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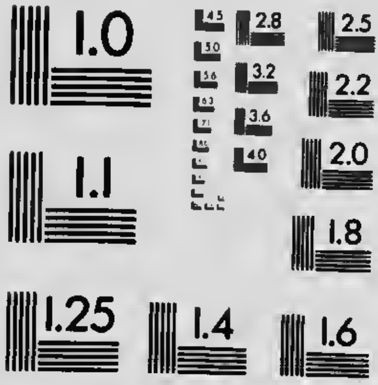

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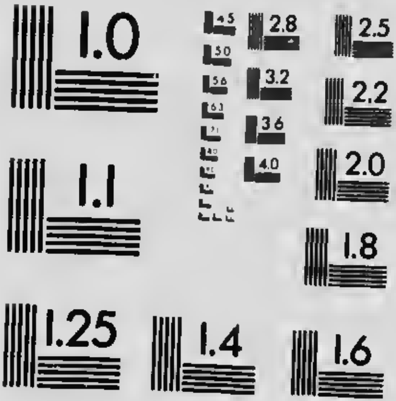

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CLASS BOOK

OF

ECONOMIC ENTOMOLOGY

LOCHHEAD

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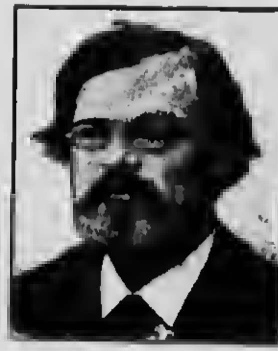

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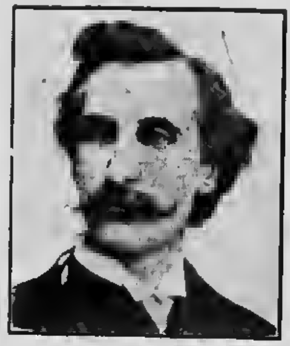

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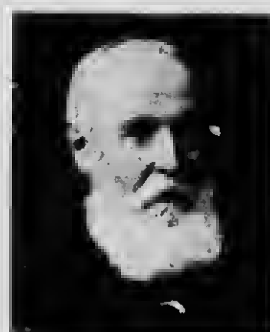

C. J. S. Bethune

Some Pioneer Workers in Economic Entomology.

ERRATA

Page vi, In 14th line from bottom read:—
J. G. Sanders of the Pennsylvania Bureau of Economic Zoology.

Page xiv, In top line read:—
Dr. T. W. Harris (1795–1856).

Page 28, The fifth paragraph should read:—
Nerve-fibres and Ganglia.—A nerve-fibre consists of (1) an *axis-cylind* of fibrillæ, derived both from the medulla of a ganglion and from single ganglionic cells, and (2) a *sheath*. A ganglion consists of a dense *cortex* of ganglionic cells, each sending off usually (*a*) a nerve-fibre, (*b*) a central *medulla* of fibrillar substance which, according to Leydig, is the continuation of the processes of the ganglionic cells and gives rise to most of the fibrillæ of the axis-cylinder, and (*c*) a *sheath*.

Page 32, In 9th line from top read Fig. 35 for Fig. 37.

Page 82, In 15th line from bottom read *cavicollis* for *clavicollis*.

Page 104, The legend of Fig. 59 should read:—
The American Cockroach (*Periplaneta americana*); and the reference to the figure should belong to 1 and not to 3.

Page 116, In legend of Fig. 71 read *Gryllus* for *Gyllus*.

Page 124, In bottom line read Fig. 80 for Fig. 79.

Page 150, In bottom line read *nerii* for *perii*.

Page 150, In 8th line from bottom read elm for plum.

Page 275, In legend Fig. 178 read cabbage for cabage.

Page 276, In 8th line from top read 179 for 180.

Page 294, In top line read *Cryptohypnus* for *Cryptohypmus*.

Page 340, In top line read *Phthorophlœus* for *Phthorophlocus*. In 8th line from bottom read yellowish for yelowish.

Page 390, In 9th line from top read 4:4:40 for 4:40:40.

CLASS BOOK

OF

ECONCMIC ENTOMOLOGY

WITH SPECIAL REFERENCE TO THE ECONOMIC INSECTS OF THE NORTHERN UNITED STATES AND CANADA

BY

WILLIAM LOCHHEAD, B. A., M. S. (Cornell)

PROFESSOR OF BIOLOGY IN THE MACDONALD COLLEGE OF McGILL UNIVERSITY; F. A. A. S.; MEMBER OF THE ENT. SOC. OF AMERICA, AND THE AM. ASSOC. ECON. ENT.; EX-PRESIDENT ENT. SOC. OF ONTARIO; PRESIDENT QUEBEC SOC. FOR THE PROTECTION OF PLANTS, ETC.

WITH 257 ILLUSTRATIONS

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PREFACE

All teachers are agreed that the best results in the classroom are secured only by the adoption of the best pedagogical methods, with ready access to the necessary specimens and literature. Just what these methods comprise, however, is, with many teachers, a matter of opinion. *Quot homines tot sententiæ*, nevertheless the indulgent reader may concede that an experience of over twenty years as a teacher of economic entomology in agricultural colleges may warrant the voicing of the author's conviction that instruction in this subject should consist of (1) studies on the structure, metamorphosis, and bionomics of insects, carried on both in the laboratory and in the field; (2) practice in the classification and description of the more common insects in their various stages; and (3) studies of the methods of control, with practical exercises in the preparation aod application of insecticides.

Although several most excellent manuals on Economic Entomology have been published in recent years, there seems to be a need for a book providing the oecessary information for the student in the class-room, laboratory and field along the lines indicated above.

This class-book, therefore, has been prepared to meet the needs of the class-room instructor, and his needs have influenced the mode of presentation of the subject material. It does not presume to take the place of the invaluable and well-known works of Folsom, Comstock, Slingerland and Crosby, and others; but rather, it aims to present such material as will best help the student in acquiring a fair working knowledge of the modern science of Economic Entomology.

The treatment of many of the topics is necessarily limited, and the keys for the identification of orders, families, and genera make no pretensions to completeness. The descriptions of the species discussed in Part III are stripped of all unnecessary verbiage so that all the essential facts of the life-histories may be included in the space at the author's disposal.

Laboratory exercises have been omitted, as the intelligent teacher is in a better position than the author to prepare *practicums* adapted to local conditions.

It was thought advisable to limit the species discussed mainly to those belonging to the Northern United States and Canada, *i.e.*, to the Canadian, Transition, and Upper Austral Zones. It was also deemed advisable to make but brief mention of the insects affecting forest trees. Students interested in such studies are referred to the recent bulletins of A. D. Hopkins of Washington and J. M. Swaine of Ottawa for the results of the latest investigations.

The author is indebted to many fellow-teachers and workers for valuable aid and suggestions in the preparation of this book. In most respects it is a compilation from recent text-books, bulletins, and articles. In a work of this kind errors are likely to appear in spite of every precaution, but considerable care has been taken to reduce them to a minimum.

Special mention must be made of the kindness of many authors and publishers in furnishing illustrations, and the writer here thanks his friend and teacher, Professor J. H. Comstock of Cornell University, for permission to use illustrations of wing-venation from his recent work, "The Wings of Insects;" Dr. C. G. Hewitt, Dominion Entomologist, for free use of cuts from the publications of the Canadian Entomological Branch; Dr. L. O. Howard, Chief of the U. S. Bureau of Entomology, for many electrotypes of the Bureau illustrations; Professor J. H. Sanders of the Pennsylvania Agricultural Experiment Station, for permission to use his admirable figures of pygidia of scale insects; Mr. J. J. Davis, Federal Agent of the U. S. Bureau of Entomology, Lafayette, Indiana, for several photographs of breeding cages, etc.; Professor L. Caesar of the Ontario Agricultural College, and Dr. S. Hadwen, Dominion Pathologist, Health of Animals Branch, Ottawa, for furnishing several cuts; Mr. Arthur Gibson, Entomological Branch, Ottawa; Professor W. H. Brittain of the Truro Agricultural College; Professor P. J. Parrott of the New York Agricultural Experiment Station; Professors Herrick, Crosby and Johannsen of Cornell University; Professor W. A. Riley of the Minnesota Agricultural College; Dr. Edith Patch of the Maine Agricultural Experiment Station; Professor W. E. Britton of the Connecticut Agricultural Experiment Station; Professor V. L. Kellogg of the Leland Stanford Jr. University, Professor

W. B. Herms of the University of California; and the MacMillan Co., the Comstock Publishing Co., Henry Holt and Co., and P. Blakiston's Son and Co., for permission to use certain illustrations from their entomological publications.

To Mr. E. M. DuPorte, M. Sc., of Macdonald College, the author is specially indebted for the drawings illustrative of the structure of insects in Part I, for valuable criticisms, and for substantial help in proof-reading.

W. LOCHHEAD.

MACDONALD COLLEGE.

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PART I—THE STRUCTURE, GROWTH AND ECONOMICS OF INSECTS

PART II.—THE IDENTIFICATION OF INSECTS INJURIOUS TO FARM, GARDEN AND ORCHARD CROPS, ETC.

PART III.—CLASSIFICATION AND DESCRIPTION OF COMMON INSECTS

PART IV.—THE CONTROL OF INJURIOUS INSECTS

INTRODUCTION

Economic Entomology is that phase of Entomology which relates to the control of injurious insects. Its scope is much wider than that of applied entomology, for the latter, properly speaking, is the application of the principles that have been formulated by the economic entomologist as a result of his investigation of insects and their relations to their environment. Its scope embraces a study of the structure, habits and life-histories of the injurious insects and of their relations to all the natural and artificial conditions to which they may be subjected. It also includes the investigation of the nature of the losses and the practicable means by which they may be prevented or lessened.

Considering the great variety of insect forms, their diverse methods of food habits, the large number of kinds of hosts which supply them with food, and the enemies which tend to destroy them, it becomes evident that the problem of insect control is most complex. As Professor Forbes says: "The subject matter of this science is not insects alone, nor plants alone, nor farming alone. One may be a most excellent entomologist or botanist, or he may have the whole theory and practice of agriculture at his tongue's end, and at his fingers' end as well, and yet be without knowledge or resources when brought face to face with a new practical problem in economic entomology. The subject is essentially the relation of these things to each other; of insect to plant and of plant to insect, and of both of these to the purposes and operations of the farm, and it involves some knowledge of all of them."

The Rise of Economic Entomology

The records of the rocks reveal the existence of insects at an early period in the world's history, long before man made his appearance. Early historic records also show clearly that not only man himself but also his crops and flocks suffered from insect attacks. The ravages of locusts, canker worms and palmer worms are frequently described in graphic language by the Old Testament prophets.

In America, too, before the advent of Europeans, the Indians were acquainted with insects that injured their corn fields, and during the seventeenth and eighteenth centuries the crops of the early settlers were seriously ravaged by "canker worms" and grasshoppers. One may say, therefore, with Webster: "the actual economic element in entomology is inevitably as old as Agriculture itself." On account, however, of the ignorance and superstition that prevailed even among the learned classes regarding the nature and habits of insects, no progress in the control of insect pests was made or was possible until the latter half of the nineteenth century. The introduction of rational methods of control had to wait until considerable advance had been made in the classification of insects and in a knowledge of their structure, habits and life-history.

In so far as America is concerned, it may be said that outbreaks of certain insects, viz., the Rocky Mountain locust, the cotton worm and the Colorado potato beetle during the last quarter of the nineteenth century produced wide-spread attention to the great losses caused by them, and forced the U. S. government at that time to appoint a commission of entomological specialists for the purpose of investigating the conditions. It was during this period that some of the modern insecticides and improved spraying machinery were introduced, Paris green becoming the standard remedy against the Colorado potato beetle and the cotton worm, and kerosene emulsion against sucking insects. The reports of Harris, Fitch and Riley, especially those on the Rocky Mountain locust laid the foundation for future ecological studies when the relations of injurious insects to other organisms and to external factors were closely investigated.

About the beginning of this century the San José scale and the cotton boll-weevil threatened two important industries, and as a result of the investigations many advances were made in the use of spraying machinery and insecticides, notably lime-sulphur wash and hydrocyanic acid gas, and in the application of biological processes and principles.

In the attempt to solve the problem of the control of the gypsy and brown-tail moths during the last twelve years another very important advance was made toward a better understanding of parasitic insects and of the part they are likely to play in the control of insects in the future. Regarding the outlook of fighting insects along this line Dr. Howard says: "There will be a very considerable development of this method of warfare against injurious insects in the future. It should be termed "the biological method of fighting insects" and, looking at the problem in a broad way, so far as this country is concerned, when we consider that more than one-half of our principal crop pests have been accidentally imported from other countries, there seems no reason why a systematic study of a very large number of parasitic and predatory insects native to the countries from which these pests were accidentally imported should not be made with a view of ultimate importation of all of them into the United States. In fact, since there exist all over the world beneficial insects, many of which can undoubtedly be acclimatized here, and some of which will undoubtedly prove of value to American agriculture, carefully planned work should be begun looking to the ultimate increase of our insect population by the addition of as many of these beneficial forms as possible. Of course this would mean a very great amount of careful biological study in the countries of origin by men specially trained in this sort of work, if results of value are to be obtained. Strikingly beneficial results could not be expected speedily, and, in fact, we might not be able for many years to estimate the benefits derived from such a service; but it seems clear that we should have in this country as many of these surely beneficial forms as can be acclimatized."

The greatest impetus to the development of economic entomology was perhaps the establishment of Experiment Stations and Agricultural Colleges where courses of instruction were given in this branch of zoology, and where hundreds of students have been trained to undertake investigations of the many insect problems that were awaiting solution. An interesting feature of the latest development in the study of injurious insects is the method of investigation that has been adopted in most entomological stations. "Field stations" where the insects are studied under both field and laboratory conditions are established in infested areas, each in charge of an expert and a staff of assistants. These officers also keep in close touch with the insect conditions of the district, and are often able to "test out" control measures at many places by interesting the farmers and orchardists in the valuable work they are conducting.

Even in a sketch of the main features of the rise of American economic entomology, such as this is, mention must be made of some of the pioneer entomologists who laid firmly and well the foundations of this modern science. Dr. T. W. Harris (1759-1856) in Massachusetts, Dr. Asa Fitch (1809-1879) in New York, Townend Glover at Washington, B. D. Walsh (1808-1869), Dr. C. V. Riley (1843-1895) in Missouri and at Washington, Dr. W. Le Baron and Cyrus Thomas in Illinois, and Dr. W. Saunders (1835-1914), Dr. C. J. S. Bethune (1838——) and Dr. James Fletcher (1852-1908) in Canada stand out prominently on account of the excellent investigations of the life-histories of injurious insects and their careful determination of effective methods of control. (*See frontispiece.*)

ECONOMIC ENTOMOLOGY

PART I

THE STRUCTURE, GROWTH AND ECONOMICS OF INSECTS

BRANCH ARTHROPODA (Arthropods)

Crabs, crayfish and lobsters, spiders and scorpions, centipedes, and millipeds have in common with insects *jointed appendages and segmented, bilaterally symmetrical bodies with a chitinized external skeleton* (exo-skeleton)—distinguishing characteristics of the great branch *Arthropoda* of the Invertebrate animals. These near relatives of insects may be grouped into four classes:

1. *Crustacea.*—Aquatic, gill-breathing, wingless Arthropods with two pairs of antennæ and at least five pairs of legs. *Examples:* Crabs, crayfish, lobsters, shrimps, sow-bugs, etc.

2. *Arachnida.*—Air-breathing, wingless Arthropods without antennæ, and usually with four pairs of legs. *Examples:* Spiders, mites, ticks, and scorpions.

3. *Diplopoda.*—Air-breathing, wingless Arthropods with one pair of antennæ and numerous body segments each of which bears two pairs of legs. The mouth-parts consist of a pair of mandibles and a compound plate. *Example:* Millipeds.

4. *Chilopoda.*—Air-breathing, wingless Arthropods with one pair of antennæ and numerous body segments each bearing one pair of legs. The mouth-parts consist of one pair of mandibles and two pairs of maxillæ. *Example:* Centipedes.

(Classes 3 and 4 are frequently grouped as sub-classes of the class *Myriapoda.*)

Class Insecta (Insects)

The *Hexapoda* or *Insecta* are air-breathing Arthropoda with one pair of antennæ, three pairs of legs, and usually one or two pairs of wings in the adult state.

Insects form a well-defined class of animals, remarkable for the large number of species. The abundance of some species is so great that frequently they constitute a menace to the life of plants upon which they feed. The economic importance of insects is being rapidly realized by the public in recent years on account of the prominence given to the part taken by the common house fly in the spread of typhoid fevers and other diseases, the mosquitoes in malaria and yellow fever, the San José scale and codling worm in orchards, the boll-weevil in cotton fields, the army worm and hessian fly in grain fields, the tent caterpillar and bark beetles in orchards and forests, and many other pests that are causing much annoyance, danger and loss.

The Structure of Insects

EXTERNAL ANATOMY

The body of the insect is bilaterally symmetrical and is divided into three distinct parts—the *head*, the *thorax* and the *abdomen*, each composed of a number of segments separated by membranous portions (Fig. 1). Each segment again is made up of a number of *sclerites*, hardened plates separated from each other by seams or impressed lines known as *sutures*. The skeleton is external, and is in form a hollow cylinder with the muscles attached within. The skin layer or cuticle is laminated, consisting of two layers secreted by the underlying hypodermal cells. The hard tough texture of the skin is due to *chitin*, an organic substance resembling that which gives the characteristic texture to horns and hoofs.

(*a*) **Head.**—The skeleton of the head or skull is composed of six or seven closely united segments, and carries the *eyes* and *antennæ*. The mouth is situated on the front ventral surface. The following regions can be easily recognized:

Epicranium {
(a) Vertex or crown, the summit of the head, often with ocelli.
(b) Front or face.
(c) Genæ or cheeks.

(d) Occiput, which surrounds the posterior opening of the skull.
(e) Clypeus, to which the labrum or upper lip is attached.
(f) Gula, to which the labium or lower lip is attached (see Figs. 2 and 3).

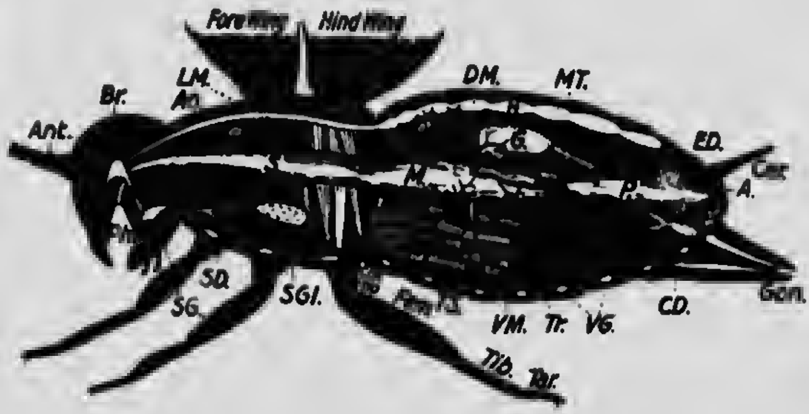

FIG. 1.—Diagram showing the position and arrangement of the principal organs nd appendages of an insect. *Ant.*, Antenna; *Br.*, brain; *Ao.*, aorta; *LM.*, leg musles originating in the thorax; *DM.*, dorsal longitudinal muscles of abdomen; *H.*, eart; *MT.*, Malpighian tubules; *ED.*, efferent duct (oviduct or vas deferens) of productive system; *G.*, gonad (ovary or testis); *Cer.*, cercus; *A.*, anus; *Gon.*, onapophyses; *CD.*, common duct (vagina or seminal vesicle) of reproductive sysem; *VG.*, ganglia of ventral nerve chain; *Tr.*, tracheal trunk showing origin and istribution of ventral, dorsal and visceral tracheal branches; *VM.*, ventral longiudinal muscles; *TS.*, tergo-sternal muscles; *Cox.*, coxa; *Tro.*, trochanter; *Fem.*, mur; *Tib.*, tibia; *Tar.*, tarsus; *SGl.*, salivary gland; *SD.*, salivary duct; *SG.*, subsophageal ganglion; *Ph.*, pharynx; *S.*, stomodæum or fore intestine; *M.*, mesenron or mid intestine; *P.*, proctodæum or hind intestine.

In addition there is in the head an internal chitinous skeleton alled the *tentorium*, which acts as a supporting structure. It varies n form in different insects but consists essentially of a central plate nd two pairs of arms connecting with the skull. (The tentorium may be isolated by boiling the head in [illegible] per cent. solution of caustic otash for ten minutes.)

Mouth-parts.—In general there are three types of mouth-parts: *mandibulate*, present in the generalized orders and in the Orthoptera,

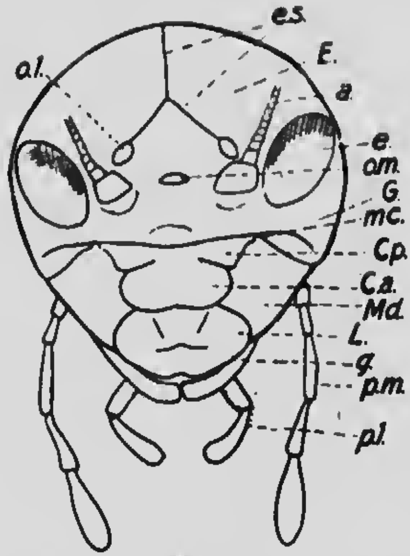

FIG. 2.

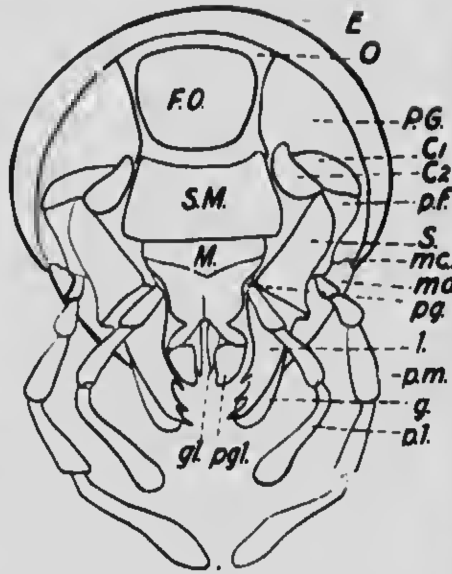

FIG. 3.

FIG. 2.—Cephalic view of the head of cricket. *a.*, Antenna; *e.*, compound eye; *E.*, epicranium; *o.l.*, lateral ocellus; *o.m.*, median ocellus; *e.s.*, sutures of the epicranium; *G.*, gena; *Cp.*, *C.a.*, clypeus; *L.*, labrum; *Md.*, mandible; *p.m.*, maxillary palpus; *p.l.*, labial palpus.

FIG. 3.—Caudal view of head of cricket. *E.*, Epicranium; *O.*, occiput; *F.P.*, occipital foramen; *P.G.*, postgena; *SM.*, submentum; *M.*, mentum; *gl.*, glossa; *pgl.*, paraglossa; *pg.*, palpiger; *pl.*, labial palpus; *C.1*, *C.2*, cardo, *pf.*, palpifer; *g.*, galea; *s.*, stipes; *l.*, lacinia; *p.m.*, maxillary palpus; *md.*, mandible.

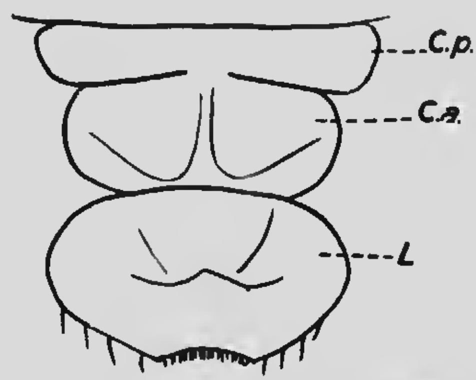

FIG. 4.—Labrum and clypeus of cricket.

Ephemerida, and Coleoptera; *suctorial*, present in the Hemiptera, Lepidoptera and Diptera; and *mandibulate-suctorial* in the Hymenoptera. The mouth-parts with the exception of the labrum are true appendages of the head segments, and in the embryo arise in exactly the same way as the legs and antennæ.

Mandibulate Mouth-parts.—The mouth-parts of *biting* insects consist of: the *labrum* or upper lip attached to the clypeus (Figs. 2 and 4); a pair of *mandibles*, simple and unjointed, articulated to the *genæ*; a pair of *maxillæ*, each made up of a basal one-, or two-jointed

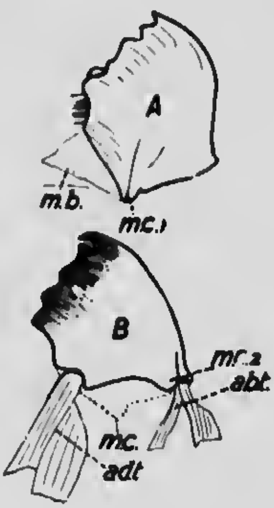

FIG. 5.

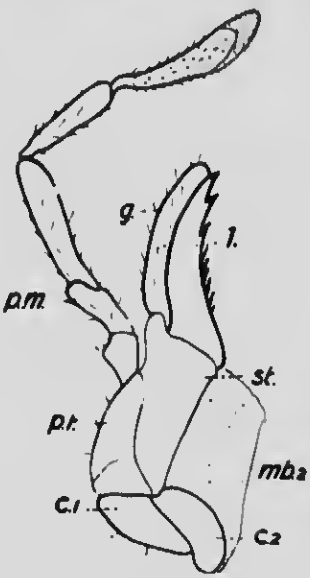

FIG. 6.

FIG. 5.—Mandible of cricket. *A*. Cephalic view; *B*. caudal view; *mb*., membrane; *mc.1*, *mc.2*, *adt*., adductor muscles; *abt*., abductor muscles.

FIG. 6.—Maxilla of cricket. *C.1*, *C.2*, Cardo; *Mb.2*, base of maxilla; *pf*., palpifer; *st*., stipes; *p.m*., maxillary palpus; *g*., galea; *l*., lacinia.

hinge segment, the *cardo*, a central segment the *stipes* which bears the *palpifer* to which the typically five-jointed *palpus* is attached, and two distal lobes the outer of which is termed the *galea* and the inner the *lacinia* (Fig. 6). The *labium* or lower lip, composed of a broad basal part, the *submentum*, joined to the *gula*, a mentum or central portion, a pair of jointed *palpi* attached to the mentum by means of a small sclerite, the *palpiger*, and a median part which may be simple or slightly bilobed in which case it is termed the *ligula*, or it may consist of a distinct pair of inner and outer lobes termed respectively the *glossæ* and *paraglossæ* (Figs. 3 and 7). A comparison of Figs. 6 and 7 will show a perfect homology between the segments of the maxillæ and of the labium. The *hypopharynx* or tongue united to the base of the labium; and the *epipharynx* under the labrum and clypeus bearing teeth, tubercles or bristles (Figs. 8 and 9).

These parts differ greatly in the different orders.

Suctorial Mouth-parts.—The suctorial mouth-parts of flies, bugs, moths and other insects have been evolved from the primitive mandibulate type. In some forms such as the squash bug and mosquito all of the mouth-parts are present and it is comparatively easy to identify them with the corresponding appendages of the biting insects. In other forms, however, the house-fly for example, some of the mouth-parts are missing or fused with others, and it is more difficult to determine their homology. The following descriptions will illustrate the typical arrangements in the three chief purely suctorial orders of insects. Three types occur in the Diptera—the piercing type, with all the mouth-parts present, *e.g.*, the female horse fly and mosquito; the piercing type with some of the mouth-parts missing or fused, *e.g.*, the horn flies and stable flies, and the non-piercing type such as the house-fly and blow flies in which the beak is used for rasping and sucking.

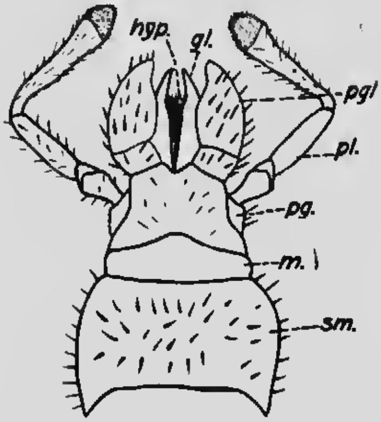

FIG. 7.

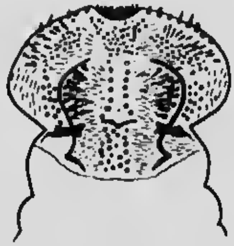

FIG. 8.

FIG. 7.—Labium of cricket. *hyp.*, Hypopharynx; *gl.*, glossa; *pgl.*, paraglossa; *pl.*, labial palpus; *pg.*, palpiger; *m.*, mentum; *sm.*, submentum.
FIG. 8.—The labrum-epipharynx of cricket.

Mouth-parts of the Horse Fly (Tabanid).—The mouth-parts of the female are composed of six blades loosely ensheathed in the *labium* which is the conspicuous median portion terminating in a large labellum (Fig. 10). The mandibles are flat and sword-like; the maxillæ are narrower, but with broad conspicuous palpi; the *hypopharynx* and *labrum-epipharynx* are also narrow and lancet-like.

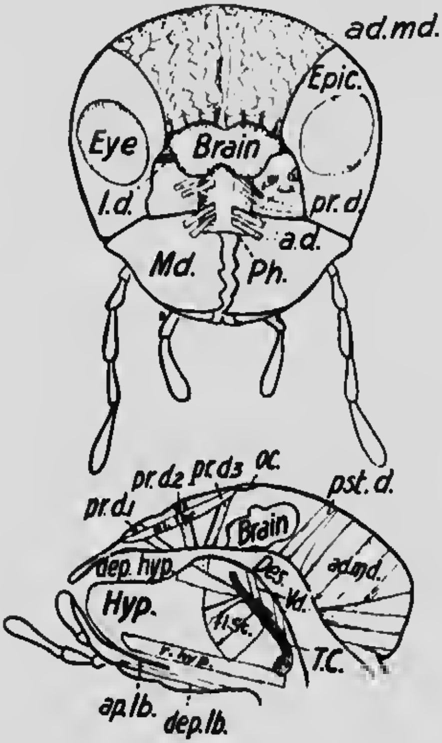

FIG. 9.—Front of head of *Gryllus pennsylvanicus* with face and vertex removed.
Upper Figure.—*Epic.*, Epicranium; *Ad.*, *prd.*, *ld.*, dilator muscles of the pharynx; *Md.*, mandible; *Ph.*, pharynx.
Lower Figure.—Longitudinal dorsoventral section through the head of *Gryllus pennsylvanicus*. *prd.*, *prd.2*, *prd.3*, *pstd.*, *Vd.*, Dilators of the pharynx; *Oc.*, ocellus; *Ad.md.*, adductor of the mandible; *Dep.hyp.*, depressor of the hypopharynx; *Hyp.*, hypopharynx; *r.hyp.*, retractor of the hypopharynx; *ap.lb.*, apodeme of the labium; *r hyp.*, retractor of the hypopharynx; *fl.st.*, flexor of the stipes; *T.C.*, central plate of the tentorium.

Mouth-parts of Mosquito.—The mouth-parts are similar in number to those of the horse fly but they are more bristle-like (Fig. 11).

Mouth-parts of the House-fly.—When the head of a living house-fly is pinched between the thumb and finger the mouth-parts are protruded to their full length. They constitute a soft "proboscis" enlarged at the tip into a pair of soft cushion-like lobes, the *oral lobes* or *labella* (Fig. 12). The under sides of these lobes are traversed by a large number of open channels, the *pseudo-tracheæ,* which open into the mouth situated near the middle; the greater portion of this proboscis is the modified labium. Lying above the grooved labium is the small spade-like *labrum* which may be raised by a pin. Near the base of the proboscis and above the labrum are two small lobes, the *maxillary palpi,* the maxillæ being fused with the fleshy base of the labium.

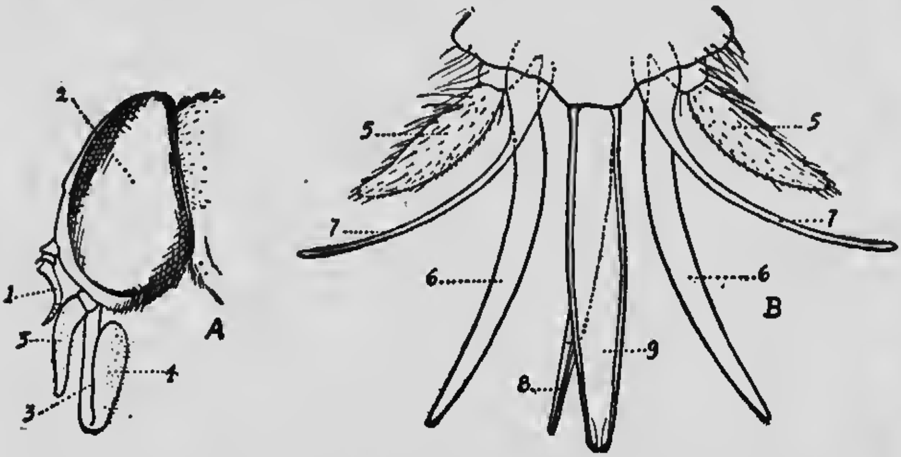

FIG. 10.—Head and mouth-parts of a horse-fly (Tabanus). The maximum number of parts is retained, but the piercing structures are distinctly blade-like. Dipteron type, second subtype. *A*, Side view of head showing: 1, antenna (brachycerous); 2, compound eye; 3, labium; 4, labella; 5, maxillary palpus; *B*, piercing structures exposed, labium removed; 6, mandibles; 7, maxillæ; 8, hypopharynx; 9, labrum-epipharynx. (*After Herms.*)

Mouth-parts of the Stable Fly.—The proboscis is awl-shaped and is adapted for both piercing and sucking (Fig. 13). It projects forward horizontally and has a prominent elbow. The labella are small and are provided with cutting and adhesive structures. Lying above and within the folds of the proboscis or labium are two unequal, sharp heavy bristles, the larger representing the labrum and the smaller the hypopharynx. The maxillary palpi are not so large as those of the house-fly. The palpi of the Horn Fly are longer and more flattened, and the proboscis is plumper and not thrown so far forward.

Mouth-parts of the Squash Bug.—The mandibles and maxillæ are reduced to needle-like structures, the two innermost (the maxillæ) are united to form a piercing tube. The needles fit in the groove of the jointed beak, the modified labium. The labrum closes the base of the groove (Fig. 14).

