ORTHOPTERA

OF

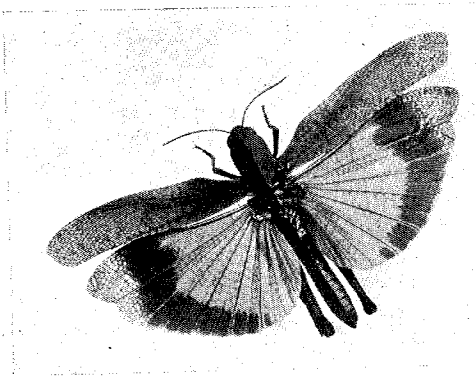
NORTHEASTERN AMERICA

WITH ESPECIAL REFERENCE TO THE FAUNAS
OF INDIANA AND FLORIDA

By

W. S. BLATCHLEY

Author of "Gleanings from Nature," "The Coleoptera of Indiana," "Woodland Idyls," "The Indiana Weed Book," etc., etc.



"And a locust unto Mahomet said: 'We are the army of the great God; we produce ninety-nine eggs; if the hundred were completed, we should consume the whole earth and all that is in it.'"

—*Arab Legend.*

1920

The Nature Publishing Company
INDIANAPOLIS

"The land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them."
—*Joel, II,* 3.

"Chiefs, who no more in bloody fight engage,
But wise through time and narrative with age,
In summer days like grasshoppers rejoice,
A bloodless race, that sends a feeble voice."—*Homer.*

"Green little vaulter, in the sunny grass,
Catching your heart up at the feel of June,
Sole noise that's heard amid the lazy noon,
When even the bees lag at the summoning brass."—*Leigh Hunt.*

"Crowds of bees are giddy with clover,
Crowds of grasshoppers skip at our feet,
Crowds of larks at their matins hang over,
Thanking the Lord for a life so sweet."—*Jean Ingelow.*

There has long been need of a single comprehensive manual on the Orthoptera of the Eastern United States. The original descriptions and information regarding the distribution and habits of these interesting insects are scattered through scores of books and pamphlets which the student has to consult in order to correctly determine the various species which he may collect or have at hand. Many of these works are out of print or very difficult to obtain. For that reason the beginner is often discouraged at the very start and the study of Orthoptera has, therefore, not kept pace with that of other orders of insects whose literature is more available.

The present work has been prepared to supply the need above mentioned. It is an outgrowth or expansion of my "Orthoptera of Indiana" issued in 1903 and long since out of print. In that work 148 species were described and keys given for their determination. Since its issue the researches of Rehn and Hebard, Caudell, Morse, Hancock, Walker, Davis and other special students of United States Orthoptera have brought about numerous changes in the nomenclature of the group and have added many new forms to the known fauna of our country. The great majority of Orthoptera inhabiting the United States east of the Mississippi River and Canada east of the 90th Meridian (the territory covered by this work) are now known. The nomenclature—always flexible and in the end largely dependent upon the view-point of the student—is fairly well established. The time is, therefore, deemed propitious for the appearance of such a work and it is offered as the best that I can accomplish with the facilities at my command.

In the preparation of this manual I have ever had in mind the needs of the tyro and not those of the specialist in Orthoptera, the primary object in view being a simple work which would enable beginners in the most direct way possible to determine the scientific names and arrange and classify the Orthoptera in their collections. As far as possible easily understood words and terms have been used in the keys and descriptions, and many of the subdivisions adopted by other authors have been omitted in order to render the work less technical and more easily followed. Keys to families, subfamilies, tribes, genera and species have been made an important feature of the work. These keys are based on the more salient or easily recognized characters separating the divi-

sions to which they pertain. In most instances, to avoid repetition and save space, these characters are not re-mentioned in the descriptions which follow, and the keys should therefore *always be used in connection with the descriptions.* Moreover, it should be remembered that the characters used and statements made both in keys and descriptions are to be considered as applying only to those species occurring in the territory covered by this work. They may be, and in general are, capable of much wider application but it is not safe to assume that such is the case.

Following the description of each species are notes on its distribution, food habits, song, etc. The general range or area of distribution given is based not only on my personal collecting in Indiana and Florida, but also on the specimens which have been examined in other cabinets and on the published local lists and other works cited in the Bibliography as well as manuscript lists furnished by several persons. The synonymy of many species is, however, so involved that the range as given, especially where it extends beyond our territory, is to be considered as open to correction. The dates of occurrence as given are usually the earliest and latest at which the species has been noted in the locality cited and do not therefore necessarily show the actual time of its appearance or disappearance.

Of the 353 species and 58 varieties of Orthoptera recognized or recorded as inhabiting the territory covered I have been able to examine personally the types, or undoubted correctly identified paratypes, of all but five.[1] The great majority of the species treated are represented in my own collection. The source of the specimens at hand as I wrote the descriptions is usually given in the notes following each description. Thus "Lakehurst, N. Jer. (*Davis*)" means that the specimens at hand were taken at Lakehurst and loaned or presented to me by W. T. Davis; while "Ormond and Dunedin, Fla. (*W. S. B.*)" signifies that the specimens examined were taken by myself at the localities mentioned. After preparing the greater part of the text I visited Cambridge and Wellesley, Mass., Staten Island, N. Y. and Philadelphia, Pa., to examine the species not previously seen and to study the types and other specimens in the Scudder, Morse, Davis and Philadelphia collections. These contain the great majority of all the types of the United States species. Other cotypes or paratypes from

[1]These are *Phyllovates chlorophæa* Blanch., a mantid of doubtful occurrence in the Southern States; *Heteronemia lævissimus,* and *H. texanus* Brunner, two phasmids of doubtful status; *Belocephalus excavatus* Davis, the unique type of which is in the American Museum of Natural History, which Institution I did not find opportunity to visit, and *Ceuthophilus scabripes* (Hald.), a camel cricket, the type of which is lost and the status therefore doubtful.

the U. S. National Museum collection at Washington were kindly loaned me from time to time by A. N. Caudell. The native and introduced and established species are numbered consecutively throughout the work, while those included but un-numbered represent adventive forms which have occasionally been taken within our bounds but which are as yet not known to breed and live throughout the year in any one locality.

CLASSIFICATION.—The classification followed in this work is not that of any one previous author, and may therefore not meet with the full approval of the up-to-date specialists in Orthoptera. In the names which I have adopted for the higher groups, I have not always followed "The Entomological Code"[2] nor the rulings of the International Commission of Zoological Nomenclature. There has been in recent years, too much of a tendency to split hairs, to divide and subdivide the old well known groups into an infinite number of minor ones which lead nowhere in particular and only serve to confuse the beginner. The law of strict priority[3] and its resultant ruling of basing the name of a subfamily or tribe upon the oldest generic name included are all right in the main, but when they lead up to two such similar names as Acridinae and Acrydiinae, confusion is sure to result, and priority should give way to simplicity. In such cases the names adopted by the more recent specialists are given in parenthesis and the student can use them if he so desires.

As with the higher groups so with the genera. I have not always adopted the generic names which have been proposed in recent years for certain of our species. A genus should be based on certain definite and fixed structures and once so founded all species then or thereafter assigned to that genus should possess those structures. Strictly speaking, a genus does not exist in nature but is only an artificial concept proposed by man to enable him the more readily to group his species. As to what really constitutes a set of generic characters there are about as many individual opinions as there are proposed or adopted genera. My reasons for rejecting or adopting certain questionable genera are usually set forth and the student can use his own judgment as to whether they are sound or not.

[2]This code, prepared at Washington in 1912 by those two eminent American entomologists, Nathan Banks and A. N. Caudell, is, in the main, an excellent thing for beginners but a number of its rulings have not been adopted by some of the leading entomologists of the country.

[3]If strict priority in the naming of the higher groups be insisted upon, the name *Orthoptera* itself, first used by Latreille in 1796 and later more definitely by Olivier in 1811, would have to give way to *Dermaptera*, the name proposed for the group by DeGeer in 1773, or to *Ulonata*, that proposed by Fabricius in 1775.

The subgenera and other minor groups of certain authors are not generally recognized in this work. In their place and solely to shorten and simplify the keys I have sometimes used "groups" or "series," usually without definite names, as they lead up more easily and with less confusion to the main object sought—the scientific name of the specimen in hand.

SYNONYMY OF SPECIES.—As already noted the synonymy of many species of Orthoptera is greatly confused. This is due to several causes, chief among which are the following: *a.—Variation in the length of tegmina and wings.* These organs of flight often vary exceedingly in individuals of the same species, thus causing the insects to appear so different in general facies that both the long- and short-winged forms have been often described under different names: *b.—Variation in color.* Many of the first described species were based mainly upon color characters alone. As is well known, these are dependent largely upon local environment and are therefore usually unreliable in the fixing of species. Where the habitat is essentially the same throughout a large area the color is more stable and can then often be used as an important specific or varietal character; *c.—Variation in the secondary genital organs,* especially those of the male. The size and form of certain abdominal appendages, as the male furcula and cerci, the form of and degree of emargination of the subgenital and supra-anal plates, the length, form and armature of the ovipositor, have been much used in the past as distinguishing characters in the separation of species. In the majority of forms these organs are fairly stable and can be satisfactorily so used, but in some they vary greatly. This is especially true of the cerci of the male and too many races, varieties and even species have been founded upon slight differences in the structure of those organs; *d.—Brief descriptions of the early known American species by European writers.* A number of the more common American species of Orthoptera were first described, usually in two or three lines, by foreign authors who never saw the insects in the field, and knew nothing of their distribution, habitat or variations. These brief descriptions were sufficient to enable their authors to distinguish the species at hand from all others known to them, but are wholly inefficient when it comes to separating them from the large number of closely allied species now known. The types of many of the species described by DeGeer, Burmeister, Serville and even Saussure and Redtenbacher, are destroyed or inaccessible, so that it is often impossible to state what form

they had in hand. Much confusion in synonymy has therefore resulted by "guessing" at what they had, as each of our American authors has usually come to a different conclusion, and described or named his own species accordingly. Unless some easily distinguished or reliable character was given by the European author by which the American insect has been or is readily distinguished, or until a direct comparison with the type, if the latter is available, has been made by some competent Orthopterologist and the American conspecies thereby reliably determined, it is often better, in my opinion, to disregard these old European names and to adopt later ones of undoubted status.

While the law of priority has been usually followed in the naming of the species in this work, there are some instances where the rulings leading up to it were technical, or, in my opinion, nonsensical, and I have therefore retained a better known name in preference to the one which, in accordance with strict priority, has been recently assigned by other authors. In such cases I have mentioned in the text or footnote my reasons for not adopting the proposed change in names.

