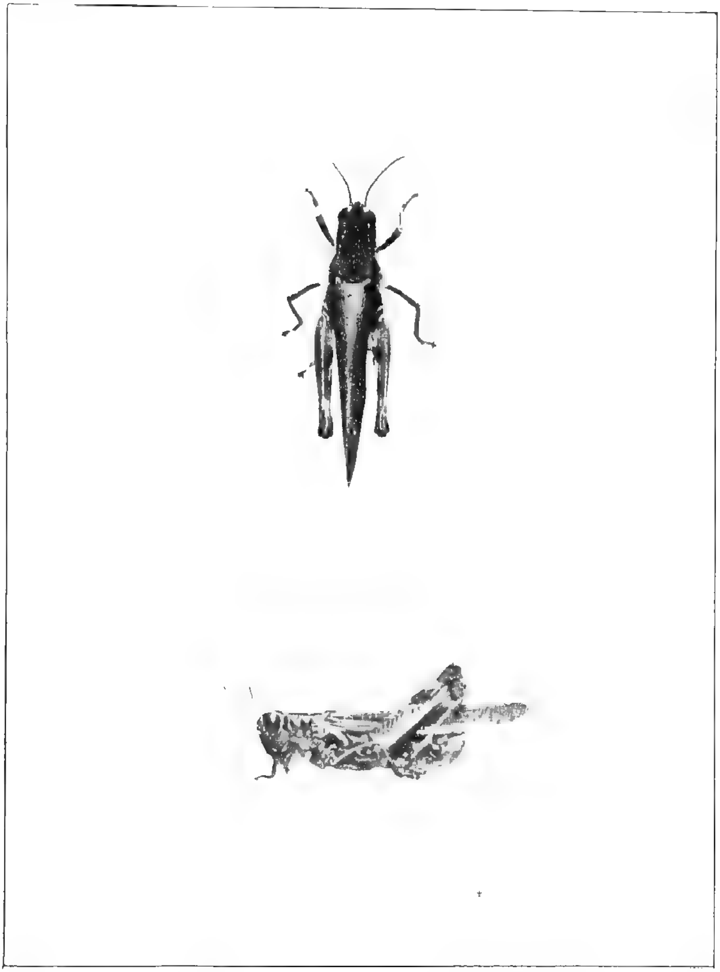
Blatchley has found this species in late spring and early summer "resting on iron-weeds and thistles in company with *M. gracilis* and *M. luridus*, and other species. The cast-off skin of their final moult is often noted on such weeds, showing that the nymph climbs thereon to change its garment of youth for one of maturity." The genus to which this species belongs comprises no less than one hundred and fifty species in North America. These inconspicuous insects often do great injury, and in certain years increase in numbers and become a pest to the agriculturist. In former times the migratory locusts, near relatives of the present species, formed into great clouds that destroyed everything in the nature of vegetation that came in their path. The more extensive and intelligent cultivation of the ground which effectually destroyed their eggs has gradually controlled these enormous swarms of locusts, so we rarely witness the clouds of these insects seen some years ago.

The Pennsylvania Cockroach

Few of us realize the great abundance of insect life that can be found in old stumps. I recall my surprise at pulling off some bark of an old tree stump one day to discover a horde of cockroaches secreted there. But so quick were they in their movements to escape that I could hardly get a satisfactory glimpse of one of them. At this time the question arose as to whether these insects were simply our common household pest, *Blatta orientalis*, or a wild species. More recently,

The Pennsylvania Cockroach (Ischnoptera pennsylvanica), one of the most common of our roaches, living under loose bark. Male, female, and cast skin.

June 1, 1905, an opportunity came again to look into this question and I satisfied myself that what I formerly saw on the old tree stumps was the wild species, the Pennsylvania cockroach, which in scientific terms is known as *Ischnoptera pennsylvanica.* I have depicted the male, female, and a nymph cuticle in the accompanying photographic illustration. On the day mentioned I was in an open wood at Flossmoor, Illinois, when I noticed a number of oak stumps. Here under the loose bark that peeled off quite easily, I encountered a large number of these cockroaches.



The Lesser Locust (Melanoplus atlanus). This species, together with other members of the same genus, occurs in great abundance and contributes to the common horde of locusts. Female above, male below.

At this time most of the individuals seen were pupæ, but associated with them were quite a number of adult males. Some of the latter were wholly translucent white, having just undergone the last moult. On removing a large-sized piece of bark, under which these insects had congregated, it was remarkable the swiftness with which they disappeared from sight. Like a flash they all scampered into various accessible cracks or crevices, hiding themselves wherever they could find cover. The flattened bodies proved to be excellently adapted to slip into narrow, confined places. A number of adult females were also found, but these were alone on the ground as a rule, on pieces of bark, seeming to indicate a desire on their part to isolate themselves from the gregarious stump colonies nearby. These insects are said to infest country houses, where they are attracted by light. On account of their fondness for the paste under the wall paper they cause much injury to these decorations.

The young in various stages survive the winter on tree stumps, and Blatchley mentions that "cold has seemingly but little effect upon them, as they scramble away almost as hurriedly when their protective shelter is removed on a day in mid-January, with the mercury at zero, as they do in June when it registers 100 degrees in the shade."