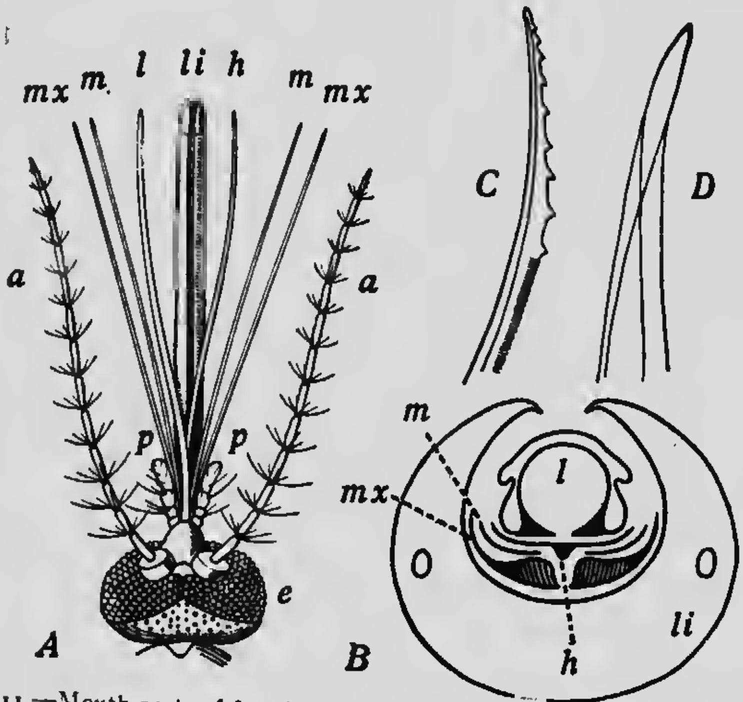

FIG. 11.—Mouth-parts of female mosquito (*Culex pipiens*). *A*, Dorsal aspect; *B*, transverse section; *C*, extremity of maxilla; *D*, extremity of labrum-epipharynx; *a.*, antenna; *e.*, compound eye; *h.*, hypopharynx; *l.*, labrum-epipharynx; *li.*, labium; *m.*, mandible; *mx.*, maxilla; *p.*, maxillary palpus. (*After Folsom and Dimmock.*)

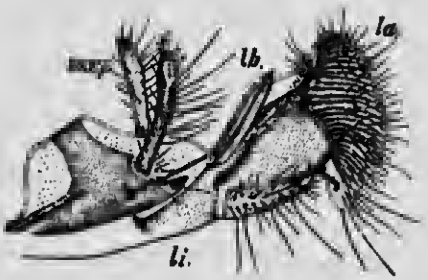

FIG. 12.—Mouth-parts of the house-fly (*Musca domestica*). *lb.*, Labrum; *mx.p.*, maxillary palpi; *li.*, labium; *la.*, labellum. (*After Kellogg.*)

Mouth-parts of the Butterfly.—The long sucking tube is composed of the two maxillæ joined together, while the other mouth-parts are rudimentary (Fig. 15).

Mandibulate-suctorial Mouth-parts.—Among the Hymenoptera we find a combination of the two types—well-developed biting mandibles and a labium or hypopharynx fitted for sucking or lapping liquid food. In ants and sawflies the mandibles are more in evidence, while the bees and wasps have well-developed sucking apparatus. Ants use their mandibles for various purposes, including the comminution of food, building of nests, transportation of larvæ, slaves, etc., and in attack and defence against their enemies; the hypopharynx is used in lapping liquid food.

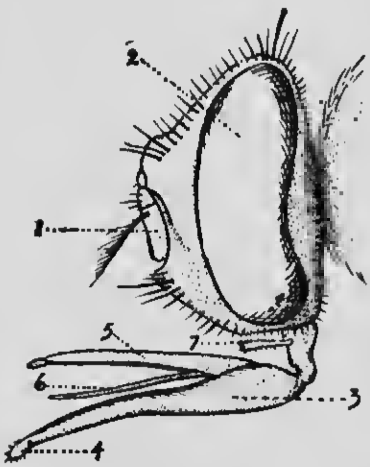

FIG. 13.

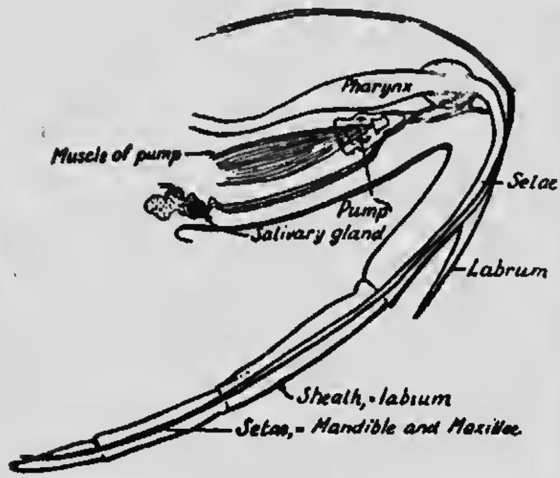

FIG. 14.

FIG. 13.—Side view of the head and mouth-parts of the stable fly (*Stomoxys calcitrans*). Stylets reduced in number and closely ensheathed by the labium. 1, Antenna; 2, compound eye; 3, labium; 4, labella; 5, labrum; 6, hypopharynx; 7, maxillary palpi. (*After Herms.*)

FIG. 14.—Beak of a hemipteron. (*After Riley and Johannsen.*)

Mouth-parts of the Honey Bee.—These consist of the *labrum* and *epipharynx* above with the short trowel-like *mandibles* on each side for moulding wax; the *maxillæ* forming conspicuous lateral wings with the *galea* and *lacinia* fused into one piece, and the *palpi* minute (Fig. 16). The *labium* is the long portion on each side of the tongue and ends in a pair of *palpi*. The middle tongue is the *hypopharynx* ending in a small *labellum*.

Antennæ.—The antennæ or feelers are sensory organs, and are very variable in structure. They carry the organs of *touch*, and probably those of *smell* and *hearing* in some cases. On the surface of some of the segments are fine hairs, connected below with nucleated nerve cells, which are believed to be *tactile* hairs. There are too in some cases pits or oval depressions, also connected with a nerve cell, which are thought to be *gustatory* organs. Other pits situated in patches at the lower end of the segments are believed to be *auditory* organs.

Eyes.—The eyes of insects are of three kinds: *simple, compound* and *agglomerate.* The simple eyes or *ocelli* appear externally as a single convex lens, and are borne by the most primitive insects such as the Collembola, all eyed larvæ, and in the adults of most of the winged insects. In winged forms there are usually three, supplementary to the compound eyes, and borne on the vertex or on the front, arranged generally in a triangle. The agglomerate eye is a compound eye in which the facets are not fused but well separated from each other, *e.g.*, male Coccids.

FIG. 15.—Head of a butterfly (*Vanessa*). *a.*, Antennæ; *l.*, labial palpi; *p.*, proboscis. (*After Folsom.*)

Organs of Hearing.—Several kinds of auditory organs occur in insects and these are variously located. In locusts they are tympanic membranes, located on the base of the abdomen; in the katydids and crickets on the tibiæ of the fore legs. In the mosquitoes and many other groups certain sensitive hairs on the antennæ serve to take up and transmit sound waves.

Organs of Smell.—These organs are variously located—on the antennæ in flesh flies, ants, bees and wasps, some moths and beetles; on the maxillary and labial palpi in *Perla* and *Silpha;* and on the cerci in the cockroach and some Orthoptera.

Organs of Taste.—Taste organs are also variously located—on the hypopharynx in the honey bee, on the epipharynx of most biting insects, and on the maxillary palpi in wasps.

All sense organs consist essentially of the following parts: (1) a nerve of the central nervous system communicating with (2) one or two modified hypodermal cells, and (3) external supporting or accessory structures such as *setæ, tubercles* or *pits.*

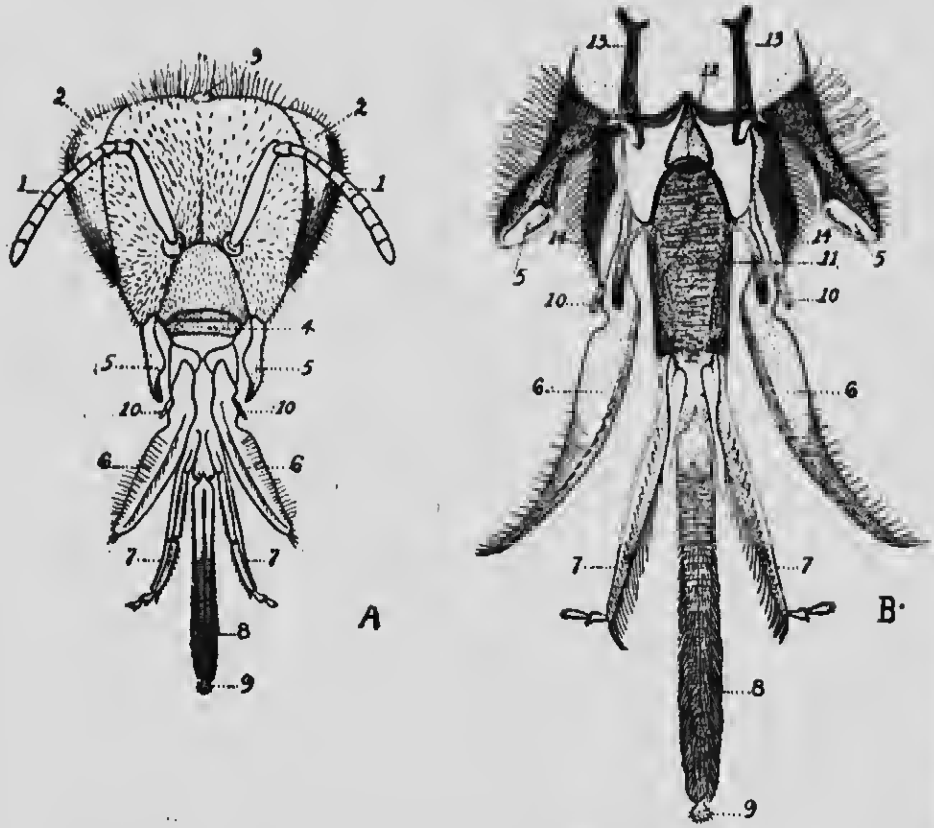

FIG. 16.—Head and mouth-parts of the honey bee (*Apis mellifera*). Both types of mouth-parts well developed but the mandibles are used chiefly for portage and modeling (Hymenopteron type). *A*, Front view of the head showing: 1, antennæ; 2, compound eyes; 3, simple eye; 4, labrum; 5, mandibles; 6, maxillæ (lacinia); 7, labium (palpi only); 8, hypopharynx(?); *B*, mouth-parts removed to show the parts; 5, mandibles; 6, maxillæ (lacinia); 7, labium (palpi only); 8, hypopharynx (?); 9, bouton; 10, maxillary palpus; 11, mentum; 12, submentum; 13, cardo; 14, stipes. (*After Herms.*)

FIG. 17.—Section through the thorax of an insect. *L.*, Leg; *P.*, pleuron; *S.*, sternum; *T.*, tergum; *W.*, wing.

Special Organs of Sense.—The *halteres* of Diptera contain sensory organs, but their function has not yet been definitely ascertained.

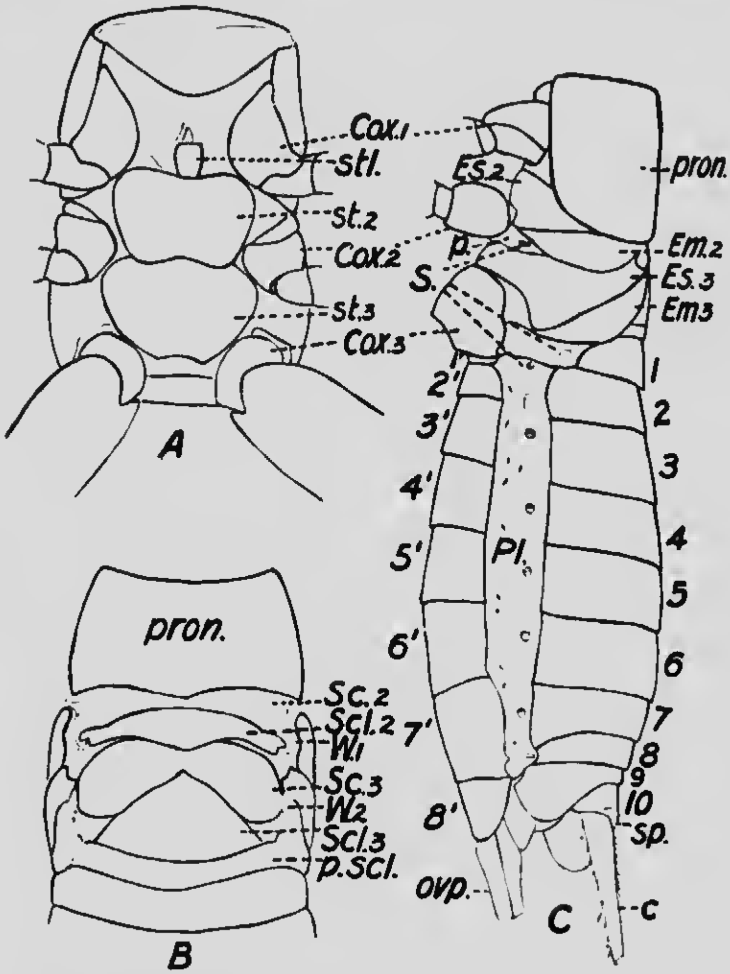

FIG. 18.—*Gryllus pennsylvanicus*. *A*, Ventral view of thorax; *B*, dorsal view of thorax, distal portion of pronotum removed; *C*, lateral view of thorax and abdomen. *Cox.*, *Cox.2*, *Cox.3*, First, second and third coxæ; *Stl.*, prosternellum; *St.2*, *St.3*, meso- and meta-sternum; *Pron.*, pronotum; *Es.2*, *Es.3*, meso- and meta-episternum; *Em.2*, *Em.3*, meso- and meta-epimeron; 1, 2, 3, etc., abdominal tergites; 1′, 2′, 3′, etc., abdominal sternites; *p.*, peritreme; *S.*, spiracle; *sp.*, supra anal plate; *C.*, cercus; *Ovp.*, ovipositor; *pl.*, pleuron; *Sc.2*, *Sc.3*, meso- and meta-scutum; *Scl.2*, *Scl.3*, meso- and meta-scutellum; *p.scl.*, postscutellum; *W.*, *W.2*, wing bases.

When deprived of halteres flies cannot maintain their equilibrium in the air.

(*b*) **Thorax.**—The thorax is composed of three segments—the *pro-*, *meso-*, and *metathorax*, each having a pair of legs. The mesothorax and metathorax bear wings. Each segment is divided into a dorsal part, the *notum* or *tergum*, a ventral part, the *sternum*, and two laterals, the *pleura* (Fig. 17). Each part is again divided by sutures into sclerites—the notum into *præscutum*, *scutum*, *scutellum* and *post-scutellum*, and the pleuron into *episternum* and *epimeron* (Fig. 18).

In most hymenopterous insects the first abdominal segment—the *propodeum* or median segment—is fused with the thoracic mass, so that the petiole of such insects is not the first but the second abdominal segment.

FIG. 19.—Leg of a beetle (*Calosoma calidum*). *c.*, Coxa; *cl.*, claws; *f.*, femur; *s.*, spur; *t.*¹–*t.*⁵, tarsal segments; *tb.*, tibia; *tr.*, trochanter. (*After Folsom.*)

Legs.—Each leg is composed of the following parts: *coxa*, *trochanter*, *femur*, *tibia*, and *tarsus* (Fig. 19). The trochanter in certain Hymenoptera is made of two segments, while the tarsus in most insects is composed of several segments, the last bearing a pair of *claws*. In some insects, *e.g.*, the Diptera, three appendages are borne between the claws, in which case the outer pair are termed *pulvilli* and the middle one the *empodium*.

Wings.—The two pairs of wings are attached to the meso- and the metathorax. They are membranous expansions of the body wall with hollow thickenings along certain lines called *veins* or *nerves*. These veins often branch and interlace, and the spaces between the veins are called *cells*. Much importance is attached in classification to the wing and its veins on account of the great variation not only in the orders and families but even in the genera of a family.

Structurally the wings of insects may be grouped into three divisions:

1. Where the fore and hind wings are of similar texture and more or less fan-like. Under this division fall the *Dragon flies*, in which both the size and form of the wings are very much alike. *Butterflies*, *wasps*, and *bees* have their hind wings smaller than the fore wings, while some of the

May flies and the males of scale insects have their hind wings very much reduced or entirely wanting. In the *flies* (*Diptera*) the hind wings are converted into *halteres* (balancers).

2. Where the fore wings are either wholly or partially chitinized. Examples of such thickening of the wings occur among the grasshoppers and crickets, the beetles and the heteropterous bugs.

3. Where the hind and fore wings are strongly reduced or completely atrophied, as in the fleas (*Siphonaptera*), bird-lice (*Mallophaga*) and sucking lice (*Siphunculata*).

Venation.—It has been found that the system of veins in the different orders of insects is fundamentally alike, being derived from the primitive type fairly well seen in some stoneflies and some cockroaches. This fact becomes evident only when a comparison is made of the wings of the more generalized members of the different orders, as specialization has greatly modified their structure in most genera. Comstock and Needham have shown by a study of the developing wings of nymphs and pupæ that the principal longitudinal veins in the more generalized orders are formed about tracheæ (Fig. 20). In the development of the wing these tracheæ grow out into the wing-bud, and later the veins are formed about them. The cross veins, however, as a rule do not arise in this manner, as tracheæ are apparently absent. In the course of development specialization has brought about changes in the venation, recognized, first, by the *addition of veins* through branching of the prin-

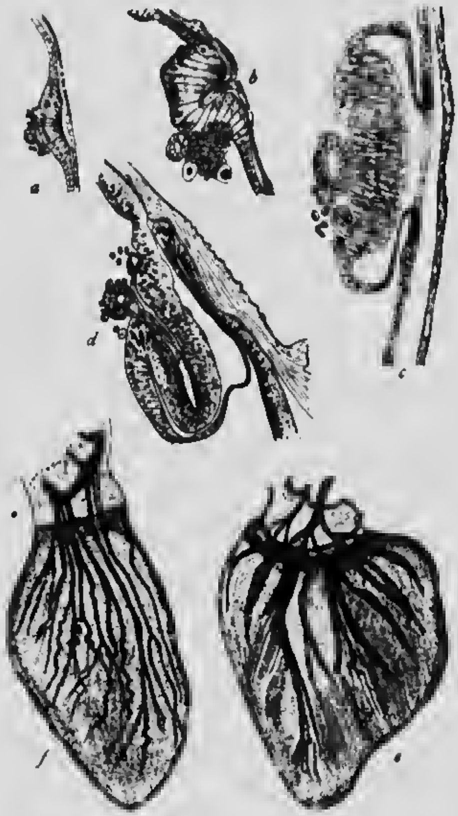

FIG. 20.—Several stages in the development of the wings of a cabbage butterfly. (*After Mercer.*)

cipal veins as in many Neuropteroids and Orthopteroids; second, by the *addition of cross veins;* and third, by the *reduction of the number of veins*

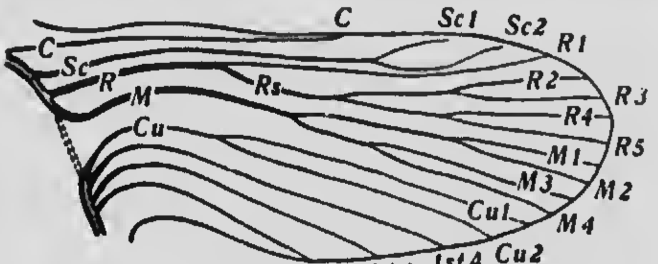

FIG. 21.—The hypothetical primitive type of wing venation. (*After Comstock and Needham.*)

through coalescence of adjacent veins, or by the disappearance of veins, as in most moths, flies and hymenopters. The chief longitudinal veins are the *costa* (C), an unbranched vein on or near the front margin; the *subcosta* (Sc); the *radius* (R); the *media* (M); the *cubitus* (Cu); and the *anal* veins (A), typically three but often reduced to one or two.

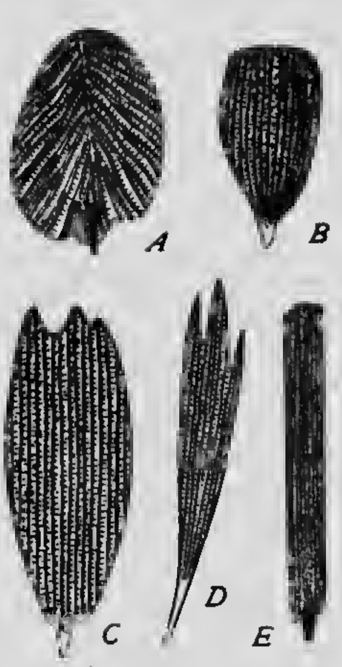

FIG. 22.—Various forms of scales. *A*, *E*. Thysanuran (*Machilis*); *B*. beetle (*Anthrenus*); *C*. butterfly (*Pieris*); *D*. moth (*Limacodes*).

A knowledge of the different types of venation is very important in classification. The Comstock-Needham system of terminology is adopted in this Classbook, and students should consult the recent work of Professor Comstock—*The Wings of Insects*—for a full discussion of the general characteristics of the wings of the several orders of insects.

Clothing of the Wings.—While the wings of many insects are naked, many are covered with fine setæ, hairs, or scales. The coating of scales is the most distinctive feature of the wings of the Lepidoptera. These scales are modified setæ, being evaginations of greatly enlarged hypodermal cells. They are provided with ridges, these serving to increase their rigidity and their protective value (Fig. 22). In addition, the beautiful colors are due to the scales, and are produced (1) by the pigments present, (2) by the reflection, refraction or diffraction of light, or (3) by a combination of these causes. Scent glands, called *androconia*, are associated with the scales, mainly on the wings of males.

(*c*) **Abdomen.**—The abdominal segments show a greater uniformity in form than do the thoracic segments, owing to the fact that the former are not specialized for the bearing of legs and wings. This uniformity is not merely external but extends to some of the internal organs, notably the muscular, respiratory and nervous systems. A greater differentiation and consequent difference from the other segments is usually found in the terminal segments which are modified to bear the genitalia and cerci, in the first segment in the Hymenoptera which has united closely with the thoracic mass, and in the petiole of the same insects which is greatly reduced in diameter and often nodulated (ants).

Typically the abdomen consists of ten segments, but in some Orthoptera eleven have been found and twelve in a few embryos. In the adult insect it is often difficult to distinguish ten abdominal segments owing to the fusion or disappearance of certain of the segments, to the modification which the terminal segments undergo, or to the telescoping of these last within the other segments. Each segment is made up of a dorsal sclerite, the *tergum*, a ventral *sclerite*, the *sternum*, and a pair of pleural membranes connecting the two. The first seven or eight abdominal segments usually bear a pair of spiracles each. Typically the *anus* opens in the tenth or last segment and the reproductive system between the eighth and ninth.

Appendages of the Abdomen.—In the embryo the abdominal segments bear paired appendages which are homodynamous with the legs and mouth-parts. These usually for the most part disappear on hatching, but they persist as prolegs during the larval life of the Lepidoptera, Tenthredinidæ and Mecoptera; in certain Thysanurans they persist as rudimentary abdominal appendages throughout the life of the insect.

The *cerci* which are present in most of the more generalized orders and in the thysanuriform larvæ are usually the appendages of the tenth abdominal segment.

The *gonapophyses* or plates of the genitalia are the appendages of the seventh, eighth and ninth segments and are known respectively as the ventral, inner and dorsal plates. The inner pair usually forms the ovipositor or the intromittent organ, and the outer pairs may form a sheath or claspers.

The Genitalia.—A knowledge of the genitalia is of importance to the taxonomist because in certain families the separation of species is based largely on these structures. It is also of importance to the economic entomologist because it enables him to understand the method of egg deposition in injurious and beneficial insects and the poisonous action in certain forms in which the ovipositor has been modified to form a sting.

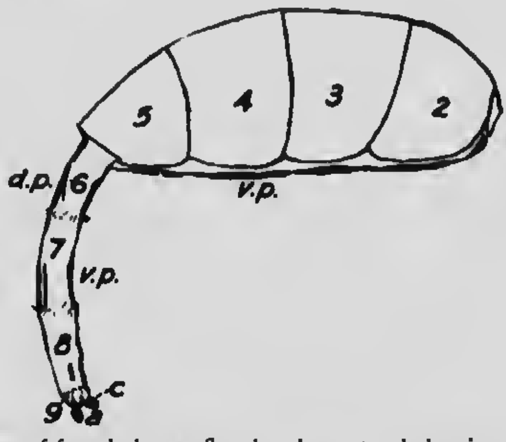

FIG. 23.—Abdomen of female house-fly, showing extended ovipositor. *a.*, Anus; *c.*, cercus; *d.p.*, dorsal plates; *v.p.*, ventral plate.

There is no true ovipositor in the Neuropteroida, Coleoptera, Lepidoptera or Diptera, the vagina opening directly to the exterior (Fig. 23). In some of these insects, however, a whip-like or tubular *pseudo-ovipositor* is formed by the last few segments of the abdomen (*e.g.*, *Cerambyx*, *Cecidomyia*, *Musca*).

A true ovipositor is developed in the Thysanura, Orthopteroida, Hemiptera and Hymenoptera (Fig. 24). In the Orthoptera the gonapophyses are used for making holes in the ground or slits in stems for the reception of the eggs. In the Hymenoptera there are various peculiar modifications of the ovipositor: *Megarhyssa*, one of the larger ichneumon flies, uses its long ovipositor as a drill, forcing it, in spite of its extreme slenderness, up to the hilt in the trunk of hardwood trees in order to deposit its eggs in the burrows of the horn-tail borer

(*Tremex columba*); the saw flies have the inner plates united to form the egg channel, the upper plates form a sheath, while the lower have serrate edges and are wielded like a saw, making slits in leaf or stem for the deposition of the eggs. In the stinging hymenoptera the ovipositor is modified to form a sting; the upper valves of the honey bee are soft, forming a pair of palpi, the inner lobes form a sheath, and the ventral lobes are represented by a pair of barbed darts. The poison is of two kinds, one alkaline the other acid, and is secreted by glands within the abdomen.

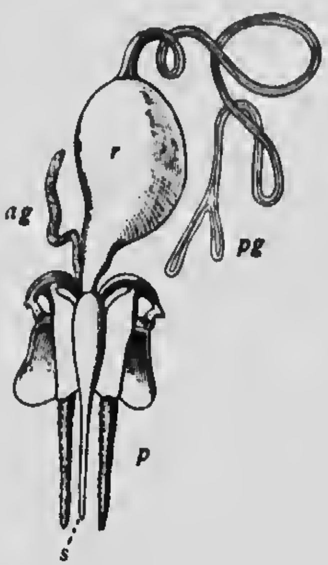

FIG. 24.—Sting and poison apparatus of honey bee. *ag.*, Accessory gland; *p.*, palpus; *pg.*, poison gland; *r.*, reservoir; *s.*, sting. (*After Kraepelin.*)

INTERNAL ANATOMY

The internal anatomy of an insect may be discussed under the following heads: (*a*) muscular system; (*b*) respiratory system; (*c*) circulatory system; (*d*) intestinal or digestive system; (*e*) nervous system; (*f*) reproductive system (Fig. 25).

(*a*) *Muscular System.*—The muscular system of insects is well developed. The muscles are attached to the inner surfaces of the exoskeleton.

In the abdomen the arrangement of the muscles is the same in each segment, except at the extremity where special muscles exist for moving the ovipositor, the cerci or other terminal organs. In the sternum of each abdominal segment there are one or two sets of longitudinal muscles on each side of the nerve chain. These are the *longitudinal sternals* or *ventral recti* (Fig. 26). In the tergum also similar sets of muscles occur on each side of the dorsal vessel; these are the *longitudinal tergals* or *dorsal recti*. Between these longitudinal muscles and the integument are numerous *oblique* and *transverse* muscles, and these, with the longitudinal muscles, bring about the various turning, wriggling or telescoping movements of the abdomen. In each abdominal segment there are also two muscles which pass from the tergum to the sternum. These are the *tergo-sternals* which bring about the contraction and expansion of the abdomen necessary for respiration.

In the thorax of larval insects and of the wingless forms the arrangement of muscles follows the same general plan as in the abdomen, but the presence of the leg muscles makes it more complicated (Fig. 27). In the winged insects, however, this primitive arrangement cannot be readily recognized owing to the presence of large wing muscles and also to the fact that the thoracic segments are very often fused together. The muscles which move the head originate in the prothorax and are inserted into the base of the head. Within the head are muscles

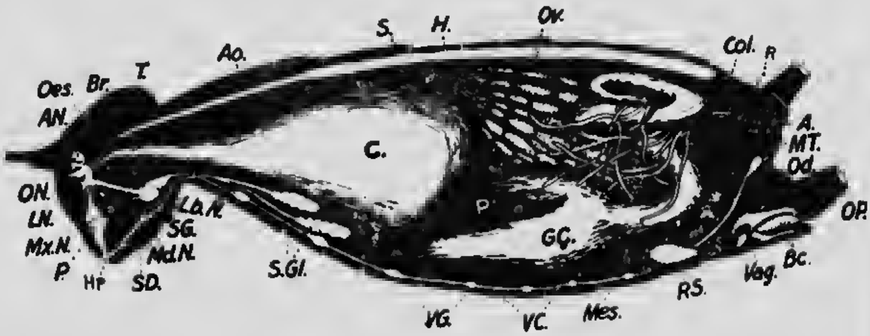

FIG. 25.—Internal organs of the cricket (*Gryllus pennsylvanicus*). *AN.*, Antennal nerve; *Oes.*, œsophagus; *Br.*, brain; *T.*, teutorium; *Ao.*, aorta; *S.*, suspensorium of ovary; *H.*, heart; *Ov.*, right ovary; *Col.*, colon; *R.*, rectum; *A.*, anus; *MT.*, Malpighian tubules; *Od.*, oviduct; *Op.*, ovipositor; *BC.*, bursa copulatrix (copulatory pouch); *Vag.*, vagina; *RS.*, receptaculum seminalis; *Mes.*, mesenteron; *VC.*, connectives of ventral nerve chain; *VG.*, ganglia of ventral nerve chain; *S.Gl.*, salivary glands; *Lb.N.*, labial nerve; *SG.*, subœsophageal ganglion; *Md.N.*, mandibular nerve; *SD.*, salivary duct; *HP.*, hypopharynx; *P.*, pharynx; *Mx.N.*, maxillary nerve; *LN.*, labial nerve; *ON.*, optic nerve; *C.*, crop; *P.*, proventriculus; *GC.*, gastric cæca.

for the control of the mouth-parts and antennæ. In the mandibulate insects the muscles which move the mandibles occupy the greater part of the head cavity.

Mention should also be made of the *alary* muscles of the heart, the *circular* and *longitudinal* muscles of the digestive canal, and the *spiracular* muscles which bring about the closure of the spiracles during respiration.

A muscle consists of a bundle of long fibres, each with several nuclei and a sheath, the *sarcolemma*. In most cases the fibres present a striated appearance due to the presence of alternate light and dark bands.

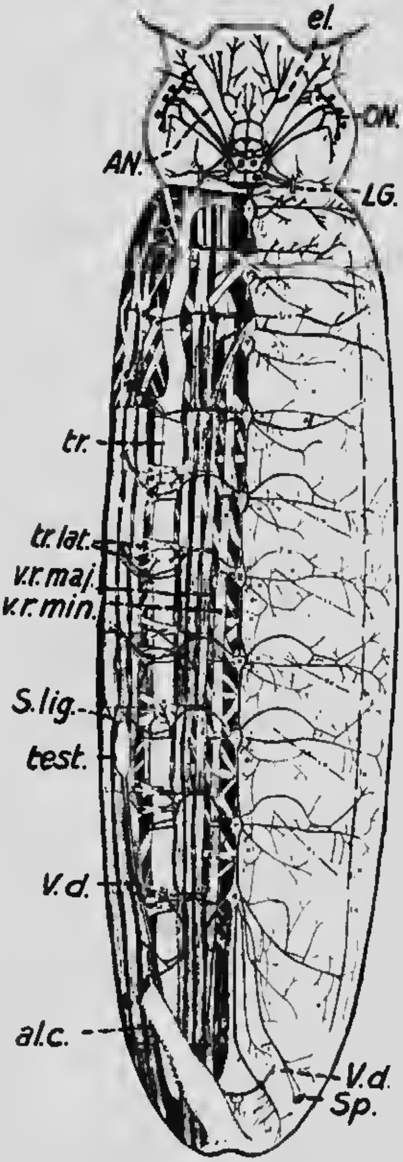

FIG. 26.—Ventral surface of larva of *Sphida obliqua*, showing arrangement of parts. *AN.*, Antennal nerve; *CL.*, clypeo-labral nerve; *Al.c.*, alimentary canal; *LG.*, lateral ganglion; *tr.*, tracheal trunk; *tr.lat.*, tergo-sternal muscles; *v.r.maj.*, *v.r.min.*, ventral longitudinal muscles; *S.lig.*, suspensorium of testes; *Test.*, testis; *V.d.*, vas deferens; *Sp.*, spiracle; *T.*, thoracic ganglia; *I, II, III*, etc. abdominal ganglia; *o.l.*, opening into leg; *tr.r.*, transverse nerve; *BB.*, brain.

(*b*) *Respiratory System.*—The exchange of gases in respiration is effected by means of a system of small tubes called *tracheæ* which extend inward from the surface and branch to all parts of the body. The external openings, called *spiracles*, are situated on the sides of the thoracic and abdominal segments (Fig. 28). From each spiracle a short tube runs inward and connects with the trunk tube running along the side of the body. There are thus two main or trunk tracheal tubes, one on each side of the body. Each gives off three large branches to each segment, the upper, the middle, and the lower. Each of these

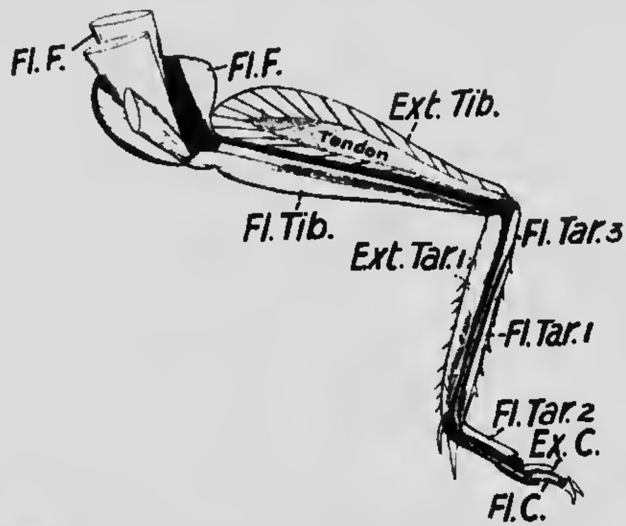

FIG. 27.—Muscles of hind leg of *Gryllus pennsylvanicus*. *Ext.F.*, Extensor of femur; *Ext.Tib.*, extensor of tibia; *Ext.Tar.1*, extensor of first tarsal joint; *Ext.Tar.2*, extensor of second tarsal joint; *Ext.Tar.3*, extensor of third tarsal joint; *Fl.Tar.1*, flexor of first tarsal joint; *Fl.Tar.2*, flexor of third tarsal joint; *Fl.C.*, flexor of claws; *Ext.C.*, extensor of claws; *Fl.F.*, flexor of femur; *Fl.Tib.*, flexor of tibia.

branches subdivides frequently so that every portion of the segment is entered. Moreover, these fine tubes anastomose to form a delicate network, and allow a continuous circulation of air to take place.