Throughout the work I have used trinominals to designate races, varieties, variants, subspecies, incipient species and sometimes even color varieties, usually noting which of these minor forms I consider the third name to represent. The name of the typical variety, if more than one exists, is not printed as a trinominal. I thus use *Nomotettix cristatus* (Scudder), not *Nomotettix cristatus cristatus* (Scudder). In many cases I have not recognized the so-called geographical races of recent authors. Where a well known species ranges over a large area, the different environments due to altitude, variation in mean annual temperature, atmospheric conditions, difference in topography, drainage and soils, varied food plants and many other causes, are sure to bring about certain changes in its external structure. If only the extremes of these variants be at hand they are often so different in appearance as to cause them to be considered races or even different species. However, where a large series from all parts of the range are present, intermediates are almost sure to be found and there is little use and often much resulting confusion in giving or recognizing a name for each slightly variable form.

Where, in the original description, the specific name was placed by the author in a genus different from that to which it is now referred, the name of the author or its abbreviation is placed in parenthesis.

The known synonyms of each species of Orthoptera belonging to our fauna are usually mentioned in the notes following the description of that species. A list of these synonyms, arranged alphabetically by both genera and species, with reference to the species to which each is now accredited and the page of its description, will be found just before the general index of this work.

BIBLIOGRAPHY.—The bibliography near the end of this volume is not a complete list of the works pertaining to the Orthoptera of Northeastern America but contains only the names of those works to which especial reference has been made in the text, and a few additional ones which it was thought might at times be of use to the student of our fauna. In the bibliography the list of papers is arranged alphabetically by authors and each author's works chronologically by years. Where more than one paper by the same author appeared in any one year the letters *a, b, c,* etc. follow the year. Thus, a citation in the text to Davis (1912a, 124) will be found by reference to the bibliography to refer to page 124 of his paper entitled "Three New Species of Belocephalus from Florida," published in the Journal of the New York Entomological Society, Vol XX, pp. 122-125. After the name of each genus and each species, as recognized in this work, is given the name of the author with year and page number of the work where the genus was founded or the species originally described. Thus, *Belocephalus sabalis* Davis, 1912a, 123, refers to the original description of that species on page 123 of the paper above mentioned; while BELOCEPHALUS Scudder, 1875, 458, means, as a reference to the bibliography will show, that the genus *Belocephalus* was founded by Scudder on page 458 of his "Century of Orthoptera Decade II. Locustariæ," which appeared in the Proceedings of the Boston Society of Natural History, Vol XVII, pp. 454-462. As the joint works of Rehn & Hebard are so numerous and the references to them so many, the abbreviations R. & H. have been, for the most part, used for citation to them throughout the text.

No attempt has been made to make reference to all the mentions of each species in the works cited, as such complete synonymy would fill a volume by itself. Special students, who wish a more extended synonymy, are referred to Scudder's "Index to North American Orthoptera," which includes every known reference to each species up to the close of the year 1900. A manuscript continuation of this index has been made by A. N. Caudell which, it is hoped, will soon be published. Another work, indispensable to the special student, is Kirby's "Synonymic Catalogue

of Orthoptera," published in three volumes (1904, 1906, 1910), which deals with the Orthoptera of the world, but contains many errors in the synonymy of the North American forms.

MEASUREMENTS.—The measurements used in this work are given in millimeters or decimals thereof. A millimeter (mm.)= .0394, or a little more than 1/25 of an inch. For all practical purposes it may be remembered that 2.5 mm.=1/10 inch; 3 mm.= 1/8+inch; 4 mm.=1/6+inch; 5 mm.=1/5 inch; 7.5 mm.=3/10 inch; 10 mm.=2/5 inch; 12.5 mm.=1/2 inch; 15 mm.=3/5 inch; 17.5 mm.=7/10 inch; 20 mm.=4/5 inch.

The measurements as given are usually those of the extremes of the series at hand and thus represent fairly well the variation in size of the different parts measured. The length of the body is taken from the tip of the vertex to the apex of the subgenital plate in male and base of ovipositor in female.

HABITS AND SONGS OF ORTHOPTERA.—The habits of any form of animal life are usually of especial interest to the student of natural history. Each individual of the myriad living moving forms found upon this old earth of ours has its daily routine of life,—its journeys great or small, its quest for food, its search for a mate, its care of offspring, its place of hiding, its means of self-protection, its limits in hours or days or years of life,—its final passing back to the dust of the common mother—to that matter which is indestructible, yet ever mutable—ever ready to become a living, moving part of a mite or a man, a mouse or an elephant. Of all these forms of life none are more interesting in habits than the Orthoptera which, while few in numbers as compared with the great bulk of insect life, have a history reaching back far beyond that of man himself. For they were the first musicians of the earth, and by the means of their shrilling organs enlivened the solitudes of the strange old Devonian forests with their love calls and wooing notes. Hancock in his charming work "Nature Sketches in Temperate America," has described the habits of many Orthopterons. Scudder has set their songs to music. Hebard and Walker, Somes and Morse, Davis and Allard, Piers and Fox have described their notes, their haunts, their daily habits. From the writings of all these and many others I have gleaned and have included in the notes on each species those observations which it was thought would be most interesting. To some this mingling of the poetical with the technical may be deemed out of place in a work like this, but Grant Allen has well said: "Our thoughts about nature and nature's objects are often too largely

interwoven with hard technicalities concerning rotate corollas and pedicellate racemes, and I, for my part, am not ashamed to confess that I like sometimes to see the dry light of science diversified with some will-o'-the-wisp of pure poetical imagination."

ACKNOWLEDGMENTS.—As already noted, this work is based largely upon my former one—"The Orthoptera of Indiana." In the preparation of that, as well as in my earlier studies of the group, I was greatly aided by two men to whom I wish to first pay tribute. One was Samuel H. Scudder of Cambridge, Mass.—a man noted for his varied accomplishments—a devoted student of insects, especially of butterflies and Orthoptera. He was the father of American Orthopterology, and to him more than to all his predecessors and contemporaries combined is due our present knowledge and classification of the group. When, in 1861, he wrote his first paper on Orthoptera fewer than 60 species were recognized from North America and a number of those were synonyms. In 1900, when he issued his second Catalogue 856 species were included, 385 of which had been described by him. A number of these have since been shown to be synonyms, for his later work, especially on *Ceuthophilus* and *Melanoplus,* was hurried and many mistakes naturally resulted. Of his published papers on Orthoptera no fewer than 81 are included in the bibliography accompanying this work, while a large number of others dealing with extra-limital species are not mentioned. Always willing to answer questions and ever interested in any new form which was discovered, his counsel was to me for many years both helpful and inspiring. His collection of Orthoptera with its many types is now in the Cambridge Museum of Comparative Zoology, where it is one of the lode-stars which attract to that Mecca of entomologists those interested in Orthoptera from all parts of the world.

Another who aided in solving many a knotty problem in my old tyro days was Lawrence Bruner, then as now the Professor of Entomology in the University of Nebraska. He has long been interested not only in the Orthoptera of this country but in those of South America, and has published many papers and described many of the species belonging to our fauna. His cabinet of North American forms with its numerous types is now a part of the Philadelphia collections.

When I began the preparation of this work I realized that I would have to call many times upon the present-day special students of North American Orthoptera, those who have kept the

science growing since the new century was ushered in. They are few in number but rich in lore, in enthusiasm and especially in a willingness to help a fellow-student when he sends out an S. O. S. for aid of any kind. To A. N. Caudell of the U. S. National Museum at Washington, D. C., I am indebted for many favors. Long a devoted student of the group, and an especial adept in the intricacies of the knotty problems of its nomenclature, he has been especially kind in answering the many questions which I have asked and in loaning me numerous volumes and many specimens for study. W. T. Davis of New Brighton, Staten Island, N. Y., who is not only a student of Orthoptera, but also a naturalist of high rank and interested in all forms of living things, has aided me greatly in many ways. His private collection of Orthoptera is rich not only in large series of some of the scarcer forms but in numerous types of the species he has described. From it he has loaned or presented me examples of many rare species. He has also furnished many notes on distribution and habits of various forms. Jas. A. G. Rehn and Morgan Hebard of Philadelphia, Pa., have loaned me numerous specimens and have verified or identified for me many others. Since 1900 they have built up at the Philadelphia Academy of Natural Sciences one of the largest and most complete collections of Orthoptera in the world—one rich in types not only of their own description, but of other authors. Their published monographs and other papers on North American Orthoptera are numerous and most valuable, and from them I have drawn freely for the pages which follow. Dr. J. L. Hancock of Chicago, Ill., the noted authority on the Tetrigidae of the world, has furnished me many notes on the distribution of the grouse locusts and loaned me numerous specimens of that interesting group. A. P. Morse of Wellesley, Mass., has shown me many favors. He has been for thirty or more years a special student of New England Orthoptera, and has also collected extensively in the Southern and Pacific states. His numerous types and other specimens have been placed freely at my service and he has furnished a number of notes on distribution and habits. Dr. E. M. Walker, of the University of Toronto, the leading student of Orthoptera in Ontario, has sent me much data regarding the forms found in eastern Canada, and from his writings and those of Piers and Morse I have gained much of the information given regarding the species found in the extreme eastern part of the territory covered. Dr. H. Fox of Macon, Ga., who has published interesting papers on the Orthoptera of Pennsylvania, New Jersey, In-

diana and Virginia, has furnished me numerous specimens and has contributed a manuscript list of the species taken near Clarksville, Tenn. T. H. Hubbell of the University Museum of Zoology at Ann Arbor, Mich., prepared for me a similar list of Michigan species and kindly loaned specimens for examination. Others who contributed distribution data, specimens or other helpful aid were the late Chas. A. Hart of Urbana, Ill.; Wm. J. Gerhard of the Field Museum, Chicago; Prof. J. R. Watson, Dr. E. H. Berger and P. W. Fattig of Gainesville, Fla.; H. P. Loding of Mobile, Ala.; Prof. H. Garman of Lexington, Ky.; Nathan Banks of Cambridge, Mass.; Dr. Wm. A. Riley of the University of Minnesota; Myron H. Swenk of Lincoln, Neb.; J. R. Malloch of Urbana, Ill., and Chas. A. Dury of Cincinnati, Ohio.

It is a pleasure to acknowledge and extend thanks to all the parties above mentioned, for, situated as I have been far from any large collection or reference library, the work in its present form would not have been possible had it not been for the aid so freely given.

Relation of an Orthopteron to Other Animals.