The Pennsylvania cockroach is a moderately large species of blattid; the male is shown in the left-hand figure of our illustration. Its body is elongated and bears long membraneous wing-covers, or tegmina. The color of the insect is dark brown, the centre of the pronotal disk being dark, while the sides are translucent whitish during life. The female shown in the middle figure of my illustration is so remarkably different from the male that for a long time it was taken for another species by naturalists and described twice under different names. An immature individual was also first given a distinct appellation until more definite observations of late have proved that the young, the female and male thus described, all belonged to a single species. The object shown to the right of the illustration is the nymph's cuticle; it was moulted from the female some time before I took the photograph for the figure. The insects forming the subjects of my three figures were found at Flossmoor, Illinois, June 1, 1905.

CLASSIFIED HABITATS OF VARIOUS SPECIES OF ORTHOPTERA BASED ON THEIR EGG-LAYING SITES, TO SHOW THEIR RELATION TO PLANT FORMATIONS IN GENERAL.[1]

First Section: *Ground Habitats.*

Geodytes.

The species belonging to this series are ground inhabiting. With their ovipositors they are enabled to prepare a place in which they lay their eggs, one at a time, to form masses in the ground humus, loam, sand, old decayed wood (locusts and crickets), or in caves (cave camel cricket). Those without conspicuous ovipositors lay their eggs either in the form of oötheca (cockroaches) in or under old wood, bark, stones, or in masses in underground galleries (mole and burrowing crickets), or drop a single egg at a time to the ground (walking-stick). One of the distinguishing features of the geodytes is that they rarely, or never, lay their eggs on live or growing vegetation. They are divisible into eleven series as follows:

I. Wet Ground Inhabiting Species: Hygrogeocolous.

1. Granulated Grouse Locust *Tetrix granulata* (Kirby) (see illustration, page 412). Swampy tracts, bogs, river bottoms, and boggy woods; 9*a*, 11*b*, 19, 22, and 23.

2. Obscure Grouse Locust *Tetrix obscura* (Hancock). Swamp forest; 23.

3. Indiana Grouse Locust *Neotettix hancocki* (Blatchley). Frequenting swamps; 22*f*.

4. Hooded Grouse Locust *Paratettix cucullatus* (Burm.). Semiaquatic, nearly always frequenting margins of lakes, ponds, and streams; 3*a*, 4*a*, and 11*a*.

[1] The Orthoptera represented are those principally found in Illinois, Michigan, and Indiana, but they may serve as well for many of the adjoining States. These habitats are presented as a working basis for dividing the various species into series. The numbers following each species refer to their defined habitats given on pages 430–433.

5. Armed Grouse Locust *Tettigidea armata* (Morse) and *depressa*. Margins of ponds bordered by woods; 4*b*.

6. Short-winged Grouse Locust *Tettigidea parvipennis* (Harris) and *pennata*. Swampy woodlands, margins of ponds bordered by woods, low tracts, and meadows; 4*b*, 10, and 23.

7. Spicated Grouse Locust *Tettigidea spicata* (Morse). Cypress swamps; 22*f*.

8. Short-horned Locust *Tryxalis brevicornis* (Linn.) (see illustration, page 403). Frequents aquatic plants along margins of lakes, ponds, streams, and swales; 3*a*, 4*a*, 7*a*, 12*a*, and 20.

9. Short-winged Green Locust *Dicromorpha viridus* (Scudd.) (see illustration, page 393). Coarse grasses along margins of lakes, ponds, streams, and swales, occasionally along borders of open woods; 3*a*, 4*a*, 7*a*, 12*a*, 20, and 24*a*.

10. Spotted Locust *Orphuella pelidna* (Burm.). Margins of lakes, ponds, and in meadows; 3*a*, 4*a*, and 10.

11. Short-winged Brown Locust *Stenobothrus curtipennis* (Harris) (see illustration, page 371). Meadows, swamps, and swales; 22*d*, 44, and 45.

12. Striped Locust *Mecostethus lineatus* (Scudd.). Among coarse grass and sedges in swales and swamps; 19, 20, and 22*d*.

13. Slender-bodied Locust *Leptysma marginicollis* (Serv.). Margins of ponds on sedges and rushes; 4*a*.

14. Leather-colored Locust *Schistocerca alutacea* (Harris) (see illustration, page 369). Wet meadows, margins of marshes, sloughs, and meadow thickets; 9, 10, 21, and 26.

15. Meadow Green Locust *Hesperotettix pratensis* (Scudd.). Margins of swales and swamps; found in dune and sandy regions, but often lays eggs at margin of swales; 21 and 22.

16. Northern Locust *Melanoplus extremus* (Walk). Peat bogs and swamps; 19 and 22.

17. Lubberly Locust *Melanoplus differentialis* (Uhler). Margins of lakes, ponds, streams, and in meadows and bottomlands along margins of creeks. Often associated with *Dicromorpha viridus*, *Tryxalis brevicornis*, and sometimes with *Schistocerca americana*. Eggs sometimes laid under bark of logs, at other times in the ground; in the former case it might be classed with the lignicolous series; 3*a*, 4*a*, 7*a*, 12*b*, and 17.

18. Two-striped Locust *Melanoplus bivittatus* (Say) or *femoratus*. Margins of streams, ditches, and in wet meadows, spreading to fields and pastures; 7, 10, 18, 45, and 46.