In many insects, in addition, are large sac-like dilatations of the tracheæ which serve as air reservoirs.

Tracheæ have a striated appearance due to the thickening of the chitinous wall into a compact elastic spiral, thus preventing the collapse of the tubes. Special respiratory devices are seen in aquatic insects. Nymphs of May-flies and Damsel-flies have *lamellate tracheal-gills*, nymphs of Stone-flies and Caddice-flies have *filiform or cylindric tracheal-gills*, larvæ of *Culex, Corethra, Simulium* and *Chironomus* have *blood-gills*, while nymphs of Dragon Flies have *internal tracheal-gills*. Tracheal gills are outgrowths of the body wall with fine tracheal tubes, in which there occurs during respiration an exchange of gases between the air in the tubes and the water. They are usually external but in the nymphs of Dragon Flies they are internal, being arranged in rows on the inner walls of a gill chamber in the posterior portion of the alimentary canal.

Blood-gills are outgrowths of the body wall in which the blood flows. The exchange of gases in respiration occurs between the blood inside and the water outside.

Structurally a trachea consists of a chitinous wall or *intima* as a lining memhrane spirally thickened at regular intervals hy elastic threads called *tænidia*, and a cellular wall of hypodermal cells, the *pavement epithelium*.

(*c*) *Circulatory System.*—While there is a blood circulation in insects the only blood vessel is a dorsal tube lying just beneath the notum. The *heart* or posterior portion of the dorsal tube contains a number of ventricles or chambers, each with a lateral valve which allows the blood to flow in but not out. There

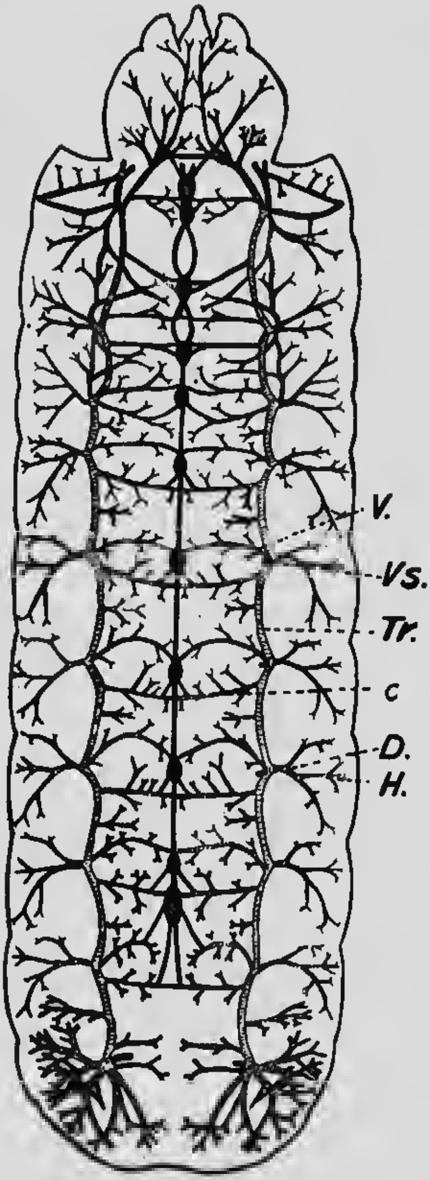

FIG. 28.—Respiratory system of the larva of the budmoth (*Tmetocera ocellana*). (Insect opened along the median dorsal line.) *C.*, tracheal commissure; *D.*, dorsal branch; *H.*, supplying heart; *V.*, ventral branch; *Vs.*, visceral branch.

are also valves between the chambers so that when the latter contract the blood is forced forward. The blood on leaving the ventricles passes into the *aortic* portion of the dorsal tube, toward the head, and thence flows into the body cavity bathing all the organs. The blood is usually colorless and consists of two portions—the watery serum and the white blood corpuscles.

Fat-bodies.—These are masses of fat-cells occupying a large part of the cavity of the body, and lying between the organs. At first the fat-cells are large and spherical, but they lose their structure to a large extent through breaking down. They contain nourishing albuminoid matter, besides uric acid and urates. Their exact function is not

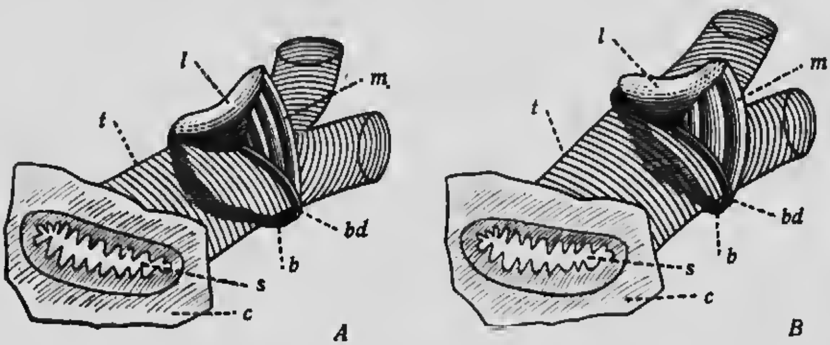

FIG. 28*a*.—Apparatus for closing the spiracular tracheæ in a beetle (*Lucanus*). *A*, Trachea opened; *B*, closed; *b*., bow; *bd*., band; *c*., external cuticula; *l*., lever; *m*., muscle; *s*., spiracle; *t*., trachea. (*After Judeich and Nitsche.*)

definitely known. Associated with the fat-bodies in the abdomen of larvæ are large yellow cells called *œnocytes* which, according to Gläser, secrete an oxidizing enzyme.

(*d*) *Intestinal or Digestive System.*—This system occupies the central portion of the body, and is divided into distinct regions with special functions (Fig. 29). The food passes from the mouth into the *pharynx* where it is subjected to the action of saliva secreted by the *salivary glands*. Thence it passes in the Orthoptera and Coleoptera through the œsophagus into the *crop*, a folded and membranous pouch, where the action of the saliva is completed. The partially digested food then passes into the *gizzard* or *proventriculus*, a muscular enlargement armed with teeth for the purpose of straining the contents before entering the true *stomach* or *ventriculus*. In many caterpillars the food passes

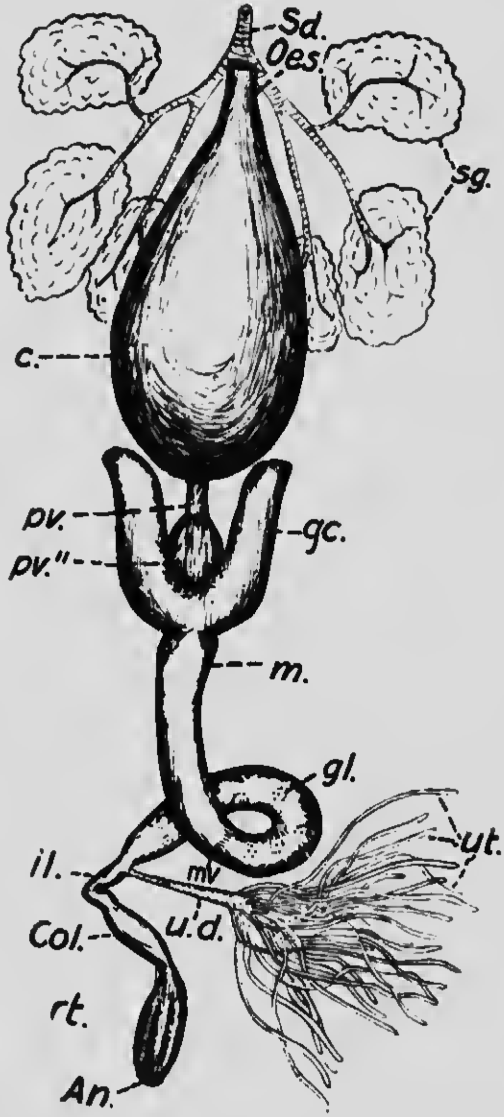

FIG. 29.—Digestive canal of *Gryllus pennsylvanicus*. *sd.*, Salivary duct; *Oes.*, œsophagus; *Sg.*, salivary gland; *C.*, crop; *pv.*, *pv.''*, proventriculus; *gc.*, gastric cæca; *m.*, mesenteron; *Mv.*, valve between two divisions of the mesenteron; *gl.*, digestive glands; *il.*, ilium; *u.d.*, duct of malpighian tubules; *ut.*, malpighian tubules; *Col.*, colon; *rt.*, rectum; *An.*, anus.

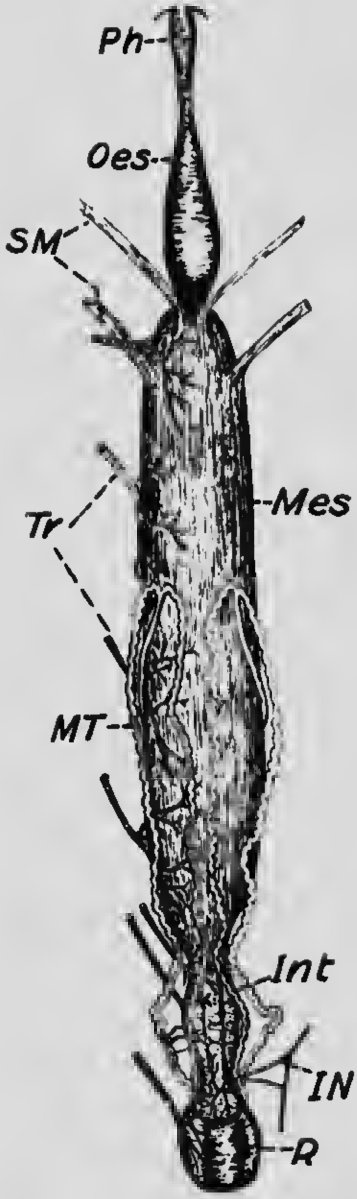

FIG. 30.—Dorsal view of alimentary canal of the larva of the budmoth (*Tmetocera ocellana*). *Ph.*, Pharynx; *Oes.*, œsophagus; *SM.*, suspensory muscles; *Tr.*, visceral tracheæ of left side; *MT.*, Malpighian tubules; *Mes.*, mesenteron; *Int.*, small intestine; *In.*, intestinal nerve; *R.*, rectum.

directly into the stomach which is long. Further digestion occurs here through the action of secretions of the *cœcal tubes*, often called the *gastric cœca*, which consist of glandular pouches emptying into the anterior end of the stomach. Most of the digested food is here absorbed and passes into the circulation. Posterior to the stomach is the *intestine* which consists of three parts—*ileum*, *colon*, and *rectum*. Into the ileum open the *Malpighian tubes* which are excretory in function, similar to the kidneys of higher animals. The undigested portions of food are expelled through the *rectum* and *anus*.

Some variations may be noted. The œsophagus is long in those insects that suck their food, and short in herbivorous forms. In sucking insects the gizzard may be absent, and the crop is often a side pocket of the œsophagus (Fig. 30).

Structurally, the wall of the alimentary canal consists of:

1. An *epithelial layer* of cells which secrete the *intima* or lining layer.
2. The delicate *basement membrane*.
3. *Circular muscles*.
4. *Longitudinal muscles*, which aid in constricting and enlarging the canal (Fig. 31).

From an embryological point of view the alimentary tract consists of three primary regions:

1. The *Stomodæum*, embracing the fore part as far as the stomach.
2. The *Mesenteron*, or mid-intestine embracing the stomach, and

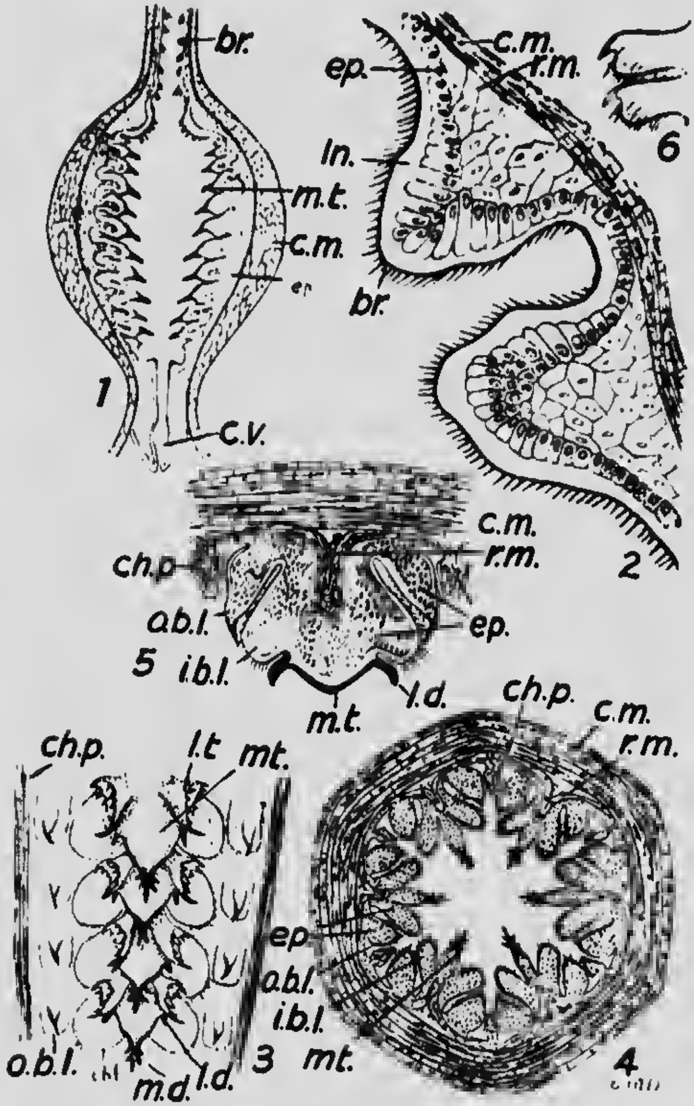

FIG. 31.—Sections through the proventriculus of *Gryllus pennsylvanicus.* (All greatly enlarged.) 1. Longitudinal section through the median denticles. 2. Transverse section passing through two folds of the anterior division of the proventriculus. 3. Surface view of a portion of one of the dental folds showing the chitinous partition and four of the transverse rows of teeth. 4. Transverse section of proventriculus passing through the median denticles. 5. Transverse section of fold cut in the region of the lateral denticles. 6. Lateral view of two adjacent inner barbated lobes. *br.*, Bristles of anterior division of proventriculus; *ch.p.*, chitinous partition between dental folds; *c.m.*, circular compressing muscles; *c.v.*, cardiac valve; *ep.*, epithelium; *i.bl.*, inner barbated lobes; *in.*, intima; *l.d.*, lateral denticle; *l.t.*, lateral tooth; *m.d.*, median denticles; *m.t.*, median tooth; *o.b.l.*, outer barbated lobes; *r.m.*, relaxing muscle.

3. The *Proctodæum*, embracing the portion posterior to the stomach. The stomodœum and proctodœum are ectodermal in origin while the mesenteron is probably entodermal.

(*e*) *Nervous System.*—The nervous system of insects consists essentially of a series of ganglia joined by a double nerve-cord lying along the ventral surface of the body. Each primitive segment had a double ganglion, but in most insects fusion of ganglia occurs in the head, the thorax, the anterior and the posterior portions of the abdomen. Great variations occur even in the same order. The largest ganglion is in the head, and is the result of the fusion of three pairs. It forms the *brain* or *supra-œsophageal ganglion*, lying above the œsophagus. There is also another large ganglion, the *sub-œsophageal*, lying below the œsophagus, and connected with the brain by a double nerve-cord about the œsophagus, the *œsophageal nerve collar* or *commissure*. It also represents the fusion of three pairs of ganglia.

From the brain nerves are given off to the antennæ, eyes, and labrum. The sub-œsophageal ganglion controls the mouth-parts. From the ganglia in the thorax and abdomen nerves supply the various segments and control their movements and activities (Fig. 26).

In addition there is the *Sympathetic nerve system* which mainly lies along the dorsal line of the alimentary canal. It consists of a *recurrent* nerve arising from a *frontal* ganglion and ending in a *stomachic* ganglion. Two pairs of *lateral* ganglia are connected with the recurrent nerve and supply nerves to the dorsal vessel and the tracheæ of the head. A ventral system lies in the main nerve cord and activates the spiracles.

Nerve-cord and Ganglia.—The nerve-cord consists of an axis-cylinder of fibrillæ and a sheath. It is concerned with the transmission of impulses and stimuli. The ganglion is a centre for the regulation of nutrition. It consists of a dense *cortical* layer of ganglionic cells with large nuclei, a clear medulla from which nerve fibrillæ originate, and a *nerve sheath.*

(*f*) *Reproductive System.*—In all insects the sexes are distinct. The sexual organs are situated in the abdomen and consist in the female of a pair of *ovaries* and a pair of *oviducts* opening into the *vagina* and frequently externally by an *ovipositor*, and in the male of a pair of *testes* and a pair of seminal ducts (*vasa deferentia*) opening into the *ejaculatory duct* and externally by an intromittent organ. The external opening lies between the eighth and ninth segments of the abdomen—never in the last. In most insects there is in the female a *seminal receptacle*, a dorsal pouch of the vagina, and in the male a *seminal vesicle*, a dilated portion of the vas deferens. The *ova* are formed in the ovarian tubes in different stages of growth, the largest and oldest being nearest the *oviduct*. The *spermatozoa* arise in the

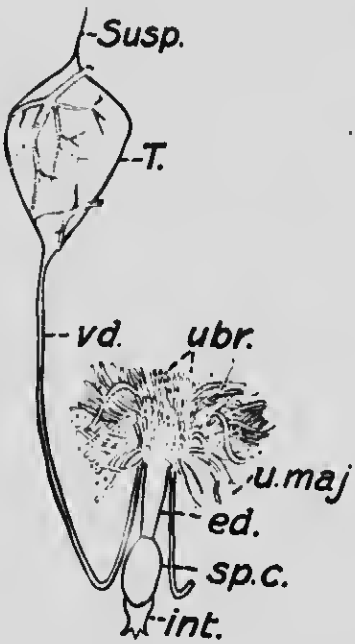

FIG. 32.

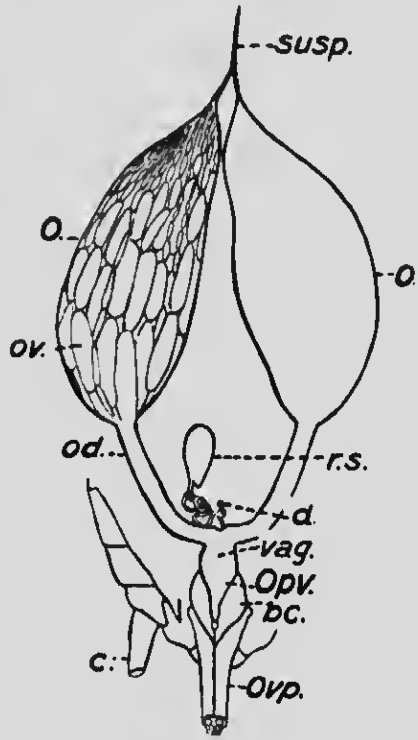

FIG. 33.

FIG. 32.—Male reproductive organs of *Gryllus pennsylvanicus*. *T.*, Testis; *Susp.*, suspensorium of testis; *vd.*, vas deferens; *ubr.*, *u.maj.*, accessory glands on surface of seminal vesicle; *ed.*, ejaculatory duct; *sp.c.*, spermatophore cup; *int.*, intromittent organ or penis.

FIG. 33.—Female reproductive organs of *Gryllus pennsylvanicus*. *Susp.*, Suspensorium of ovaries; *O.*, ovaries; *ov.*, ovarian eggs; *od.*, oviduct; *C.*, cercus; *r.s.*, seminal receptacle; *d.*, duct of seminal receptacle; *vag.*, vagina; *bc.*, copulatory pouch; *Ovp.*, ovipositor.

follicles of the testes. There are also usually *accessory glands* which secrete mucus that envelopes the spermatozoa and ova (Figs. 32 and 33).

Parthenogenesis, or reproduction without fertilization, occurs in many insects—in aphids, *Cynips*, *Lasius* (Ant), and some Coccids.

Several generations of females only which bring forth living young may occur, but at intervals males appear and fertilized eggs are laid.

In some species of the Cecidomyiidæ the young are produced by larvæ. Such a method is called *pædogenesis*. After several generations, however, the last larvæ pupate and form normal male and female flies. Examples are *Tanytarsus dissimilis* and *Miastor americana* (Fig. 33*a*).

Another method of asexual reproduction, called *polyembryony* occurs in certain parasitic insects, *e.g.*, *Polygnotus*, belonging to the Hymenoptera. Each egg produces many embryos, instead of one, which develop into as many adult insects of the same sex.

FIG. 33.—Young pædogenetic larvæ of *Miastor* in the body of the mother larva. Greatly enlarged. (*After Pagenstecher from Folsom.*)

THE DEVELOPMENT OF INSECTS

All insects that reach maturity pass through two distinct stages of development—the embryonic changes within the egg, and the changes after leaving the egg until the adult condition is reached. The growth of the embryo within the egg progresses from the segmentation of the ovum to the formation of the *blastoderm* with its ventral plate and germinal groove, and the gradual growth of the *ectoderm*, *mesoderm* and *entoderm*, from which layers the various organs of the body arise.

(*a*) **Embryology.**—The egg or ovum is a single cell containing—(1) The nucleus or germinal vesicle. (2) The yolk, or nutritive material. (3) The cytoplasm. (4) The cell wall or vitelline membrane. (5) The egg shell or chorion. (6) The micropyle or opening in the chorion to admit the spermatoza (Fig. 34).

When the sperm nucleus unites with the nucleus of the egg, and forms a *segmentation nucleus*, fertilization is accomplished.

By division of the segmentation nucleus a large number of nuclei are formed many migrating outward toward the margin of the egg. There a layer of cells internal to the yolk membrane called the blastoderm is finally produced. This stage of the embryo is known as the *blastula*.

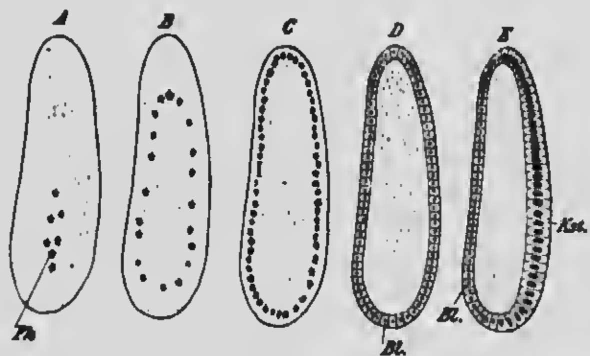

FIG. 34.—Formation of the blastoderm and the germ band. *Fk.*, Cleavage nuclei; *Bl.*, blastoderm; *Kst.*, germ band. (*After Escherich.*)

The blastoderm thickens by cell division in one region forming the *primitive streak* or *germ band* which presents in surface view an oval or elongated area along the ventral face of the egg. Soon a groove

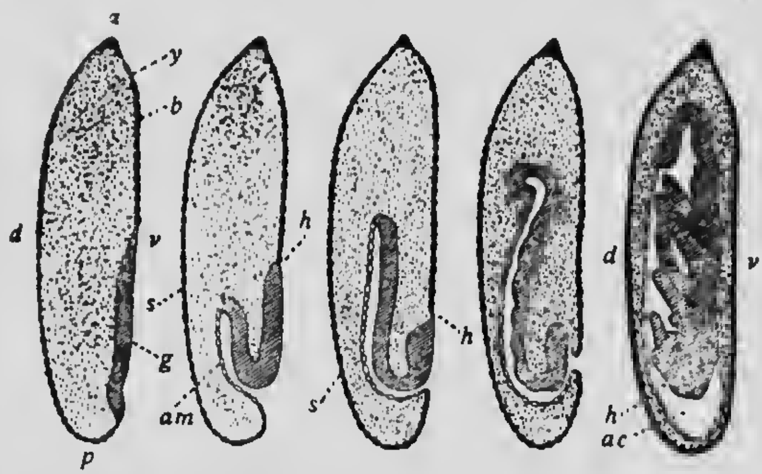

FIG. 35.—Diagrammatic sagittal sections to illustrate invagination of germ band in *Calopteryx*. *a.*, Anterior pole; *ac*, amnion cavity; *am.*, amnion; *b.*, blastoderm; *d.*, dorsal; *g.*, germ band; *h.*, head end of germ band; *p.*, posterior pole; *s.*, serosa; *v.*, ventral; *y.*, yolk. (*Folsom after Brandt.*)

appears in the centre of the germ band due to invagination of the blastoderm. The lips of the groove close over the invaginated portion, producing an outer layer, the *ectoderm* or *ectoblast* and the inner layer, the endoblast (*meso-entoderm*). This stage of the embryo is known as the *gastrula*.

Meanwhile the blastoderm is folding over the germ band from either side, producing an inner membrane—the *amnion*, and an outer membrane—the *serosa* (Fig. 35).

Two types of germ bands may be noted. The *overgrown* type retains its original position (Fig. 36), and the blastoderm folds over the germ band from either side forming the two layers *amnion* and *serosa*. In the *invaginated* type, seen in aphids and Odonata (Fig. 37), the germ band invaginates into the egg so that its ventral surface faces the dorsal surface of the egg. At a later stage the embryo turns and regains its original position.

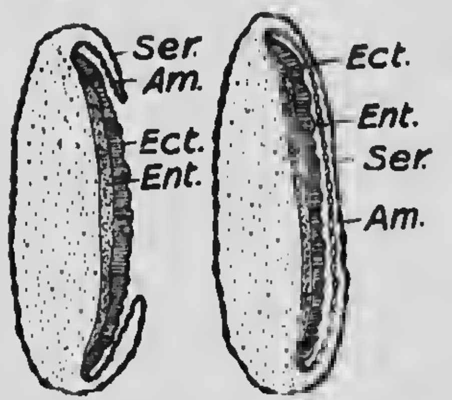

FIG. 36.—Formation of the embryonic membranes—*overgrown type*. *Am.*, amnion; *Ect.*, ectoderm; *Ent.*, entoderm; *Ser.*, serosa. (*After Korschelt and Heider.*)

The germ band shows early signs of segmentation, beginning first at the anterior end. An invagination of the ectoderm near the anterior end forms the *stomodæum* or fore gut, and a similar posterior invagination forms the *proctodæum* or hind gut. The segmentation shows about 21 segments, 6–7 to the head, 3 to the thorax, and 11–12 to the a[illegible] men. On each segment [illegible] the first and last a pair of tiny limbs (buds) are seen.

Soon the germ band widens and closes over the yolk to form the dorsal wall.

Before dorsal closure occurs the beginnings of the nerve-cord form in the median groove. This primitive nerve-cord is double, and a pair of swellings in each segment develop into the ganglia of the ventral system.

The tracheæ arise as invaginations of the ectoderm.

The entoderm arises from the endoblast, the inner embryonic layer, as two cell masses situated at either end of the embryo. These masses grow backward and forward respectively, and unite to form the mid-gut (*mesenteron*).

The rest of the inner layer forms the mesoderm from which arises the blood system, muscles, reproductive organs, fat-body, etc. The division of the mesoderm into two layers produces paired cavities in each segment—the *cœlomic pouches* (Fig. 37).

(*b*) **Metamorphosis.**—The various changes that occur after the hatching of the egg are comprised under the term *metamorphosis.*

After the escape of the embryo from the egg the development may be (1) *holometabolic, i.e.,* with *complete* metamorphosis, the insect passing through two distinct phases, *larva* and *pupa,* before assuming the adult form; (2) *heterometabolic, i.e.,* with *incomplete* metamorphosis, without a distinct pupal stage, the larva being like the adult but without wings or mature reproductive organs; (3) *ametabolic, i.e.,* without metamorphosis, the young being like the adult. Insects belonging to the orders Neuroptera, Mecoptera, Trichoptera, Lepidoptera, Coleoptera, Diptera, Siphonaptera, and Hymenoptera are holometabolic; the Orthoptera, Platyptera, Plecoptera, Odonata, Ephemerida, Thysanoptera, Homoptera and Hemiptera are rometabolic; and the Thysanurans Collembolans are ametabolic. Most insects are oviparous, but some like certain scale insects and Sarcophagidæ are larviparous.

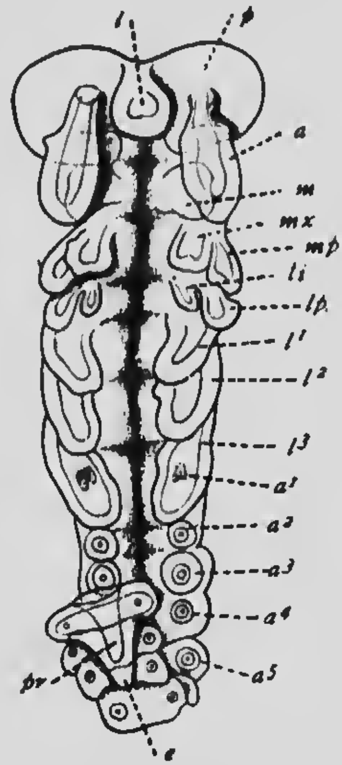

FIG. 37.—Embryo of *Æcanthus,* ventral aspect. *a,* Antenna; *a.*¹–*a.*⁴, abdominal appendages; *e.,* end of abdomen; *l.,* labrum; *li.,* left fundament of labium; *lp.,* labial palpus; *l.*¹–*l.*³, thoracic legs; *m.,* mandible; *mp.,* maxillary palpus; *mx.,* maxilla; *p.,* procephalic lobe; *pr.,* proctodœum. (*From Folsom after Ayers.*)

Larval Stage.—In general two types of larvæ are recognized: the *thysanuriform* and the *eruciform.* The former type is considered quite generalized and primitive in form, and is common among the heterometabola. The body is flattened, the legs and antennæ are long, the caudal cerci are well-developed, and the mouth-parts are mandibulate.

The eruciform type prevails among the holometabola. The body is cylindrical, and the legs, antennæ and cerci are much reduced.

Many transitional forms, however, occur, and it is believed that the eruciform type has been developed from the thysanuriform.

Ecdysis or Moulting.—All larvæ shed their outer skin (cuticula), at intervals to allow for growth. The number of moults varies in different insects, but is constant for the same species under the same conditions.

In the Lepidoptera the larva is known as a *caterpillar*, and is characterized by the possession of three pairs of true legs, and usually

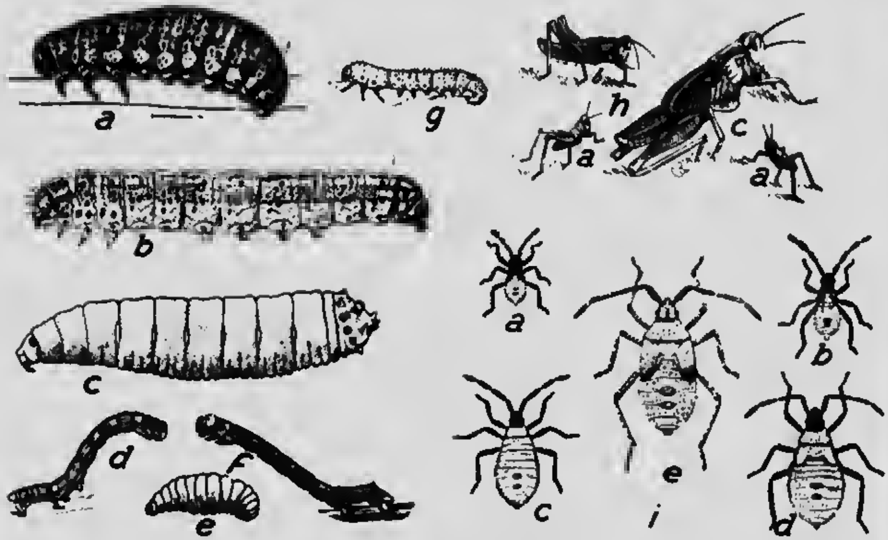

FIG. 38.—Types of larvæ. *a*. Grub of asparagus beetle; *b*. cutworm; *c*. cabbage root maggot; *d*. fall canker worm; *e*. maggot of honey bee; *f*. spring canker worm; *g*. false caterpillar of saw fly; *h*—*a*. *b*. *c*. nymphs of locust; *i*—*a*. *b*. *c*. *d*. *e*. nymphs of squash bug. (*After various authors.*)

five pairs of prolegs on the abdominal segments. In the Diptera and Hymenoptera the larva is a *maggot*, characterized by the absence of legs. In the group of Saw-flies of the Hymenoptera, however, the larvæ are caterpillar-like, possessing three pairs of true legs and often seven or more pairs of prolegs.

In the Coleoptera the larva is termed a *grub*, and has usually but three pairs of legs (Fig. 38).

Classification of Larvæ.—Escherich classifies larvæ as follows:

Primary Larvæ.—Larvæ like the adult, and without provisional larval organs —*Thysanura, Mallophaga, Pediculidæ, Orthoptera, Isoptera, Corrodentia.*

Secondary Larvæ.—Larvæ like the adult, and with a few provisional larval organs—*Ephemerida, Plecoptera, Cicadidæ, Odonata, Coccidæ.*

Tertiary Larvæ.—Larvæ unlike the adult and with numerous provisional larval organs—*Lepidoptera, Diptera, Coleoptera, Hymenoptera,* etc.

Classification of Tertiary Larvæ.

A. Larvæ without prolegs.

B. Larvæ with well-formed sternum.

C. Larvæ more or less strongly chitinized; thorax or at least the prothorax differing from the other segments quite noticeably, large or more strongly chitinized, or otherwise sculptured; head generally with lateral eye points. *Examples:* Rhaphidians Ant-lions, *Carabidæ, Dytiscidæ, Silphidæ, Coccinellidæ, Elateridæ, Chrysomelidæ.*

CC. Larvæ weakly chitinized, soft skinned, and mostly whitish, but with chitinized dark head; thorax differing but little from the other segments. *Examples:* White Grubs, Stag Beetles, Dung Beetles.

BB. Larvæ with poorly developed or rudimentary sternum. *Examples:* Many Cerambycids, *Sirex.*

BBB. Larvæ with sternum wholly atrophied or undeveloped.

C. Larvæ with a head-capsule and typically formed mouth-parts. *Examples:* Bark Beetles, Snout Beetles, Bees, Wasps, Ants, Ichneumons, Midges.

CC. Larvæ without a head-capsule or well-formed mouth-parts. *Examples:* Most Diptera.

AA. Larvæ with prolegs.

B. Larvæ usually with five pairs of prolegs. *Butterflies and Moths.*

BB. Larvæ with more than five pairs of prolegs. *Sawflies.*

Provisional Larval Organs.—Provisional larval organs are those which belong to the larva and not to the imago. According to Escherich such organs represent adaptations for special functions, so that the more numerous these organs are the greater the difference in mode of life and in appearance between the larva and imago. As the imago is older phylogenetically than the larva the larval organs have arisen in a secondary manner.

"Secondary" larvæ possess numerous imaginal characters, so that the form of the imago remains more or less evident. In "tertiary" larval forms the characters of the imago are so repressed by those of the larva that a new form unlike the imago results.