If we compare the body of a locust or other insect with that of any vertebrate animal, as a fish, bird or squirrel, we find at once great and important differences. The vertebrate is an animal with an inner bony skeleton, two pairs of jointed limbs or appendages, and breathes by means of lungs or gills, according as it dwells in air or water. The locust is an animal which has no inner skeleton or bones whatever, but only a hard crust on the surface which surrounds the muscles and vital organs. This crust is composed of separate rings, placed end to end.

Animals whose bodies are thus composed of rings are called *Articulata*. They are in turn divided into two great groups, the *Vermes* and the *Arthropoda*. The *Vermes* (worms) have all the rings composing the body very nearly alike, not hardened into an outer crust or exoskeleton, and without paired limbs which are jointed. The *Arthropods* have a part of the rings bearing paired jointed appendages, and have the cuticle or outer surface consisting largely of a peculiar substance called "chitin," which is secreted or exuded by the cells which compose the cuticle. Chitin itself is insoluble and is not composed of cells, but consists of fine, irregular plates. It hardens the cuticle and thus aids the latter in protecting delicate vital organs within, and also in forming a framework to which the muscles of movement may be attached. Between

the joints the cuticle is devoid of chitin and is thin, delicate and flexible, thus allowing the necessary freedom of motion.

The Arthropoda are divided into four classes, as follows:

(*a*) *Crustacea* (crayfish, lobster, etc.), mostly aquatic; having the head and thorax usually united and distinct from the abdomen; breathing by means of gills or directly through the skin, the exoskeleton with carbonate and phospate of lime in addition to chitin.

(*b*) *Arachnida* (spiders, mites, etc.), terrestrial; head and thorax usually combined, and bearing four pairs of legs; breathing by means of tracheæ.

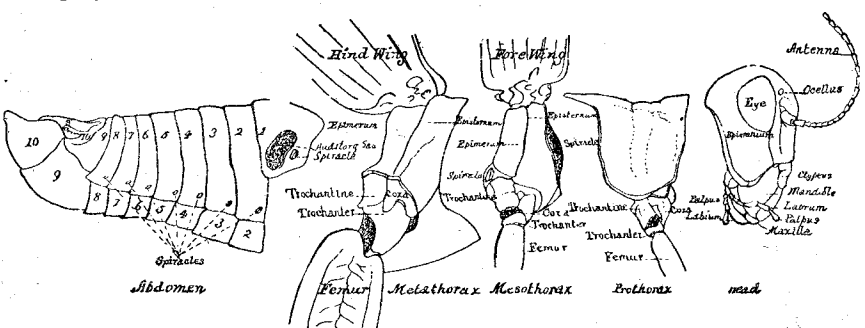


Fig. 1. Body of a locust, side view, showing the rings of which the body is composed, the thorax being separated from the head and abdomen and divided into its three segments. (After Packard.)

(*c*) *Myriapoda* (myriapods, centipedes, etc.), terrestrial; usually worm-like, with only the head distinct; legs numerous; breathing by means of tracheæ.

(*d*) *Insecta* (grasshoppers, flies, beetles, etc.), in great part terrestrial; legs six; adults usually with one or two pairs of wings; breathing by a system of tubes called tracheæ, which branch and ramify through every portion of the body, and which open externally in about ten places on each side of the body instead of at the front end. The rings of the body are grouped in three regions; the *head,* the *thorax* and the *abdomen.* In general it may be said that the head contains or bears the organs of sense and of prehension and mastication of food; the thorax the organs of locomotion, and the abdomen those of reproduction.

The External Anatomy of a Locust.

Having thus shown that a locust belongs to the class *Insecta* it is thought best, before giving its relation to the other orders

of that class, to describe briefly the external parts of a typical specimen. The beginner may thus the more readily grasp the name and location of the parts used in classification, as well as the meaning of many of the technical terms which, of necessity, have to be used in such a work as this. The three regions of the body, the head, the thorax, and the abdomen, with their appendages, will therefore be considered in order.

THE HEAD.—The head of the locust is composed of four or more segments or rings, solidly fused together to form a single cavity or hard box of chitin, known as the *epicranium*. This contains the brain and accessory ganglia, and the mouth cavity. It bears or gives support to the antennae, mouth parts, eyes and ocelli; also internally to the muscles moving the mandibles or jaws. The broad basal portion of the epicranium back of the eyes is known as the *occiput*, the narrower portion between the eyes, the *vertex*, while the long frontal portion as far down as the prominent transverse suture is the *front* or *face*.

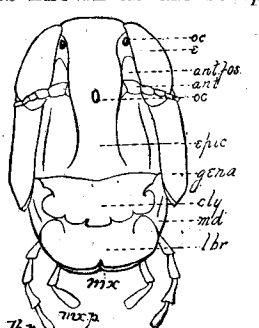


Fig. 2. Front view of the head of a locust. (After Lugger).

The short plate (*cly*), below or in front of the epicranium, is the *clypeus*. Below this and hinged to its front edge is a movable flap known as the *labrum* (*lbr*) or upper lip, to which are attached a pair of jointed *labial palpi*. This forms the roof or covering of the front part of the mouth, within which are the large, black-tipped, toothed jaws or *mandibles* (*md*), which are so attached to the epicranium as to move only in and out or to and from a median line. As has been shown by Nininger (Psyche, XXII, 13) the two mandibles in Orthoptera are not alike as is generally supposed, but the left one is slightly the larger and projects beyond the right one ventrally when closed. The distal ends of the two mandibles are beveled differently so that when closed the beveled surfaces are contiguous throughout and do not meet on the median line, but always to the right of it. Inserted on the sides of the head just behind the mandibles and arched over the tongue will also be found a pair of accessory jaws, the *maxillae* (*mx*), each of which is composed of three parts, the most important being the jointed *maxillary palpus*. The segments of these palpi are usually five in number and vary in size and form in different groups therefore being often used in classification. The development and shape of these maxillæ in the lo-

cust, as well as in other Orthoptera, depend very largely upon the nature of the food, as these organs serve not only to seize and hold the food in the mouth, but also as accessory jaws, aiding the mandibles in rendering the food more suitable for swallowing. Their palpi are not only organs of touch, but in many cases act as hands in helping to prehend and carrying morsels of food to the mouth.

Above the clypeus, is a ridge extending upward along the median line of the face to the vertex. This is the *frontal costa,* and its characters are often used in classification. In one species it may be sulcate or grooved, in another, flat. Its edges, or *carinæ* may be parallel the full length or may diverge or converge. Its width and prominence are also often mentioned.

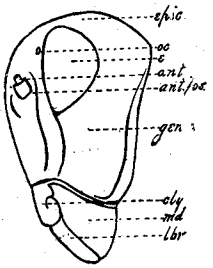


Fig. 3. Side view of head. (After Lugger.)

The region on the side of the head, behind the eye and above the base of the mandibles, is the cheek or *gena* (*gen.*). To its inner wall is attached the large muscle which moves the mandible.

The eyes of a locust are five in number, two large compound ones and three small, simple ones. The compound eyes are present in all Orthoptera. In the locust they vary in shape, but for the most part are oval, and are located on the upper portion of the sides of the head. Each is made up of many thousands of six-sided facets or lenses, in each of which a single filament of the optic nerve ends. The simple eyes or *ocelli* (*oc.*) are absent in some Orthoptera, as the Tettigoniidae, some of the Gryllidae and the females of some Mantidae, but are present in the locust. Two of them are situated just above the base of the antennae, close to the inner margins of the compound eyes, while the third is located near the middle of the frontal costa. Their position varies in the different families of Orthoptera, and there are but two in the Gryllotalpinæ or mole crickets.

These ocelli are thought to be inherited from the obscure eyes of the worm-like ancestry of the locust, while the many facetted compound eyes of insects and crustaceans have been evolved to satisfy the needs of the more recent existence of these groups.

The *antennæ* (*ant.*) of the locust are simple, many jointed appendages, located on the face between the eyes and articulating with the head by a ball and socket joint. They are principally organs of touch, but are also supposed to contain the nerves of

smell. They vary much in length and form among the different families of Orthoptera, the variation being the result of adaptation to their peculiar surroundings and habits. For instance, in those camel crickets (*Ceuthophilus*), which dwell in caves, they are very much longer than in those members of the same genus which dwell above ground. Characters pertaining to their form, length, and point of union with the head, are much used in classification. Such terms as *filiform, clavate, setaceous,* etc., relating to their form, are defined in the accompanying glossary.

Characters pertaining to the vertex, or that part of the epicranium, between the eyes, are much used in separating the different species of Orthoptera. The central portion of the vertex, known as the disk (*dv*) or *scutellum* (*sv*) is often depressed, or separated from the remainder. Its bounding walls are termed *lateral carinæ* and often a median carina divides it into two parts. The front portion, or apex, often called the *fastigium,* is variable in form and its characters are also much used. On the outer side of, and a little below the front half of each lateral carina of the vertex there is, in many Orthoptera, a little space or concavity bounded by elevated ridges. These spaces are the *lateral foveolæ* (*f.*) and their variations in size and form also afford characters much used in classification.

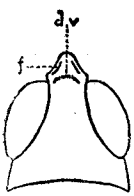


Fig. 4. Showing fastigium, disk and foveolæ of vertex. (After Lugger.)

The Thorax and its Appendages.—The middle region of the body of a locust or other insect is called the *thorax.* To study its parts aright, the wings and legs attached to it should be removed, when it will be seen to consist of three rings or segments. These are known as the *prothorax, mesothorax* and *metathorax.* Within these rings are located the muscles for moving the wings and legs, as well as some of the digestive organs.

The prothorax of the locust (Fig. 5) has its entire dorsal surface, and sides in great part, covered by a large sunbonnet-shaped piece known as the *pronotum* (*pro*). This varies much in shape and size in the different families of Orthoptera. Its upper surface is called the *disk,* and its sides the *lateral lobes.* Raised lines known as the *lateral carinæ* usually separate the disk from the sides, while often a third line, the *median carina* runs lengthwise through the middle of the disk.

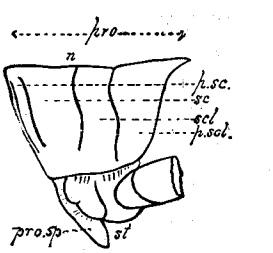


Fig. 5. Side view of prothorax of a locust. (After Lugger.)