19. Nebraska Locust *Phœtaliotes nebrascensis* (Thos.). Marshes and swales; 9 and 20.

20. Hoosier Locust *Paroxya hooseri* (Blatchley). Borders of swales, ponds, and tamarack bogs; 4*b*, 19, and 20.

21. Scudder's Paroxya *Paroxya scudderi* (Blatchley). Borders of swales and ponds; 4*a* and 20.

22. Striped Ground Cricket *Nemobius fasciatus* (DeGeer). Frequenting grasses at margins of marshes and swales; 9 and 20.
23. Swamp Ground Cricket *Nemobius canus* (Scudder). Marshes and swales; 9 and 20.
24. Marsh Ground Cricket *Nemobius palustris* (Blatchley). Tamarack swamps and bogs seeking sphagnum mosses; 19*c* and 22*d*.
25. Small Brown Cricket *Anaxipha exigua* (Say). Tamarack swamps among sphagnum mosses, and margins of ponds; 4*a* and 21*d*.
26. Beautiful Crimson Cricket *Phylloscirtus pulchellus* (Uhler). Margins of ditches, borders of marshes, wet thickets and ponds, frequenting grasses and shrubs. Eggs (site unknown) may possibly be laid in stems of shrubs; 4*a*, 9*a*, 18*a*, and 40*b*.

II. Medium Dry Ground Inhabiting Species: Humicolous.

27. Crested Grouse Locust *Nomotettix compressus* (Morse) and *atavus*. Dry pastures and glens among dunes. Eggs, twelve or more, laid in shallow excavation in the ground or in moss; 41 and 64.
28. Ornate Grouse Locust *Tetrix ornata* (Say) and *triangularis*. Dry open woodlands, grassy and gravelly fields, and sun-exposed slopes; 47, 54, and 65.
29. Hancock's Grouse Locust *Tetrix hancocki* (Morse). Dry open woodlands, gravelly fields, and pastures; 46, 47, and 54.
30. Sand Grouse Locust *Tetrix arenosus* (Burm.). Dry open woods; 54. (Southern Indiana and Illinois and southward.)
31. Pasture Locust *Orphuella speciosa* (Scudd.) (see illustration, page 401). Pastures, grasslands, and fields of sandy loam; 44, 46, and 47.
32. Varied-winged Locust *Arphia xanthoptera* (Gemar) (see illustration, page 353). Dry pastures, stubble fields, sandy wastes, and borders of dry open woodlands; 46*a*, 47*c*, *e*, 48, and 54*a*.
33. Sulphur-winged Locust *Arphia sulphurea* (Fab.). Dry open woods and pastures of light sandy loam, among dead leaves; 46*a*, *b*, 54*a*, *b*.
34. Green-striped Locust *Chortophaga viridifasciata* (DeGeer) (see illustration, page 409). Dry open woods, grasslands, and pastures of bluegrass; 44, 46, and 54.
35. Clouded Locust *Encoptoloplus sordidus* (Scudd.) (see illustration, page 373). Stubble fields and dry pastures; 46 and 47*e*.
36. Clear-winged Locust *Camnula pellucida* (Scudd.). Fields, dry pastures, and wastes; 46, 47, and 48.

37. Orange-winged Locust *Hippiscus phœnicopterus* (Gemar). Open fields and wastes; 47, 48, and 54.

38. Rough Locust *Hippiscus rugosus* (Scudder). Dry abandoned pastures, open woodlands, and stubble fields; 46*b*, 47*d*, *e*, and 54.

39. Carolina Locust *Dissoteira carolina* (Linn.). Sandy wastes, cultivated fields, frequenting bare ground; 47 and 48.

40. Boll's Locust *Spharagemon bolli* (Scudder). Dry woodland pastures, stubble, and abandoned fields and slopes; 46, 47, 54, and 65.

41. American Locust *Schistocerca americana* (Drury). Dry abandoned fields, meadows, oak barrens, prairies, and marshes; 47*d*, *e*, 49, 52, and 22*d*.

42. Injurious Locust *Schistocerca damnifica* (Sauss.). Dry abandoned fields and barrens; 47 and 48.

43. Scudder's Short-winged Locust *Melanoplus scudderi* (Uhler). Borders of open woods; 54.

44. Obovate-winged Locust *Melanoplus obovatipennis* (Blatchley). Open woods of oak and beech and bordering marshes; 9 and 54.

45. Green-legged Locust *Melanoplus viridipes* (Walsh). Woods of beech and maple among leaf mould, also borders of woods and grassy ravines; 32 and 39.

46. Graceful Locust *Melanoplus gracilis* (Bruner). Wooded pastures, grasslands bordering woods, in ravines and borders of marshes and sloughs; 9*a*, 21*a*, 39, and 46.

47. Morse's Locust *Melanoplus Morsei* (Blatchley). Dry forests and thickets sparsely vegetated, among leaves; 55 and 56.

48. Dawson's Locust *Melanoplus dawsoni* (Scudd.). Bed of forests and thickets; 32 and 40.

49. Striped Brown Locust *Melanoplus fasciatus* (Barnston—W.). Oak woods bordering lakes, and black oak barrens; 3*b* and 49*b*.

50. Blatchley's Locust *Melanoplus blatchleyi* (Scudder) or *amplectens*. Beech and maple woods, thickets, and borders of fields; 32, 40, and 47.

51. Lesser Locust *Melanoplus atlanis* (Riley). Fields, pastures, meadows, particularly in dry fields; 45, 46, and 47.

52. Common Locust *Melanoplus impudicus* (Scudder). Dry grassy fields and wooded slopes; 47*c* and 65*c*.

53. Red-legged Locust *Melanoplus femur-rubrum* (DeGeer). Meadows, pastures, and fields; 45, 46, and 47.

54. Small Locust *Melanoplus minor* (Scudder). Fields, grassy pastures on sandy loam; 46 and 47*c*.

55. Lurid Locust *Melanoplus luridus* (Scudd.). Dry open woodlands, thickets, pastures, sandy terraces, wastes, and barrens; 46, 48, 49, 54, and 55.