Larval organization distinct from that of the imago may be observed: (1) in the amount of chitinization, the color and the armature of hairs, bristles, spines of the skin; (2) in the number of glands; (3) in the form and segmentation of the body; (4) in the development of feelers and mouth-parts, (5) in the number and development of organs of locomotion and (6) in the alimentary, tracheal and nervous systems. Examples can be readily found to illustrate the differences outlined above.

Pupal Stage.—After a short period of rest the full-grown larva of holometabolic forms changes to a *pupa* within a pupal skin. Usually the outer skin is shed, but sometimes, as in the Diptera, the outer skin becomes a *puparium.* During the pupal stage not only are all the

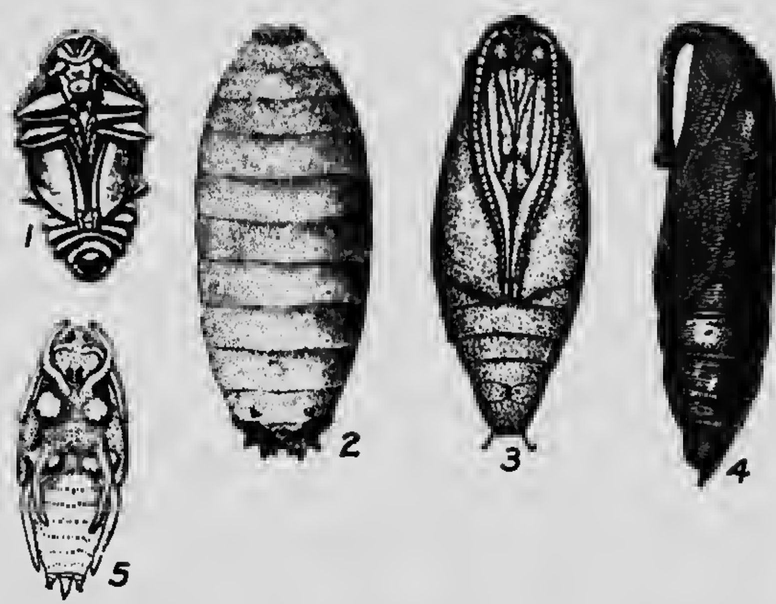

FIG. 39.—Types of pupæ. 1, Asparagus beetle (free); 2, puparium of cabbage root maggot (coarctate); 3, bud moth (obtect); 4, tobacco sphinx (obtect); 5, male of maple scale (free).

external organs of the adult insect formed, but even the internal organs undergo profound changes. The organs break down and reform, and the structures are adapted to the new creature with its new mode of life.

In most insects the pupa is quiescent but it is quite active in the Culicidæ and other families. There is but little difference, except the presence of rudimentary wings, between the larval and pupal stages of the insects belonging to the Hemiptera and the Orthoptera.

Three types of pupæ are recognized (Fig. 39): (1) *obtect,* where the appendages and body are closely united, as in Lepidoptera and some Coleoptera; (2) *free,* where the appendages are free, as in Neuroptera, Trichoptera, Coleoptera, Hymenoptera and Nematoceran Dipera; and (3) *coarctate* in which the entire pupa is surrounded with a hardened skin, and the appendages are not outwardly visible, *e.g.*, higher Diptera (Muscids, etc).

Pupæ are protected in different ways: (1) in puparia, (2) in earthen cells in the ground, (3) in a rude cocoon in wood or earth, (4) in silken cocoons, (5) in folded leaves, (6) as chrysalids. Examples of the above types are everywhere about us.

Internal Changes.—In the *heterometabola* the internal changes are as direct as the external changes. In the *holometabola*, however, some

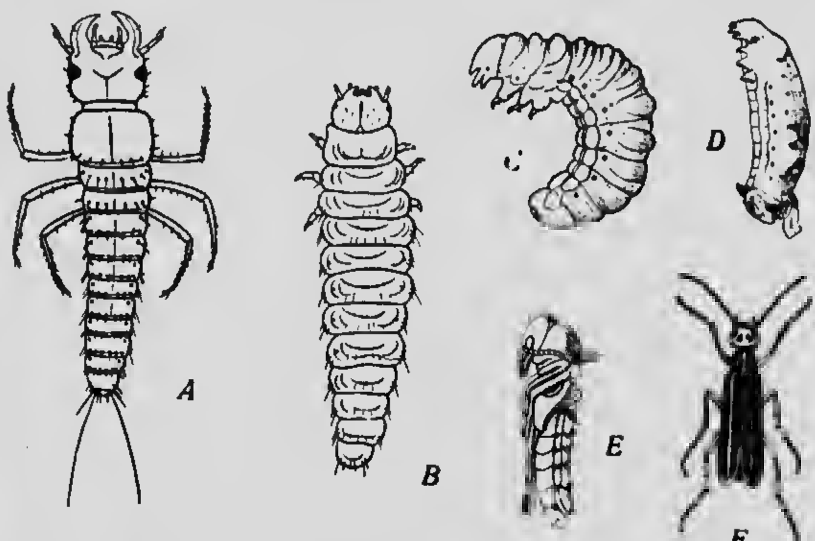

FIG. 40.—Stages in the hypermetamorphosis of *Epicauta*. *A*, Triungulin; *B*, carabidoid stage of second larva; *C*, ultimate stage of second larva; *D*, coarctate larva; *E*, pupa; *F*, imago. *E* is species *cinerea;* the others are *vittata*. All enlarged except *F*. (*After Riley, from Trans. St. Louis Acad. Science.*)

of the larval organs are reconstructed into imaginal or adult tissues. The imaginal organs arise from embryonal tissues (the imaginal buds) which for the most part remain practically dormant in the larval stage; in the pupal stage the purely larval organs disappear and the imaginal organs continue their development. *Histolysis* is the term used to express the destruction of larval tissue by leucocytes, and *histogenesis* for the construction of imaginal tissues.

Imaginal Buds.—The reproductive organs, the dorsal vessel, and the nervous system gradually mature, but many of the organs develop from "buds" in the larva. In the caterpillar, for example, from the inner skin or hypodermis arise buds which develop into the wings and legs of the butterfly. In a midge or fly the head with the eyes, feelers, and jaws, are developed by an inpushing of the skin. The food-canal, glands, and air-tubes of a moth or a bee arise from imaginal buds.

Imago or Adult Stage.—The pupa transforms into the imago or adult insect. On the splitting of the pupal case the full-grown perfect insect emerges.

(*c*) **Hypermetamorphosis.**—With some insects more than two intermediate stages may be noted in metamorphosis. In *Meloe* the young larva (*triungulin*) is thysanuriform; later it resembles a lamellicorn larva, being cylindrical, fleshy, and less active (the *scarabœidoid* stage), then a pseudo-pupa (the *coarctate* stage), and later a legless eruciform larva. In *Epicauta* also triungulate, carabidoid, scarabœidoid and coarctate or pseudo-pupa stages occur (Fig. 40). In *Platygaster*, a proctotrypid, the following supplementary larval stages are observed: (1) the cyclops, (2) the oval, and (3) the elliptical.

Losses Due to Insects

While everyone will acknowledge the fact that damage is done by insects, the enormity of the losses is not generally recognized. However, fairly reliable data covering such losses for several decades in the United States are available in State and Federal records.

Every person admits large losses due to such pests as Potato Beetle, Codling Moth, San José Scale, Tent-caterpillar, Cattle Horn Fly, and Grasshoppers, but later pages will show many other injurious forms that remain practically unobserved by the average person, on account of their small size, or their underground or boring habits. The damage they do is often attributed to other causes, and frequently reports are unreliable, unless corroborated by competent observers.

The following estimate is based on statistics prepared by experts and published in the Year Book, U. S. Department of Agriculture. The loss on farm products, such as cereals, hay and forage, cotton, tobacco, truck crops, sugars, fruits, farm forests, miscellaneous crops and animal products, valued at 8370 millions of dollars in 1909, is greater than 10 per cent. for there is a loss of 972 millions, not including those in connection with natural forests and forest products, and products in storage, which would make a probable total loss of over one billion dollars. The losses are estimated at $1,182,000,000 for 1915, and $1,400,000,000 for 1917 (J. Ec. Ent., Feb., 1918).

Estimates of the losses inflicted by insect pests on the farm products of Canada are mainly based on similar ones for the United States. At the present time it is difficult to form a reliable estimate of average annual losses due to insects from Canadian records. In some of the older provinces fairly complete records covering a series of years are available, but in the newer provinces the records are incomplete.

Estimates have been made of the losses from some of the more serious pests that occasionally cause great damage, such as the Hessian Fly and the Pea Weevil. In Ontario the loss from the Hessian Fly in each of the years 1900 and 1901 was about two and one-half million dollars, and from the Pea Weevil in 1902 over two millions.

If, however, the percentage loss in the United States, viz., 10 per cent. be taken as a fair basis for insect loss in Canada it can be readily reckoned that the total loss every year in that country exceeds 100 millions of dollars.

Beneficial Insects

While the damage done by insects is enormous it must not be supposed that all insects are injurious. As a matter of fact there are more insects that are either beneficial or non-injurious than there are injurious forms. Man owes much to the beneficial insects for their good service in keeping the injurious forms in check.

The fact that most plants with colored flowers are largely dependent upon the visits of insects for their fertilization and the setting of their fruit should make it quite evident that insects play a most important part in the economy of nature, and are no mean things after all. Let one reflect for a moment on the loss to the world if the blossoms of apple, plum, peach, grape, strawberry and raspberry among fruits were not fertilized by bees and wasps; if the clovers were not visited by bees, and if the hundreds of beautiful wild flowers of the fields and meadows were allowed to die without setting seeds.

In addition, one should not forget the part played by scavenger and carrion insects that feed upon dead and decaying organic matter. They help to make our surroundings purer and cleaner. Besides, "insects constitute the most important portion of the food of adult fresh water fishes, furnishing 40 per cent. of their food," according to Dr. Forbes, of Illinois. They also furnish food for most of our birds, and this food may consist of many noxious forms.

There are also many insects that are decidedly beneficial, inasmuch as they prey upon injurious forms or are parasitic upon them. At the present time a great experiment is being conducted in Massachusetts for the suppression of the gypsy and brown-tail moths by the importation of certain parasitic insects from Europe and Japan (see Part IV). From an economic point of view it is important for us to know the beneficial forms so that we may not unwittingly destroy them. Few persons, perhaps, fully recognize the valuable work done hy the modest lady-bird beetles in keeping plant-lice within bounds. Without their intervention it is quite probable that most plants would die from the attacks of the fast reproducing plant-lice. Ground-beetles are also important agents in the destruction of injurious larvæ, and their value can hardly be estimated.

Beneficial insects may, therefore, be classified into:

(*a*) Those that prey, or are parasitic, upon injurious forms (*entomophagous*) such as lady-bird beetles, ground beetles, parasitic diptera and hymenoptera, etc.

(*b*) Those that pollinate plants, such as bees, wasps, moths, etc.

(*c*) Those that play the part of scavengers, feeding upon dead or decaying organic matter, such as carrion beetles, etc.

(*d*) Those that serve as food for fresh-water fishes, birds, etc.

(*e*) Those that secrete or elaborate substances of commercial value to man, such as honey-bee, lac insect, cochineal insect, silkworm, etc.

Berlese divides entomophagous insects into *predatory* and *endophagous*. Predatory insects are those which devour other insects and their eggs outside the maternal body; while endophagous insects are those which enter the body or eggs of their victim and destroy them.

Some entomophagous insects feed exclusively on one species, while others feed on several species (*polyphagous*). From the standpoint of efficiency in the destruction of injurious species Berlese arranges them in the following order:

1. Those preying on a single species and having few enemies and adverse factors, *e.g.*, *Novius cardinalis*, *Prospaltella berlesei*, etc.

2. Polyphagous endophagous species which are themselves subject to severe competition and meet with many adverse factors, *e.g.*, *Scutellista cyanea*, etc.

3. Predators with special victims, *e.g.*, many lady-birds.

4. Polyphagous predatory species; *Calosoma.*

Entomophagous insects include members of the Coleoptera, Hymenoptera, Diptera, Hemiptera and Neuroptera. The coleopterous members are the lady-bird beetles, murky ground-beetles, and tiger-beetles.

The *lady-birds* are small, convex, nearly hemispherical beetles, generally red or yellow and spotted. Their antennæ or feelers are club-shaped, and their tarsi are apparently three-jointed. They feed upon small insects and the eggs of larger species, and are specially valuable for keeping plant-lice in check.

The larvæ of lady-birds are quite active and hunt for their prey. Some bear spines, while others are protected by fine white down.

Ground-beetles (*Carabidæ*) are active forms that live on the surface of the ground. They are usually black, but some have bright colors. They hide under stones or boards in the day-time but leave their shelters at night. They destroy large numbers of caterpillars, such as cutworms, canker-worms, tent-caterpillars, and the grubs of curculio. The larvæ feed underground on the larvæ of *leaf-feeding* insects.

The ground-beetles have thread-like antennæ, five-jointed tarsi, and legs fitted for running.

Tiger-beetles (*Cicindelidæ*) are carnivorous insects, and are most active in the day time. Their activity, markings, and stealthy habits have given them their common name. In structure they are closely related to the ground-beetles, and like them have thread-like antennæ and five-jointed tarsi.

The larvæ of these beetles live in holes in the ground and prey upon unwary insects. They have large heads, immense jaws, long sprawling legs, and two prominent humps on the back.

The *Hymenoptera* possess several very important beneficial forms, mostly parasites:

Ichneumon-flies (*Ichneumonidæ*) vary greatly in size, and the females of some species possess a protruding ovipositor. A common example is *Megarhyssa* (*Thalessa*) a very long tailed ichneumon, which bores a hole in wood infested with pigeon Tremex borers and deposits an egg beside the larval Tremex (Fig. 41); other common ichneumons are:

Trogus, which parasitizes the chrysalids of *Papilio;* and *Ophion*, a form with a compressed body, which lives on the Polyphemus moth and yellow-necked caterpillar.

The Braconids (*Braconidæ*) are smaller and are also parasitic. The most common genera are *Microgaster*, whose cocoons are often found on the backs of sphinx and cabbage butterfly larvæ; and *Aphidius* which parasitizes plant-lice.

Chalcids or *chalcis flies* (*Chalcididæ*) are minute metallic insects. One species, *Pteromalus puparum*, is a parasite of the chrysalids of the

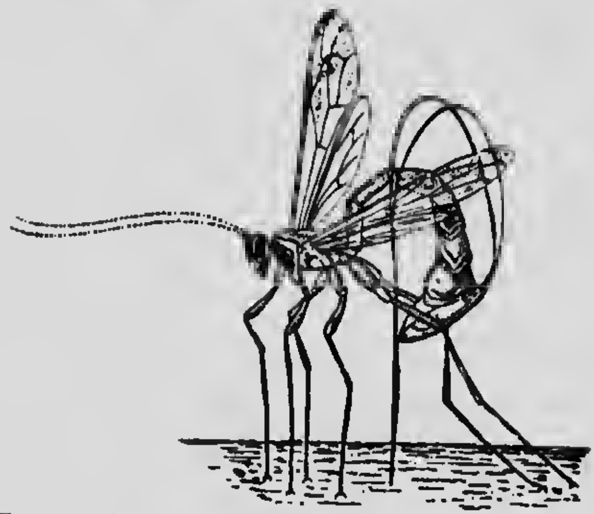

FIG. 41.—Female of Megarhyssa (*Thalessa*) ovipositing.

cabbage butterfly. Another, *Aphelinus*, is parasitic on scale insects (see also p. 354).

Proctotrypids are very minute parasitic hymenoptera often preying upon the eggs of other insects.

Besides these parasitic forms there are predaceous Hymenoptera, such as the mud-wasps, digger-wasps, wood-wasps, etc., that feed their larvæ on insects. They fill the brood cells with caterpillars, grasshoppers, plant-lice, or grubs of small beetles or flies. *Sphecius* makes use of cicadas as food for its young.

Several families of the Diptera are either parasitic or predaceous. The two best known are the Tachinids and the Syrphids.

Tachinids or tachina flies (*Tachinidæ*) are bristly flies closely related to the ordinary house-flies. They parasitize many kinds of caterpillars and sawfly larvæ, either by inserting eggs within the bodies of their victims or by allowing the victims to swallow the eggs that are deposited on leaves.

Syrphids or flower flies (*Syrphidæ*) lay their eggs in colonies of plant-lice which are devoured by the larvæ. They are large, often bee-like in form.

The Hemiptera include a few beneficial forms, mostly belonging to the assassin-bug family (*Reduviidæ*). They are predaceous, sucking the blood of other insects. Sometimes higher animals, including man, are attacked. The following forms may be noted:

Melanolestes picipes is a large black form, and *Opsicœtus personatus*, or masked bed-bug hunter, is black and over ½ inch long.

The Stink Bug Family (*Pentatomidæ*) also furnishes a few beneficial species, although a very large percentage of the species is injurious to plant life. Two common forms are: *Podisus spinosus* (spined tree bug) destroys potato beetles and currant worms, and *Perillus circumcinctus* which appeared recently in large numbers in potato fields where it destroyed potato beetles (Fig. 42).

FIG. 42.—*Perillus circumcinctus*, an enemy of the Colorado potato beetle.

The Damsel Bugs (*Nabidæ*) prey upon leaf-hoppers.

The Ambush Bugs (*Phymatidæ*) are also predaceous, destroying large numbers of injurious insects.

Among the Neuroptera are some important beneficial forms, known as aphis-lions and ant-lions.

The adults of *aphis-lions*, also called lace-winged flies, are readily recognized by their delicate veined green wings. Their larvæ are predaceous and destroy large numbers of plant-lice. Their mandibles are very long. The genus *Chrysopa* is the main one in the family.

The adults of *Ant-lions* (*Myrmeleonidæ*) have "long narrow delicate wings and a slender body." The larvæ are very predaceous and possess enormous mandibles. They capture their prey by using pitfalls.

Hyperparasitism.—It happens that many of the primary parasites are often infested with parasites which reduce very appreciably the effectiveness of the primary. Frequently, however, these secondary forms are infested with tertiary parasites.

In the control of injurious forms it is evident that primary parasites are beneficial, secondary harmful and tertiary beneficial, on the other hand, when beneficial insects are parasitized the primary are harmful, the secondary beneficial and the tertiary harmful.

Insects and Birds

When it is known that about two-thirds of the food of our common birds consists of insects, it becomes evident that the agency of birds in the control of insects is of the highest importance. The seasonal diet of the robin, bluebird, catbird, king-bird, flycatchers, chickadee, wren, swallow, woodpecker, cuckoo, night-hawk, warblers, oriole and many other birds has been carefully studied in recent years, with the resulting discovery that insects form in most cases their only food, and only at certain seasons are small fruits eaten.

Birds are no doubt of special value to the farmer in nipping incipient scourges in the bud on account of their ability to move rapidly from place to place in search of food, and on account of their varied character and habits. Especially is this true of our winter birds which search every cranny and nook for the hibernating forms of insects at a season when every form destroyed means in most cases the absence of hundreds or thousands of their progeny the following summer.

An international treaty between Great Britain and the United States for the protection of migratory birds in the United States and Canada was signed in Washington in August, 1916. For many years the numbers of such birds had been decreasing to such an extent, through careless and indiscriminate slaughter, that the agricultural and forest crops of the two countries were in danger of suffering serious losses from insect depredations. It was deemed advisable, therefore, in the interests of the two countries to adopt a uniform system of bird protection, such as the treaty provides. The most important provision relates to close seasons, viz: (1) a close season on migratory game birds from March 10th to September 1st except for maritime shore birds when the close season is from February 1st to August 15th; (2) an open season for three and one-half months for wild fowl; and (3) a close season throughout the year on insectivorous birds.

Inter-relations Between Insects and Plants

The idea of inter-relations in Nature was first emphasized by Sprengel, Darwin and Müller, and later ecological studies reveal still more clearly how all Nature is linked together into a system, one part dependent upon another in an intricate web of life. Disturbances in one portion of the system are followed by disturbances in another. In this chapter reference is made to some of the relations between insects and plants, between insects and birds, and between insects and their parasites. Numerous other relations might be mentioned but these are sufficient to show that a knowledge of these relations is an important part of the equipment of the economic entomologist who would deal successfully with the prohlems confronting him.

In a region undisturbed by man the various parts of the system of Nature have practically reached a state of balance through the ceaseless action for long ages of the "struggle for existence." Plant struggles with plant, animal with animal, and both with the environment. With the advent of man, however, the balance has been disturbed by the clearing of the forests, the cultivation and drainage of the land, the growing of crops, and the introduction of foreign plants and animals, since the new set of conditions will be favorable to the increase in numbers of certain plants and animals, including insects, and unfavorable to others. This disturbance is often widespread. Favored insects will multiply rapidly on account of the abundant supply of food furnished by the cultivated crops, faster at first than their parasitic enemies; and insectivorous animals such as snakes, toads, birds and predaceous insects will be deprived of the necessary shelter and hiding places by the clearing of the land, and become less abundant.

On the other hand insects not favored, by the destruction of their food plants under the new conditions, will diminish in numbers, as will also their parasites, both sometimes no doubt to the verge of extinction. If, however, as is sometimes the case, conditions again favor the insect it will multiply very rapidly because the development of the parasite lags behind its host. Moreover, there is always a limit to the increase of the parasite, otherwise it would exterminate its host, and eventually itself.

Many examples of inter-relationships among insects in addition to that of parasite and host might be given. Certain ants attend certain plant-lice with the object of feeding upon the nectar excreted—and not of feeding upon the plant-lice as some ignorantly suppose. Forbes has shown that the corn-root plant-louse is actually dependent upon the brown ant, *Lasius niger americanus*, for its existence, for its transfer to suitable winter quarters, to suitable weeds in early spring, and finally to the corn itself.

In bumble-bees' nests one may often find a related bee, *Psithyrus*, living as a guest and fed by the worker bumble-bees. This guest bee is not content to live quietly in the nest; she often destroys the Bombus queen and gets "the poor workers to rear her young instead of their own brothers and sisters" (Sladen).

Ants' nests or formicaries often contain a motley crew of other insects, among which are rove-beetles, pill-beetles, fly larvæ, small crickets, thieving ants, and parasites—the majority being thieves and robbers.

Again, no satisfactory explanation has yet been given for the preferences many insects exhibit in their feeding habits. As examples, we are at a loss to know why in some districts the wheat midge does more damage to spring wheat than it does to fall wheat; why the Hessian fly injures certain varieties of wheat more than others; why the grape blossom midge injures the early varieties of grapes most; why the Leconte and Kieffer pears are practically immune from the San José scale and the white peach scale; why the Northern Spy apple is not troubled with the woolly aphis; why the Red Dutch cabbages are free from the cabbage root maggot; why the spiny elm caterpillar and the European elm scale prefer the American elm to the imported English elm; why the European elm saw-fly and the elm leaf beetle prefer the European elm to the American; why the forest caterpillar attacks the sugar maple in preference to the soft maple; why the maple scale prefers the soft maple to the sugar maple; why the apple maggot is more injurious to sweet and sub-acid summer varieties than to fall and winter-acid varieties; why the brown mite is seldom seen in quince and apricot; and why the phylloxera is more injurious to the European vine than to the native American species.

Long-continued observations show that there are "all grades of association between plants and insects from most casual contact to mutual dependence, and that there are grades of fitness on both sides" (Needham, *General Biology*). Reference has already been made in the section dealing with *Beneficial Insects* to the important part played by many insects in the fertilization of plants. To this end many beautiful adaptations occur among plants such as in legumes, iris, milkweed, yucca, orchids, mints, figworts, honeysuckles, canna, Smyrna fig, etc., but it should be borne in mind that there has been also probably much adaptation on the part of the insects.

Galls.—Another type of inter-relation is the *galls* seen on many plants, produced by certain insects belonging to the families *Cecidomyiidæ, Trypetidæ, Aphididæ, Psyllidæ, Cynipidæ* and *Tenthredinidæ*. Mites, (Acarina) also produce galls. Usually an egg is laid within the growing tissue and the larva excites the surrounding tissue to abnormal growth. The transformations occur within the gall, and the adult escapes to make new galls.

Galls are of various forms, often characteristic of the insects producing them. The *nutritive cells* lying next to the contained larva contain both sugar and starch and appear to function as feeders for both the larva and the growing cells of the gall.

Insectivorous Plants.—Certain plants such as the sundew, Venus' fly-trap, pitcher-plant and bladderwort entrap small insects and feed upon them. These plants secrete digestive fluids which convert the tissues of the captured insects into liquid food capable of heing absorbed.

Diseases of Insects.—Many insects are killed by the action of certain fungi and bacteria. Such diseases are frequently epidemic, and attempts have heen made to control insect infestations by the propagation and distribution of artificial cultures. Probably the best known experiment of this nature was carried out by Dr. Snow and Dr. Forbes against the chinch bug in the middle States by the distribution of cultures of the fungus *Sporotrichum globuliferum*. The result was only moderately successful, for it was found that the disease spreads rapidly in moist seasons, but not in dry ones when the chinch bugs are injurious. There is no doubt, however, that the fungus is an important factor in lessening the severity of the insect's attacks.

In South Africa, Algeria and Argentina the locust has been controlled by the introduction of hacterial cultures of *Coccobacillus* *acridiorum*, but in other regions where the weather conditions are not so favorable this method has not met with success.

In the southern States the San José scale is often attacked by *Sphærostilbe coccophila*, but as a means of control artificial propagation of the disease on a large scale has not been successful.

Tent-caterpillars, brown-tail and gipsy moth caterpillars are destroyed in large numbers by bacterial disease.

Following is a list of the more important entomogenous fungi: *Empusa muscæ* on flies, *E. grylli* on crickets, etc. and *E. aphidis* on plant-lice. *Entomophthora aphidis* on plant-lice, and *E. sphærosperma* on many caterpillars. *Cordyceps militaris* on larvæ and pupæ of white grubs, wireworms and some lepidopterous forms. Most of the conidial forms of *Isaria* and *Sporotrichum* belong to the ascus genus *Cordyceps.*

Botrytis, *Verticillium*, *Cladosporium*, *Ægerita* and *Fusarium* attack many kinds of insects, especially scale insects, plant-lice, white flies, and the chrysalids of moths.

Future investigations will probably lead to the better utilization of fungi in the control of many of the most noxious insects.

Insects as Carriers of Plant Diseases

Flea-beetles by eating holes in the leaves of potato permit the entrance of the spores of Early Blight (*Macrosporium solani*) with consequent partial destruction of the leaves. It has also been sbown fairly conclusively that certain aphids and other insects[1] act as carriers of Twig Bligbt (*Bacillus amylovorus*) of apples and pears, that the beet leaf-bopper (*Eutettix tenella*) transmits to sugar beets the "Curly Leaf" disease, and it is now believed that the squash bug (*Anasa tristis*), the striped cucumber beetle (*D. vittata*), the 12-spotted cucumber beetle (*D. 12-punctata*), the cucumber flea-beetle (*Epitrix cucumeris*), the melon apbis (*Aphis gossypii*), and the 12-spotted lady-beetle (*Epilachna borealis*) frequently inoculate the stems of cucurbits with the cucurbit wilt (*Bacillus tracheiphilus*). Again, the punctures made by the plum curculio in plum, cherry and peach permit entrance of the spores of the Brown Rot Disease (*Sclerotinia fructigena*).

[1] Gossard mentions among others *Aphis avenæ*, *Empoasca mali*, *Eccoptogaster rugulosus*, and *Lygus pratensis.* "Any sucking insect can become a carrier, also any insect with the bark-burrowing habit."

and the greenhouse white fly (*Aleyrodes vaporariorum*) often transmits the disease *Cladosporium fulvum* to tomatoes.

Tree crickets (*Œcanthus*) are said to be responsible for the inoculation of trees and shrubs with canker, of raspberries with the cane blight, and probably for the production of other diseases.

INSECTS AND DISEASE

(Consult *Handbook of Medical Entomology* by Riley and Johannsen, and *Medical and Veterinary Entomology* by Herms.)

During the last twenty years important discoveries have been made regarding the transmission of certain diseases by arthropods such as the mosquitoes, house-flies, stable-flies, gad-flies, tsetse-flies, fleas, bed-bugs, lice and ticks.

Insects and arachnidans cause disease in one or more of the following ways: by *direct infection*, that is by the introduction of a pathogenic organism into the circulation, as in the case of the malarial mosquito, the yellow fever mosquito, the sleeping-sickness flies, horse flies and others; by *indirect infection*, that is by infecting food, as in the case of the house-fly; by *internal parasitism* as in the case of warble flies and bots; by *external parasitism* as in the case of lice, fleas, bed-bugs and ticks; and by the *introduction of poisons* as in the case of bees, wasps, kissing bugs and others.

Brues and Sheppard have divided the diseases that are carried by insects into three groups:

Group A.—Characteristically insect-borne diseases.

Group B.—Often insect-borne diseases.

Group C.—Possibly insect-borne diseases.

Under Group A are included malarial fever, yellow fever, filariasis, sleeping sickness, typhus fever, bubonic plague, African tick-fever, Rocky Mountain spotted fever of man, and Nagana and Texas fever of horses and cattle.

Under Group B. are included typhoid fever, cholera, dysentery, diarrhœa, tuberculosis, septicæmia.

Under Group C. are included anthrax, rabies, pellagra, hookworm, beriberi, black water and relapsing fever of man; and equine infectious anæmia.

Anopheles Mosquito and Malaria:

Malarial fever and ague were common a generation ago, and our fathers vaguely attributed the disease to the presence of swamps whose numbers have fortunately been greatly reduced by drainage.

The story of the discovery of the causal organism and of its life-history in connection with the Anopheles mosquito is one of the interesting chapters in modern biological investigation. The organism belongs to the amœboid Protozoa and was discovered by Laveran, a French army surgeon, in 1880. The part of Anopbeles as a second or intermediate host of the malarial organism was worked out later by Doctors Manson and Ross. (A full account of the discovery will be found in Kellogg's "American Insects.")

The malarial plasmodium on gaining access to the human body lives within a red blood-corpuscle and thrives at the expense of the hæmoglobin. A characteristic excretory product in affected cells is the black granules of *melanin*. In 48 hours the plasmodium reaches maturity and divides into many spores, termed *merozoites*, which are set free in the blood. These soon enter new blood-corpuscles and reach maturity in 48 hours as before. This production of spores coincides with the characteristic "chill" of ague, and is followed by a fever when the spores enter the blood-corpuscles. As a result of the destruction of the red blood-cells the patient becomes *anæmic*. Certain of these spores, however, make no attempt to enter new blood-corpuscles and may remain in the blood for an indefinite period. These are the *gametes*—the *micro-* and *macro-gametes*—which, if taken into the stomach of an Anopheles mosquito, will, however, undergo further development. The male or micro-gamete produces a number of whip-like threads or *flagellæ*, which are capable of uniting witb the female or macro-gametes, producing *vermicules* or *ookinetes*. These penetrate into the wall of the stomach of the mosquito where they rest as *cysts*, forming little lumps on the outer surface. These cysts mature in about ten days and burst, liberating large numbers of *sporo-blasts* into the body cavity, whence they find their way to the salivary glands. When such an affected mosquito bites a human being these spores are injected into the blood and enter the red corpuscles. It will be seen, therefore, that ordinarily the Anopheles mosquito is the only agency for the transmission of malaria to man (Fig. 43).

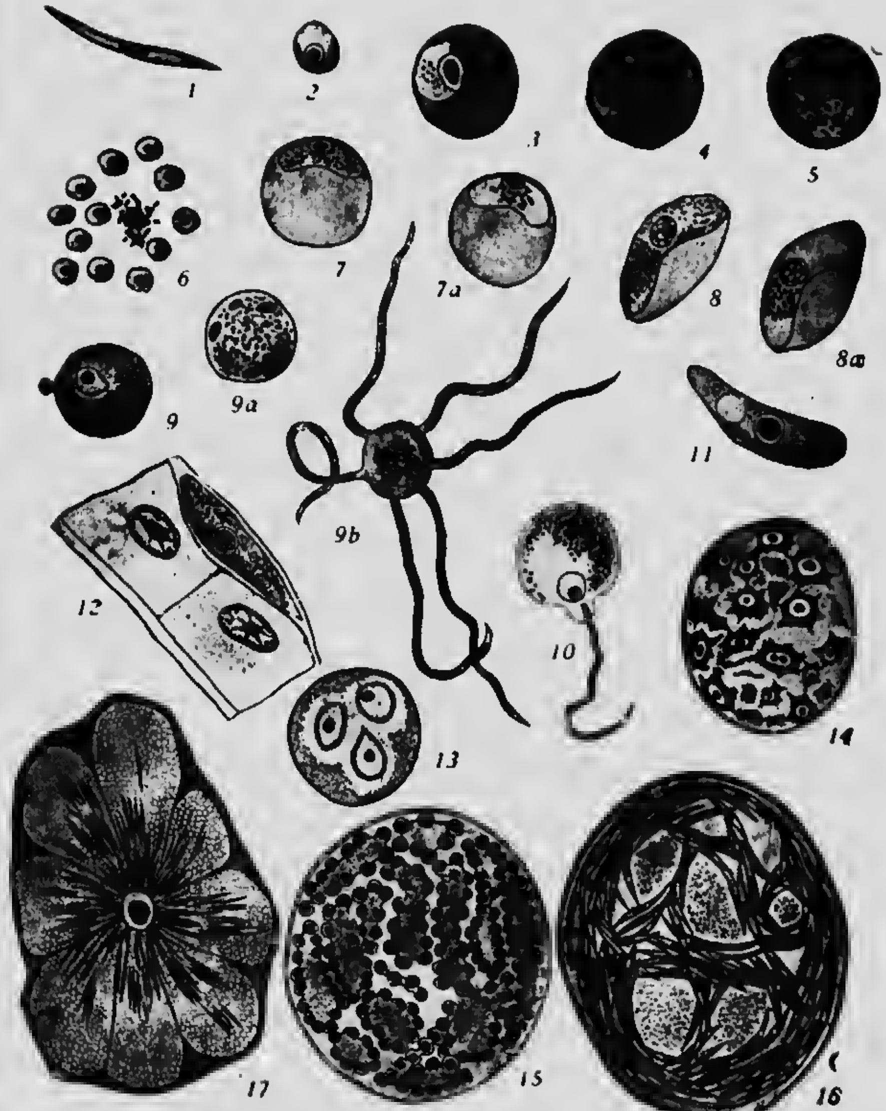

FIG. 43.—Life history of malaria parasite, *Plasmodium præcox.* 1. Sporozoite, introduced by mosquito into human blood; the sporozoite becomes a schizont. 2. Young schizont, which enters a red blood corpuscle. 3. Young schizont in a red blood corpuscle. 4. Full-grown schizont, containing numerous granules of melanin. 5. Nuclear division preparatory to sporulation. 6. Spores, or merozoites, derived from a single mother-cell. 7. Young macrogamete (female), derived from a merozoite and situated in a red blood corpuscle. 7*a*. Young microgametocyte (male) derived from a merozoite. 8. Full-grown macrogamete. 8*a*. Full-grown microgametocyte. In stages 8 and 8*a* the parasite is taken into the stomach of a mosquito; or else remains in the human blood. 9. Mature macrogamete, capable of fertilization; the round black extruded object may probably be termed a "polar

Stegomyia Mosquito and Yellow Fever:

The demonstration of the causal relation between the Stegomyia mosquito and yellow fever is another interesting story, and was worked out mainly by Major Walter Reed of the U. S. Army Medical Service in Cuba in 1900 and 1901. In his experimental camp Major Reed and his associates proved that yellow fever could not be transmitted by contact with yellow fever patients, but only by the bites of infected mosquitoes and by the artificial injection of diseased blood. The causal organism has not yet been discovered on account of its being a filterable virus. It is known, however, that a 12-day incubation period is required in *Stegomyia* before its bite becomes infectious to a second person. Moreover, the mosquito can obtain infected blood from a patient during only the first three days of his disease.