This may be high or low, crested, arched, distinct, aborted, etc. It is usually cut by one or more notches formed by shallow grooves or *sulci* which cross the disk of the pronotum and extend down its sides. The hindmost of these sulci or grooves divides the disk of the pronotum into two parts known as the *prozona* (*pz*) and *metazona* (*mz*). The fore and hind margins of the disk of pronotum may be truncate, rounded, angled, notched, etc. The surface of the disk is usually smooth, but sometimes wrinkled and may be rugose or roughened with numerous tubercles.

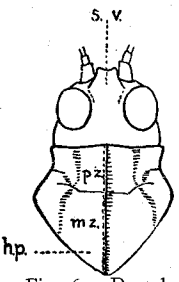


Fig. 6. Dorsal view of head and pronotum. (After Lugger.)

The under or ventral side of the prothorax is a narrow, somewhat movable piece called the prosternum.. On its center it often bears a tooth or spine (*pro. sp.*), the presence or absence and shape of which form characters used in classification. Near the outer ends of the prosternum are shallow sockets in which are attached the front pair of legs.

The *mesothorax* and *metathorax*, the second and third segments of the thorax, are, in the locust, rather firmly united with the basal abdominal segment of the abdomen to form a firm walled box, though in the Blattidae they are distinct. The upper portion of these segments is, in most Orthoptera, partly or wholly covered by the pronotum or base of the outer wings. To the mesothorax are attached the tegmina or outer pair of wings and the second or middle pair of legs. To the metathorax are joined the inner wings and the third or hind pair of legs. The under or ventral portion of these segments are called respectively the *mesosternum* and *metasternum*. (Fig. 7.) The former in the locust is composed of a front transverse portion, with two nearly rectangular lobes projecting backward. Between these lobes is dove-tailed a squarish tongue, or forward prolongation of the metasternum. The latter is united with the

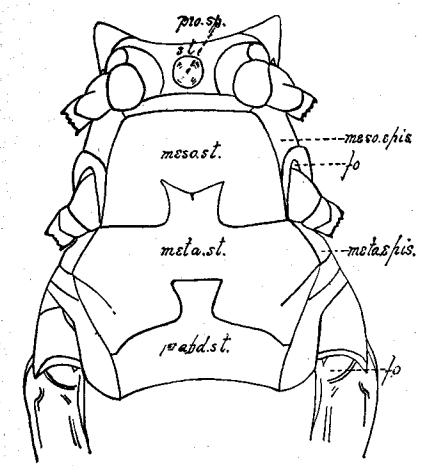


Fig. 7. Lower or ventral view of the thorax of a locust. (After Lugger.)

basal abdominal segment by the dove-tailing of a similar but narrower tongue between its lobes. The side pieces of the mesothorax and metathorax are called *pleurites* and bear the prefixes *meso* and *meta*.

The *wings* are thin, broad, more or less leaf-like folds of the integument or body covering, which are joined to the thorax and moved by powerful muscles located within the thoracic cavity. The first or outer pair of wings of the locust and other Orthoptera serve as shields or covers for the more delicate inner pair. In the text which follows they are called *tegmina*. Each wing cover or tegmen is a thin, more or less transparent, leathery or parchment-like plate of chitin, strengthened by a network of tubes called nerves or veins. The spaces enclosed by the veins and their cross branches are called cells. When folded and at rest upon the body the outer face of the tegmen of a locust is vertical, with the front or costal margin below, and the posterior or sutural margin lying along the back; that of the left tegmen slightly overlapping the right.

The principal veins of the tegmen of a locust diverge from the basal end and are seven in number. The one nearest the front or lower margin of the tegmen is the *submarginal* or *costal* vein (*c*).

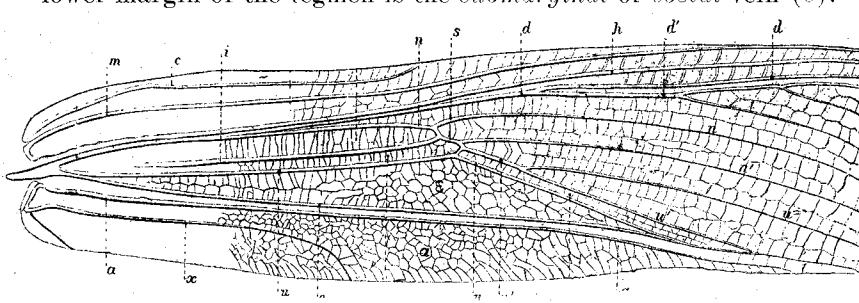


Fig. 8. Right tegmen of a locust, showing the venation. The names of the veins designated by the letters are given in the text. (After Saussure.)

It is undivided, and may usually be traced for a little more than half the length of the tegmen, though in some locusts it is lacking. The second and longer vein, also undivided, is the *mediastinal* (*m*). The third and much larger vein is the *humeral* (*h*), sometimes called the *subcostal*. It gives rise to several large branches, the subdivisions of which form the framework of the greater part of the tegmen. The larger of these branches (*d*), is known as the *discoidal* vein, its branches being designated as *d'*, *dd''*, etc. The fourth or median vein (*n*), is much smaller and soon divides into

branches of nearly equal size. Above or behind the median vein is sometimes present a short, undivided vein (*i*), known as the *intercalary* vein. Next in order is the *ulnar* vein (*u*), which gives off several branches (*u'*, *u''*, etc.). The upper division of this vein (*o*) is known as the *posterior ulnar* or the *submedian* vein. Close to and parallel with it near the upper or hind margin of the tegmen, is the undivided *anal* vein (*a*), while the uppermost vein of the tegmen, also undivided, is the *axillary* vein (*x*).

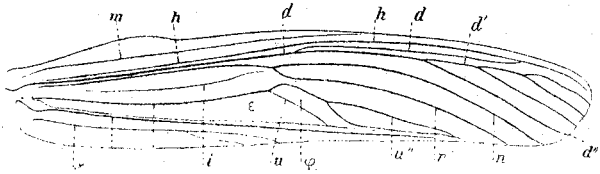


Fig. 9. Right tegmen of the locust, *Dissosteira carolina* (L.). Showing the venation. (After Saussure.)

The tegmen is divided by these veins into three areas: The *costal* or *marginal* area (*M*) forms the lower or front edge of the wing cover and is bounded above and behind by the humeral vein. The *median* or *discoidal* area (*D*) is much the largest and lies between the humeral and posterior ulnar veins. The *anal* or *dorsal* area (*X*) is the free margin lying along the back above and behind the anal vein. The posterior end of the tegmen (*A*) is known as the *apical margin*.

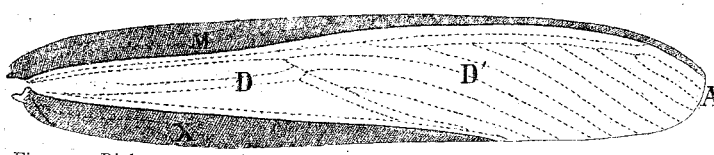


Fig. 10. Right tegmen of a locust, showing the "areas" designated in the text. (After Saussure.)

The inner or second pair of wings are joined to the metathorax, and when at rest lie folded beneath the tegmina. If, in a fresh example, the dark colored marginal vein be pulled outward or forward with a pair of forceps, it will be seen that the wing is a thin, parchment-like membrane, with a stiff front edge, which is nearly straight, while the rounded outer and hind margins are thin and flexible. When in flight, the wing is fully extended, its upper surface being convex, while its front margin is rendered still more rigid by being overlapped by the internal margin of the upper wing or tegmen. The numerous veins radiating from the base are so arranged that their elasticity causes the wing to fold upon itself like a fan as soon as its margin is released. The prin-

cipal veins correspond in position to those of the tegmina, and have the same names. Both tegmina and wings are wanting in a number of species of Orthoptera, while in others the tegmina are present and the wings absent.

The *legs* of a locust are six in number, arranged in pairs, one pair being joined to each of the divisions of the thorax. The first and second pairs are, in the leaping Orthoptera, much smaller than the third, but the number and name of the joints is the same. They unite with the body at a different angle from the hind or third pair, and are therefore adapted to crawling and clinging to grass stems or other support rather than to leaping.

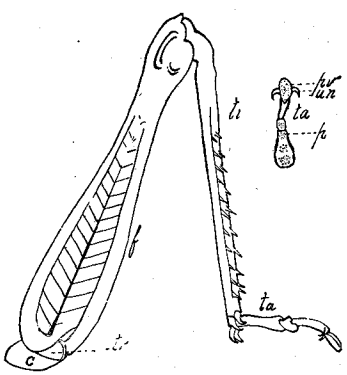


Fig. 11. Hind leg of a locust. (After Lugger.)

The hind pair or leaping legs of the locust are composed of five parts: The *coxa* (*c*), or basal division, which is joined to the metathorax; a small segment, the *trochanter* (*tr*), immovably joined to the upper apical portion of the coxa; the *femur* (*f*), a long, swollen, club-shaped segment, which makes up nearly half the length of the limb. When the insect is at rest, it extends upward and backward, with its apical end above the dorsal surface of the body. This segment contains powerful leaping muscles. The *tibia* (*ti*) is about as long as the femur but is very slender and of uniform diameter. When at rest it extends downward and backward, at an acute angle from the apex or knee of the femur, but in the act of jumping it is jerked backward against the ground or other support, into which the tibial spurs are driven, then the sudden straightening of the legs by the powerful internal muscles propels the insect into the air. In leaping the tibia is kept from wobbling by a lobe extending back each side of its base, from the apex of the femur. The tibia usually bears on each of its upper outer margins a row of spines, and at the end one or more pairs of longer spines or spurs known as *calcaria*. The tibiae of the fore legs of a number of Orthoptera are much modified for use in burrowing or prehending food. The *tarsus* (*ta*) or foot of the locust is made up of three movable joints.[4] The first and longest has upon its lower surface a soft

[4]In the grouse locusts or Tetrigidæ and the sand crickets or Tridactylinæ the fore and middle tarsi have but two joints, while the tarsi of most Tettigoniidæ have four and those of the Blattidæ, Mantidæ and Phasmidæ five.

pad or *pulvillus* (*p*) which, by its adhesion to foreign bodies, serves as a point of resistance in leaping. The second joint is much shorter and carries a smaller pad. The third joint is long and slender, with two curved pointed claws or *ungues* (*un*), between which is a concave sucking disk or pad, known as the *arolium*.