56. Thick-backed Grasshopper *Atlanticus pachymerus* (Burm.). Open woodlands and forests; young often frequent leaves of low shrubs; 32 and 33.

57. Shield-back Grasshopper *Atlanticus dorsalis* (Burm.). Forests and dry open woodlands; 32 and 33.

58. Curved-backed Grasshopper *Camptonotus carolinensis* (Gerst.). Oak woods and thickets, frequently found curled up on leaves; 55 and 56.

59. Blatchley's Camel Cricket *Ceuthophilus blatchleyi* (Scudd.). Woods and thickets, on sandy loam, under logs and rails; 32 and 40.

60. Uhler's Camel Cricket *Ceuthophilus uhleri* (Scudd.). Woods and thickets, on sandy loam; 32 and 40.

61. Ground Camel Cricket *Ceuthophilus terrestris* (Scudd.). Woods and thickets, on sandy loam; 32 and 40.

62. Short-legged Camel Cricket *Ceuthophilus brevipes* (Scudd.). Woods and thickets, on sandy loam; 32 and 40.

63. Cuban Ground Cricket *Nemobius cubensis* (Sauss.). Sandy bed of old canal (recorded by Blatchley).

64. Small Ground Cricket *Nemobius exiguus* (Blatchley). Grass-covered banks of streams and open woodlands; 28*b* and 33.

65. Scudder's Ground Cricket *Nemobius caroliensis* (Scudder). Banks of streams and open woodlands; 28*b* and 33.

66. American Field Cricket *Gryllus americanus* (Blatchley). Open woods; young hibernate under logs; 33.

67. Sociable Field Cricket *Gryllus abbreviatus* (Serv.). Fields, pastures, and open woodlands; sociable and seeking shelter under rubbish, logs, and old wood. Eggs laid in masses of several hundred according to McNeil; 33, 46, and 47.

68. Pennsylvania Field Cricket *Gryllus pennsylvanicus* (Burm.). Open woods, fields, and pastures; nymphs hibernate under logs and rubbish; 33, 46, and 47.

69. Saussure's Lesser Cricket *Miogryllus saussurei* (Scudd.). Woodland hillsides scantily vegetated, living under logs and flat stones; 65.

III. Dry Sand Inhabiting Species: Ammocolous.

70. Sand Locust *Ageneotettix arenosus* (Hancock) or *Scudderi*. Frequenting sandy wastes covered by bunch and other grasses; 48 and 51*a*.

71. Coral-winged Locust *Hippiscus tuberculatus* (Pal de Beauv.). Sandy wastes scantily vegetated, barrens, plains, and slopes; 48, 49, 52, and 65*a*.

72. Haldeman's Locust *Hippiscus haldemanii* (Scudd.). Sandy wastes scantily vegetated; 48.

73. Mottled Sand Locust *Spharagemon wyomingianum* (Thomas). Sparingly vegetated sandy wastes, abandoned

sandy fields, and blow sand with bunchgrass vegetation; 47*d*, 48, 39, and 63.

74. Ash Brown Locust *Mestobregma cinctum* (Thomas) or *Trachyrhachis thomasi* (Caudell). Sandy barrens, abandoned fields, and dry wooded slopes; 47, 48, 63, and 64.

75. Maritime Locust *Trimerotropis maritima* (Harris). Pure sandy beaches and dunes along south shore of Lake Michigan; 3*c*, 63, and 64.

76. Yellow-winged Sand Locust *Trimerotropis citrina* (Scudder). Gravelly and sandy bars along margins of rivers; 58.

77. Long-horned Locust *Psinidia fenestralis* (Serv.). Stretches of sandy wastes sparingly vegetated some distance inland from shore of Lake Michigan. Associated with Mottled Sand and Maritime Locusts; 3*c*, 63, and 64.

78. Narrow-winged Locust *Melanoplus angustipennis* (Dodge). Sandy wastes and barrens, abandoned fields; 48, 49, 59, and 64.

79. Yellowish Locust *Melanoplus flavidus* (Scudd.). Sandy wastes and barrens scantily vegetated; 48, 49, and 59.

80. McNeill's Locust *Melanoplus macneilli* (Hart). Sandy wastes and blowouts; 48 and 59.

81. Sand-loving Field Cricket *Gryllus arenaceus* (Blatchley).

IV. Rock Inhabiting Species: Petricolous.

82. Smooth Cockroach *Ischnoptera inæqualis* (Sauss.). Tops of hills under rocks and chunks; 51*b*.

83. Large Cockroach *Ischnoptera major* (Sauss.). Tops of hills under flat rocks; 51*b*.

V. Old Wood Loving Species: Lignicolous.

84. Small Shield Cockroach *Temnopteryx deropeltiformis.* (Brunn.). Low sandy woods bordering marshes, under logs, accumulations of sticks and leaves, and under stones; 9*a* and 32.

85. Perplexing Cockroach *Ischnoptera intricata* (Blatchley). Slopes of hills under old woods and chunks; 32.

86. Sprinkled Locust *Chlœaltis conspersa* (Harris). Borders of woods. Eggs to the number of sixteen are laid in old soft or decaying wood, logs, and stumps; 9*c*, 54, and 55.