Based on these facts, the control of yellow fever has become an easy matter. The patients are isolated as soon as the disease appears, and standing water in which Stegomyia might develop is treated with kerosene. Besides, all rooms in the building and adjacent buildings are fumigated, for the purpose of destroying living mosquitoes.

Culex Mosquito and Filariasis:

The tropical disease, filariasis, is caused by a minute nematode worm, *Filaria*, which lives in the blood of man and certain species of *Culex* (*C. fatigans*). The worms escape from the mid-intestine of the mosquito into the muscular tissue where they grow for two or three weeks. They then migrate to other portions of the body and often collect at the base of the proboscis, whence they are carried into the human blood circulation. Sometimes the worms become three or four inches long and obstruct the lymphatic canals, causing elephantiasis, characterized by enormous swellings of the legs, arms and other parts of the body.

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body." 9*a*. Mature microgametocyte, preparatory to forming microgametes. 9*b*. Resting cell, bearing six flagellate microgametes (male). 10. Fertilization of a macrogamete by a motile microgamete. The macrogamete next becomes an oökinete. 11. Oökinete, or wandering cell, which penetrates into the wall of the stomach of the mosquito. 12. Oökinete in the outer region of the wall of the stomach, *i.e.*, next to the body cavity. 13. Young oöcyst, derived from the oökinete. 14. Oöcyst, containing sporoblasts, which are to develop into sporozoites. 15. Older oöcyst. 16. Mature oöcyst, containing sporozoites, which are liberated into the body cavity of the mosquito and carried along in the blood of the insect. 17. Transverse section of salivary gland of an *Anopheles* mosquito, showing sporozoites of the malaria parasite in the gland cells surrounding the central canal.

1–6 illustrate *schizogony* (asexual production of spores); 7–16, *sporogony* (sexual production of spores). (*After Grassi and Leuckart, by permission of Dr. Carl Chun.*)

House-fly and Typhoid Fever:

Much attention has been directed in recent years to the dangers of the house-fly (*Musca domestica*) and other flies as agents in the transmission of disease. All Public Health Departments now take cognizance of the house-fly and issue warnings against its presence about the home. Epidemics of typhoid and cholera in many cities, as well as the outbreaks during the Spanish-American war brought out the fact that tbe house-fly was largely responsible for the troubles.

Tbe habits of this insect are such as to make its presence dangerous. It breeds in filth, and as an adult fly it feeds on all kinds of decaying and fecal matter as well as the sweets and liquids of the dining table. Its feet and prohoscis are admirably adapted for carrying those bacterial germs tbat cause typhoid fever, cholera, dysentery, diarrhœa, tuberculosis, etc. Moreover, it has been shown that typhoid bacilli swallowed by the house-fly when it feeds on and crawls over contaminated substances survive the passage of the alimentary canal, so that "fly-specks" may contain many active typhoid germs.

It has been shown that several other species of flies that frequent houses may also convey typhoid bacilli. The "little bouse-fly" (*Fannia canicularis*), the Latrine-fly (*Fannia scalaris*), the blow-fly (*Calliphora erythrocephala*), *Muscina stabulans*, the cluster-fly (*Pollenia rudis*), and the stable-fly (*Stomoxys calcitrans*) have all been found guilty and precautions should be taken to guard against their presence.

The charges proven against the house-fly as an active agent in disseminating not only typhoid fever but also cholera, dysentery and tuberculosis are overwhelming. This insect pest should, therefore, be banished from our midst. If we do not care for our own health we should at least protect the helpless children who are perbaps the greatest sufferers.

(For further particulars the excellent works of Doctors Hewitt and Howard sbould be consulted.)

Anthrax and Infantile Paralysis:

The stable-fly (*Stomoxys calcitrans*), the horn-fly (*Hæmatobia serrata*), gad-flies (*Tabanus* and *Chrysops*), and the black-fly (*Simulium*) have both piercing and sucking beaks and are true blood-suckers. As such they are liable to introduce virus into the human blood. Anthrax is a disease of many domesticated animals and of man; and it is believed that these blood-sucking flies are agents of transmission by inoculation forming malignant pustule; but the pulmonary and intestinal forms of the disease require other methods of infection.

In the recent outbreaks of acute anterior poliomyelitis or infantile paralysis in different parts of the United States and Canada the stable-fly was strongly suspected at first of being the transmitter of the causal organism. Later, however, in many experiments in which monkeys, rabbits and other rodents were inoculated by stable-flies caught in the wards of hospitals containing poliomyelitis patients, and flies that had fed on animals inoculated with the virus were allowed to feed upon healthy animals, no symptoms of the disease developed. Besides, the disease spread on some occasions in mid-winter when stable-flies could not be active agents. The present opinion is that insects play a subordinate rôle, if any, in spreading the disease and that it is transmitted by contact with infected persons. The causal organism has not yet been isolated, being filterable and ultra-microscopic like that of yellow fever.

Tsetse-flies and Trypanosomiasis:

Tsetse-flies (*Glossina spp.*) are not native to America, but belong to tropical and sub-tropical Africa. They are blood-sucking flies, closely related to stable-flies, and in recent years have been shown to be causally related to severe diseases of both man and domesticated animals. Dr. Bruce made the important discovery that *nagana*, a very fatal disease to horses, cattle, dogs and donkeys in South Africa, was produced by a trypanosome carried to the blood by the bites of tsetse-flies. These trypanosomes are flagellate protozoa, and when they occur in the blood of certain warm-blooded animals set up a disease called *trypanosomiasis*. They are carried from one host to another by certain invertebrates, such as mosquitoes, lice, fleas, and especially by such blood-sucking flies as the tsetse-flies.

The Nagana disease is caused by *Trypanosoma brucei* and the tsetse-flies mostly concerned are *Glossina morsitans* and *G. pallidipes*.

In the Congo Basin of Central Africa the terrible "sleeping-sickness" disease carries off tens of thousands of natives every year. Doctors Forde and Dutton isolated the specific causal organism of this disease, which was named *Trypanosoma gambiense*, and Bruce and Navarro traced the organism to the bite of the tsetse-fly, *Glossina palpalis*. Folsom states: "In the first stage of the disease, marked by the appearance of trypanosomes in the blood, negroes show no symptoms as a rule, though whites are subject to fever. The symptoms may appear as early as four weeks after infection or as late as seven years.

"In the second stage trypanosomes appear in the cerebro-spinal fluid and in large numbers in the glands, those of the neck, axillæ and groins becoming enlarged. There is tremor of the tongue and hands, drowsiness, emaciation and mental degeneration. The drowsiness passes into periods of lethargy which become gradually stronger until the patient becomes comatose and dies. Some victims do not sleep excessively but are lethargic and profoundly indifferent to all going on around them."

Late investigations go to show "that *Glossina morsitans* may act as a host for a human trypanosome which is probably identical with *T. gambiense*." Probably also "that some of the vertebrates other than man may harbor *T. gambiense* and that there is a possibility of these things being transmitted to man" (Doane).

With regard to the development of *T. gambiense* in *Glossina palpalis* it is known that "two days after biting an infected animal the fly becomes incapable of infecting other animals and remains so for about 22 to 28 days, when it again becomes infective and may remain so for at least 96 days. During the infection period the salivary glands are found to be invaded with the type of the trypanosome that is found in the vertebrate blood" (Doane).

Rat Fleas and Plague:

Plague, known in three forms as bubonic, septicæmic and pneumonic, is caused by *Bacillus pestis* which attacks rats, mice, cats, dogs and other animals. The disease is transmitted mainly by fleas, sometimes by bed-bugs, and the wounds made by the bites allow entrance to plague bacilli. "Plague is primarily a disease of rats, an epidemic of plague in these animals having often been observed to precede as well as to accompany an epidemic among human beings."

The recent outbreak of pneumonic plague in Manchuria showed another phase of infection. This disease is not dependent on fleas for its transmission, but it could be traced to an outbreak of plague in the tarabagans or marmots, a kind of squirrel. Dr. Cantlie says that Plague may develop or appear in the following stages: (1) as a disease in animals; (2) as *pestis minor* conveyed by infected insects; (3) bubonic plague, sporadic cases, carried from animals to man by insects; (4) epidemic bubonic plague carried from man to man by insects; and (5) pneumonic plague passing from man to man directly, or conveyed by insects. Dr. Kitasato is quoted as saying that the (Manchurian) pulmonary plague cannot spread through the air as the digestive tract is plague-proof, and that direct contact is necessary.

Lice and Certain Diseases:

Typhus fever is transmitted from man to man by the Body Louse (*Pediculus vestimenti*), and Beriberi probably by the Head Louse (*Pediculus capitis*).

Ticks and Certain Fevers:

Although ticks are not true insects yet they have been considered as coming under the field of the entomologist. In certain western states, viz., Montana, Idaho, Wyoming, Utah and Nevada, the Rocky Mountain Spotted Fever occurs and is produced by the bites of ticks (*Dermacentor venustus, et al.*) which carry spirochætes. The African tick-fever is carried by another tick (*Ornithodoros moubata*), the African Relapsing fever possibly by a tick, the African East Coast fever of cattle by ticks (*Rhipicephalus appendiculatus*) and the Texan fever of cattle by a tick (*Margaropus annulatus*) inoculating cattle with the protozoan spirochæte *Babesia bovis*, a fact observed by Dr. Theobald Smith.

Other Diseases:

The terrible "hookworm" disease of the South is probably carried by the common house-fly. The causal organism (*Anchylostoma duodenale*) a round worm may also enter the skin from infected soil. *Pellagra* is transmitted, according to many authorities, by the bites of species of black-fly (*Simulium*) or by the ingestion of mouldy corn. White grubs (*Lachnosterna*) are hosts for the thorn-headed worm (*Echinorhynchus gigas*) and food for swine which in turn becomes food for man.

Leprosy, that most dreaded disease, is now believed to be transmitted by flies, fleas, mosquitoes and bed-bugs. Possibly also certain mites may be occasional carriers of the bacillus (*B. lepræ*).

It will be seen from this account that the insects concerned in the transmission of disease are of two kinds: those, like the mosquito which transmit malaria and filiariasis, which are essential hosts of the disease organisms, and those which transmit the disease mechanically. Any insect which habitually attacks man or which may enter the house or milking stable after having fed on human excreta is potentially a disease vector, so that we cannot too strongly emphasize the necessity of keeping all foods adequately screened and of preventing such insects as house-flies, blow-flies or mosquitoes from entering human dwellings.

Besides carrying disease germs many insects may themselves cause disease in man. Many mites, lice and fleas cause dermatitis, scabies or ulcers in man. The larvæ of many flies, notably the blue bottles, blow-flies, flesh flies and bot flies, cause intestinal, dermal, muscular, nasal or auricular myiasis in man.

MacGregor in a recent paper (Bul. Ent. Res., Vol. viii, pp. 155–163) lists eighty organisms causing disease which may be transmitted by insects.

Insect Behavior Toward Stimuli

In recent years a large mass of facts regarding the behavior of insects toward their environment—both organic and inorganic—has been collected, and in a few cases this information has been of service in the control of injurious forms. In general, however, the application of such methods of control is still in its infancy stage, but it gives promise of valuable results in the near future.

As the relations of insects to plants and to other insects have been discussed in previous sections attention will be confined here to the behavior of insects under the influence of environmental stimuli, such as light, heat, moisture, chemical contact, winds, etc.

For some time it has been known that plants show tropistic movements with regard to light, heat, gravity, moisture, contact, etc. Moreover, some progress has been made toward an understanding of the processes. Plants, for example, bend toward the light because the cells on the side away from the light grow faster than those on the side next to the light. There is no conscious control of the movement by the plant. Animals, too, exhibit movements under the influence of tropic or taxic[1] stimuli. In the case of insects, butterflies, bees, house-flies, and many moths and caterpillars are positively phototropic or phototactic and move toward the light, while maggots, bed-bugs and cockroaches move away from the light.

[1] The term *taxic* is now more commonly used than *tropic* when applied to the locomotor movements of animals under the action of stimuli, *tropic* being usually reserved for the turning or orienting movements.

Again, most moths move away from sunlight but move toward a lesser light such as electric or oil lamps. Davenport explains this difference by saying that "butterflies are attuned to a high intensity of light, moths to a low intensity." Loeb explains the circling of moths and other insects about a light. The stimulus orients the insect by its more intense action on the muscles next the light, and the insect then moves toward the light.

Loeb states that caterpillars of the brown tail moth as they emerge from hibernation in spring are positively phototropic, but after they have eaten this response disappears, showing that taxic reactions are sometimes dependent on the state of the body.

"Swaine finds that the destruction of piled logs by the wood-boring larvæ of the sun-loving *Monohammus* can be prevented by forming a dense shade over the logs by means of brush. In his study of the army cutworm (*Euxoa auxiliaris*) in Alberta, Strickland found that the larvæ are negatively phototropic and hide beneath the soil till about four or five o'clock in the afternoon when they come to the surface to feed. With the weaker light they become positively phototropic and a general migration in a westerly direction takes place. When food is scarce hunger may overcome their aversion to sunshine with the result that the larvæ come above ground, but they still display a modified negative phototropism and migrate in a northwesterly direction. These facts are of practical value in controlling outbreaks of this insect (Hewitt)."

Insects are very responsive to the stimulus of heat, *i.e.*, they are thermotactic.

Some insects respond to the stimulus of touch or contact, and are said to be either positively or negatively thigmotactic. Cockroaches are in the habit of squeezing into narrow crevices, and Loeb mentions the case of a moth *Pyrophila* which also has the same habit.

Chemical substances and foods also act as stimuli influencing the movements of insects. Maggots orient themselves with regard to their food and then move toward it, the orientation being the result of unequal chemical stimulation of the muscles of the two sides of the body. The deposition of eggs by most insects on certain plants is also the result of chemotropism. The house-fly and many piercing insects such as the biting flies and mosquitoes are repelled by phenol and other coal tar products.

Wheeler and Loeb give several examples of geotropism among insects. They observed that lady-birds and cockroaches at rest placed themselves on vertical rather than horizontal surfaces.

Observations show that taxic reactions are very adaptive. Ants and aphids are positively phototaxic when they get wings; and honey bees are periodically phototaxic, thus leading to swarming. Ants, moreover, are strongly thermotaxic, thus securing for their brood the optimum temperature conditions.

Relation of Insects to Temperature and Humidity

Two important factors influencing the life of insects are temperature and humidity. Their general regulatory action has been known for a long time, but scientific data obtained in recent years enable us to speak more definitely regarding the behavior of insects toward the varying temperature and humidity of their environment.

Pierce in his studies of the cotton boll weevil and other forms says: "A careful study of the records of any species, charting for the time required for each activity and the temperature and then similarly for the humidity, will disclose temperature and humidity points of maximum efficiency. With the boll weevil these points lie approximately near 83°F., and 65 per cent. relative humidity."

Ewing has found that a constant temperature of 90°F. prevents the development of *Aphis avenæ*, and that the optimum temperature for the production of the wingless agamic forms is about 65°F.

The larvæ of the common house-fly are killed at a temperature of 105°F., and the close-packing of manure is sufficient to prevent the breeding of flies.

With regard to changes in humidity, insects vary somewhat widely in their reactions. For example, moist air is favorable to most aphids and hastens the development of the larva of the Hessian fly. On the other hand, dry seasons favor the development of the chinch bug and wheat midge.

Gardeners and florists have long observed that red spiders and most species of thrips are more abundant, and hence more injurious, under warm dry conditions.

The investigations of Bachmetjew show that humidity is an important factor modifying the effects of temperature, and that the metabolic activities of insects are related to both temperature and humidity. He says: "Apparently there is a degree of atmospheric humidity which being the most favorable to the maximum speed of insect metabolism should be designated as the optimum; that this optimum varies for each species, for each stage of each species, and for each stage of each individual."

The codling moth is an example of a common insect whose development is greatly influenced by weather conditions. Even within the limits of a single state or province the rate of its development and the time of its stages are influenced by latitude, by early and late seasons, by cool and warm seasons, and by wet and dry seasons. The student will find in the observations of Simpson in Idaho, Pettit in Michigan, Sanderson in New Hampshire, Hammar in Pennsylvania and Michigan, Jenne in Arkansas, Cæsar in Ontario, Headlee in Kansas, Siegler and Simanton in Maine, Brooks and Blakeslee in Virginia, and Forbes in Illinois much valuable data for investigations on the relation of insects to climatic factors.

The Distribution of Insects

On account of the large increase of international trade many economic forms of importance have been introduced into Canada and the United States from other countries, and as it is a matter of public interest to know if such imported forms are likely to become injurious considerable attention has been given of late years to the investigation of this problem. The problem is not yet completely solved, but progress may be reported.

The common *natural* means of dispersal are *flight*, *wind*, *animals*, and *railways*, etc. Many insects are able to fly long distances, many are carried by wind currents and many are transported on materials of commerce. A few examples of such dispersal may be cited. The brown-tail moth is a good flyer, and is thus able to spread rapidly. On the other hand, the female of the gipsy moth cannot fly, consequently the spread of this insect follows the lines of trade. It has been observed that the Hessian fly spreads most readily in the direction of the prevailing winds at the time of the emergence of adults, and that the larvæ of the San José scale are carried by the winds. Again, warble and bot flies are transferred from one district to another by their hosts. Man himself is responsible for the carrying of lice from district to district, often resulting in war time in serious epidemics.

The Colorado potato beetle migrated eastward from its home in Colorado, preferring the cultivated potato to the wild solanums, and the asparagus beetles followed the lines of travel westward from the Atlantic.

On the other hand, there are many barriers to the spread of insects: oceans, seas, mountain ranges and deserts are natural barriers and tend to prevent wide distribution. Climatic conditions, such as temperature and moisture, are also very important factors in insect distribution, often indirectly due to the absence of suitable food plants. The chinch bug and the Rocky Mountain locust, for example, do not thrive under moist conditions.

As the habits of insects are very variable, some being limited, others almost cosmopolitan in their distribution; some sensitive to temperature and moisture extremes, others more or less indifferent to these factors; some feeding only on one or two hosts, others more or less general feeders and therefore not so likely to be restricted in their range, the problem of the determination of probable insect distribution is not an easy one to solve. Moreover, the presence or absence of parasites complicates the problem.

Dr. Merriam's map of the Life Zones of North America shows the distribution of birds and mammals and plants into seven zones running east and west, viz.: *Arctic*, ***Hudsonian*** and ***Canadian*** of the Boreal region; the ***Transition***, ***Upper Austral*** and ***Lower Austral*** of the Austral region; and *Tropical* (see Map).[1] It must be understood, however, that the boundaries of these zones are not hard and fixed, for there is necessarily an overlapping to some extent. It is interesting to note that the great agricultural areas of Canada and the United States lie mainly in the Transition and Upper Austral zones. Recent studies go to show that in general insects *tend* to conform to the same zonal distribution, although several forms, such as the house-fly, mosquito, chinch bug and army-worm, range through several zones.

[1] Merriam states the laws of temperature control as follows:

1. "Animals and plants are restricted in northward distribution by the total quantity of heat during the season of growth and reproduction; and 2. "Animals and plants are restricted in southward distribution by the mean temperature of a brief period during the hottest part of the year."

FIG. 44.—Map of North America showing the life zones. (*After Merriam.*)

As a rule, however, insects diffuse most readily in the zone in which they originated, and in the direction of least resistance. The Transition and Austral zones are differentiated into an eastern humid, a western arid and a Pacific humid division and certain insects occur in one division and not in the others.

As examples of the economic importance of a study of the factors of distribution of insects the cases of the imported elm-leaf beetle and San José scale may be given. Fernald says:

"The Elm-leaf Beetle . . . thrives in tbe Upper Austral Zone, but is noticeably absent in tbe higblands of the Pennsylvania mountain regions, though it is present again west of tbem. To tbe nortb it has caused serious loss to the elms of New England, resulting in the appropriation of large sums for spraying of the trees to protect them from its ravages. Careful studies of this pest in Massachusetts show tbat while a serious menace to the life of the elms in the southern part of the state and in the river valleys, it becomes of little importance in the higher and northern parts, and many towns which formerly appropriated money for the protection of their elms from this insect have now learned that this was unnecessary, as the trees would suffer but little at most, in any case.

"With the San José Scale similar facts are now coming to light. This pest finds the best conditions for its life in the Lower and Upper Austral Zones, where it has caused the loss of many millions of dollars. Even in the Upper Austral territory of Massachusetts, it is one of the most destructive enemies of tbe fruit-grower. As we pass into tbe Transition Zone, however, its ravages become less severe, and by the time the centre of this zone has been reached it is of only medium importance. In tbis case it has seemed to those studying tbis problem that this insect was originally limited by the Upper Austral, but has gradually acquired some degree of resistance to lower temperatures and has thus been able to extend into the Transition Zone."

As Webster has shown, the migration and diffusion of insects have occurred along four main lines. The first was from the east by way of New York or one of the North Atlantic states and the open pathway into the interior past lakes Ontario and Erie. Examples of such migration are the imported cabbage butterfly, the two species of asparagus beetles, the clover-leaf weevil, the clover-root borer, the Hessian fly, the horn fly and the willow curculio. The second line was northward from the West Indies by way of Florida up the Atlantic coast, bringing in many beetles, scale insects, the harlequin cabbage bug and other Hemiptera. The third line was northward from Central and South America by way of Mexico, passing up the Mississippi valley or up the western valleys. Examples of such migration are the Diabroticas, the cotton boll weevil, the Argentine ant, the potato beetle, *Halisidota*, harlequin cabbage bug and the chinch bug. The fourth was southward from Asia by way of Alaska. Examples of such a diffusion are certain lady-birds, *Lina* spp. and *Silpha* spp.

Regarding the fauna of British Columbia E. M. Walker believes it represents a mingling of Asiatic, Californian and Mexican types.

With regard to insects that have come in from foreign countries it is generally true that they confine themselves to zones similar to those from which they have come. Of these mention may be made of *Crioceris asparagi*, *Pieris rapæ*, *Hylastinus obscurus*, the warble and bot flies, the San José scale, and the gypsy and brown-tail moths. Some forms, such as the codling moth and other insects, tend to become cosmopolitan, but they seldom become epidemic outside of their special zones.

Similarity of climatic conditions in corresponding zones of two continents renders it easy for species introduced from one to the other to gain a footing, as the absence of native parasites affords an opportunity for excessive multiplication.

The influence of elevation on the distribution of insects is seen in the southward extension of the zones in hilly or mountainous regions. In an understanding of the distribution of many northern forms often isolated on summits south of their normal zone geological history comes to our aid. The great Tertiary extension of land areas in the northeast and the northwest, making land connections with Europe and Asia, permitted northern forms from these continents to pass to America, and the advance of the Great Glacier southward during the Glacial Period forced many northern forms southward, some of whom were left stranded on mountain summits on the retreat of the ice.

Methods of Studying Economic Insects

It has been already pointed out that one of the characteristics of modern-day investigations in economic entomology is the introduction of the "field station" method, whereby each pest is studied under natural conditions both in the open field and in the laboratory. By this method it is possible to study all or most of the factors that play a part in the life of both host and pest. No phase is too trivial for examination, for it may sometimes happen that apparently trivial and minor facturs turn out to be important; for example, the discovery of a preoviposition period for many Diptera furnishes a means of controlling them at this vulnerable period.

An important part of the equipment of the economic entomologist is a knowledge of the principles of "ecology" which enables him to analyze and scrutinize the various factors that play upon insects. The ecological sciences that have a more or less direct bearing upon economic entomology are Botany, Zoology, Chemistry, Physics, Geology and Geography, and their outgrowths, Bacteriology, Forestry, Meteorology, Physiology, and the group termed Agriculture.

While a knowledge of these sciences is valuable in the study of insect problems it must necessarily be general in its character and insufficient for the solution of many of the more difficult problems. The worker should, therefore, confer with specialists in other departments. Especially is this necessary in dealing with measures of control. Sometimes recommendations are made which are at variance with the most approved farm practice. By consultation with an agronomist, horticulturist or forester such conflicting recommendation would not be given to the public but would first be revised to meet all requirements.

In the study of insects of farm crops, for example, the investigator, working along his own line, frequently reaches a position where he cannot make further progress without more information from workers in other branches and from experienced farmers. Such information may relate to methods and action of fertilizers, methods of cultivation and rotation, meteorological and physiographic influences, and the practical application of measures of procedure. Similarly in dealing with orchard insects progress in investigation can only be made when there is full co-operation with the expert horticulturist, the orchardist, the pathologist and others, who are able to give valuable advice and assistance.

As one might expect, every kind of insect demands its own particular method of investigation, for no two kinds of insects are operated upon by the same factors. Hence the successful investigator must be able to contrive simple but effective devices for the determination of the various factors. Costly insectaries and appliances are not absolutely necessary; on the other hand, the tendency among the best workers is to use inexpensive appliances. The most important consideration in the rearing of insects for the purpose of ascertaining their life history is to make conditions as nearly natural as possible. Cages of various kinds covered with muslin or wire netting are in common use. Some may be flower pots and lamp chimneys in which the host plants are

FIG. 45. Types of underground breeding cages. 1, 15-inch pots with wire-screen cover tops; 2, 15-inch pots with cylinder-shaped tops. (After Davis

growing; others, breeding cages of larger size and more elaborate construction.

In the study of underground forms such as white grubs and wire-worms the cages are usually buried to the full depth in the earth. Davis has found large flower pot cages, deep cylinder-shaped cages and

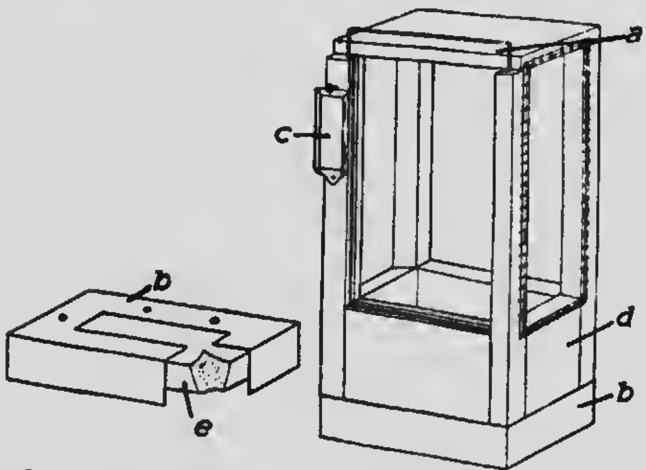

FIG. 46.—Insect breeding cage. *a*, Sliding glass door; *b*, galvanized iron base; *c*, galvanized iron holder for records; *d*, wooden base; *e*, wooden bottom detachable. Sides are covered with cheesecloth. (*After Webster.*)

FIG. 47.—A gasoline or electric trap lantern with attachment of four cups for insects, which fit into each other and are separated by netting of different sizes, and one for cyanide at the bottom. (*After photo by Davis.*)

cages constructed of wire gauze useful. One-ounce tin salve boxes are employed to study the habits of the grubs, their growth and moults.

In the breeding of aphids and other insects which readily succumb to heat, the cages are placed in "shelters" covered with a canvas screen so as to permit free air circulation (Figs. 45-49). When trees are convenient the shelters may be placed under them and the screens removed.

The rearing and distribution of parasites of insects demands special contrivances which may be easily made. Much valuable information

FIG. 48.—Insectary and aphid breeding shelter, showing canvas curtain rolled up. (*Photo by J. J. Davis.*)

is available as a result of the experiences of the workers in the Parasite Laboratory at Melrose Highlands, Mass.

The economic entomologist should be a good photographer, and the laboratory should possess a full photographic outfit and a dark room. Camera records are among the most valuable.

A very important part of the work of the investigator is the keeping and filing of records of the collections, experiments and observations. Two catalogues of the collections—the *Accessions* Catalogue and the *Species* Catalogue—and an *Experiment Record* of the experiments that are conducted should be kept. The Loose-leaf filing system is one that is admirably adapted for these purposes.

The *observational* notes are best made on separate detachable slips of a note book that can be conveniently carried in the pocket. These slips are torn off and filed in card index trays under the name of the insect discussed. This method saves unnecessary transcribing, is

FIG. 49.—A large breeding cage used in the study of locusts, army worms, etc. (*Photo by J. J. Davis.*)

simple, and serviceable in matters of correspondence and the preparation of reports and bulletins.

Three types of collections should be made: (1) the *reference* collection in standard cases such as the Schmitt, the Comstock or other form of box in which the specimens are arranged in systematic order according to the latest check lists; (2) the *economic* collection where the specimens are arranged according to host, where the life-stages and the work of the insect are given prominence; and (3) the *illustrative* collection in Riker mounts for lecture purposes.

TABI

(Co

Roots:
(a

Stems a
(a

(*b*)

(*c*)

(*d*)

(*e*)

(*f*)

(*g*)

(*h*) I

PART II

TABLES FOR THE IDENTIFICATION OF INSECTS INJURIOUS TO FARM, GARDEN AND ORCHARD CROPS, ETC.

I. INSECTS INJURIOUS TO CEREAL CROPS

(Wheat, Rye, Barley, and Oats)

(Consult Bull. 52 C. E. F. Ottawa, Bull. 44 W. Va., and Farmers' Bull. 132 U. S. Dep. Ag.)

Roots:

(*a*) Plants stunted, yellow, and withered or dead; roots eaten.

1. Smooth, slender, wire-like, six-legged worms present in the soil.—*Wire-worms*, p. 293.
2. Presence in the soil of large soft-bodied whitish grubs with brown heads, and hinder portion of body thicker than fore end. When disturbed grubs curl up.—*White Grubs*, p. 302.
3. Large dirty-brown maggots, ½–1 inch long.—*Meadow Maggots*, p. 242.

Stems and Leaves:

(*a*) Young plants dwarfed, and color changed to yellow or brown; stems shrivelled at the base, often bent or broken off; flaxseed objects found embedded at or near the base. Oats immune.—*Hessian Fly* (*Mayetiola destructor*), p. 245.

(*b*) Stems above last joint dead, and the heads white—"silver top" or "white head" disease. Greenish maggot in stem above last joint.—*Wheat Stem Maggot* (*Meromyza americana*) and *American Frit-fly* (*Oscinis carbonaria*), pp. 260–1.

(*c*) Swellings or galls on the joints, and stems bent or broken before harvest.—*Joint Worm* (*Isosoma tritici*), p. 354.

(*d*) Stems broken down and tunnelled, blackish near the joints; heads turning white; presence in tunnel of yellowish-white larva of saw-fly; oats immune.—*Western Wheat-stem Saw-fly* (*Cephus occidentalis*), p. 349.

(*e*) Leaves sickly and whitish; the presence of small red and larger black-and-white bugs.—*Chinch Bug* (*Blissus leucopterus*), p. 161.

(*f*) Stems and leaves sickly; the presence of many green or yellowish-green plant-lice.—*Wheat Plant-louse* (*Aphis avenæ*), *English Grain Plant-louse* (*Macrosiphum granarium*), p. 142.

(*g*) Stems and leaves eaten by large dingy striped caterpillars.—*Army-worm* (*Cirphis unipuncta*), p. 190.

(*h*) Leaves eaten by locusts or grasshoppers. *Red-legged and other Grass-hoppers.*—(*Melanoplus femur-rubrum et al.*), pp. 109–113.

Heads:

(*a*) Heads turn white and grains are shrivelled or imperfectly filled.—*Wheat Stem Maggot* (*Meromyza americana*) and *American Frit-fly* (*Oscinis carbonaria*), p. 261.

(*b*) Heads shrivelled and blighted, and imperfectly filled; the presence of orange-colored maggots.—*Wheat Midge* (*Diplosis tritici*), p. 249.

(*c*) Heads covered with green plant-lice.—*Grain Louse* (*Aphis avenæ*), p. 142.

(*d*) Heads turn white; minute dots or lines on leaves usually run parallel with the veins and remain white; the work of minute insects.—*Grass Thrips* (*Anaphothrips striatus*), p. 119.

(*e*) Spotting of the leaves, spots whitish at first, turning brown or black.—*Six-spotted Leaf-hopper* (*Cicadula 6-notata*), p. 154.

(*f*) Heads blasted and stems withered; the presence of frothy masses on the stems.—*Grass-feeding Froghopper* (*Philænus lineatus*), p. 153.

II. INSECTS INJURIOUS TO INDIAN CORN OR MAIZE

(Consult Bull. 44 Illinois Agric. Exper. Station)

Planted Seed:

(*a*) Plant fails to come up after planting; grain destroyed by a maggot which eats out the interior.—*Seed-corn Maggot* (*Phorbia fusciceps*), p. 277.

(*b*) Plant fails to come up, or the young plant suddenly wilts after it is above ground; the presence of hard, smooth, yellowish, wire-like worms.—*Wire-worms* spp., p. 293.

Roots:

(*a*) Young plants killed or withered; roots eaten.—*White Grubs or Wire-worms*, p. 303.

(*b*) Young plants unequal in growth; roots dwarfed without external injury; presence of ants.—*Corn-root Louse* (*Aphis maidi-radicis*).

Stalks:

(*a*) Plants cut off near surface of ground.—*Cutworms*, p. 185.

(*b*) Plants unthrifty and covered with greenish plant-lice.—*Corn Plant-louse* (*Aphis maidis*), p. 142.

(*c*) Stalks punctured and slit.—*Corn Bill Bugs* (*Sphenophorus* spp.), p. 338.

(*d*) Pith of stalk and pedicel of cob tunneled by a flesh-colored caterpillar, terminal internode broken.—*European Corn Borer* (*Pyrausta nubilalis*).

Leaves:

(*a*) Leaves thickly covered with green plant-lice.—*Corn Plant-louse* (*Aphis maidis*).

(*b*) Leaves eaten.—*Army-worm* (*Cirphis unipuncta*) and *Grasshopper*, p. 190.

(*c*) Leaves perforated by round or oblong holes arranged in parallel transverse rows.—*Corn Bill Bugs*, p. 338.

(*d*) Leaves wilted and brownish, sometimes sickly and whitish; the presence of small red and larger black-and-white bugs.—*Chinch Bug* (*Blissus leucopterus*), p. 161.

(*e*) Leaves wilted and brownish caused by the maggot of a syrphid fly.—*Corn-feeding Syrphid Fly* (*Mesogramma politus*), p. 251.