THE ABDOMEN.—The abdomen or hind portion of the body of the locust (Fig. 1) is composed of ten more or less complete segments, so united as to be movable in a small degree. Each segment is composed of two parts, a *tergum* or upper portion, and a *sternum* or under piece. The tergum is crested or bent in the median line to form a ridge, the two sides, sloping downward, being known as *tergites*. The sternum of the first or basal abdominal segment is united firmly to that of the metathorax. The tergites of this segment, in the locust, each contain a large opening closed by a membrane, the auditory organ or ear. However, the ears of many Orthoptera are borne upon the basal portion of the front tibiæ. Eight of the abdominal segments of the locust have a small opening on the lower margin of each tergite. These are *spiracles* or external openings of tubes which serve as air passages. The ninth and tenth abdominal segments of the locust are more or less modified in both sexes. The abdomen of the female ends in a double pair of short curved movable horny plates, known as the *valves of the ovipositor*. In the other families of Orthoptera in which the ovipositor is visible, these plates vary greatly in form and size. The valves in the female locust are used in forcing the earth aside, thus forming a pit in which the eggs are deposited. Between and hidden by them is the ovipositor proper.

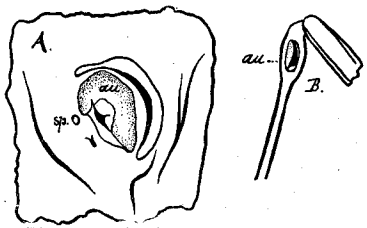


Fig. 12. Auditory organs or ears (A) of a locust; (B) of a katydid. (After Lugger.)

The ventral portion of the last abdominal segment of the male locust is a large, upcurved, spoon-shaped piece known as the *subgenital* plate. Attached to the tergum of the next to the last segment are a pair of appendages known as the *cerci*. In the male locust these are unjointed, and in the different species vary much in size and shape, often affording valuable characters for classification. In many of the other families they are jointed, and more or

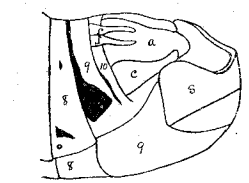


Fig. 13. Tip of abdomen of male locust; *a*, supra-anal plate; *c*, cerci; *f*, furcula; *s*, subgenital plate; 8, 9, 10, abdominal segments. (After Hart.)

less hairy. The cerci of the female locust are much smaller than those of the male, and in other Orthoptera are often wanting. The tergum or upper portion of the tenth abdominal segment is a triangular, often thick solid plate, known as the *supra-anal* plate. At the base of this plate and resting upon it, a pair of projections, known as the *furcula,* are usually present in the male. In certain genera of locusts the shape, size and relative position of these afford valuable specific characters. Lying within the cavity of the subgenital plate, and occupying the space beyond the tip of the supra-anal, there is in the Melanopli a structure covered with a soft integument. This is known as the *pallium* and is used to some extent in classification.

The above constitute the more important external parts of the locust, the characters of which are used in determining the name and position of any member of the order Orthoptera. As will be seen in the pages which follow, these different parts vary much in size and in form, but the names given to them apply as well to the members of one family as to another. By referring to the accompanying figures, and by observing carefully the parts of the specimen in hand, the beginner need have little hesitation in deciding as to whether the description agrees with that specimen.

The Relation of Orthoptera to Other Insects.

All true insects can be separated into one or the other of two great groups, based upon the kind of changes or transformations which they undergo before reaching the adult or winged stage. To one group—the *Metabola*—belong those insects which undergo what is termed a *complete metamorphosis.* In this group there are four distinct stages—the egg, larval, pupal and imago—in the order named. No insect is hatched from the egg with wings, and when an insect reaches the winged stage it is adult, and never grows thereafter. Thus the gnats and midges are not the sons and daughters of the larger flies, but are full grown insects of themselves, which are undergoing the fourth or last stage of their lives. The second, the larval or worm-like stage, is the one in which the insect of this group is commonly the most injurious, for then it eats voraciously, and then is the only period of its life when it grows in size. The pupal, or third stage, is usually a quiescent one, the insect eating nothing and not increasing in size,

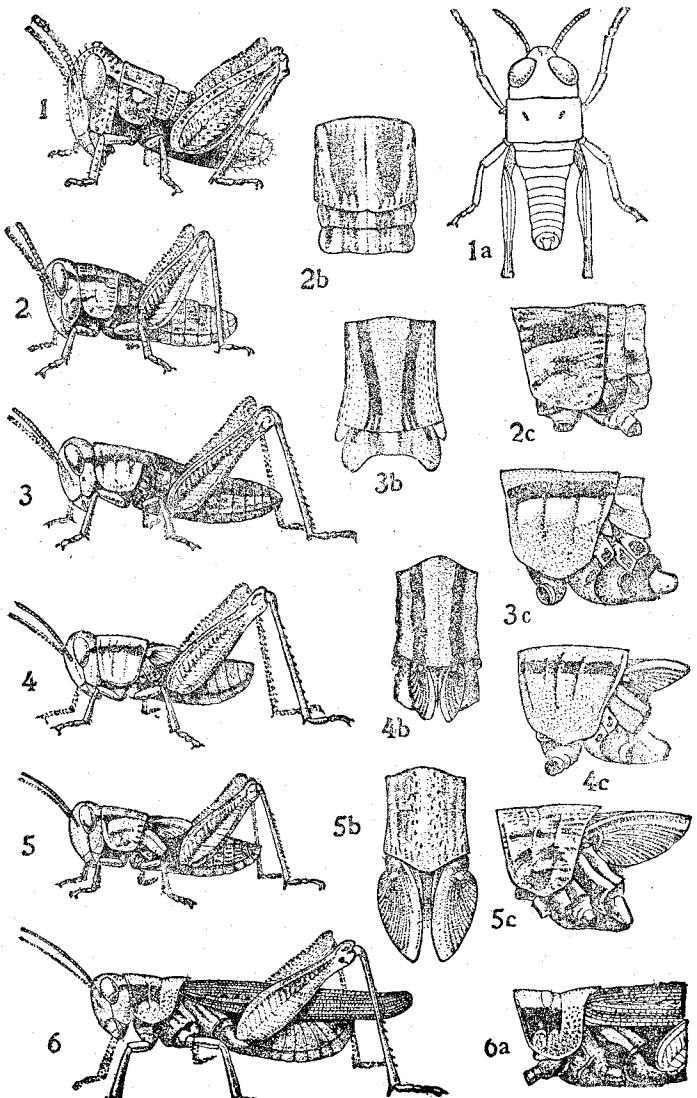


Fig. 14. Partial metamorphosis of *Melanoplus femur-rubrum*, showing the five nymph stages, and the partial growth of the wings, which are first visible externally in 3, 3b, 3c. (After Packard.)

but undergoing great changes of form. Thus the homely and often repulsive grubs, maggots and caterpillars, which are the larval forms of the beetles, flies and butterflies, respectively, enter the third stage as worm-like crawling creatures, and emerge from it as beautiful winged forms, sometimes glistening and gleaming with all the colors of the rainbow. This change of life and form is undoubtedly of great advantage to the most of this group of insects, as it tends to prevent the extinction of the species; since, if at a given moment the parents were swept out of existence, the young, living in a different station, would continue to represent the species.

The second group, the *Heterometabola,* comprises those insects in which the *metamorphosis* is *incomplete*; the young, when hatched from the egg being wholly wingless and of the same general form as the parent. As the insect grows it moults its skin a number of times and wings develop gradually, there being no sharp line defining the larval and pupal stages. The young of all stages are called *nymphs* and continue active and feed from the time of hatching until they reach the final moult and emerge therefrom mature or in the imago stage. The number of moults which Orthoptera undergo varies in the different families. In the true locusts there are five, while cockroaches and some mantids are said to have as many as seven.

It is to this second group, the *Heterometabola,* whose members undergo an incomplete metamorphosis, that the Orthoptera, the order of which this paper treats, belong. From other orders of the group, as the Hemiptera or true bugs, Odonata or dragonflies, etc., the Orthoptera may be known *by having the wings, when present, net veined, four in number, the outer pair leathery or parchment-like and usually overlapping when at rest*; *the inner pair thinner, more delicate and folded in plaits like a fan*; *mouth parts biting*; *hind legs in the greater number of forms, greatly enlarged for leaping.* The name Orthoptera is derived from two Greek words, *orthos,* straight, and *pteron,* a wing, and refers to the longitudinal folding of the hind wings. The fore wings, or tegmina, are not used in flight, the hind pair alone being used for that purpose.

Enemies of Orthoptera.

With the exception of the Mantids, all our Orthoptera are injurious, most of them being vegetable feeders. Were it not for the many natural enemies which prey upon them, they would

abound each season in such vast numbers as to prove a veritable scourge. These enemies are many of them parasites which live only upon Orthopterous forms, and when the latter are abundant the parasites also increase in number, and soon devastate the hordes of insects. Besides these parasites, many predaceous or beneficial insects feed upon locusts and crickets; and birds, both wild and domesticated, are exceedingly fond of them. These parasites, predaceous insects and birds are, therefore, of great benefit to the farmer, and he should do all in his power to increase their number, in order to keep within bounds the different species of Orthoptera.

VEGETABLE PARASITES.—Among the most common parasites of locusts are two or three species of vegetable fungi, which in wet seasons attack them, sap their veins and in time destroy many of their tissues. One often finds, after a long, damp spell in late summer, many dead specimens of our larger locusts clinging to the tops of weeds. A close examination will show that their bodies are soft, and issuing from them in many places are the ends of fungus tubes. These locust fungi, *Entomopthora calopteni* Bessy, *Empusa grilli* Fres., and *Sporotrichum globuliferum* Speg., for some unexplained reason often impel the insects affected to climb some tall weed or grass stem and cling to it with such tenacity that the body remains long after death. The spores given off from the fungus of the diseased or dead locust, are more widely scattered by this peculiar habit which the host insect has of climbing tall weeds, as they can the more readily be dispersed over wide areas. Besides these fungus parasites, other vegetable bacteria attack locusts in favorable seasons. But this takes place only in long warm, damp spells; during which the locust has sought shelter and been deprived of food. Many are then often congregated together and one individual affected by the disease may inoculate hundreds. In a dry season, the locusts and green grasshoppers are much more healthy and abundant and the damage which they do is much greater than in a wet one.

Fig. 15. Locust— *Melanoplus bivittatus* (Say)—killed by a fungus. (After Lugger.)

In our northern states the number of Orthoptera and other insects which will be present in any summer depends largely upon the character of the preceding winter. Most insects pass the winter in either the egg or the pupal stage; since these forms can readily withstand long and severe cold weather, in fact may be frozen solid for weeks and retain life and vigor, both of which are shown when warm weather and food appear again. Indeed, it is not an unusually cold winter, but one of successive thawings and freezings, which is most destructive to insect life. A mild winter encourages the growth of mold which attacks the hibernatting larvæ and pupæ as soon as, from excess of rain or humidity, they become sickly; and it also permits the continued activity of insectivorous mammals and birds. Thus, moles, shrews, and field mice, instead of burying themselves deeply in the ground, run about freely during an open winter and destroy enormous numbers of pupæ; while such birds as the woodpeckers, titmice and chickadees are constantly on the alert, and searching in every crevice and cranny of fence and bark of tree for the hibernating eggs and larvæ.