87. Grizzly Locust *Melanoplus punctulatus* (Uhler). Pine woods and tamarack swamps. Eggs sometimes to the number of twenty-three are laid in the cracks of dead stumps; 22*d*.

88. Spotted Camel Cricket *Ceuthophilus maculatus* (Say). Forests, thickets, and ravines, frequenting dark recesses under logs and old pieces of wood on sandy loam; 32.

89. Black-sided Camel Cricket *Ceuthophilus latens* (Scudder). Woodlands, on sandy loam, under logs and pieces of old wood and stones; 32.

90. Spotted Ground Cricket *Nemobius maculatus* (Blatchley). Open woodlands, under logs, or near them; 33.

VI. Under Bark Inhabiting Species: Subcorticolous.

91. Forceped Earwig *Forficula aculeata* (Scudd.). Woods and tamarack swamps; under bark of logs, old tree stumps, and under leaves where the eggs are laid; 22*d* and 32*h*.

92. Small Earwig *Labia minor* (Linn.). Woods, under bark of trees; 32.

93. Pennsylvania Cockroach *Ischnoptera pennsylvanica* (DeGeer). Open woods under loose bark of old stumps and logs. Eggs laid together in the form of oötheca under bark; 32.

94. Uhler's Cockroach *Ischnoptera uhleriana* (Sauss.). Woods, under bark of old stumps, chunks, and rubbish; 33.

VII. Ground-Tree Inhabiting Species: Geosylvacolous.

95. Common Walking-stick *Diapheromera femorata* (Say). Frequenting trees and shrubbery in adult life; common on oak, wild cherry, and apple trees. Eggs dropped singly to the ground on leaf mould. The young first live on the ground, but later climb upon higher vegetation; 32, 37, and 40.

96. Two-striped Walking-stick *Anisomorpha ferruginea* (Pal. de Beauv.). Oak and other trees; commonly hiding under loose bark of old stumps during mating; 32.

97. Blatchley's Walking-stick *Bacunculus blatchleyi* (Caudell). On coarse vegetation; 52.

VIII. Underground Inhabiting Species; Burrowing: Subgeocolous.

98. Northern Mole Cricket *Gryllotalpa borealis* (Burm.). Margins of streams and ponds, burrowing underground, living in galleries. Whitish eggs in masses attached to roots of plants, sometimes sixty or more in lateral chambers; 4*a* and 7*a*.

99. Larger Burrowing Cricket *Tridactylus apicalis* (Say). Sandy and muddy margins of streams, ponds, and wet sand bars; 4*a*, 7*a*, and 58.

100. Minute Burrowing Cricket *Ellipes minuta* (Scudd.). Sandy shores of ponds and streams; 4*a* and 7*a*.

IX. Cave Dwellers Troglocolous.

101. Cave Camel Cricket *Ceuthophilus stygius* (Scudd.). Near the mouth, and also within the dark recesses of caves.

X. Inhabiting Man's Houses: Brotiocolous.

102. German Cockroach *Blattella germanica* (Linn.). Common in city houses, living in warm steam-heated buildings;

feeding on various foodstuffs made of wheat flour. Eggs to the number of thirty-six contained in the oötheca; 76.

103. Oriental Cockroach *Blatta orientalis* (Linn.). Frequenter of both country and city houses, dark basements preferred, but occasionally going to the upper floors of steam-heated buildings. Eggs to the number of sixteen contained in the oötheca; 76.

104. American Cockroach *Periplanata americana* (Linn.). Largest of the household cockroaches, originally a native of the tropics; it frequents basements; 76*a*.

105. Australian Cockroach *Periplanata australasiæ* (Fab.). Least common of the cockroaches in houses of the North, but very common in the South; 76.

106. House Cricket *Gryllus domesticus* (Linn.). Ground floor of country dwellings, but quite rare; also found in sandy fields under rubbish; 47 and 76. This species is often confused with the Sociable Field Cricket, No. 67, which often enters country houses.

XI. Inhabiting Galleries of Ants: Myrmecolous.

107. Pergande's Ant-loving Cricket *Myrmecophila pergandei* (Bruner). Frequenting the underground galleries of ants, feeding on the oily secretions of their bodies, and such substances, lining the galleries. It lives as a tenant or inquiline.

Second Section: *Habitats above Ground.*
Phytodytes.

The species belonging to this series live above ground on vegetation. With their round, rasp-like, or flattened blade-like ovipositors they are enabled to place their eggs in various ways. Some of the eggs are deposited in the pith of twigs or in bark of trees by drilling holes (meadow, shrub, and tree crickets), or the eggs are inserted between the stems and leaves of grasses (meadow grasshoppers and cone-head katydids), or they are inserted in slits in the edges of leaves (meadow and shrub katydids), or in crevices of bark (true katydids), or they are plastered to the stems or along the outside margin of leaves (large-winged katydids and mantis[1]). The phytodytes generally lay their eggs on or in parts of live vegetation. They are divisible into five series as follows:

[1] The mantids have inconspicuous ovipositors.

XII. Grass Inhabiting Species: Gramnicolous.

108. The Sword-bearer *Conocephalus ensiger* (Harris), or *attenuatus*. Tall grasses, border of ditches, along fence rows, and in meadows. Eggs laid between the stem and lower leaves of tall grasses, such as timothy and Andropogon; 18*a*, 42, and 45.