Ears:

(*a*) Developing kernels eaten; presence of much excrement.—*Corn Ear Worm* (*Heliothis obsoleta*), p. 195.

(*b*) Stalks of ears covered with plant-lice.—*Corn Plant-louse* (*Aphis maidis*), p. 142.

(*c*) Developing kernels eaten; cob and tassel stalk tunneled.—*European Corn Borer* (*Pyrausta nubilalis*), p. 212.

III. INSECTS INJURIOUS TO CLOVER AND ALFALFA

(Consult Bull. 134 Illinois Agric. Exper. Station, 1909)

Roots:

(*a*) Second year plants wilted and dead, breaking off easily at the crown. Main root tunnelled and occupied by white footless grubs or little dark brown cylindrical beetles.—*Clover Root Borer* (*Hylastinus obscurus*), p. 341.

(*b*) Plants wilted and leaves dead, mealy bugs near crown of root.—*Clover Root Mealy Bugs* (*Pseudococcus trifolii*), p. 133.

Stems:

(*a*) A long burrow with brown discolored walls in the pith of the stem which falls to the ground prematurely.—*Clover Stem Borer* (*Languria mozardi*).

(*b*) Stems cut off or eaten.—*Cutworms, Army-worms* (*Cirphis unipuncta*) and *Grasshoppers*, p. 109.

(*c*) Stems and leaves withered and dead; plants covered with large green long-legged plant-lice.—*Pea* or *Clover Plant-louse* (*Macrosiphum pisi*), p. 149.

Leaves:

(*a*) Leaves full of round holes, and edges gnawed.—*Clover Leaf Weevil* (*Phytonomus punctatus*), p. 331.

(*b*) Leaves eaten and with a ragged appearance.—*Grasshoppers*, p. 109.

(*c*) Leaves folded along midrib, yellowish or brownish, with white or orange maggots or silken cocoons within the folds.—*Clover Leaf Midge* (*Dasyneura trifolii*), p. 248.

Heads and Seed:

(*a*) Florets at blossoming-time green and undeveloped; the ovaries empty or with an orange pink or whitish maggot.—*Clover Seed Midge* (*Dasyneura leguminicola*), p. 246.

(*b*) Florets withered and seeds undeveloped; the presence of frothy masses on stems.—*Meadow Froghopper* (*Philænus spumarius*), p. 153.

(*c*) Seeds eaten, becoming brown, brittle, and hollow; affected seeds dull brown and often misshapen and of small size; maggot minute, white and footless.—*Clover Seed Chalcid* (*Bruchophagus funebris*), p. 355.

(*d*) Unopened blossoms destroyed, a cavity eaten in the head.—*Clover Seed Caterpillar* (*Laspeyresia interstinctana*), p. 228.

Stacked or Stored Clover Hay:

(*a*) Hay containing white silky webs and particles of excrement.—*Clover Hay-worm* (*Hypsopygia costalis*), p. 208.

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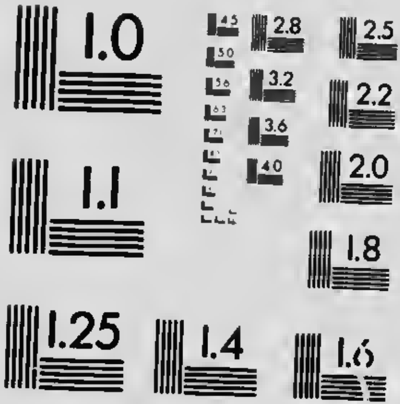

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IV. INSECTS INJURIOUS TO PEAS AND BEANS

Planted Seeds:

(*a*) Plant fails to come up, due to work of *White Grubs* or *Wireworms*, or *Bean* or *Seed Corn Maggot*, p. 277.

Stalks and Leaves:

(*a*) Plants cut off at night near surface of the ground.—*Cutworms*, p. 185.

(*b*) Plants unhealthy, often killed by sucking lice.—*Pea Louse* (*Macrosiphum pisi*), p. 149.

(*c*) Plants (beans) sickly and sooty, caused by a black aphis feeding at the tips at blossoming time.—*Bean Aphis* (*Aphis rumicis*), p. 148.

Seeds:

(*a*) Seeds (peas) within the pod partly eaten and web-covered; pellets of excrement about injured seed.—*Pea Moth* (*Laspeyresia nigricana*), p. 226.

(*b*) Seeds within the pod (peas) perforated with holes; footless grubs within.—*Pea Weevil* (*Bruchus pisorum*), p. 319.

(*c*) Seeds (Beans) perforated with (sometimes many) holes; footless grubs within.—*Bean Weevil* (*Bruchus obtectus*), p. 319.

V. INSECTS INJURIOUS TO STORED GRAIN PRODUCTS

(After Girault, Bull. 156 Illinois Ag. Exp. St.)

Moths or Millers.

(*a*) Caterpillar small, whitish, living in grains of corn or wheat, pupating within the grain, and emerging through a round hole covered with silk at or near the tip of the kernel. Adult moths grayish clay-yellow, small.—*Angoumois Grain Moth* (*Sitotroga cerealella*), p. 214.

(*b*) Caterpillars, spinning much silk, usually forming a silken tube to which they retire; this tube covered with food particles. Living in flour, meal, chaff, sometimes among grain, or in food substances. Full-grown caterpillars make a cocoon.

1. Caterpillar free-living usually not concealed within a silken tube, olive-green to pinkish, infesting grain or meal, webbing particles together, covering bags of grain with a web of silk and generally scattering silk in all directions. The moth is brown and gray. Cocoon elliptical, slender, fragile and of clear silk.—*Indian Meal Moth* (*Plodia interpunctella*), p. 214.
2. Caterpillars living in densely woven silken cases covered with particles of the food substance. Common in flour or chaff in corners.

   (1) A yellowish white to pinkish caterpillar in flour, webbing it together and forming a cocoon covered with particles of flour. Moth dark grayish.—*Mediterranean Flour Moth* (*Ephestia kuehniella*), p. 213.

   (2) A soiled grayish caterpillar, darker at each end, living in chaff or other vegetable débris in dark damp places,

securely webbing the food substance together, so that it becomes matted; larval case and cocoon completely hidden, covered with the food substance. Adults very beautiful and delicately colored moths.—*Meal Snout Moth* (*Pyralis farinalis*), p. 208.

Beetles or Weevils.

(a) Small insects living in kernels of grain, or among grain and other stored products.

1. A very small, fat, humped-backed grub, in kernels of wheat or corn; yellowish-white, legless, and wrinkled, unable to crawl; pupa within the kernel. Adult smaller than a grain of wheat, with a snout, and elbowed feelers attached to the snout.
   (1) Adult beetle chestnut-brown, without spots on its upper wings. Slightly larger than the next, more common in the North.—*Granary or Black Weevil* (*Calandra granaria*), p. 337.
   (2) Adult beetle somewhat duller brown than the preceding with four reddish spots, one on each outer corner of the upper wing. A southern species.—*Rice or Spotted Weevil* (*Calandra oryzæ*).
2. Small, more or less slender, somewhat flattened grubs, with distinct head and thoracic legs, crawling about in the débris of various grains or their products, or in vegetable foodstuffs. Adults flattened, longer than wide, the head not prolonged into a snout. They occur with the grubs, actively feeding.
   (1) Grub uniform in color, whitish, about one-fourth inch long, slender, its head narrower than the first body segment; pupa with the thorax not toothed laterally, but with most of the abdominal segments bearing a tooth-like lobe, acute at each outer corner and toothed along its sides. Adult beetle active, smooth, elliptical, and reddish brown.—*Confused Flour Beetle* (*Tribolium confusum*), p. 328.
   (2) Grub whitish, with a rectangular yellowish area on each segment above, only the margin whitish as seen from above; head broader than first body segment. Pupa bears along each side of the thorax and abdomen a series of stout lobe-like teeth, which are cylindrical-rectangular and blunt. Adult beetle smaller than in the preceding species, color dark chocolate-brown, sides of the thorax saw-toothed.—*Saw-toothed Grain Beetle* (*Silvanus surinamensis*), p. 326.
   (3) Grub dull white with a dark brown head; fleshy, three-fourths inch long; posterior end with two dark horny points. Pupa white, adult beetle, elongate, depressed,

nearly black, one-third inch long.—*Cadelle* (*Tenebroides mauritanicus*), p. 326.

(*b*) Large insects, concealed in the bottoms of bins, corners, and the like, feeding upon flour, meal or bran. Adults large black beetles; the larvæ, large, cylindrical, wormlike creatures, resembling wireworms.

1. Adult not quite black in color, shining, its third antennal joint not quite twice as long as the second; larva light yellowish, shining.—*Yellow Meal-worm Beetle* (*Tenebrio molitor*), p. 327.
2. Adult black and without luster, its third antennal joint thrice as long as the second; larva very dark, shining.—*Dark Meal-worm Beetle* (*Tenebrio obscurus*), p. 328.

VI. INSECTS INJURIOUS TO ROOT CROPS

(*Turnips, rape, mangels, and carrots*)

(Consult Bull. 52 C. E. F., Ottawa, and Bull. 60, Ill. Exp. Sta.)

Roots:

(*a*) Tips of roots of young carrots with rusty patches on surface, or rust colored tunnels in the pulp, due to slender yellowish-white maggots.—*Carrot Rust Fly* (*Psila rosæ*), p. 262.

(*b*) Roots of turnips bored or tunnelled by minute grubs or maggots.—*Turnip Flea Beetle* (*Phyllotreta vittata*); *Cabbage Root Maggot* (*Phorbia brassicæ*), p. 273.

(*c*) Roots cut off.—*Wireworms, White Grubs, Cutworms*, pp. 185, 293, 302.

Stem and Leaves:

(*a*) Young plants cut off at the ground.—*Cutworms*, p. 185.

(*b*) Surface of first leaves of turnip and rape eaten into small holes by small active black striped beetles.—*Turnip Flea Beetle* (*Phyllotreta vittata*), p. 314.

(*c*) Leaves partly consumed by pale-green caterpillars.—*Cabbage Worm* (*Pieris rapæ*), p. 175.

(*d*) Leaves eaten by caterpillars with black and yellow stripes.—*Zebra Caterpillar* (*Ceramica picta*), p. 188.

(*e*) Leaves wilt and turn yellow, with presence of greenish lice.—*Turnip Plant-louse* (*Aphis brassicæ*), p. 148.

(*f*) Young leaves eaten into holes and irregular blotches by small active green caterpillars.—*Diamond Back Moth* (*Plutella maculipennis*), p. 232.

(*g*) Under-surface of leaves covered with a very fine loose web; leaves yellowish in patches, and minute red objects present.—*Red Spiders*, p. 367.

(*h*) Leaves eaten by red beetles with black stripes (Prairie Provinces).—*Red Turnip Beetle* (*Entomoscelis adonidis*), p. 309.

VII. INSECTS INJURIOUS TO THE POTATO CROP

Tubers:

(*a*) Surface of tuber eaten and eyes sometimes destroyed so that growth does not take place; or holes bored in the tuber.—*White Grubs, Wireworms, Millipedes*, p. 369.

Stalks and Leaves:

(*a*) Stalks cut off at the ground.—*Cutworms*, p. 185.

(*b*) Leaves eaten and infested with reddish soft grubs and striped beetles.—*Colorado Potato Beetle* (*Leptinotarsa decemlineata*), p. 308.

(*c*) Leaves riddled with small holes or surface eaten in spots by small active jumping black beetles.—*Potato Flea Beetle* (*Epitrix cucumeris*), p. 313.

(*d*) Leaves eaten and with a ragged appearance; presence of long black or striped soft beetles.—*Blister Beetles* (*Epicauta* spp.), p. 325.

(*e*) Stalk wilts and dies, tunnel in stalk near the ground, and presence of a white footless grub.—*Potato Stalk Borer* (*Trichobaris trinotata*), p. 334.

(*f*) Green plant-lice on the leaves; migrating to the rose.—*Potato Plant-louse* (*Macrosiphum solanifoliæ*).

VIII. INSECTS INJURIOUS TO GARDEN VEGETABLES

[Under the term "Garden Vegetables" may be included Asparagus, Beets, Cabbage, Cauliflower, Celery, Cucumber, Onion, Parsnip. (Carrots, beans, peas and potatoes have already been considered.)]

Roots:

(*a*) Roots of cabbage and cauliflower and bulb or base of onion mined by white maggots.—*Root Maggots* (*Phorbia brassicæ* and *Phorbia cepetorum*), p. 273.

(*b*) Roots of cucumber, squash, melon and pumpkin eaten, and plants fail to come up.—*White Grubs, Wireworms.*

(*c*) Roots of cucumber, etc., gnawed and mined, plants wilt and die.—*Striped Cucumber Beetle* (*Diabrotica vittata*), p. 307.

Stems and Leaves:

(*a*) Young plants cut off near surface of ground.—*Cutworms.*

(*b*) Stalks, vines and leaves of cucumber, etc., eaten, and base, mined by small white grubs.—*Cucumber Beetles* (*Diabrotica* spp.), p. 307.

(*c*) Vines of cucumber, etc., wilted, and presence of large dark stink-bugs on leaves.—*Squash Bug* (*Anasa tristis*), p. 160.

(*d*) Leaves and vines of cucumber, etc., sickly and dirty, under surfaces infested with greenish-black lice.—*Melon Plant-louse* (*Aphis gossypii*).

(*e*) Surface of leaves of cucumber, etc., eaten by small black beetles.—*Cucumber Flea Beetle* (*Epitrix cucumeris*), p. 313.

(*f*) Leaves of cabbage, etc., ragged, eaten by pale-green caterpillars.—*Cabbage Worm* (*Pieris rapæ*), p. 175.

(*g*) Leaves of cabbage, etc., wilted, and under-surface covered with greenish plant-lice.—*Cabbage Plant-louse* (*Aphis brassicæ*), p. 148.

IX. INSECTS INJURIOUS TO THE APPLE

(Consult *Manual of Fruit Insects* by Slingerland and Crosby)

Roots:

(*a*) Bluish-white mouldy lice causing knots or swellings on the smaller roots.—*Woolly Aphis* (*Schizoneura lanigera*), p. 145.

(*b*) Large white grubs feeding on the roots of nursery stock.—*White Grubs* (*Lachnosterna* spp.), p. 302.

Trunk, Branches and Twigs:

(*a*) A green curiously shaped bug producing longitudinal slits in the bark; eggs laid under the edges of the slits.—*Buffalo Tree Hopper* (*Ceresa bubalus*), p. 157.

(*b*) White woolly patches on the twigs which are usually scarred.—*Woolly Aphis* (*Schizoneura lanigera*), p. 145.

(*c*) Green soft-bodied sucking insects in clusters on young growths, particularly at ends of twigs, producing distortions.—*Apple Aphids* (*Aphis mali, A. sorbi* and *A. avenæ*), p. 143.

(*d*) Snout beetles gnawing off the bark in patches.—*Imbricated Snout Beetle* (*Epicærus imbricatus*).

(*e*) *Fixed to bark:*

1. Scales round and gray and black producing an ashy gray incrustation on the bark.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
2. Bark rough with mussel-shaped scales.—*Oyster-shell Scale* (*Lepidosaphes ulmi*), p. 124.
3. Bark scurfy with white scales.—*Scurfy Scale* (*Chionaspis furfura*), p. 125.

(*f*) *Making tunnels in the wood:*

1. Large square-headed legless borer at or near the ground in tunnels, with sawdust-like excrement.—*Round-headed Borer* (*Saperda candida*), p. 320.
2. Large flat-headed legless borer in upper trunk in tunnels with sawdust-like excrement.—*Flat-headed Borer* (*Chrysobothris femorata*), p. 300.
3. Large grub in decaying wood.—*Eyed Elater* (*Alaus oculatus*) and *Rough Osmoderma* (*Osmoderma scabra*), p. 305.
4. Making tunnels between the bark and wood. *Fruit Bark Beetle* (*Eccoptogaster rugulosus*), p. 339.

Buds:

(*a*) Light green caterpillars with brown head and shield, folding together the opening leaves and feeding within.—*Oblique Banded Leaf-roller* (*Cacœcia rosaceana*), *Fruit-tree Leaf Roller* (*C. argyrospila*), and *Leaf Crumpler* (*Mineola indigenella*), p. 230.

(*b*) Brownish caterpillar with black head and shield eating the centre of the bud, or tunnelling it.—*Eye-spotted Bud Moth* (*Tmetocera ocellana*), p. 225.

(*c*) Measuring worms, eating leaves of buds.—*Canker Worms* (*Alsophila pometaria* and *Paleacrita vernata*), p. 205.

(*d*) Caterpillars feeding within pistol-shaped cases and eating irregular holes in the bud leaves.—*Pistol Case Bearer* (*Haploptilia malivorella*), p. 235.

(*e*) Caterpillars feeding within cigar-shaped cases and eating small round holes in the bud leaves.—*Cigar Case Bearer* (*Haploptilia fletcherella*), p. 234.

(*f*) Click beetles feeding on buds.—*Corymbites* spp., p. 297.

Leaves:

(*a*) Gregarious caterpillars:

Caterpillars protected by webs:

1. Webs in forks of branches in spring.—*Tent-caterpillar* (*Malacosoma americana*), p. 203.
2. Webs covering the leaves in summer and early autumn.—*Fall Web Worm* (*Hyphantria textor*), p. 181.
3. Leaves partly eaten and drawn together by a web.—*Palmer Worm* (*Dichomeris pometella*), p. 215.

Caterpillars not protected by a web:

1. Clustered on limbs.—*Yellow-necked Caterpillar* (*Datana ministra*), p. 198.
2. *Red-humped Apple-tree Caterpillar* (*Schizura concinna*), p. 199.
3. *Forest Caterpillar* (*M. disstria*), p. 204.

(*b*) Solitary caterpillars:

Protected caterpillars:

1. Mining within the leaf, pupa inside of folded leaf.—*Apple Leaf Miner* (*Tischeria malifoliella*), p. 235.
2. Mining within the leaf, mature larva and pupa within a small oval seed-like body.—*Resplendent Shield Bearer* (*Aspidisca splendoriferella*), p. 232.
3. Feeding within a pistol-shaped case which stands out from the leaf.—*Pistol Case Bearer* (*Haploptilia malivorella*), p. 235.
4. Feeding within a cigar-shaped case which stands out from the leaf.—*Cigar Case Bearer* (*Haploptilia fletcherella*), p. 234.
5. Feeding within a folded leaf.—*Leaf Roller* (*Teras malivorana*), *Cacœcia* spp., *Apple Leaf Sewer* (*Ancylis nubeculana*), p. 230.
6. Feeding within a tube of silk, open at both ends, on epidermis and inner tissues, leaving the veinlets.—*Bud Moth* (*Tmetocera ocellana*), p. 225.
7. Feeding on tissues of leaves beneath a silk web.—*Apple Leaf-skeletonizer* (*Psorosina hammondi*), p. 213.
8. Brown caterpillar feeding within a crooked black case and attached to twigs in winter.—*Leaf Crumpler* (*Mineola indigenella*), p. 213.

Unprotected caterpillars:

1. Measuring worms in spring, feeding in the daytime.—*Canker Worms* (*A. pometaria* and *P. vernata*), p. 205.
2. Sleek 16-legged caterpillars, feeding at night.—*Cutworms*, p. 186.
3. Large green caterpillar, covered with spiny tubercles.—*Cecropia Moth* (*Samia cecropia*), p. 180.
4. Large apple-green caterpillar with white oblique stripes on sides.—*Polyphemus Moth* (*Telea polyphemus*), p. 180.
5. Hairy caterpillar with long black tufts over head and tail.—*Tussock Moth* (*Hemerocampa leucostigma*), p. 202.
6. Large green caterpillar with a reddish-brown horn at tail, and seven oblique stripes on each side.—*Apple Sphinx* (*Sphinx gordius*), p. 178.

7. Small caterpillars with brown head and yellowish-green body, feeding on leaves.—*Apple-leaf Bucculatrix* (*Bucculatrix pomifoliella*), p. 236.

(c) *Plant-lice.* Greenish or rosy colored sucking insects feeding on the under sides of leaves, often distorting them.—*Aphis mali, A. sorbi,* and *A. avenæ,* p. 143.

(d) *Beetles:*

1. Large brown beetles feeding at night on leaves.—*May Beetles* (*Lachnosterna* spp.), p. 302.
2. Small brown beetles, feeding at night.—*Leaf Beetles,* p. 301.

(e) *Mites.* Oval reddish-brown mites feeding on leaves causing them to become blanched, yellow or sickly.—*Clover Mite* (*Bryobia pratensis*), p. 367.

Fruit:

(a) *Boring tunnels through the fruit:*

1. Tunnels made mostly about the core; made by a pinkish caterpillar three-fourths inch long when full grown; brown excrement often visible at opening at blossom end of apple.—*Codling Moth* (*Carpocapsa pomonella*), p. 219.
2. Tunnels not so deep as in 1, often blotched mines near the surface. Made by caterpillars not so large as codling worms.—*Lesser Apple Worm* (*Laspeyresia prunivora*), p. 227.
3. Tunnels irregular and numerous made by a maggot.—*Apple Maggot* (*Trypeta pomonella*), p. 266.

(b) *Puncturing the fruit:*

1. Four-humped beetles puncturing the fruit and distorting it.—*Apple Curculio* (*Anthonomus quadrigibbus*), *Plum Curculio* (*Conotrachelus nenuphar*), p. 329.
2. Purplish spots about the circular scales.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
3. Puncturing and deforming the fruit.—Several species of *Capsidæ* (False tarnished plant bug and the apple red bugs); and *Syntomaspis druparum* (p. 165).

(c) *Eating holes in the fruit:*

1. Large light yellow or apple-green caterpillars with a narrow cream colored stripe along middle of the back.—*Green Fruit Worms* (*Graptolitha* spp.), p. 197.
2. Yellowish hairy beetle one-half inch long.—*Bumble Flower Beetle* (*Euphoria inda*), p. 305.
3. Green worm-like saw-fly larva hibernating in cavities scooped out of apple.—*Dock False Worm* (*Ametastegia glabrata*), p. 347.

X. INSECTS INJURIOUS TO THE PLUM

Roots:

(a) Burrows made by a caterpillar about the crown of the roots, occasionally in young trees.—*Peach-tree Borer* (*Synanthedon exitiosa*), p. 216.

Trunk, Branches and Twigs:

(a) Tunnels in the wood by flat-headed grubs; sawdust-like excrement at the mouth of tunnels.—*Flat-headed Borer* (*Chrysobothris femorata*), p. 300.

(*b*) Tunnels in the bark by small legless grubs.—*Fruit Bark-beetle* (*Eccoptogaster rugulosus*), p. 339.

(*c*) Bases of buds perforated, bark becomes discolored, and leaves and fruit wither.—*Pear Blight Beetle* (*Anisandrus pyri*), p. 340.

(*d*) *Fixed to bark:*

1. Flat or saddle-shaped, or hemispherical dark-brown scales; wintering forms small and flattish. Large scales appear after mid-summer, brittle, contain only a whitish dust or empty egg-shells.—*Fruit Lecanium* (*Lecanium corni*), p. 120.
2. Ashy-gray appearance of bark of badly infested trees due to small gray or black circular scales.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
3. Mussel-shaped scales, with whitish eggs underneath in winter.—*Oyster Shell Scale* (*Lepidosaphes ulmi*), p. 124.
4. Bark scurfy with scales with purplish eggs underneath in winter.—*Scurfy Scale* (*Chionaspis furfura*), p. 125.

(*e*) A grass green curiously shaped bug producing longitudinal slits and eventually oval-shaped scars on the back of the twigs.—*Buffalo Tree-happer* (*Ceresa bubalus*), p. 157.

Leaves:

(*a*) Feeding in Colonies.

1. Caterpillars protected by webs in the forks of branches.—*American Tent-caterpillar* (*Malacosoma americana*), p. 203.
2. Caterpillars protected by webs covering the leaves.—*Fall Web-worm* (*Hyphantria textor*), p. 181.
3. Not protected by webs; greenish lice with sucking mouths.—*Plum-leaf Aphis* (*Aphis prunifolii*).

(*b*) Solitary.

1. Measuring worms, feeding in the day time in spring.—*Canker Worms* (*Alsophila pometaria*), p. 205.
2. Fat greasy caterpillars, feeding at night in spring.—*Cutworms*, p. 192.
3. Hairy caterpillars with long black plumes over head and tail.—*Tussock Moth* (*Hemerocampa leucostigma*), p. 202.
4. Large buzzing beetles.—*June Beetles* (*Lachnosterna* spp.), p. 302.
5. Large apple-green caterpillar, with a horn near the tail, and with seven broad oblique white stripes along each side.—*Plum-tree Sphinx* (*Sphinx drupiferarum*), p. 178.

Other larvæ are occasionally found feeding on the leaves of plum.—*The Viceroy* (*Limenitis disippus*), *Polyphemus* and *Cecropia*, p. 180.

Fruit:

(*a*) A snout-beetle puncturing and making a crescent-shaped slit in the skin of the young fruit which soon drops.—*Plum Curculio* (*Conotrachelus nenuphar*), p. 329.

(*b*) Making a round hole in the young fruit.—*Plum Gouger* (*Coccotorus scutellaris*).

(c) A medium sized beetle eating holes in the ripe fruit.—*Bumble Flower-beetle* (*Euphoria inda*), p. 305.
(d) A long-legged straw-colored beetle eating holes in the half-ripe fruit.—*Rose Chafer* (*Macrodactylus subspinosus*), p. 305.

XI. INSECTS INJURIOUS TO THE CHERRY

Root:

(a) A thick whitish grub, with brown head and legs, feeding in decaying roots. Beetle large with powerful mandibles.—*Stag Beetle* (*Lucanus dama*), p. 31?.
(b) A large white fleshy grub, with reddish head, feeding in old roots.—*Rough Osmoderma* (*Osmoderma scabra*), p. 305.

Trunk, Branches and Twigs:

(a) A snout beetle gnawing the twigs and fruit.—*Imbricated Snout Beetle* (*Epicærus imbricatus*).
(b) A small beetle boring in the branches just above a bud, and burrowing downward.—*Apple Twig Borer* (*Amphicerus bicaudatus*), p. 327.
(c) A flattened grub tunneling in the bark and sap-wood; beetle bronzy metallic.—*Divaricated Buprestis* (*Dicerca divaricata*).
(d) Large sucking insect with transparent wings, inflicting wounds on the smaller limbs and depositing eggs therein in August and September.—*Dog-day Cicada* (*Cicada tibicen*), p. 157.
(e) Small circular scales, black in winter, with a circular depression about a central nipple.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
(f) Dirty nests inclosing a colony of yellow caterpillars one-half inch long at end of twigs.—*Cherry-tree Tortrix* (*Cacœcia cerasivorana*), p. 230.

Leaves:

(a) A small beetle feeding on the leaves of red cherry.—*Cherry Leaf Beetle* (*Galerucella clavicollis*), p. 311.
(b) A shiny, dark-green slug, one-half inch long, feeding on soft tissues, leaving the veins.—*Pear or Cherry Slug* (*Eriocampoides limacina*), p. 348.
(c) Shining black plant-lice infesting the terminal twigs chiefly, which become distorted and discolored.—*Cherry Plant-louse* (*Myzus cerasi*), p. 144.
(d) Large bluish-green caterpillar two inches long with blue warts on each segment, and coral red ones on the third and fourth segments.—*Promethea Moth* (*Callosamia promethea*), p. 180.
(e) Large pale-green spiny caterpillar, striped on each side with white and lilac.—*Io Moth* (*Hyperchiria Io*), p. 180.
(f) Caterpillars in colonies protected by webs in forks of branches in spring.—*American Tent-caterpillar* (*Malacosoma americana*), and *Forest Tent-caterpillar* (*M. disstria*) not in webs, p. 203.
(g) Caterpillars in colonies protected by webs covering the leaves in summer and early autumn.—*Fall Web Worm* (*Hyphantria textor*), p. 181.

Fruit:

(*a*) A crescent cut on the cherry; grub, white and footless, with a brownish horny head, feeding within.—*Plum Curculio* (*Contrachelus nenuphar*), p. 329.
(*b*) Yellowish-white maggots feeding on the pulpy juices near the pit, inducing a rotting.—*Cherry Fruit Flies* (*Rhagoletis cingulata* and *R. fausta*), p. 265

XII. INSECTS INJURIOUS TO THE PEACH

Root and Lower Trunk:

(*a*) Tunneling in the bark and sapwood of the root and lower trunk, causing an exudation of gum, which is seen at base of tree mingled with the castings.—*Peach Tree Borer* (*Synanthedon exitiosa*), p. 216.

Trunk and Branches:

(*a*) In early spring a minute caterpillar bores into the shoots of new leaves, killing the growing terminals.—*Peach Twig Borer* (*Anarsia lineatella*), p. 215.
(*b*) Black hemispherical scales attached to the bark.—*Peach Leaf Lecanium* (*Lecanium nigrofasciatum*), p. 129.
(*c*) A beetle eating the buds and gnawing into the base of the twigs, causing them to break and fall.—*New York Weevil* (*Ithycerus noveboracensis*).
(*d*) Round scales, gray or black; twigs presenting a scurfy appearance.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
(*e*) Oval scars and longitudinal slits on bark produced hy a green buffalo-shaped bug.—*Buffalo Tree Hopper* (*Ceresa bubalus*), p. 157.

Leaves:

(*a*) Plant-lice, living in colonies under the leaves, causing them to thicken and curl.—*Peach Tree Aphis* (*Myzus persicæ*), p. 144.
(*b*) Minute round scales located usually along the veins.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.
(*c*) Caterpillars protected:
1. In a tortuous tube.—*Leaf Crumpler* (*Mineola indiginella*), p. 213
2. In folded leaves.—*Oblique Banded Leaf Roller* (*Cacoecia rosaceana*), p. 230.

Fruit:

(*a*) Long-legged yellowish beetles eating holes in half-grown peaches.—*Rose Chafer* (*Macrodactylus subspinosus*), p. 305.
(*b*) Large yellow hairy beetles eating holes in ripe peaches.—*Bumble Flower Beetle* (*Euphoria inda*), p. 305.
(*c*) Small snout-beetles making a puncture and crescent in the young fruit.—*Plum Curculio* (*Conotrachelus nenuphar*), p. 329.

XIII. INSECTS INJURIOUS TO THE RASPBERRY AND BLACKBERRY

Roots and Base of Canes:

(*a*) Large grub over two inches long, boring large tunnels in the woody portion of main root. The canes suddenly die.—*Giant Root Borer* (*Prionus laticollis*), p. 321.

(b) Canes at base of main root girdled by a yellowish white caterpillar in late summer and autumn. *Bramble Crown Borer (Bembecia marginata)*, p. 218

Canes:

(a) Longitudinal row of punctures on canes. *Black-horned Tree Cricket (Œcanthus nigricornis)*, p. 116.

(b) Tips of raspberry canes wilting in early summer, due to a girdling of the canes inside the bark.—*Raspberry Cane Maggot (Phorbia rubivora)*, p. 277

(c) Tips of shoots of raspberry wilting in July and August; two rows of horizontal punctures one inch apart at base of wilted portion, with a small hole between. Canes burrowed to the base before autumn.—*Raspberry Cane Borer (Oberea bimaculata)*, p. 321.

(d) Swellings on canes of raspberry and blackberry.—*Red-necked Cane Borer (Agrilus ruficollis)*, p. 301.

Buds:

(a) A small snout-beetle puncturing the flower stem close to the buds, and also the buds.—*Strawberry Weevil (Anthonomus signatus)*, p. 232.

(b) A small yellowish beetle eating the flower buds, which either fail to open or wither.—*Pale Brown Byturus (Byturus unicolor)*, p. 292.

(c) A small brownish caterpillar eating the opening buds.—*Bud Moth (Tmetocera ocellana)*, p. 225.

Leaves:

(a) Bugs sucking the sap of young growing parts, and arresting their development.—*Tarnished Plant Bug (Lygus pratensis)*, p. 163.

(b) Suckers and leaves curled up with enclosed lice.—*Bramble Flea Louse (Trioza tripunctata)*, p. 152.

(c) Small greenish larvæ with spiny tubercles eating the leaves in spring.—*Raspberry Saw-Fly (Monophadnus rubi)*, p. 347.

Fruit:

(a) A looper feeding on fruit of raspberry and blackberry.—*Raspberry Geometer (Synchlora aerata)*.

XIV. INSECTS INJURIOUS TO THE GOOSEBERRY AND CURRANT

Canes:

(a) Tips of canes girdled and wilted; pith tunneled.—*Currant Stem Girdler (Janus integer)*, p. 345.

(b) Centre of cane tunneled by a white caterpillar.—*Imported Currant Borer (Synanthedon tipuliformis)*, p. 217.

(c) Small flat circular scales, black or gray, with a depressed ring about a central nipple in black forms.—*San José Scale (Aspidiotus perniciosus)*, p. 126.

(d) Oval hemispherical scales.—*Currant Lecanium (Lecanium ribis)*.

(e) Longitudinal rows of punctures on canes.—*Black-horned Tree Cricket (Œcanthus nigricornis)*, p. 116.

Leaves:

(a) Larvæ, 20-legged, dull white when young, then greenish with black spots, finally greenish yellow, eating holes in the leaves in early spring.—*Imported Currant Worm* (*Pteronus ribesii*), p. 346.

(b) Leaves curled, blistered, and with a reddish appearance on upper surface, caused by yellowish plant-lice.—*Currant Plant-louse* (*Myzus ribis*), p. 145.

(c) Leaves turning brown and dying.—*Four Lined Leaf-bug* (*Pœcilocapsus lineatus*), p. 163.

(d) Measuring worm feeding on leaves of gooseberry and black currant.—*Currant Span-worm* (*Cymatophora ribearia*), p. 206.

(e) White spots on leaves, produced by a pale green sucking insect occurring on the under surface.—*Currant Leaf Hopper* (*Empoasca*), p. 155.

(f) Green plant-lice.—*Green Gooseberry Aphis* (*Aphis sanborni*).

Fruit:

(a) Greyish caterpillar boring into young fruit and eating out its contents.—*Gooseberry Fruit Worm* (*Zophodia grossulariæ*).

(b) Purplish spots surrounding small circular scales.—*San José Scale* (*Aspidiotus perniciosus*), p. 126.

(c) Yellow oval maggots eating the gooseberry.—*Gooseberry Midge* (*Cecidomyia grossulariæ*).

(d) Small white maggot eating the currant and gooseberry, causing the fruit to turn red and fall.—*Currant Fruit-miner* (*Epochra canadensis*), p. 265.

XV. INSECTS INJURIOUS TO THE GRAPE

(Consult Bull. 331, N. Y. Ag. Exp. St. and Farmers' Bull. 70, U. S. Dep. Ag.)

Roots:

(a) Producing soft yellow irregular spherical galls on rootlets and larger roots, causing death.—*Grape Vine Phylloxera* (*Phylloxera vastatrix*), p. 148.

(b) Large borer, cutting a tube through the root near the surface.—*Broad-necked Prionus* (*Prionus laticollis*).

(c) Grub eating the bark of both the large and small roots.—*Grape Vine Fidia* (*Fidia viticida*), p. 311.