ANIMAL PARASITES.—A number of parasites belonging to the animal kingdom use as their chief hosts the bodies of locusts and other member of the order Orthoptera. Among the more common of these animal parasites is the red locust mite, *Trombidium lo-*

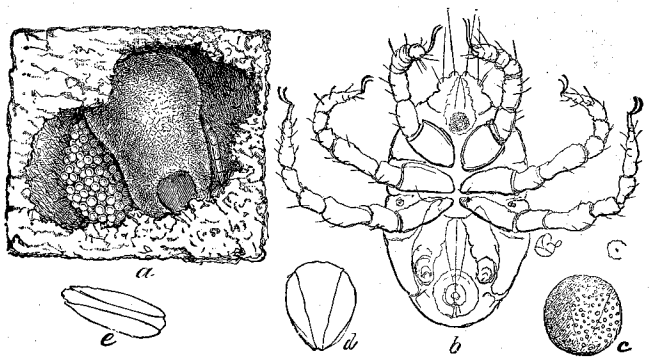


Fig. 16. *Trombidium locustarum.*—*a*, female with her batch of eggs (after Emerton); *b*, newly hatched larva, natural size indicated by the dot within the circle; *c*, egg; *d*, *e*, vacated egg shells. (After Riley.)

custarum Riley. On the first warm, sunny days of spring, as soon as the surface of the earth is fairly dry and warm, scores of minute "red spiders" can be seen along any pathway in the woods and fields. They are especially common if locusts were abundant

the year before. These red spiders are in fact mature red mites, the two sexes of which are shown in Fig. 17. Soon after appearing in spring, the sexes mate and the female soon deposits 300 or more small, globular eggs at a depth of a few inches in the soil. From each of these eggs there hatches, about the time the young locusts appear, a minute six-legged mite, which runs actively about in search of some host to which it may attach itself. When it happens upon a young locust, it fastens itself to the wings, wing pads or abdomen and uses its mouth parts to suck up the fluid portions of its host. In a short time its body increases in size, the legs grow smaller, and the mite resembles a small, globular mass of blood attached to the locust. Sometimes as many as twenty mites can be counted on a single host. When thus infested, the locust often becomes disabled, and drags itself about

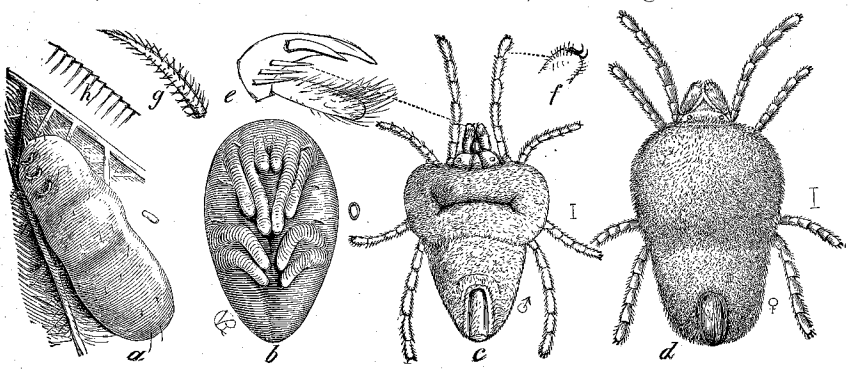


Fig. 17. *Trombidium locustarum* Riley.—*a*, mature larva when about to leave the wing of a locust; *b*, pupa; *c*, male adult when just from the pupa; *d*, female—the natural sizes indicated to the right; *e*, pupal claw and thumb; *f*, pedal claws; *g*, one of the barbed hairs *h*, the striations on the larval skin. (After Riley.)

in a clumsy fashion, eats less and dies early, often before the mating and egg-laying season has arrived. In the swollen and almost legless condition which the mite soon attains, it can not move about, and so remains in one position until full grown, when it drops to the ground and enters the pupal stage from which it emerges as the "red spider-kin" of spring. It often becomes mature in late autumn and passes the winter in the ground where it is not idle, except when the temperature sinks below the freezing point. It feeds upon all sorts of soft food, and whenever it has access to the eggs of locusts it greedily eats them. In soil containing eggs of locusts large numbers of these mites congregate. They creep into every hole in search of these eggs and thrive upon such rich food. The great advantage of fall plowing over all

other remedies against locusts is seen in regard to these red mites, as the plowing of fields in which the eggs of locusts have been deposited will destroy the young locusts hatching from them, but not the mites, which can easily work their way toward the surface.

Other parasitic animals besides these mites often attack the different species of Orthoptera. On a number of occasions I have found protruding from the abdomens of green grasshoppers and crickets a slender "hair worm" or "horse-hair snake," a species of *Gordius*. If the body of such grasshopper or cricket be cut open the interior is often found to be almost filled with this parasite, which is many times longer than its host, and it will be seen that all the important organs of the latter are pressed to one side and unable to perform their necessary functions. Locusts so affected are seldom able to propagate their kind.

Among insect enemies of the Orthoptera, which aid largely in keeping down their numbers, are "Tachina Flies," "Flesh Flies," "Bee Flies," and "Blister Beetles." Tachina flies are mostly of a gray color, and resemble large house flies. In fields where locusts are abundant, one of these flies may often be seen hovering over a large specimen, awaiting a favorable opportunity to deposit one or more of its eggs on the neck or beneath the wing. These eggs hatch into larvæ or maggots which eat their way into the body of the locust. There they seem to avoid the most vital parts, but feed upon the fatty secretions stored up for future use of the reproductive organs. Locusts so affected have a soft, flabby body, and can often be readily caught by the hand. They never mate, and perish much sooner than the healthy, unaffected individuals.

The flesh flies of the genus *Sarcophaga* attack locusts, katydids and grasshoppers in much the same manner as do the tachina flies, and their maggots are often found existing as true parasites upon the vitals of these Orthopterous insects. When the maggots of these flies become full grown, they burrow through the body wall of the locust and drop to the ground, where they enter the earth and pass through the pupal stage from which they emerge as fully winged insects, ready for attack upon a new generation of locusts. Webster (1907) records the receiving from Wyoming of a large number of dead specimen of *Melanoplus differentialis* (Thos.) which had been doing much damage to alfalfa. When received the material was full of the maggots and pupæ of *Sarcophaga georgiana* Wied.

The egg clusters of locusts, crickets and other Orthoptera in the ground are often attacked by the larval forms of bee flies and blister beetles. The bee flies are of a blackish gray color, densely covered with pale yellow hairs, and in June and July may often be seen hovering above the ground, or feeding upon the honey of various species of wild flowers. Their eggs are laid among or close to the egg masses of the locust, and their larvæ feed upon and destroy myriads of the eggs of the locusts and crickets.

A dozen or so species of blister beetles or "old fashioned potato beetles" of the genera *Macrobasis* and *Epicauta* occur in our Eastern States and in the winged or full grown stage are often very injurious to potatoes and allied plants. The eggs of the blister beetles are laid in the ground in late summer, and the larvæ soon hatch and move actively about in search of animal food, in the form of egg masses of other insects. They have often been found feeding upon the eggs of locusts and other Orthoptera and are undoubtedly of much aid in keeping within bounds these injurious forms.

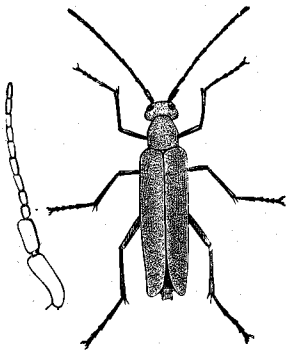


Fig. 18. *Macrobasis unicolor* Kirby. The ash-gray blister beetle. Female. X 2. (After Chittenden.)

Many of the ground beetles or Carabidæ feed, during both their larval and mature stages, upon locust eggs. More than 500 species of this family of beetles occur east of the Mississippi, and all are beneficial. In the mature stage they are long legged, rapid moving forms, which mostly hide by day beneath logs and rubbish and run actively about at night in search of some form of flesh upon which they may make a meal. Since insect life is the most common form which they find on or beneath the ground, it is but natural that most of their food is composed of it. The species of *Calosoma, Agonoderus* and *Harpalus,* examples of which are figured herewith, are among the most common and beneficial of this family of beetles. The larvæ of *Harpalus* may, in autumn, often be found feeding on the egg masses of the locust.

Higher in the scale of animal life are many forms which are among the best friends the farmer possess, yet many of them he destroys on sight through ignorance of their beneficial habits. Chief among these are skunks, shrews, moles, salamanders, toads and snakes. Skunks are very fond of both grasshoppers and their

egg masses, as well as of white grubs and larvæ of many other injurious insects, and one can often see where they have dug small cavities in the ground in search of this form of food. They are regarded by the U. S. Biological Survey, which has made a special

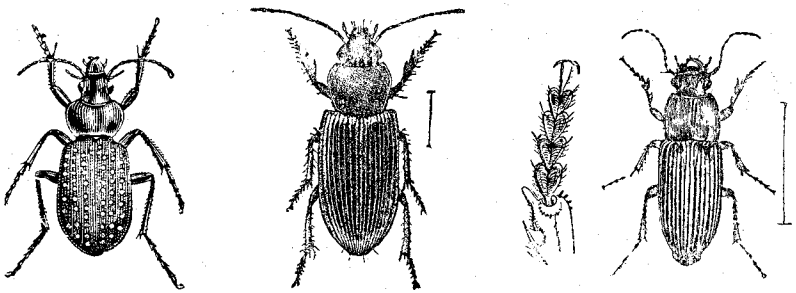


Fig. 19. *a, Calosoma calidum* Fab. × 1.2; *b, Agonoderus pallipes* Fab. × 5; *c, Harpalus pennsylvanicus* DeJ. × 2.

study of their habits, as the most useful of our wild mammals and therefore deserve protection rather than destruction by the farmer. Both shrews and moles are burrowing mammals which feed almost wholly upon insect life. True, the latter sometimes destroy the seeds of corn and vegetables, but the good which they do in destroying the eggs and larvæ of injurious insects far outweighs the bad. Salamanders, or ground puppies, live beneath logs and chunks and burrow into the surrounding region in search of eggs and larvæ, while toads and snakes feed largely upon the young and mature of grasshoppers and locusts, yet all are usually destroyed at sight by farmers or their sons.