109. The Nebraska Cone-head *Conocephalus nebrascensis* (Bruner). Tall grasses bordering ponds and ditches, fence rows, and in meadows; 4, 18*a*, and 42.

110. Bruner's Cone-head *Conocephalus bruneri* (Blatchley). Tall grasses at margins of river bottoms; 10*b*.

111. Robust Cone-head *Conocephalus robustus* (Blatchley). Shores of Lake Michigan; 3.

112. Marsh Cone-head *Conocephalus palustris* (Blatchley). Tall grasses at margins of ponds; 4*a*.

113. Slender Meadow Grasshopper *Xiphidium fasciatum* (DeGeer). Grassy pastures and meadows; 45 and 46.

114. Short-winged Meadow Grasshopper *Xiphidium brevipenne* (Scudder). Meadows, grasslands, and pastures; 44, 45, and 46.

115. Black-sided Grasshopper *Xiphidium nigropleura* (Bruner). Grasses, cat-tails, and sedges along margins of ditches, borders of lakes and ponds. Eggs deposited between stems and leaves of grasses, and occasionally between sheaths, and at top of Indian corn; 3*a*, 4*a*, and 18.

116. Glade Grasshopper *Xiphidium saltans* (Scudder). Grasslands and prairies, among tall grasses; 44 and 52.

117. Lance-bearing Grasshopper *Xiphidium attenuatum* (Scudder). Tall grasses and cat-tails bordering ponds, and swamps. Eggs laid between stems and leaves of grasses; 4*a* and 22.

118. Straight-lanced Grasshopper *Xiphidium strictum* (Scudder). Meadows, fields, prairies, and pastures; 45, 46, 47, and 52.

XIII. Inhabiting Composites and Herbaceous Plants: Compositicolous.

119. Curved-lanced Katydid *Scudderia curvicauda* (DeGeer). Wet meadows; 10.

120. Texas Katydid *Scudderia texensus* (Sauss. — Pict.). On composites and grasses in wet meadows, borders of lakes and ponds. Eggs laid in margins of leaves between the upper and lower epidermis in such plants as the goldenrod; 3, 4, and 10.

121. Pistillated Katydid *Scudderia pistillata* (Brunn.). Sedges and tall grasses at borders of lakes, ponds, thickets, in wet meadows, and tracts adjoining peat-bogs; 3, 10, and 19.

122. Common Meadow Grasshopper *Orchelimum vulgare*

(Harris). Meadows and along fence rows. Eggs laid in standing and prostrate stems of composites; 4*a*, 45, and 47*f*.

123. Green Meadow Grasshopper *Orchelimum glaberrimum* (Burm.). Meadows and borders of ponds. Eggs often laid in stems of composites.

124. Field Grasshopper *Orchelimum campestre* (Blatchley). Meadows and prairies; 10 and 52.

125. Black-legged Grasshopper *Orchelimum nigripes* (Scudder). Wet meadows, at border of lakes and ponds, frequenting tall grasses and other aquatic plants; 3*a*, 4*a*, and 10.

126. Small Indiana Grasshopper *Orchelimum indianense* (Blatchley). Margins of tamarack swamps on grasses and sedges; 22*d*.

127. Delicate Grasshopper *Orchelimum delicatum* (Bruner). Wet meadows and margins of ponds and streams; 4*a* and 10.

128. Gladiator Grasshopper *Orchelimum gladiator* (Bruner). Wet meadows and marshes; 9 and 10.

129. Nimble Grasshopper *Orchelimum volantum* (McNeill). Margins of lakes and ponds frequenting aquatic plants such as knotweed and Sagittaria; 3*a* and 4*a*.

XIV. Shrub Inhabiting Species: Thamnocolous.

130. Fork-tailed Katydid *Scudderia furcata* (Brunn.). Margins of thickets and wet meadows. Eggs inserted between the upper and lower epidermis of leaves of shrubs, from one to five eggs in row along the margin; 10 and 40.

131. Oblong-winged Katydid *Amblycorypha oblongifolia* (DeGeer). Margins of thickets, woods, and wet meadows; 32, 39, 40, and 45.

132. Round-winged Katydid *Amblycorypha rotundifolia* (Scudder). Margins of thickets and in ravines; 39 and 40.

133. Woodland Grasshopper *Xiphidium nemorale* (Scudder). Borders of woods and thickets and along fence rows. Eggs supposedly laid in old wooden posts and fence rails, a departure from the usual habits of the members of this genus; 32 and 42.

134. Sworded Grasshopper *Xiphidium ensiferum* (Scudder). Margins of thickets. Eggs frequently laid between the scales of the erect conical galls of a certain species of willow; 40*b*.

135. Broad-winged Shrub Cricket *Œcanthus latipennis* (Riley). Margins of thickets and in fields. Eggs frequently laid in drilled holes in the pithy interior of blackberry shrubs and grape-vines. As many as two hundred eggs are said to be laid by one female; 40, 47.

136. Snowy Shrub Cricket *Œcanthus niveus* (DeGeer). Shrubs along borders of thickets, in orchards, fields of blackberries, grape-vines; eggs laid frequently in stems of blackberry shrubs; 37, 40, and 47.

137. Narrow-winged Shrub Cricket *Œcanthus angustipennis* (Fitch). Margins of thickets, fields of wild blackberries and raspberries, also in pastures; 40, 46, and 47.