Branches:

(a) Young shoots suddenly break off or droop in spring; a small hole just above the base of the shoot leading into a burrow.—*Apple Twig Borer* (*Amphicerus bicaudatus*), p. 327.

(b) Canes show roughened longitudinal rows of perforations in the bark.—*Tree Cricket* (*Œcanthus nigricornis*), p. 116.

(c) Canes exhibiting white cottony masses attached to a reddish-brown scale.—*Cottony Scale* (*Pulvinaria vitis*), p. 130.

Leaves:

(a) Leaves riddled with irregular holes about mid-summer by a little beetle.—*Grape Vine Fidia* (*Fidia viticida*), p. 311.

(*b*) Small, shining, blue beetle boring into buds in spring, also eating small holes in expanding leaves.—*Grape Vine Flea Beetle* (*Haltica chalybea*), p. 315.

(*c*) Long-legged brownish beetles eating the blossoms, leaves and fruit.—*Rose Chafer* (*Macrodactylus subspinosus*), p. 305.

(*d*) Greenish caterpillar, feeding within a folded leaf and skeletonizing it, about mid-summer.—*Grape Leaf Folder* (*Desmia funeralis*).

(*e*) Leaves blotched and scorched, finally curling up and falling, caused by little jumping insects.—*Grape Thrips or Leaf Hopper* (*Typhlocyba comes*). p. 155.

(*f*) Large greenish caterpillar, with a pale yellow stripe down each side and a horn near tail.—*Grape Vine Sphinx* (*Ampelœca myron*), p. 178.

(*g*) Several other sphingid larvæ feed on the leaves of the grape.

(*h*) Black beetle eating the tissues on the upper surface of the leaves, and discoloring them.—*Red-headed Systena* (*Systena frontalis*), p. 315.

(*i*) Producing small, irregular, spherical galls on the lower surface of the leaves. —*Grape Vine Phylloxera* (*Phylloxera vastatrix*), p. 148.

(*j*) Large reddish-yellow beetle with six black spots on wing cover, eating holes in leaves.—*Spotted Pelidnota* (*Pelidnota punctata*), p. 302.

Fruit:

(*a*) Ripening fruit discolored and burrowed by a whitish caterpillar.—*Grape Berry Moth* (*Polychrosis viteana*), p. 228.

(*b*) Holes eaten in ripe fruit; beetle large, yellowish, hairy.—*Bumble Flower Beetle* (*Euphoria inda*), p. 305.

(*c*) Holes eaten in young fruit by a long-legged beetle.—*Rose Chafer* (*Macrodactylus subspinosus*), p. 305.

XVI. INSECTS INJURIOUS TO THE STRAWBERRY

Roots:

(*a*) A pinkish caterpillar boring irregular channels through the crown and larger roots, causing them to wither and die.—*Strawberry Root Borer* (*Anarsia lineatella*), p. 215.

(*b*) A white grub boring downward from the crown.—*Strawberry Crown Borer* (*Tyloderma fragariæ*), p. 332.

(*c*) A large white grub eating the roots.—*May Beetle* (*Lachnosterna sp.*), p. 302.

(*d*) Grubs girdling the roots, causing death.—*Strawberry Root-weevil* (*Otiorhynchus ovatus*), p. 336.

Leaves:

(*a*) Brownish caterpillars, in June and August, rolling the leaves into cases and fastening them with silk.—*Strawberry Leaf Roller* (*Ancylus comptana*), p. 232.

(*b*) Young plants gnawed off at the surface.—*Cutworms*, p. 185.

(*c*) Small pale spotted active beetles riddling the leaves with holes in June.—*Spotted Paria* (*Paria 6-notata*).

(*d*) Small active jumping striped beetles, eating holes in the leaves.—*Striped Flea Beetle* (*Phyllotreta vittata*), p. 314.

(*e*) Twenty-legged grubs eating holes in the leaves.—*Strawberry Saw fly* (*Emphytus maculatus*)

Fruit:

(*a*) Caterpillars feeding on the berry.—*Stalk Borer* (*Papcipcrna nitela*), p. 196.
(*b*) Minute black bugs producing a buggy odor when eaten with berry.—*Flea-like Negro Bug* (*Corimelæna pulicaria*), p. 167.
(*c*) Flower huds drooping and bending over.—*Strawberry Weevil* (*Anthonomus signatus*), p. 332.
(*d*) Fruits deformed to "buttons."—*Strawberry Thrips* (*Euthrips tritici*), p. 122.

XVII. INSECTS AFFECTING SHADE TREES

(Consult *Insects Affecting Park and Woodland Trees* by Felt)

(*a*) Feeding on the leaves.
(*b*) Feeding or resting under webbed tents.
(1) Hairy yellowish-brown and black marked caterpillars feeding on leaves within webbed tents in July-Sept.; adult moths white or black-spotted.—*Fall Web Worm* (*Hyphantria cunea*), p. 181.
(2) Hairy black caterpillars, white stripe along middle of back, lateral white and yellow line with blue spots. Resting in silken wehbed tents at angles of branches.—*Orchard Tent-caterpillar* (*Malacosoma americana*), p. 203.
(*bb*) Feeding free on the leaves.
1. Adult moths not white.
(1) Caterpillars with a broken line of white dots along back, and resting in masses on sides of branches and trunks, not within webs.—*Forest Tent-caterpillar* (*Malacosoma disstria*), p. 204.
(2) Caterpillars with red heads and yellow and hlack tufts and pencils. Female moth wingless.—*White-marked Tussock Moth* (*Hemerocampa leucostigma*), p. 202.
(3) Brownish caterpillars with blue and reddish warts; hibernating as egg-masses covered with hair; adult female moth with white wings marked with dark wavy lines, wings of males light brown.—*Gipsy Moth* (*Porthetria dispar*), p. 200.
(4) "Measuring worms" feeding in the daytime in spring and early summer.—*Fall Canker Worm* (*Alsophila pometaria*), p. 205.
(5) Caterpillars with tufts of white, black, or yellow hairs, and pencils of black or orange or white hairs. Feeding on hickory, butternut, etc.—*Tiger Moths* (*Halisidota* spp.), p. 183.
(6) Caterpillars with sharp pale yellow hairs and with a pair of long black hair pencils on the first and third abdominal segments, and a single one on the eighth. Feeding on elm, maple, hickory, oak, asb, poplar, etc.—*American Dagger Moth* (*Acronycta americana*), p. 198.

(7) Caterpillars black with a loose covering of soft whitish hairs. Feeding in clusters on walnut, hickory, oak, beech, etc.—*Walnut Caterpillar* (*Datana integerrima*), p. 199.

(8) Small green caterpillars, skeletonizing the leaves of birches and forming small round white moulting cocoons on the twigs and leaves.—*Birch Leaf Skeletonizer* (*Bucculatrix canadensisella*), p. 236.

(9) A bright yellow looper with rust-colored head and with ten crinkled black lines along the back. Attacks elm, basswood, hickory, apple, etc.—*Lime-tree Winter Moth* (*Erannis tiliaria*).

2. Adult moths white.

(1) Caterpillars reddish-black with only two pairs of prolegs; with three pairs of small tubercles on back; hibernate as egg-masses of 20–100 on branches.—*Snow-white Linden Moth* (*Ennomos subsigniarius*), p. 206.

(2) Dark brown caterpillars, with a lateral row of white hairs and bright red tubercles on sixth and seventh adbominal segments; hibernate as one-fourth grown caterpillars in nests of webbed leaves on tips of trees; adult moth with a tuft of brown hairs at tip of abdomen.—*Brown Tail Moth* (*Euproctis chrysorrhœa*), p. 200.

3. Adults are butterflies. Caterpillars large, black, red-marked and spiny, feeding in clusters on terminal branches of elm, willow, poplar.—*Spiny Elm Caterpillar* (*Aglais antiopa*). p 176.

4. Adults are beetles. Adults eating irregular circular holes in elm leaves and grubs skeletonizing the under surface.—*Elm Leaf Beetle* (*Galerucella luteola*), p. 309.

5. Adults are Saw-flies.

(1) Larvæ cylindric, coiled, yellowish-white, with a black line down the middle of back, feeding on elm, poplar, willow, etc.—*Elm Saw-fly* (*Cimbex americana*), p. 347.

(2) Larvæ with jet black head and green body, each segment except second marked with double parallel rows of dark dots; feeding on larch leaves.—*Larch Saw-fly* (*Lygæonematus erichsonii*), p. 346.

(*aa*) Boring in trunks and branches.

(*b*) Adults are moths.

1. Whitish caterpillars with distinct spots and tubercles making burrows in twigs and larger branches, which often die and project above leafy branches. Moths are white with blue and black markings.—*Leopard Moth* (*Zeuzera pyrina*), p. 237.

2. Large white or reddish-white caterpillars making large round irregular borings in oak, maple and locust. Moth is large, dark grey.—*Carpenter Worm* (*Prionoxystus robiniæ*), p. 238.

(*bb*) Adults are beetles.

1. Long-horned or cerambycid beetles.
   (1) Large fleshy legless grubs making broad shallow tunnels in sapwood of sugar-maples, often killing limbs. Adult beetle brilliantly marked with yellow and black.—*Sugar Maple Borer* (*Plagionotus speciosus*), p. 323.
   (2) A whitish hairy grub making a central burrow plugged with sawdust, and cutting off twigs of maple or oak.—*Twig Pruner* (*Elaphidion villosum*), p. 323.
   (3) White flattened legless grubs working under the bark of elm; adult a gray beetle with red lines and black spots.—*Elm Borer* (*Saperda tridentata*), p. 321.
   (4) White legless grubs making large irregular channels in sapwood and inner bark of poplar; large blackened swollen scars on the surface of the trunk and limbs of affected trees.—*Poplar Borer* (*Saperda calcarata*) tunnels in poplar producing rough discolored scars on the trunk. *Saperda candida* bores into hawthorn, mountain ash, and fruit trees, and *Saperda vestita* into basswood.
   (5) Club-shaped grubs, making irregular ugly scars opening into burrows in black locust. Adult beetle is dull black brightly marked with golden yellow, and feeds on golden rod blossoms.—*Locust Borer* (*Cyllene robiniæ*), p. 321.
2. Metallic wood borers or Buprestid beetles.
   (1) Large headed flattened legless grubs making shallow tunnels.—*Flat-headed Borer* (*Chrysobothris femorata*), p. 300.
   (2) A flattened whitish grub with a large flattened head, making irregular spiral burrows in the inner bark of bircb.—*Bronze Birch Borer* (*Agrilus anxius*), p. 301.

(*aaa*) Sucking the juices from twigs or leaves.

(*b*) On the leaves.

1. Producing terminal galls on white and Norway spruce; branch scraggly deformed.—*Spruce Gall Aphis* (*Chermes similis*), p. 150.
2. Producing galls on white and Norway spruce, not terminal, pineapple shaped.—*Spruce Gall Aphis* (*Chermes abietis*), p. 149.
3. Snow-white woolly plant-lice on leaves of larch.—*Larch Woolly Aphis* (*Chermes strobilobius*).

(*bb*) On the bark.

1. Clusters of woolly aphis on elm.—*Woolly Aphis of Elm* (*Schizoneura americana*), p. 145.
2. Reddish woolly bordered bark-lice on under surface of elm leaves.—*Elm Bark-louse* (*Gossyparia spuria*), p. 130.
3. Cottony masses attached to brown scales on under side of twigs of soft maple, elms, etc.—*Cottony Maple Scale* (*Pulvinaria vitis*), p. 130.

4. Hemispherical reddish scales mottled with black lines on under side of branches of maples.—*Terrapin Scale* (*Lecanium nigrofasciatum*), p. 129.
5. Flocculent white masses upon greenbark of cultivated white pine.—*Pine Bark Aphis* (*Chermes pinicorticis*), p. 150.
6. Twigs of balsam twisted and leaves curled by plant-lice.—*Balsam Twig Aphis* (*Mindarus abietinus*).

XVIII. INSECTS INJURIOUS TO GREENHOUSE PLANTS

(*a*) Minute active white four-winged flies living on the under side of leaves, sucking tbe juices; young are oval, flat and greenish.—*White Fly* (*Aleyrodes vaporariorum*), p. 151.

(*b*) Small soft mealy-covered bugs, with eggs enclosed in cottony sacks.—*Mealy Bugs* (*Pseudococcus* spp.), p. 131.

(*c*) Oval, flat or saddle-shaped scales, on leaves of lemons, ferns, oleanders, crotons, etc.—*Soft Scale* (*Lecanium hemisphericum*), p. 134.

(*d*) Round scales on leaves and twigs of ivy, date palms, etc.—*Hard Scale* (*Aspidiotus* spp.), p. 134.

(*e*) White scales on leaves of Boston fern, aspidistra, etc., causing spotting and browning.—*Aspidistra Scale* (*Hemichionaspis aspidistræ*), p. 135.

(*f*) Green plant-lice, often infesting violets and sucking tbe juices from the leaves, checking the growth.—*Green Aphis* (*Myzus persicæ*), p. 144.

(*g*) Black plant-lice sucking the juices of chrysanthemums.—*Black Aphis* (*Macrosiphum sanborni*), p. 149.

(*h*) Red mites, spinning fine webs on under surface of leaves and sucking the juices rendering the leaves sickly yellow.—*Red Spider* (*Tetranychus bimaculatus*).

(*i*) A small maggot, causing the edges of violet leaves to curl and turn yellow.—*Violet Gall-fly* (*Diplosis violicola*).

(*j*) A small greenisb-white and striped caterpillar, eating lower epidermis of chrysanthemums, cinerarias, roses, carnations, etc., and tying the leaves together.—*Greenhouse Leaf-tyer* (*Phlyctænia ferrugalis*), p. 210.

(*k*) Maggots feeding in flower and leaf buds of greenhouse roses, causing them to brown, blacken and die.—*Rose Midge* (*Dasyneura rhodophaga*), p. 248.

(*l*) Flesb-colored legless grub attacking roots of cyclamen, gloxinia, primula.—*Cyclamen Borer* (*Otiorhynchus sulcatus*), p. 336.

XIX. INSECTS AFFECTING DOMESTIC ANIMALS

(Consult *Insects Affecting Domestic Animals* by Osborn, Bull. 5, U. S. Div. Ent.)

A. Sheep

(*a*) Maggots in nostrils and in nasal sinuses, causing catarrh and staggers; deposited by a two-winged fly in June and July.—*Sheep Bot-fly* (*Œstrus ovis*).

(*b*) Wool falls off in patcbes and large scabs form on body with much itching due to a mite.—*Sheep Scab* (*Psoroptes communis*), p. 366.

(*c*) Brownish flattened tick-like insects sucking the blood; common on lambs in spring.—*Sheep Tick* (*Melophogus ovinus*), p. 279.

B. Cattle

(*a*) Swellings or "warbles" along the back in winter; bee-like flies bothering cattle in June and July.—*Ox-warble* (*Hypoderma lineatum* and *H. bovis*), p. 255.

(*b*) Small flies clustering on base of horns, flanks and belly of cattle in summer, causing them much annoyance.—*Horn Fly* (*Hæmatobia serrato*), p. 272.

(*c*) Slaty-colored sucking lice, often abundant on neck and shoulders of neglected cattle.—*Short-nosed Ox Louse* (*Hæmatopinus eurysternus*), p. 000. *Long-nosed Ox Louse* (*Hæmotopinus vituli*), p. 169.

(*d*) "Little red lice" feeding on the rough parts of the skin and on the hairs, causing irritation; most abundant in spring.—*Biting Cattle Louse* (*Trichodectes scalaris*), p. 100.

(*e*) Hair falls off in patches and large scabs form—with much itching—due to mites. *Common Cattle Scab Mites* (*Psoroptes Communis bovis*), *Sarcoptic Scab Mite* (*Sarcoptes scabiei bovis*), *Tail Mange Mite* (*Chorioptes bovis bovis*). (See Farmers' Bull. 1017, U. S. Dep. Ag.).

C. Horses

(*a*) Bots attached to wall of stomach—adult fly light brown; does not bite but horse is worried; eggs laid on hairs of legs and shoulders.—*Horse Bot-fly* (*Gastrophilus intestinalis*), p. 258.

(*b*) Similar to (*a*) but eggs are attached to hairs of lips and nostrils.—*Chin Bot-fly* (*Gastrophilus nasalis*) and the *Red-tailed Bot-fly* (*G. hæmorrhoidalis*), p. 259.

(*c*) Large black fly that flies swiftly and bites severely, giving much annoyance to horses.—*Horse Gadfly* (*Tabanus atratus*), p. 252.

D. Hogs

(*a*) Gray sucking lice, often quite large.—*Hog Louse* (*Hæmatopinus urius*), p. 169.

E. Poultry

(*a*) Yellowish or reddish mites infesting hens and [illegible]icks at night; piercing the skin and sucking the blood, causing much irritation a[illegible]n death.—*Chicken Mite* (*Dermanyssus gallinæ*), p. 364.

(*b*) Small pale yellow active insects feeding on rough parts of skin and bases of hairs and feathers, causing much irritation.—*Common Hen Louse* (*Menopon pallidum*), p. 100.

(*c*) Minute mites burrowing under the scales of foot, leg, comb and beak, producing "scaly leg" with much irritation. Contagious.—*Itch Mite* (*Sarcoptes mutans*), p. 365.

(*d*) Small mites causing the feathers to break off. Contagious.—*Depluming mite* (*Sarcoptes gallinæ*).

XX. INSECTS OF THE HOUSEHOLD

A. Annoying the Inmates

(*a*) Slender two-winged insects; only the females bite or pierce the skin; larvæ and pupæ live in stagnant water.—*Common Mosquito* (*Culex pipiens*), p. 243.

(*b*) Similar to (*a*) but larger and with wings spotted.—*Malarial Mosquito* (*Anopheles maculipennis*), p. 244.

(*c*) Two-winged insects, with four black lines on thorax; they lap but do not pierce; eggs laid on manure or decaying organic matter.—*House Fly* (*Musca domestica*), p. 270.

(*d*) Similar to (*c*) but with six black lines on thorax, and with piercing mouth-parts.—*Stable Fly* (*Stomoxys calcitrans*), p. 271.

(*e*) Compressed, wingless long-legged insects with piercing and sucking mouth-parts, hiding in bedding and clothing; eggs laid among hairs of cat or dog.—*Cat and Dog Flea* (*Pulex serraticeps*), p. 280.

(*f*) Reddish-brown, flat bugs with buggy odor, hiding in day time in cracks, but active at night; with piercing and sucking mouth-parts.—*Bed-bugs* (*Cimex lectularius*), p. 167.

B. Feeding on or Destroying Clothing, Carpets, Upholstery, Etc.

(*a*) Tiny dusky moths, laying eggs in furs or woolens, the larvæ eating holes in them.—*Case-making Clothes Moth* (*Tinea pellionella*), p. 236. *Webbing Clothes Moth* (*Tinea bisselliella*), p. 237. *Tapestry Clothes Moth* (*Trichophaga tapetzella*), p. 237.

(*b*) Small oval red, black and white beetles, whose grubs are hairy, feeding on carpets on underside, usually along a crack of the floor.—*Buffalo Carpet Beetle* (*Anthrenus scrophulariæ*), p. 291.

(*c*) Tiny active wingless insects with silvery appearance, and with three long feelers at hind end of body, feeding on linen or paper containing starch, sugar, etc. *Silver-fish* (*Lepisma saccharina*), p. 95.

C. Feeding on Food Products

(*a*) Active wary light-brown insects with a "roachy" odor, found in pantries and bakeries; several species but the most common is the *Croton-bug* or *German Cockroach* (*Ectobia germanica*), p. 105.

(*b*) Brown beetles, one-third inch long, whose grubs are brown above, white below and covered with long brown hairs; found where meats, skins and feathers are kept.—*Larder Beetle* (*Dermestes lardarius*), p. 291.

(*c*) Large black flies with bluish abdomen and with black spines on thorax; eggs laid on meat.—*Blow or Meat Fly* (*Calliphora vomitoria*), p. 273.

(*d*) Little red ants that have their nests in the wall or beneath the flooring.—*House Ants* (*Monomorium pharaonis*), p. 361.

(*e*) Black ants and pavement ants living outdoors sometimes invade houses.—*Black Ants* (*Monomorium minutum*), p. 361.

PART III

CLASSIFICATION AND DESCRIPTION OF COMMON INSECTS

THE COMMON ORDERS AND GROUPS OF INSECTS

SYNOPSIS OF THE ORDERS OF INSECTS REFERRED TO IN THE CLASS BOOK

Aptera Group.	I. Thysanura.
	II. Collembola.
Neuropteroida Group.	III. Plecoptera.
	IV. Ephemerida.
	V. Odonata.
	VI. Neuroptera.
	VII. Mecoptera.
	VIII. Trichoptera.
Orthopteroida Group.	IX. Mallophaga.
	X. Isoptera.
	XI. Corrodentia.
	XII. Blattoidea.
	XIII. Mantoidea.
	XIV. Phasmoidea
	XV. Dermapter
	XVI. Orthoptera
	XVII. Thysanoptera.
Hemipteroida Group	XVIII. Homoptera.
	XIX. Hemiptera.
	XX. Siphunculata.
	XXI. Lepidoptera.
	XXII. Coleoptera.
Dipteroida Group.	XXIII. Diptera.
	XXIV. Siphonaptera.
	XXV. Hymenoptera.

A. With two wings; mouth-parts formed for sucking or piercing; metamorphosis complete.—*DIPTERA* (Flies).

AA. With four wings.

B. Mouth-parts formed for biting.

C. Upper wings horny; metamorphosis complete.—*COLEOPTERA* (Beetles), p. 280.

CC. Upper wings parchment-like; lower wings folded under the upper; metamorphosis incomplete.—*ORTHOPTEROIDA Group* (Locusts, etc.), p. 102.

CCC. Upper wings membranous with many veins.—*NEUROPTEROIDA Group* (Nerve-winged insects), p. 96.

BB. Mouth-parts formed for sucking and biting; wings with few cross veins and similar in texture; metamorphosis complete.—*HYMENOPTERA* (Bees, etc.), p. 343.

BBB. Mouth-parts formed for sucking; wings covered with scales; metamorphosis complete.—*LEPIDOPTERA* (Butterflies and moths), p. 160.

BBBB. Mouth-parts formed for piercing.

C. Beak jointed; palpi absent; last joint of tarsi not bladder-like.

D. Wings of uniform texture; beak arising from the hinder edge of under side of the head; metamorphosis incomplete.—*HOMOPTERA*, p. 122.

DD. Fore wings leathery at base, membranous at tip; beak arising from the front of the head; metamorphosis incomplete.—*HEMIPTERA* (True Bugs), p. 158.

CC. Beak unjointed, palpi present; last joint of tarsi bladder-like, and without claws; wings similar; metamorphosis incomplete.—*THYSANOPTERA* (Thrips), p. 118.

AAA. Wingless.

B. Mouth-parts formed for biting; louse-like insects.

C. Mouth-parts retracted within the head; no metamorphosis.—*APTERA Group*, p. 94.

CC. Mouth-parts not retracted within the head.

D. Antennæ with many segments; metamorphosis incomplete.—*CORRODENTIA* (Book-lice), p. 103.

DD. Antennæ with not more than five segments; metamorphosis incomplete.—*MALLOPHAGA* (Biting-lice), p. 100.

BB. Mouth-parts formed for sucking.

C. Tarsus with a single hook-like claw; with a fleshy unjointed beak; parasitic on mammals (*Parasitica*).—*SIPHUNCULATA*, p. 167

CC. Tarsus five-jointed; body compressed; metamorphosis complete.—*SIPHONAPTERA* (Fleas).

The Aptera Group

Chief Orders and Families:

A. Abdomen with at least 10 segments; antennæ many-jointed; usually with terminal abdominal appendages.—*Thysanura Order*.

B. Body covered with scales.—*Lepismidæ*.

BB. Body not covered with scales.
C. Caudal appendages many-jointed.—*Campodeidæ.*
CC. Caudal appendages sickle-shaped.—*Japygidæ.*
AA. Abdomen with not more than six segments; antennæ with not more than eight joints; no caudal appendages.—*Collembola Order.*
B. Ventral spring present.
C. Spring on penultimate abdominal segment.
D. Abdomen globular.—*Sminthuridæ.*
DD Abdomen cylindrical.—*Entomobryidæ.*
CC. Spring on antepenult abdominal segment.—*Poduridæ.*
BB. Ventral spring absent.—*Aphoruridæ.*

Of the above Apterous families only one, the *Lepismidæ* of the Thysanura, contains forms that are of economic importance.

ORDER THYSANURA

LEPISMIDÆ (Fish-moths)

The **Fish-moth, Silver Fish, or "Slicker"** (*Lepisma saccharina* Linn.) sometimes does injury to books, papers, labels and starched clothing. It shuns light and is quite active.

Adult.—A minute, glistening, scaly, fish-like active insect, wingless, ⅓ inch long, body tapering to hind end where are three long, bristle-shaped appendages; antennæ prominent; coxæ strongly developed; biting mouth parts.

Another species, *Lepisma domestica* Pack., is found in bakeries and mills in some localities. It has dusty markings on its upper surface and is ½ inch long.

Control.—Frequent use of fresh insect powder, sodium fluoride, or a poison-bait of sweetened gluey paste and white arsenic on bits of cardboard.

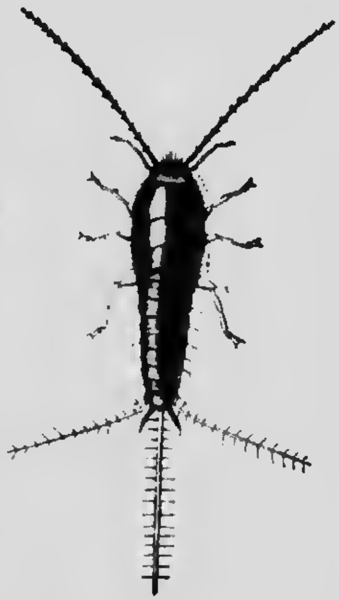


Fig. 50.—The silver fish (*Lepisma saccharina*). (*After Marlatt.*)

PODURIDÆ (Springtails)

Two species may be noted in passing: *Achorutes armatum* sometimes attacking seedlings causing disfigurement and loss, and *A. nivicola* often abundant in maple sap in early spring. Both species are minute, and have some of the habits of flea-beetles (Fig. 51).

The Neuropteroida Group

Certain orders of aquatic insects have a superficial resemblance of wing venation, and were formerly grouped together into one order, the Neuroptera. Of the six main Orders three have *incomplete* metamorphosis, viz., *Plecoptera*, *Ephemerida* and *Odonata*, and three complete metamorphosis, viz., *Trichoptera*, *Neuroptera* and *Mecoptera*.

Fig. 51.—The snow flea (*Achorutes nivicola*). Enlarged greatly. (*After Folsom.*)

It is probable, therefore, that the first three orders are not so highly evolved as the last three. The former are lower than the Orthoptera, while the latter are higher and come between the *Hemiptera* and the *Lepidoptera*.

Chief Orders:[1]

The Neuropteroida (or nerve-winged) group of insects includes six main orders which may be separated as follows:

A. Lower wings folded in plaits under the upper.
  B. Wings covered with hairs; tarsi 5-jointed; metamorphosis *complete*.—*Trichoptera* (Caddice-flies).
  BB. Wings not covered with hairs.
    C. Tarsi 5-jointed; wings equal and with many veins and cross-veins; mouth-parts well developed; metamorphosis *complete.—Neuroptera* (Dobson flies, Aphis lions, etc.).
    CC. Tarsi 3-jointed; hind wings larger than fore-wings; with caudal filaments; biting mouth-parts poorly developed; metamorphosis *incomplete.—Plecoptera* (Stone-flies) (Fig. 54).

AA. Lower wings not folded under the upper.
  B. Head prolonged into a beak; antennæ long; metamorphosis *complete.—Mecoptera* (Scorpion-flies).
  BB. Head not prolonged into a beak; antennæ inconspicuous; metamorphosis *incomplete*.

[1] Handlirsch arranges these orders into groups as follows:

Odonata	Sub-class Libelluloidea.
Plecoptera (Ephemerida)	Sub-class Ephemeroidea.
Plecoptera	Sub-class Perloidea.
Neuroptera, Megaloptera, Raphidioidea	Sub-class Neuropteroidea.
Panorpatæ, Trichoptera, *Lepidoptera*	Sub-class Panorpoidea.

C. Abdomen with 2 or 3 long filaments; lower wings much smaller than upper; antennæ short.—*Ephemerida* (May-flies) (Fig. 53).

CC. Abdomen without jointed filaments; wings about equal in size; antennæ short. *Odonata* (Dragon-flies).

The larvæ of most of the Neuropteroid insects are aquatic and are of little economic importance in agriculture. They are of importance, however, in fish-culture. In the Stone-flies Newcomer has recently reported that several species of *Tæniopteryx* (especially *T. pacifica*) with well developed mouth-parts cause considerable injury to foliage and fruit in Central Washington.

FIG. 52.—May-fly (*Hexagenia*), adult. (*After Folsom.*)

FIG. 53.—May-fly, nymph.

LARVAL FORMS OF THE NEUROPTEROIDA

A. Body cylindrical, caterpillar-like.—*Mecoptera*.

AA. Body more or less depressed, not caterpillar-like.

B. Mandibles united with corresponding maxillæ.—*Neuroptera*.

BB. Mandibles separate from corresponding maxillæ.

C. Body encased in a shell of gravel, etc.—*Trichoptera*.

CC. Body not encased in a shell.

D. Abdomen with external lateral gills and terminated by 2 or 3 long gill processes.—*Ephemerida* (Fig. 53).

DD. Abdomen without external lateral gills.

E. Lower lip strong extensile and furnished with a pair of opposable hooks; abdomen terminated by 3 leaf-like tracheal gills, or with 5 spine-like appendages. *Odonata.*

EE. Lower lip not extensile and without hooks; caudal filaments and antennæ long and slender; thorax with 3 pairs of tracheal gills.—*Plecoptera.*

On account, however, of their common occurrence the economic entomologist should know a little at least regarding their habits and life-history.

Stone-flies (Plecoptera).—The nymphs live under stones in swift streams, are flattish, and have tracheal gills, long legs, cerci and

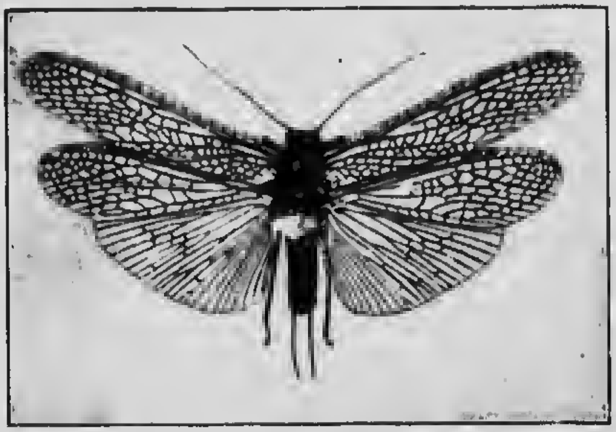


FIG. 54.—An adult stone-fly (*Pteronarcys regalis*). Slightly reduced. (*After Folsom*).

antennæ. The adults are greyish and have prominent wings. The hind wings are the larger and when at rest are folded under the front ones. The larvæ furnish food for fishes (Figs. 54 and 55).

May-flies (Ephemerida).—May-flies are well-known insects, being attracted to lights in immense numbers in early summer. They have large delicate wings and 2 or 3 long caudal filaments. The fore wings are much larger than the hind ones. The nymphs live at the bottoms of bodies of water, and have long legs, caudal filaments and prominent tracheal gills. They mature in 1 to 3 years, and furnish abundant food for fishes.

Dragon-flies and Damsel-flies (Odonata).— These insects are also well known. They are rapid fliers over bodies of water, feeding on flies and mosquitoes. The nymphs live at the bottom of ponds and streams. They have long legs, and are flat and spiny. Dragon-flies hold their wings horizontally when at rest, and the nymphs have rectal respiration; while the damsel-flies hold their wings vertically when at rest, and the nymphs have three caudal tracheal gills (Fig. 56).

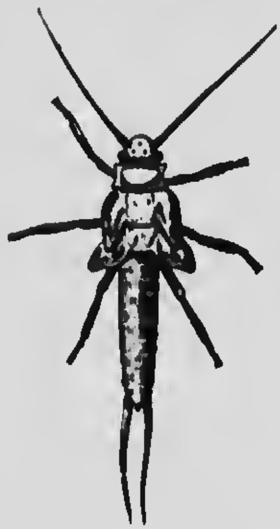


FIG. 55.—Nymph of stone-fly (*Pteronarcys regalis*).

Caddice-flies (Trichoptera).—The larvæ of these insects are known as *caddice-worms*, and live in water within protecting cases of fine gravel, leaves, sticks, stalks or small shells, fastened together by threads of silk. They crawl about carrying their cases with them. When full-grown they change to *pupæ* within the cases and at length emerge as four-winged flies. During summer immense numbers are attracted to lights at night. The wings are hairy, and, at rest, are held like a roof over the back. The eggs are usually laid on water plants.

FIG. 56.—Dragon-fly (*Libellula pulchella*). Last nymphal skin and wings. Slightly reduced. (*After Folsom.*)

Dobson-flies, Lace-wings, Ant-lions (Neuroptera).—*Dobson-flies* are large insects with prominent biting mouth-parts and wings. Their larvæ live under stones in swift streams, and have rather conspicuous tracheal gills. They become full-grown in about three years.

Lace-wings are delicate pale-green insects with finely veined wings. The larvæ have large jaws, and owing to their habit of feeding upon aphids are called *aphis-lions*. The pupæ are enclosed in a white cocoon of silk (Fig. 57).

Fig. 57.—A lace-wing (*Chrysopa*). Slightly reduced. (*After Folsom.*)

Ant-lions are predaceous larvæ, which lie in wait for their prey at the bottom of funnel-shaped pits. The adults have narrow delicate wings.

Scorpion-flies (Mecoptera).—*Scorpion-flies* have their head prolonged into a beak. The larvæ live in the ground and are caterpillar-like. Both larva and adult are carnivorous.

ORDER MALLOPHAGA (BITING LICE)

Chief Families and Genera:

A. Antennæ filamentous, exposed, 3- or 5-jointed; maxillary palpi absent; mandibles vertical; middle and hind segments of thorax fused.
  - B. Antennæ 3-jointed; tarsi with a single claw; infesting mammals.—*Trichodectidæ*.
    - Genus: *Trichodectes.*
  - BB. Antennæ 5-jointed; tarsi with two claws; infesting birds.—*Philopteridæ*.
    - Genera: *Docophorus, Lipeurus, Nirmus, Goniodes, Goniocotes.*

AA. Antennæ clavate or capitate, concealed, 4-jointed; maxillary palpi 4-jointed; mandibles borizontal; middle and hind segments of thorax separated by a suture.
  - B. Tarsi witb a single claw; infesting mammals.—*Gyropidæ*.
    - Genus: *Gyropus.*
  - BB. Tarsi witb two claws; infesting birds.—*Liotheidæ*.
    - Genera: *Menopon, Trinoton.*

(Consult Bull. 5, n.s. Divison of Etomology, U. S. Dept. of Agriculture, by Osborn)

Although most commonly found on poultry, Biting Lice sometimes infest the larger domestic animals. They do not suck blood but feed on the rough parts of the skin and at the base of hairs and feathers, causing considerable irritation. Young chicks frequently suffer severely from their attacks.