More than 100 species of birds are known to use as food either the young or full grown individuals of many kinds of Orthoptera. The U. S. Biological Survey at Washington and other authorities, have made investigations of the stomachs of many species of birds, and have found that the following are some of the more common birds of our Eastern States which feed largely upon locusts and grasshoppers.

PARTIAL LIST OF EASTERN BIRDS WHICH ARE KNOWN TO FEED UPON ORTHOPTERA.

Franklin's Gull.
Black Tern.
American Bittern.
Least Bittern.
King Rail.
Sora.
Great Blue Heron.
Wilson's Snipe.
Golden Plover.
Barn Owl.

Screech Owl.
Red-tailed Hawk.
Red-shouldered Hawk.
Broad-winged Hawk.
Black Hawk.
American Sparrow Hawk.
Yellow-billed Cuckoo.
Black-billed Cuckoo.
Red-headed Woodpecker.
Hairy Woodpecker.
Downy Woodpecker.
Flicker.
Night Hawk.
Whip-poor-will.
Phoebe.
Kingbird.
Prairie Horned Lark.
Blue Jay.
Common Crow.
Bobolink.
Cowbird.
Red-winged Blackbird.
Meadow Lark.
Killdeer.
Quail.
Ruffed Grouse.
Prairie Hen.
Wild Turkey.
Mourning Dove.
Marsh Hawk.
Baltimore Oriole.
Common Blackbird.
Song Sparrow.
Chipping Sparrow.
Vesper Sparrow.
Chewink.
Dickcissel.
Scarlet Tanager.
Butcher Bird.
Red-eyed Vireo.
Yellow-throated Vireo.
Black-poll Warbler.
Pine Warbler.
Golden Warbler.
Water Wagtail.
Yellow-breasted Chat.
Mockingbird.
Catbird.
Tufted Titmouse.
White-breasted Nuthatch.
Ruby-crowned Kinglet.
Brown Thrasher.
Wilson's Thrush.
Wood Thrush.
Hermit Thursh.
House Wren.
Robin.
Bluebird.

Of the foregoing list, those which feed mainly on Orthoptera during the summer season are the hawks, blackbirds, crows, blue jay, prairie chicken, mockingbird and bluebird. All of the birds mentioned are, however, beneficial in the highest degree and should, at all times, be protected from their enemies, chief among which is the youth with his shotgun, or the small boy with egg-hunting proclivities.

Preventive and Remedial Measures Against Destructive Locusts.

Aside from the locusts or short-horned grasshoppers, few of our Orthoptera ever appear in such numbers as to do excessive damage. However, almost every summer there is in some of our Eastern States an outbreak of locusts which, for a time, cause serious loss. In 1918 they appeared in greater numbers and were more destructive throughout Indiana than for many years. While

this work is not intended as an economic treatise there are four methods of preventing or dealing with a locust outbreak which are practical in application and of low cost. These should be known to every farmer and are briefly stated as follows:

DESTROYING THE EGGS.—This is a preventive measure which is practical when an outbreak is feared in any locality. It may be easily accomplished by either plowing, disking or cultivating in late fall or winter all waste lands such as roadsides, ditch banks, margins of cultivated fields, uncultivated fields and grassy margins along fences. Fields in young clover or alfalfa which cannot be plowed should be thoroughly disked in fall and harrowed in early spring. Stirring the soil to a depth of two or three inches will usually be sufficient, as the eggs are laid in clusters within that distance from the surface and the stirring breaks up the egg clusters, exposes them to their natural enemies or buries them so deep that the young never emerge.

DESTROYING WITH POISONED BAIT.—After the grasshoppers have appeared in numbers they can be killed by a poisoned bait scattered freely about throughout their haunts. Two formulas for this bait have both been used with success. As given by J. J. Davis,[5] they are as follows:

POISONED BRAN AND SAWDUST BAIT.

Bran (half and half bran and sawdust, or sawdust alone)	25 lbs.
Paris green or crude arsenious oxide	1 lb.
Molasses, cheap feeding grade	2 qts.
Lemons, bananas or oranges	6 fruits.
Water	1 to 2 gals.

The poison should be thoroughly mixed with the bran. The water, molasses and finely chopped fruit are then mixed and added to the poisoned bran. Thoroughly mix and add water if necessary. The mixture should be wet so that it will mold in the hands, but should not be soppy. Coarse bran is the best material for making the bait, but the use of half hardwood sawdust and half bran, or of sawdust alone as a substitute for bran, gives very good results. The bait should be scattered broadcast early in the morning, at the rate of seven to ten pounds to the acre.

THE CRIDDLE MIXTURE.

This consists of one-half barrel of fresh horse droppings, one pound of Paris green or crude arsenious oxide, or one and one-half pounds of

[5]"Grasshopper control in Indiana."—Circ. No. 88, Purdue Univ., Agri. Exper. Stat., 1919, 1—8. See also Farmers' Bulletin No. 691.

white arsenic; six or eight lemons, oranges or bananas or one and one-half ounces of cheap lemon extract, and water to make a wet but not sloppy mash. These ingredients are thoroughly mixed and scattered broadcast, the same as recommended for poisoned bran bait.

USE OF A "HOPPERDOZER" OR "GRASSHOPPER CATCHER."—These two devices for catching grasshoppers where they are too plentiful have both been extensively used with great success. Webster (1907) describes a cheaply constructed but efficient hopperdozer as follows: "It is constructed of sheet iron, preferably galvanized, of reasonable thickness to insure strength, and, except for the end pieces, made of a single sheet ten or twelve feet long and 26 inches in width. . The front is formed by turning up one edge a couple of inches, and the back may be turned up a foot, thus making a shallow pan one foot wide, with the back the same height and with the front two inches high. Ends are riveted in and soldered. Runners of old wagon tire are placed at each end, and another in the center is turned over in the front and back to strengthen the pan at these points. These runners are riveted to the pan, and should extend both backward and forward in order to overcome to some extent the inequalities of the ground and cause the hopperdozer to run more smoothly. By soldering it about the heads of the rivets the pan will be made water-tight. A central partition six inches high will keep the contents from flowing to one side and running over the edge on uneven ground. The pan is filled with water on which is poured enough kerosene to cover it with a film, a horse is hitched to the end runners, and the outfit is then ready for use. As the hopperdozer is drawn over the ground the locusts will either jump into the kerosene and water direct or against the back and drop into it and there be killed. By using longer, wider, and heavier sheet iron a larger and stronger pan can be made and this further strengthened by additional runners; a horse can then be hitched to each end, or the pan may be mounted on low wheels. Crude oil or tar may be used instead of kerosene and water."

The "Grasshopper Catcher" is a somewhat similar device, but instead of killing the locusts by having them fall into a kerosene mixture, it is arranged so that when they strike the upright metal back they fall to the bottom and back through a narrow trap opening into a screened box. This has a hinged lid and when full, the locusts can be easily removed into sacks and hung up to dry for poultry feed. Full details explaining the structure of this device are given in the Purdue circular above cited. The dried locusts are rich in protein and make an excellent winter food for poultry.

UTILIZATION OF POULTRY.—Where locusts are abundant each season farmers can protect their crops and at the same time make a profit off the insects by keeping large flocks of poultry. This has been done many times in Kansas and other locust-infested States. Portable poultry yards which can be easily moved from one point to another will keep a flock of chickens in plentiful food and at the same time rid large areas of the locust pest.

About the best remedy for Orthoptera on a farm is a large flock of turkeys. Under the leadership of an experienced gobbler, almost their entire time during the summer and fall months is spent in wandering over the fields and pastures in search of the fat and juicy nymphs of locusts, grasshoppers and crickets. Indeed, most of the luscious white and brown meat of our Thanksgiving and Christmas dinners was once grass, then grasshoppers, and finally turkey. No better and more practical remedy can be devised, for the damage which the insects do, especially in these days of "turkey trusts," is often more than compensated by the value of the pounds of flesh which this domesticated fowl stores up from its favorite food of locusts..

THE COLLECTING AND PRESERVATION OF ORTHOPTERA.[6]

As will be noted in the pages which follow, each species of Orthoptera has its favorite local habitat or chosen haunt, the place where it finds the struggle for existence least fierce, food most abundant, protection or concealment from its enemies most easy. Here the collector will find that species most abundant and for the beginner a few directions for its capture and preservation will perhaps be useful.

INSECT NETS.—The most efficient device for taking the majority of forms of Orthoptera is a strong sweep net. The frame of the folding steel landing net made for fishermen and sold in most sporting-goods houses serves admirably for the frame of a sweep net. When unfolded it should have a diameter of about 16 inches; and the handle should be preferably of one piece and not over 30 inches long. The bag should be made of light canvas or very heavy unbleached muslin and should be 20 to 24 inches in depth. Such a net can be easily used with one hand both in sweeping from side to side herbs and small shrubs as one walks leisurely along, or it can be used more forcibly in quick upward sweeps against the branches of larger shrubs and trees, thus jar-

[6]For more detailed directions on this subject see Bruner (1895a) or Banks (1909.)

ring the insects into the net, where they can be captured with fingers or forceps, or by placing the mouth of the killing bottle quickly over them. This net also serves well instead of an umbrella as a beating receptable. For this purpose it is held under the foliage with one hand while the limb is struck a quick, sharp downward blow with a strong stick. The sweep net serves best in the capture of such Orthoptera as do not fly quickly as mantids, phasmids, most katydids, long-horned grasshoppers, tree crickets, ground and sand crickets, etc.

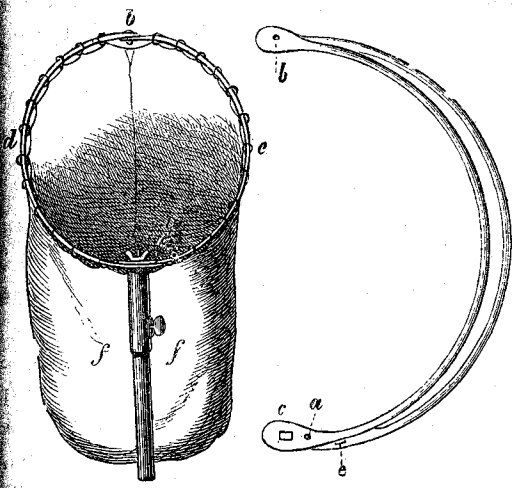


Fig. 20. One form of a sweeping or beating net opened and attached to handle, with frame of same folded. (After Kiesenwetter.)