138. Striped Shrub Cricket *Œcanthus fasciatus* (Fitch). Fields and meadows occupied by such vegetation as composites, horseweed, *Leptilon*, sunflowers and goldenrod, and blackberry shrubs. Eggs laid in the stems of these plants; 45 and 47.

139. Four-spotted Shrub Cricket *Œcanthus quadripunctatus* (Bentenm.). Fields and meadows; 45 and 47.

140. Two-spotted Shrub Cricket *Xabea bipunctata* (DeGeer). Borders of thickets; 40.

XV. Tree Inhabiting Species: Hylacolous.

141. Carolina Mantis *Stagmomantis carolina* (Linn.). On trees. Eggs to the number of about forty are attached to twigs, forming a case about an inch in length, and covered with silk; 32.

142. Angle-winged Katydid *Microcentrum laurifolium* (Linn.). Woods, thickets, and ravines. Eggs laid in two flat rows, one egg being laid under the other, on twigs, or along the margin of leaves. The number of eggs varies from two to thirty; 32, 39, and 40.

143. True Katydid *Cyrtophyllus perspicillatus* (Linn.). Forests, thickets, groves, ravines, and orchards. The grayish, slate-colored eggs are laid in crevices of bark on trunks of forest trees; when first laid the eggs are shining black.

144. True Tree Cricket *Apithes agitator* (Uhler). Elm and oak woods, and thickets of prickly ash. Eggs laid in twigs of white elm and other trees; 32.

145. Jumping Tree Cricket *Orochares saltator* (Uhler). Elm and oak woods, and thickets of prickly ash. Eggs laid in twigs, in the bark of the trunk, and older branches of the elm; 32.

DEFINITIONS OF COMMON ENVIRONMENTAL COMPLEXES AND THE VARIOUS HABITATS OF PLANTS, GROUPED UNDER FORMATIONS[1]

I. WATER PLANT FORMATIONS: HYDROPHYTIA.

1. Ocean: One of the large bodies of water into which the great ocean is regarded as divided; the great ocean covers more than three-fifths of the surface of the globe.

2. Sea: One of the larger bodies of salt water, less than an ocean, found on the earth; (*a*) surface, and (*b*) deep sea.

3. Lake: A large body of water contained in a depression of the earth's surface and supplied from drainage of more or less extended area; (*a*) margin; (*b*) wooded margin; (*c*) sandy shore.

4. Pond: A confined body of water of less extent than a lake; referred to sometimes as a basin; (*a*) margin; (*b*) wooded margin.

5. Pool: A small and rather deep collection of fresh water, as one supplied by a spring; (*a*) margin.

6. Stagnant water: not flowing; (*a*) margin.

7. Stream: A flowing river or brook; (*a*) margin; (*b*) bottom-land; (*c*) wooded margin.

8. Salt Marsh: Similar to fresh marsh, but land covered wholly or in part with saline water; (*a*) margin.

9. Fresh Marsh: A tract of soft, wet land, commonly covered wholly or partially with fresh water; (*a*) margin.

10. Wet Meadow: Lowland covered with coarse grass or rank herbage.

11. River: A stream larger than a rivulet or brook; (*a*) margin; (*b*) bottom-land.

12. Creek: A stream of water smaller than a river and larger than a brook; *a*) margin; (*b*) bottom-land.

13. Brook: A natural stream of water smaller than a river or creek; (*a*) margin.

14. Rill: A very small brook; (*a*) margin.

15. Torrent: A stream suddenly raised and running rapidly, as down a precipitous slope; (*a*) margin.

16. Freshet: An overflowing of a stream caused by heavy rains or melted snow, usually occurring in the spring.

17. Spring: An issue of water from the earth; (*a*) margin.

18. Ditch: A trench made in the earth by digging for draining the land; (*a*) margin; (*b*) bottom; (*c*) canal.

19. Bog: A quagmire, or wet, spongy ground, where a heavy body is apt to sink; (*a*) sandy; (*b*) cold; (*c*) peat or sphagnum; (*d*) margin.

[1] Ocean, sea, and desert are added to make this nomenclature more complete. See note, p. 433.

20. Swale: A tract of low and usually wet land; see fen; (*a*) margin.
21. Slough: A wet place of deep mud or mire; (*a*) margin.
22. Swamp: Wet, low, spongy land, saturated but not usually covered with water; (*a*) sandy; (*b*) wet; (*c*) cedar; (*d*) tamarack; (*e*) wooded; (*f*) cypress; (*g*) margin.
23. Swamp Forest: A tract of land saturated with water and covered with trees that have never been cultivated; (*a*) margin.
24. Swamp Open Woodland: Wet lowland sparingly covered with trees; (*a*) margin.
25. Savannah: A tract of damp level land with a growth of grass or reeds; in the south.
26. Meadow Thicket: Lowland covered with thickly set trees and shrubs: (*a*) margin.
27. Fen: Lowland overflowed.
28. Bank: The rising ground bordering a lake or river; the margin of a watercourse; (*a*) rocky; (*b*) grassy; (*c*) sandy; (*d*) alluvial; when rising steeply it is (*e*) a bluff.
29. Rocky Seashore: The stony land lying adjacent to the sea.
30. Sandy Shore: The sandy land lying adjacent to the sea; (*a*) lake.
31. Tank: A large basin: (*a*) a cistern; (*b*) margin; (*c*) atoll.

II. Middle Plant Formations: Mesophytia.

Subsection: Shade-plant formations: Sciophytia.

32. Forest or Woodland: Land covered with trees; the forest refers to a tract of land covered with trees that has never been cultivated; (*a*) dry; (*b*) moist; (*c*) cold damp; (*d*) rich; (*e*) deep; (*f*) wet; (*g*) rocky; (*h*) border.
33. Open Woodland: Land openly scattered with trees; (*a*) thin; (*b*) border.
34. Grove: A smaller group of trees than a forest, and without underwood; (*a*) border.
35. Copse: A wood of small growth; a thicket of brushwood; (*a*) border.
36. Glade: An open passage through a wood; a grassy open or cleared space in a forest; (*a*) border.
37. Orchard: An enclosure containing fruit-trees; not usually applied to nut-bearing trees.
38. Canyon: A deep gorge or gulch between high steep banks worn by watercourses; occurring in western United States.
39. Ravine: A deep narrow hollow, usually worn by a stream or torrent of water; (*a*) border; (*b*) damp.
40. Thicket: A wood or collection of trees, shrubs, etc., closely set; (*a*) dry; (*b*) moist; (*c*) low; (*d*) border.

41. Glen or Dale: A depression between hills.

42. Fencerow: A strip of land along the course of a fence left untilled.

43. Hedgerow: A thicket of bushes between any two portions of land, often planted, but sometimes left after clearing wild land.

Subsection: Sun plant formations: Heliophytia.

44. Grassland: Land kept in grass and not tilled.

45. Meadow: Lowland covered with (*a*) coarse grass, or (*b*) composites or other herbage; (*c*) dry or drained.

46. Pastures: Grasslands for cattle, horses, etc.; (*a*) dry; (*b*) abandoned.

47. Field: Open cleared land; (*a*) sandy; (*b*) gravelly; (*c*) grassy; (*d*) abandoned; (*e*) stubble; (*f*) cultivated.

48. Waste: Unproductive and unused land.

49. Barren: A tract of barren or elevated land on which grow small trees, but not timber; (*a*) pine barrens; (*b*) oak barrens; (*c*) sterile; (*d*) fertile.

III. Dry Plant Formations: Xerophytia.

50. Desert: Vast sandy tracts of land, appearing in western United States, where evaporation exceeds rainfall.

51. Hill: A natural elevation of land rising above the common level of the surrounding land, in height less than a mountain: (*a*) sandy; (*b*) limestone.

52. Prairie: An extensive tract of level or rolling land, destitute of trees, covered with coarse grass, and usually characterized by a deep fertile soil; plains.

53. Plains: An open field or broad stretch of land with an even surface, or surface little varied by inequalities; prairie.

54. Dry Open Woodland: Land well drained, openly scattered with trees; (*a*) border; (*b*) sandy loam.

55. Dry Thicket: Land covered with a wood consisting of trees, shrubs, etc., but with well drained soil; (*a*) border.

56. Dry Forest: wild land, well drained, covered with trees; (*a*) border.

57. Gravel Slide: Sliding land made up largely of small stones and sand; (*a*) gravelly hillsides; (*b*) gravel pit.

58. Sand Bar: An extensive ridge of sand formed by currents in the water; usually submerged, but sometimes exposed by receding water.

59. Blowout: An excavation in sandy ground produced by the action of the wind.

60. Strand: The shore, especially the beach of the sea, ocean, or lake; rarely, the margin of a navigable river.

61. Terrace: A level plain usually with a steep front, bordering a river, lake, or sea.

62. Cave: An underground hollow place, or cavern.

63. Sand Drift: A tract of drifting sand.

64. Dune: A hill of drifting sand usually formed on the shore or coast, but often carried far inland by the prevailing winds.

65. Slope: An incline of land; (*a*) sun exposed; (*b*) shaded; (*c*) wooded.

66. Ridge: The upper part of a range of hills, or extended elevation between valleys.

67. Cliff: A high steep rock, a precipice; (*a*) wet; (*b*) light; (*c*) shaded.

68. Crevice: A narrow opening resulting from a crack or split.

69. Rock: Natural deposit of earth's crust of a concrete stony material; in this region limestone crops out on the surface; the soils over it: (*a*) sandy; (*b*) humus; (*c*) clay.

70. Humus: That portion of the soil formed by the decomposition of animal and vegetable matter; (*a*) clay; (*b*) sandy; (*c*) moist; (*d*) dry; also under mesophytic condition.

71. Heath: A tract of land overgrown with shrubs and coarse herbage (dry meadow); (*a*) border.

72. Moor: An extensive waste covered with patches of heath and bearing a poor light soil, but sometimes marshy and abounding in peat; (*a*) atoll.

73. Snow: Watery particles congealed into white or transparent crystals or flakes in the air, and falling to the earth, covering the ground in winter.

74. Alkali: Soils containing alkali.

75. Sterile: Unproductive land; (*a*) dry; (*b*) sandy; (*c*) open; (*d*) moist.

76. Man's Houses: Country and City Houses; (*a*) basements; (*b*) upper floors.

Note.—These habitats are arranged with reference to water and topography. The primary divisions under this grouping relate to water, forest, grasslands, and desert. These divisions are often further classified as hydrophytes, mesophytes, hylophytes, poophytes, and xerophytes, respectively, but I have restricted the classification, giving only the three main divisions. I have omitted regional classification, as being too extensive to enter here, and which can be found well amplified in such works on ecology as those of Schimper and Warming, and in those of Clements. The habitats here referred to are those often mentioned in descriptive books and in the present work.

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