For the quick flying or leaping Orthoptera, as the short-horned locusts, species of *Scudderia,* etc., a strong butterfly net with the bag of gauze, bruxelle or mosquito netting will be most useful. With this the insect may usually be taken by a quick swoop just as it rises, or by bringing the net suddenly down over it from above, as it rests on the ground. The thin meshed bag has the advantage of the insect being readily visible when captured, whereas one must open the sweep net and peer into its depths, thus giving many a fine specimen a chance to dart out and away. A cheap frame for either sweep or butterfly net can be made of a piece of heavy No. 4 or larger wire bent into the proper form with about three inches of each end bent in such a way that they can be made parallel and then forced into the end of a bamboo or other handle.

Another device used by collectors is the forceps net made of two rings five or six inches in diameter, each with gauze stretched tightly across it, the two handles to which the rings are attached being hinged like a pair of large shears and the rings tightly fitting when closed. This net is useful in taking tree crickets and other Orthoptera which have been located by their song at night.

It is opened and then clapped suddenly together about the insect which is held tightly between the two pieces of gauze until removed. Many Orthoptera can also be taken by beating into an open umbrella, but quick action is usually necessary to capture the specimen after it is once in the ungainly receptacle.

Most of the ground crickets hide by day in burrows or beneath stones, logs, piles of dead leaves or other debris, while roaches hide beneath loose bark or behind signs attached to trees. These nocturnal forms can usually easily be taken by overturning their cover and capturing with fingers or forceps. Mole crickets may often be found beneath a stone or chunk at the end of their burrows, or by digging with a spade or trowel into the muck about the border of a lake or pond.

Trapping Jars.—W. T. Davis and others have had much success in taking camel-crickets (*Ceuthophilus*) and other terrestrial species by trapping with a special molasses bait. This bait is made by taking a pint of cane or New Orleans molasses (not corn syrup) and adding to it a teaspoonful of fusel oil. Into an old tin or wide mouthed jar or bottle this bait is poured to a depth of about one-third of an inch. The jar is then sunk in the ground to the level of its mouth and a chip or flat stone placed at an incline just above it to keep out rain or falling debris. If visited two or three times a week many insects will be found which, when removed with forceps into a box, then thrown into water for half an hour and afterward dried, will be ready for mounting. These traps are most successful when placed along woodland paths, borders of fields, near an old log, a pile of stones or base of a cliff, especially where dead leaves or other debris occurs in quantity.

Night Collecting.—Many rare species of nocturnal Orthoptera can best be captured by using a flash light or small camp acetylene lantern after night. They will then be found moving freely about over foliage or along pathways. Many can be located by their night song. By taking two cross-bearings, thus closely approximating the exact locality of the singer, it can be cautiously approached and captured with net or hand. Numerous species of Orthoptera are attracted by light, and good night collecting will often be found at the proper season beneath or near the electric street lights of cities and towns.

Killing Bottles.—After capturing a specimen for a cabinet it is best to kill it as quickly as possible before its antennæ, legs or other delicate appendages are broken. This is best accom-

plished by the cyanide bottle, which is made by placing in a large mouthed bottle (one of the form shown in Fig. 21, about five inches high by two and a half in diameter, is preferable for Orthoptera) small broken pieces of potassium or sodium cyanide to a depth of two-thirds of an inch. Cover this with one-half inch of plaster paris. Moisten the latter with just enough water to cause it to set and hold the cyanide in place. Then cover with two thicknesses of blotting paper so cut as to closely fit the inside of the bottle. Keep the bottle tightly corked and *in a place where children cannot reach it, as the cyanide in any form is a most deadly poison.* Any Orthopteron placed in the bottle will usually be killed in a few minutes. Several bottles of different size for both large and small specimens should be taken on each day's trip. After six months or more the cyanide usually loses its poisonous qualities and must be renewed or the bottle discarded for a fresh one.

Fig. 21. A cyanide bottle with paper strips enclosed to keep the insects from jostling too freely. (After Banks.)

A small wooden or tin box with layers of felt or cotton should be taken into the field and after a half dozen or so specimens have been killed in the bottle they should be removed to this box, as they are apt to be broken if carried about for several hours. The cyanide bottle after being used several times for large Orthoptera will often be found to contain much moisture. It should then be wiped out with dry cotton and new pieces of blotting paper substituted for the moist ones. A large bottle with a solid lump or two of cyanide held in place by a mass of cotton or shreds of tissue paper can be temporarily used for very large specimens.

After the day's collecting the specimens should be either mounted or, if away from home, packed for carrying or shipment. They are best transported by placing between layers of felt or cotton in small cigar boxes. If in a moist climate and packed too closely they are apt to mold in a short time. With the larger spec-

imens this can often be prevented by slitting the abdomen along the middle or sides of under surface with a pair of sharp pointed scissors and removing the intestines and other internal organs with a pair of forceps. Then wipe out the cavity with a small piece of cotton and stuff with loose raw cotton or very small pieces of cheese-cloth, taking care not to fill too full and distend the abdomen beyond its original size. Press the sides of the ab-

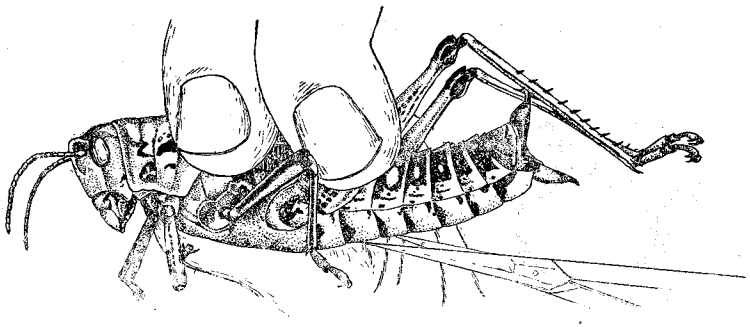


Fig. 22. Showing method of slitting abdomen of large Orthopteron. (After Bruner.)

domen gently into shape and mount on a pin or pack for shipment. Specimens so stuffed do not become soft and turn dark, but retain their original color and are less apt to be attacked by museum pests or mold.

LABELLING SPECIMENS.—With each layer of specimens in a box place a label giving the date and place of capture and an accession number referring to a similar number in a note book giving any special data regarding the occurrence, song, food plant or other information concerning the specimens which may be of value in the future. When mounted each pin should bear below the insect a locality and date label and also an accession number referring to note book data. Without such labels a specimen is of little scientific value. Personally I would at any time rather have a label without a specimen than a specimen without a label.

Dried specimens can be relaxed sufficiently for mounting by placing between thoroughly moistened layers of blotting paper in a tightly closed box or other receptacle for 10 or 15 hours. If the weather is very warm a drop or two of carbolic acid or alcohol had best be sprinkled over the blotting paper. The mold on specimens can be removed by using a camel's hair brush and alcohol to which a few drops of carbolic acid have been added.

PRESERVING THE NATURAL COLORS.—Most Orthoptera retain their natural colors after drying, but the green or bright colored ones usually fade to a dull yellow or other hue. This can be prevented by placing the specimens, when first captured, in a solution of 19 parts water and one of commercial formalin. If on a long collecting trip, they should be packed closely enough to prevent jostling and should be removed, dried and mounted after two or three weeks' stay in the solution.

PINNING SPECIMENS.—In pinning specimens of Orthoptera for the cabinet care should be taken to so locate and pass the pin as to hold solidly the insect and at the same time not interfere with its future study. In the locusts, katydids and other jumping forms the pin should be pushed through the right side of the metazona, inclining the point slightly backward so that it will pass through the metasternum, thereby holding the body rigidly in place. In the roaches, mantids, etc., it should be inserted behind the pronotum through the right tegmen near the middle of the body, care being taken not to run it through the base of any leg. After mounting and labelling, the pin should be run through the lid of a pasteboard box, or thin piece of cork placed on supports, far enough for the bottom of the specimen to be brought down to the level of the box cover or cork, the tibiae being folded back under the femora or the legs crossed so as to take up as little room as possible and yet be available for study. One specimen of each species should have the left tegmen and wing spread out and pinned at right angles to the body, so that the veining and color of the inner wing may be studied. The antennae, when long, should be bent back along the sides of the body. The "tray" or lid of specimens should then be placed in a drying cage, which is easily made by screening two sides of a narrow box standing on end with fine mesh wire, thus allowing the air to pass through and at the same time preventing the speci-

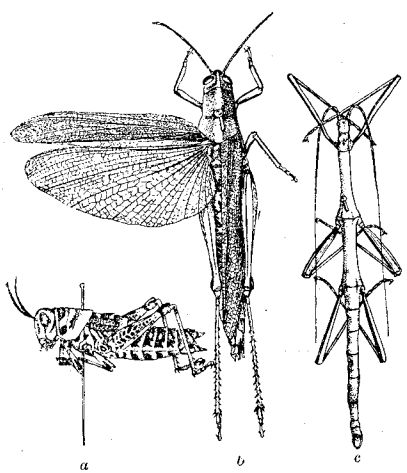


Fig. 23. Showing manner of pinning Orthoptera, spreading wings, arranging antennæ, etc. (After Bruner.)

mens from becoming infested with the eggs of dermestids and other museum pests. Small cleats tacked at intervals on the inside will serve to support the pasteboard trays. After drying for a week or so the specimens can be transferred to permanent cabinet boxes, which should be as nearly dust-proof as possible.

Earwigs, small crickets and other minute forms should be mounted (as is the beetle in Fig. 24) with transparent glue or shellac on the tip of a small narrow triangular card through the base of which a pin has been run. Only a very small amount of the glue is necessary, it being most readily applied to the card with the tip of a wooden toothpick. The legs should be carefully spread before mounting and the body then pressed down firmly on the glued card, which should be placed at right angles on the left side of the pin with the head of the insect away from the person.

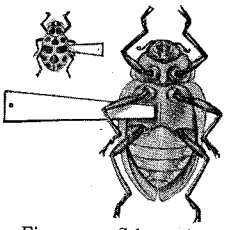


Fig. 24. Showing method of gluing an insect on paper point. (After Banks.)

MUSEUM PESTS.—On account of their bulky bodies Orthoptera are especially subject to the attacks of museum pests. Flakes of napthaline kept in each box will usually serve as a repellant for such pests. Each box should be examined three or four times a year, and if by dust, exuvia or other debris, the presence of pests is indicated, a few drops of carbon bisulphide should be poured in the box and the lid quickly closed. The vapor of this will soon destroy the eggs, larvæ or other living form of any pest.