The most abundant species found on fowls is the **common hen louse** (*Menopon pallidum*), a pale yellow active insect, 1/25 inch long, with six legs (Fig. 58).

The eggs or "nits" are oval objects attached to the vanes and barbs of the feathers, usually on the down feathers. They hatch in 8 to 10 days and become full grown in 2 to 3 weeks.

Dampness, filth and warm weather favor their increase.

Control.—(*a*) Sanitary surroundings with access to a dust bath. (*b*) Dusting with lice powder, such as insect powder, or one prepared as follows: 3 parts gasoline, 1 part crude carbolic acid (90–95 per cent.), or 1 part cresol. Mix together and add, with stirring, plaster-of-Paris to take up all the moisture (about 4 qts. to 1 qt. of liquid). (*c*) Dusting with sodium fluoride. All remedies should be applied more than once.

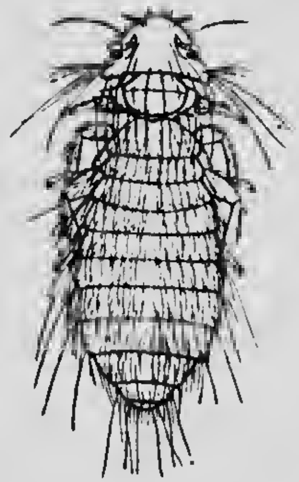


FIG. 58.—Chicken louse. (*Menopon.*)

Following are the common Mallophaga infesting domesticated birds:

A. *Feather-lice Infesting Chickens:*

1. Head nearly square, abdomen not conspicuously marked, 1/25 inch long.—*Goniocotes hologaster* Nitzsch (Lesser Chicken Louse).
2. Head almost circular in front, narrowed behind, thorax small; head, thorax, and legs yellowish; white stripes on segment of abdomen, 1/8 inch long.—*Goniocotes abdominalis* Piaget (Larger Chicken Louse).
3. Yellowish with black markings, uncommon.—*Goniocotes burnetti* Pack.
4. Smooth and shining, head squarish, 1/10 inch long, tawny, pubescent.—*Goniodes dissimilis* Nitzsch.
5. Body elongated, smooth and shining, black margins.—*Lipeurus variabilis* Nitzsch.
6. Yellowish, slender louse, 1/20 inch long, common.—*Menopon pallidum* Nitzsch (Hen or Chicken Louse).

B. *Feather-lice of Ducks and Geese:*

1. Head and thorax red with dark bands; abdomen whitish at middle, brown at sides, 1/2 inch long.—*Docophorus icterodes* Nitzsch.
2. White, smooth, and shining, on goose.—*Lipeurus tadornæ* Denny.

3. Large, 1/6 inch long, elongated, yellowish, head cone-pointed, on ducks.—*Lipeurus squalidus* Nitzsch.
4. Large well-marked louse, 1/5 inch long, on ducks.—*Trinotum luridum* Nitzsch.
5. White, almost transparent louse, on goose.—*Trinotum lituratum* Nitzsch.

C. *Feather-lice of Turkey:*

1. Head with hind angles extending backward into bristly styles; 1/8 inch long.—*Goniodes stylifer* Nitzsch.
2. Yellowish, elongated, flat pointed body, 1/5 inch long.—*Lipeurus polytrapezius* Nitzsch.

ORTHOPTEROID INSECTS

The old Order Orthoptera is now broken into several new Orders by the elevation of certain Families to ordinal rank. The relationship of these and other allied orders is shown by the following grouping:

I. *Sub-class:* Orthopteroida.
Orders: Orthoptera, Phasmoidea and the allied orders Dermaptera and Thysanoptera.

II. *Sub-class:* Blattæformia.
Orders: Mantoidea, Blattoidea and the allied orders Isoptera, Corrodentia and Mallophaga.

Chief Economic Orthopteroid Orders:

A. Hind femora large and fitted for jumping.—*Orthoptera* (*Locusts, Crickets, etc.*

AA. Hind femora not large, not fitted for jumping.

B. Body elongate; abdomen without movable forceps.

C. Front legs spined and fitted for grasping.—*Mantoidea* (*Mantids*).

CC. Front legs not formed for grasping, legs long and slender.—*Phasmoidea* (*Walking sticks*).

BB. Body elongate; abdomen with movable forceps; fore wings sh[illegible]d horny, hind wings nearly circular.—*Dermaptera* (*Earwigs*).

BBB. Body oval, flattened; legs fitted for running.—*Blattoidea* (*Cockroaches*).

ORDER ISOPTERA (WHITE ANTS)

Family TERMITIDÆ

This order is characterized by incomplete metamorphosis, biting mouth-parts and net-veined wings that fold flat upon the back.

There is but one Family—the *Termitidæ*. The members of each species live in communities in the ground or sometimes on trees and include males, females and neuter workers and soldiers. They feed upon vegetable fibre, and are often injurious to furniture, books and wooden structures.

Termites are most abundant in tropical or semi-tropical countries. A few species such as *Leucotermes flavipes* are found as far north as Canada.

ORDER CORRODENTIA (BOOK-LICE)

Family PSOCIDÆ

These insects have biting mouth-parts and are either wingless or with roof-like wings. The Family *Psocidæ* includes the minute *book-lice* which are often injurious to old books, herbaria and insect collections. The most common species is *Atropos divinatoria*, a minute, pale-colored wingless insect. It feeds upon the paste of book bindings and upon decaying vegetable and animal matter.

Control.—When severe infestations occur, fumigate with sulphur (2 lb. to 1000 cu. ft.) or with hydrocyanic acid gas.

ORDER BLATTOIDEA (COCKROACHES)

Family BLATTIDÆ

Genera and Species:

A. Last ventral segment of female abdomen plane not compressed; fore femora rarely provided with spines.

  B. Sub-genital stylets present in the males, upper wings of females short. —*Ischnoptera.*

    I. pennsylvanica brown, sides of pronotum yellow.

  BB. Sub-genital stylets absent in the males. Upper wings of both sexes long.—*Blattella* = *Ectobia* = *Phyllodromia.*

    B. germanica (Croton bug), length ½ inch.

AA. Last ventral segment of female abdomen compressed and divided; fore femora spined.

  B. Wing-covers not reaching tip of abdomen.—*Blatta.*

    B. orientalis (Oriental Cockroach).

  BB. Wing-covers reaching beyond the abdomen.—*Periplaneta.*

    C. Wing-covers much exceeding abdomen.—*P. americana.*

    CC. Wing-covers but little exceeding abdomen; a bright yellow stripe on basal half of their outer margin.—*P. australasiæ.*

Several injurious species of cockroaches occur: (1) American Cockroach, (2) Australian cockroach, (3) Oriental cockroach, and (4) German cockroach or Croton Bug.

1. **American Cockroach** (*Periplaneta americana* L.), a native species, is a large dark brown insect 1½ inches long, with well-developed wings in both sexes, 1½–2 inches long; thorax with an obscure yellow border. Eggs held within a capsule until hatched. Duration of life-cycle about a year. Nocturnal.

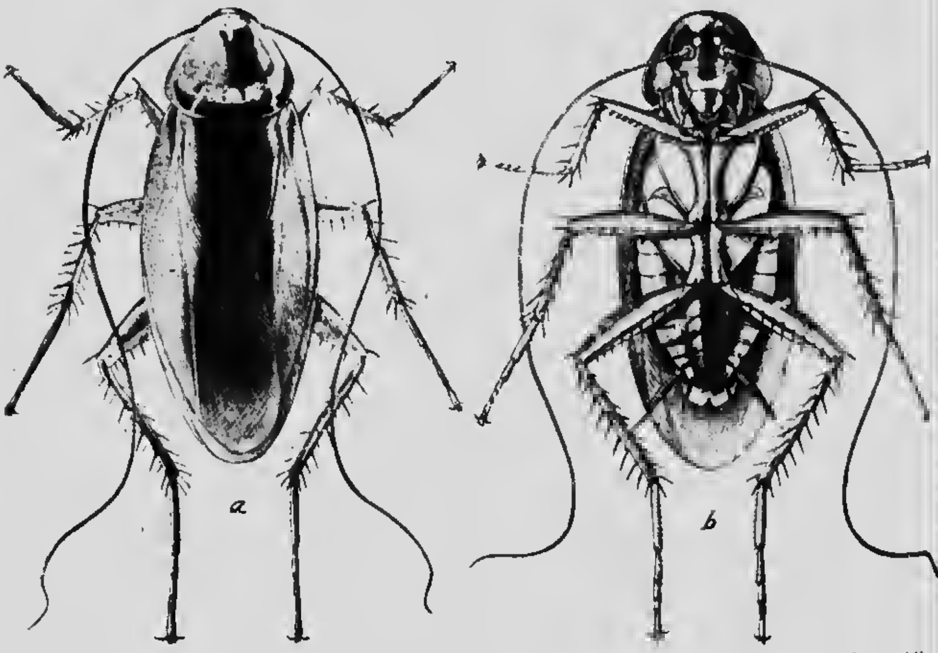


FIG. 59.—The oriental roach (*Blatta orientalis*): *a*, female; *b*, male. All natural size. (*After Marlatt, U. S. Bur. Ent.*)

2. **Australian Cockroach** (*Periplaneta australasiæ* L.), 1¼ inches long; resembles preceding but the yellow band on thorax is much brighter and more definitely limited. Upper wings have a dash of yellow on each side. Abundant in the south.

3. **Oriental Cockroach** (*Blatta orientalis* Fol.) or "black beetle," is a nearly wingless dark brown or black robust form, about an inch long—the male with wing cases one-half to three-fourths length of abdomen; female wingless. Notably gregarious and larger than the Croton Bug (Fig. 59).

4. **German Cockroach** or **Croton Bug** (*Ectobia germanica L.*), has a light brown thorax marked with two dark brown stripes. Both sexes with well-developed wings. Active and wary, relatively [illegible], 5/8 inch long.

All the roaches have a fœtid roachy odor, and are said to feed on the bedbug (Fig. 60). They are particularly abundant in pantries, kitchens and bakeries and they feed on almost any kind of dead animal matter and cereal products. The eggs are produced in a brown capsule which is often carried about for a time before deposited in a crevice or nook.

Control.—A bait of powdered borax mixed with sweetened chocolate; a trap of flour and plaster-paris and water; fumigation with hydro-

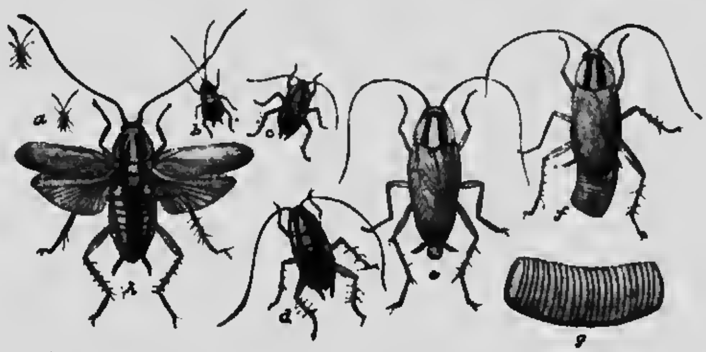


FIG. 60.—The German roach (*Ectobia germanica*): *a*, first stage; *b*, second stage; *c*, third stage; *d*, fourth stage; *e*, adult; *f*, adult female with egg case; *g*, egg-case, enlarged; *h*, adult with wings spread. All natural size except *g*. (*From Riley.*)

cyanic acid gas. Dust the runways or hiding places with sodium fluoride mixed with flour by means of a dust gun or blower. Boric acid is also effective.

ORDER MANTOIDEA (PRAYING MANTIDS)

Family MANTIDÆ

The Praying Mantids are predaceous insects and for centuries have been looked upon as uncanny creatures both in the old and new worlds. The most common American species is *Stagmomantis carolina*, but this form does not breed normally north of southern New Jersey, Pennsylvania and Ohio. In 1899, however, the European species

(*Mantis religiosa* Linn.) was found in New York State, and in 1914 n Ontario.

The adult forms are elongated, with large grasping forelegs, long prothorax and a small transverse head. The eggs are laid in shingled masses on twigs, coated with a hard gummy substance.

ORDER PHASMOIDEA (WALKING-STICKS)

Family PHASMIDÆ

This Family is represented by the common Walking-stick insect (*Diapheromera femorata*, Say), a peculiar creature with long slender body and legs. The outer wings are either wanting or very short.

Life-history.—The eggs are dropped singly in autumn from the shrubs and rest on the ground all winter among the leaves, hatching in early summer. The nymphs feed upon leaves, and reach maturity in late summer and early fall, when they resemble the twigs upon which they rest. Occasionally this insect becomes injurious on hazel and beech.

ORDER DERMAPTERA = EUPLEXOPTERA (EARWIGS)

European Earwig (*Forficula auricularia* Linn.).—This insect is held in check in Europe by parasites and other natural agencies but the practical absence of these checks allows it to multiply rapidly in America wherever it has been introduced. At Newport, R. I., it is a serious pest of Lima-beans, dahlias, early roses, chrysanthemums, clovers, grasses, etc.

The adult females hibernate in the soil, and the white eggs are laid in the soil. The nymphs are night feeders. They are white at first but gradually darken in color to a steel grey—4 instars. Adults appear about the middle of July. They are rich reddish brown with yellow brown wing-covers and legs; about ¾ inch long. The forceps is nearly straight in the female, but curved in the male.

Control.—Use poison bait before July 1st and spray plants with arsenate of lead; collect by traps.

Labia minor Linn., also an adventive earwig from Europe, is widely distributed in U. S. and Canada. Not of economic importance.

ORDER ORTHOPTERA (LOCUSTS, GRASSHOPPERS AND CRICKETS) FAMILIES

A. Antennæ shorter than body.—*Acrididæ* (*Locusts* or *Short-horned Grasshoppers*).

AA. Antennæ longer than body.

B. Tarsi 4-jointed.—*Locustidæ* (*Long-horned Grasshoppers*).

BB. Tarsi 3-jointed.—*Gryllidæ* (*Crickets*).

Acrididæ (Locusts or Short-Horned Grasshoppers)

Sub-families, Genera and Species (Figs. 61–63).

Sub-families:

A. Pronotum extending over abdomen; claws of tarsus without pulvillus; size small.—*Tettiginæ.*

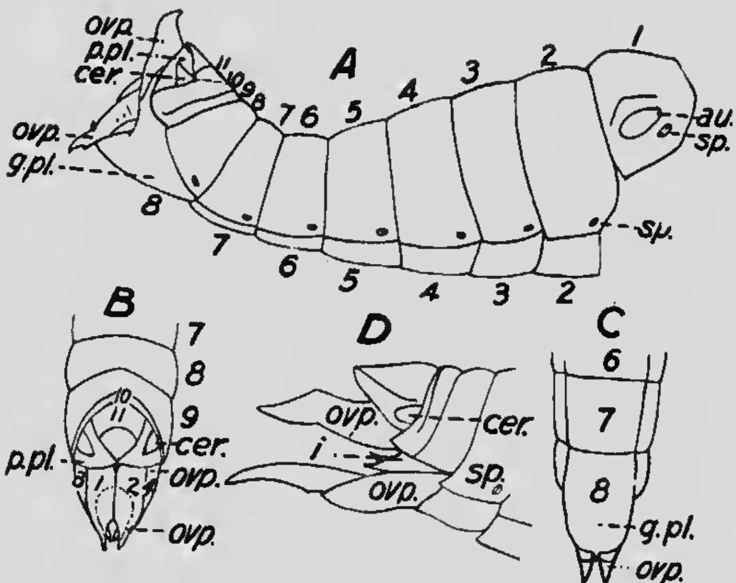


Fig. 61.—Abdomen of female *Melanoplus bivittatus.* *A*, lateral view; *B*, dorsal view; *C*, central view; *D*, egg guide; *au.*, the auditory organ; *sp.*, spiracle; *ovp.*, ovipositor; *g.pl.*, genital plate; *p.pl.*, podical plate; *cer.*, cercus. (*After Lugger.*)

AA. Pronotum not extending over abdomen; claws of tarsus with pulvillus; size larger.

B. Prosternum with tubercle.—*Acridinæ.*

BB. Prosternum without tubercle.

C. Vertex and front of head meeting at an acute angle.—*Tryxalinæ.*

CC. Vertex and front rounded.—*Œdipodinæ.*

Genera of the Tettiginæ:

A. Antennæ 12-jointed and pronotum rounded.—*Batrachidea.*

AA. Antennæ 13–14-jointed; pronotum horizontal.—*Tettix.*

AAA. Antennæ 22-jointed; pronotum horizontal.—*Tettigidea.*

(For species see Blatchley's *Orthoptera of Indiana.*)

Genera of the Acridinæ:

A. Wings as long or longer than the abdomen.

B. Pronotum sloping from median carina; extremity of abdomen in males not swollen.—*Acridium* or *Schistocerca.*

BB. Pronotum flattened; extremity of abdomen in males swollen.—*Melanoplus.*

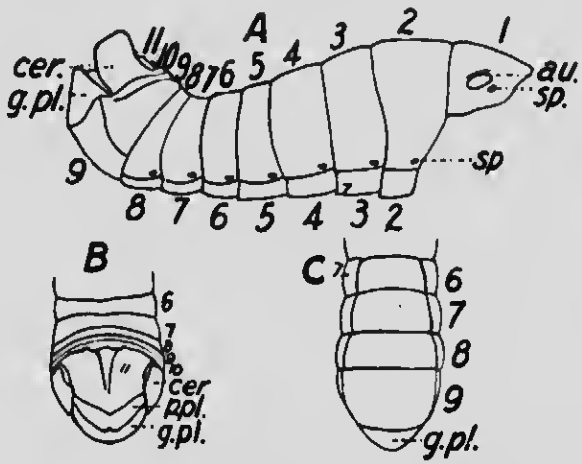


FIG. 62.—Abdomen of male *Melanoplus bivittatus.* *A*, lateral view; *B*, dorsal view; *C*, ventral view. (*After Lugger.*)

Species of Acridium:

A. Size large; antennæ rather short.—*A. americana.*

AA. Size medium; antennæ longer.

B. Color yellowish-brown or olive-green.—*A. alutacea.*

BB. Color rusty-brown; no yellowish stripe on dorsum.—*A. rubiginosa.*

Species of Melanoplus:

A. Apex of last ventral segment of male distinctly notched (Fig. 63).

B. Length of body to tip of wing-covers 29–35 mm.—*M. spretus.*

BB. Length of hody to tip of wing-covers 23–26 mm.—*M. atlanis.*

AA. Apex of last ventral segment of male entire, or at least obscurely notched

B. Anal cerci enlarged at apex.—*M. bivittatus.*

BB. Anal cerci tapering.

C. Species of medium size; anal cerci much narrowed, but without a notch.—*M. femur-rubrum.*

CC. Species of large size; anal cerci suddenly narrowed, making a prominent right-angled notch on lower side.—*M. differentialis*

Genera of the Tryxalinæ:

A. Foveolæ of vertex present, and visible from above. Lateral carinæ of pronotum incurved.—*Stenobothrus curtipennis.*

AA. Foveolæ absent; lateral carinæ nearly parallel.—*Chrysochraon conspersum.*

Genera and Species of Œdipodinæ:

A. Wings with the disk yellow.

B. Apical half of wing dusky.

C. Dorsal aspect of head with a slight median carina which is quite prominent in the central foveola.—*Encoptolophus sordidus.*

CC. Dorsal aspect of head without median carina; central foveola less distinct.—*Chortophaga viridifasciata.*

BB. With a dark band across the wings.—*Spharagemon æquale.*

AA. Wings with the disk black.—*Dissosteira carolina.*

AAA. Wings transparent with dark veins; tegmina smoky brown with darker spots and yellowish blotches on sides.—*Camnula pellucida.*

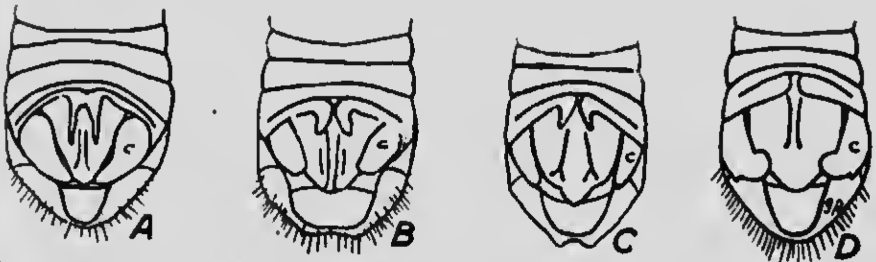


FIG. 63.—Tip of male abdomen of *Melanoplus*, dorsal view. *A*, *M. femur-rubrum;* *B*, *M. spretus;* *C*, *M. atlanis;* *D*, *M. differentialis.*

In the West the Rocky Mountain Locust (*Melanoplus spretus*) did, and occasionally does, produce much injury to grain and other crops. Another species more widely distributed is *M. atlanis* which sometimes becomes migratory. The Red-legged Locust or Grasshopper (*M. femur-rubrum*), the Two-striped Locust (*M. bivittatus*) and the Pellucid Locust (*Camnula pellucida*) in the East and the Differential Locust (*M. differentialis*) in the South are the species that do most injury.

Red-legged Locust or Grasshopper (*Melanoplus femur-rubrum* DeG.).—This locust is usually the most abundant form in the East, and is most numerous in low grounds and cultivated fields where vegetation is more or less rank (Fig. 64).

Adult.—Of medium size, about an inch long; reddish brown in color; tegmina sometimes without spots but usually spotted, surpassing the hind femora, which are reddish brown; hind tibiæ red with black spines; cerci of male narrowing from tip to base and subgenital plate narrower at apex than at base.

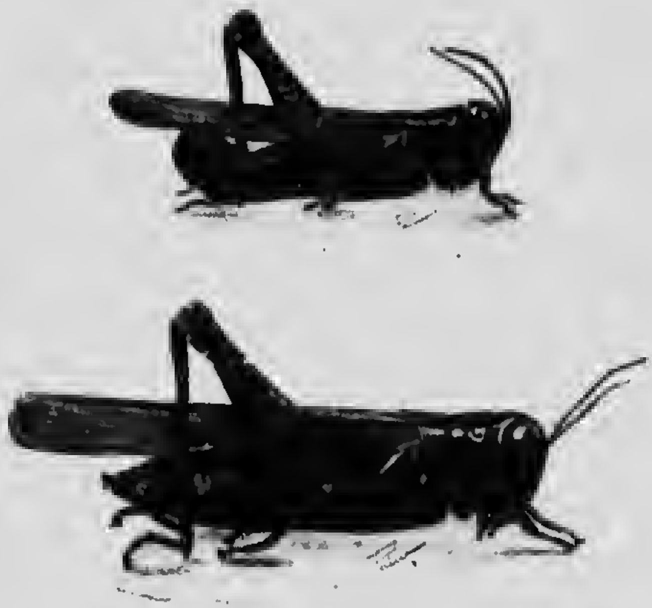


FIG. 64.—Red-legged grasshopper (*Melanoplus femur-rubrum*): Above, adult male; below, adult female. About twice natural size. (*After W. R. Walton, U. S. Bur. Ent.*)

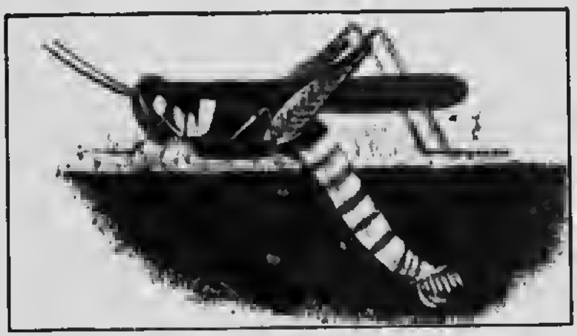


FIG. 65.—Locust ovipositing; egg pod in ground at right. Enlarged one-half. (*After Gibson, Ent. Circ. 5, Dept. Agric., Ottawa.*)

Eggs.—Deposited in pod-like masses in the ground; oblong-oval.

Nymphs.—Vary in size according to age and month; all stages of developing wings; grey to yellow; five moults.

Life-history.—Nymphs hatch from eggs in spring; these mature in August and September, when eggs are laid in the ground and overwinter there (Figs. 65 and 66).

FIG. 66.—Egg pod of locust opened to show arrangement of eggs; individual eggs at side, natural size. (*After Gibson, Ent Circ. 5, Dept. Agric, Ottawa.*)

The Lesser Migratory Locust (*Melanoplus atlanis* Riley).—A native American species; often abundant in Eastern Canada, causing serious injury. Compared with *M. femur-rubrum* the female has a yellow under surface, and more distinctly banded hind femora, and the male has the apex of the subgenital plate notched, the cerci shorter and less tapering, and longer tegmina which are also more distinctly spotted. It has a distinct patch of black on the neck or collar. Egg deposition occurs from July to September. Mature forms appear from July 1st, and are often abundant in open sandy regions with sparse vegetation.

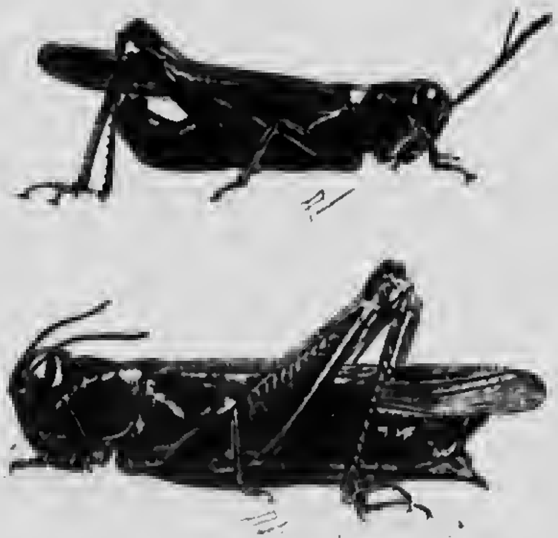


FIG. 67.—Lesser migratory grasshopper (*Melanoplus atlanis*): Above, adult male; below, adult female. About twice natural size. (*After W. R. Walton, U. S. Bur. Ent.*)

The nymphs undergo five moults; the eggs are deposited in the ground in small pod-like capsules, and hatch in the spring (Fig. 67).

Differential Locust (*Melanoplus differentialis* Uhler).—This locust is larger than those described above, about 1½ inches long, and is dark brownish-green or olive-brown in color. The hind legs are yellow with black basal tibial ring and black spines. The subgenital plate short and broad, and the cerci of male boot-shaped. It is fond of the Greater Rag-weed. It is a southern form.

FIG. 68.—Two-striped grasshopper (*Melanoplus bivittatus*): Above, adult male; below, adult female. Twice natural size. (*After W. R. Walton, U. S. Bur. Ent.*)

Two-striped Locust (*Melanoplus bivittatus* Say).—This locust is not so large as the Differential locust, being about 1¼ inches long, and is dull olive-brown above and yellowish beneath. A narrow yellowish stripe runs along each side from the eye to the tip of the tegmen. The hind femora are yellow, and the hind tibiæ coral red with black spines. The cerci of the male are stout, and two lobed; the subgenital plate is narrow. The young and newly transformed adults are greenish (Fig. 68). Its transformations are later than those of *M. atlanis.*

Clear-winged Locust (*Camnula pellucida* Scudder).—This locust occasionally does serious injury in the West, and frequents high dry soil. It is of a light brown color; the tegmina are smoky brown with darker spots and yellowish blotches on the sides and a yellowish brown stripe along each humeral angle. The wings are transparent and pellucid with dark veins. Body of male 19 mm. long, of female 22 mm. It is often associated with *M. atlanis* in the East, and is the earliest of the grasshoppers (Fig. 69).

FIG. 69.—Pellucid or clear-winged grasshopper (*Camnula pellucida*): Adult female. About twice natural size. (*After W. R. Walton, U. S. Bur. Ent.*)

Carolina Locust (*Dissosteira carolina* Linn.).—This locust is larger than the preceding species and is of a pepper-and-salt color, with variations from grey to yellow or reddish. The hind wings are black margined with yellow. It is sometimes injurious to corn, wheat, alfalfa and soy beans.

Natural Enemies of Locusts.—Robber-flies, bee-flies, flesh-fly and blow-fly larvæ, digger wasps and blister-beetle larvæ; birds and domestic fowls; toads, snakes, moles, mice, ground squirrels, skunks and hogs; mites, spiders, "hair-snakes," etc.

Control of Locusts.—(*a*) Application of poisoned baits (see Part IV, p. 398). (*b*) Use of hopperdozers. (*c*) Destruction of eggs by fall cultivation. (*d*) Co-operation of communities.

Consult U. S. Com. Rept. on Rocky Mt. Locust, 3 vols., Farmers' Bulls. 691 and 747, U. S. Dept. Agr.; Circ. 5, Ent. Br. Dept. Agr., Can.; Cornell Bull. 378; Mich. sp. Bul. 83)

LOCUSTIDÆ (LONG-HORNED GRASSHOPPERS OR LOCUSTS)

More Common Genera and Species

A. Wingless or with rudimentary wings and wing-covers.
  B. Pronotum not extended over meso- and metanotum.—*Ceuthophilus.*
  BB. Pronotum extended over meso- and metanotum.—*Thyreonotus.*
AA. Winged.
  B. Tegmina expanded in the middle.
    C. Tegmina much broadened in the middle, concave.—*Cyrtophyllus.*
    CC. Tegmina somewhat broadened in the middle, not concave.
      D. Ovipositor very small.—*Microcentrum.*
      DD. Ovipositor of medium size.—*Amblycorypha.*
  BB. Tegmina not expanded in the middle.
    C. Vertex of the head with a conical projection forward.—*Conocephalus.*
    CC. Vertex of the head without a conical projection.
      D. Ovipositor straight or very nearly so; insect small.—*Xiphidium.*
      DD. Ovipositor curved; insect large.
        E. Ovipositor curved sharply upward.—*Scudderia.*
        EE. Ovipositor sword-shaped.—*Orchelimum.*

Species of Ceuthophilus:
  A. Fore femora about as long as pronotum.—*C. maculatus.*
  AA. Fore femora longer than pronotum.—*C. brevipes.*

Species of Thyreonotus:
  A. Pronotum well rounded behind.—*T. dorsalis.*
  AA. Pronotum nearly square.—*T. pachymerus.*

The members of this family are seldom of sufficient importance economically to require special treatment. The katydids, shield-backed grasshoppers, cricket-like grasshoppers, and meadow grasshoppers belong here and are interesting objects of study. Recently it was found that two species of katydids (*Scudderia furcata* Brunner and *Microcentrum rhombifolium* Sauss.) are injurious to oranges in California, often causing serious loss. (Bull. 256, Bur. Ent. U. S. Dept. Agr., 1915.)

GRYLLIDÆ (CRICKETS)

Genera and Species

A. Fore tibiæ broad, fitted for digging (Fossorial Crickets).
  B. Insect small; antennæ ten- to twelve-jointed.—*Tridactylus.*
  BB. Insect large; antennæ many-jointed.—*Gryllotalpa.*

AA. Fore tibiæ slender.
B. Hind femora stout (True Crickets).
C. Last segment of the maxillary palpi of the same length as the next to the last.—*Gryllus.*
CC. Last segment of the maxillary palpi double the length of the next to the last.—*Nemobius.*
BB. Hind femora slender (Tree Crickets).—*Œcanthus.*

Species of Gryllus:

A. Black field crickets.
B. Ovipositor 13–14 mm. long; male more slender.—*G. pennsylvanicus.*
BB. Ovipositor 18 mm. long; male stout.—*G. abbreviatus.*
AA. Straw colored house crickets.—*G. domesticus.*

Species of Nemobius:

A. Ovipositor longer than hind femora and straight; color blackish, arranged in longitudinal bars.—*N. fasciatus.*
AA. Ovipositor shorter than hind femora and arcuate.—*N. exiguus.*

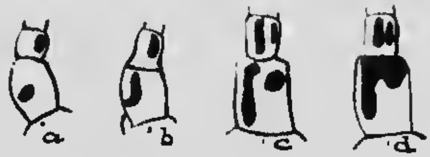


FIG. 70.—Markings on basal segments of antennæ of *Œcanthus*: *a*, *Œc. niveus*; *b*, *Œc. angustipennis*; *c*, *Œc. nigricornis*; *d*, do.

Species of Œcanthus (Fig. 70):

A. Antennæ with one black mark on each basal joint.
B. Black marks like small rounded dots.—*Œ. niveus.*
BB. Mark on first joint long and hooked, that on second oblong.—*Œ. angustipennis.*
AA. Antennæ with two black marks on the first basal joints.
B. Antennæ wholly black, also head, thorax and legs. Marks on first joint of antennæ generally connected at apex.—*Œ. nigricornis.*
BB. Pale greenish white; marks on antennæ elongate, parallel, distinct.—*Œ. 4-punctatus.*
AAA. Antennæ without marks on first joints, wing-covers broad; head and first joints of antennæ pink.—*Œ. latipennis.*

The **Pennsylvania Field Cricket** (*Gryllus pennsylvanicus* Burm.).—The field cricket is omnivorous and seldom does enough damage to merit special attention. It is fond of grain, however, and often enters barns destroying a considerable amount of grain.

Adult.—A large black cricket existing in two forms—the commoner short-winged form in which the wings are rudimentary and the long-winged form in which they project beyond the tip of the tegmina. The tegmina are deep black to grayish brown, in the male reaching the tip of the abdomen, in the short-winged female not quite so long and in the long-winged form slightly surpassing the tip of the abdomen. The ovipositor never exceeds the body in length. Length of insect 16–20 mm. (Fig. 71).

Eggs.—Yellow, cylindrical, laid in the soil in late summer and autumn in Quebec, in June and July farther south.

FIG. 71.—The Pennsylvania field cricket (*Gyllus pennsylvanicus*). (*After Lugger.*)

Nymphs.—In the north the nymphs hatch in early summer from hibernated eggs; in the neighborhood of Indiana they hatch in July and August and hibernate.

Snowy Tree Cricket (*Œcanthus niveus* DeG.).—Sometimes injures apple and plum trees by egg-punctures, and occasionally eats holes in the ripe fruit (Fig. 74).

Adult.—Ivory-white tinged with green, 1/2 inch long; wing-covers nearly twice as long as abdomen; those of male flattened, crossed by oblique veins, semi-transparent and broader than body, those of female wrapped close about the body; ovipositor short, straight and tipped with black; maxillary palpi relatively long. July–October.

Eggs.—Elongate, cylindrical, yellow, 1/8 inch long; laid singly in punctures in the bark of smaller branches of apple, plum and peach, in the fall; hatch in May and June.

Nymphs.—Feed on plant-lice and other insects.

Black-horned Tree Cricket (*Œcanthus nigricornis* Walker).—Consult Bull. 388, N. Y. Ag. Exp. St.) Injures blackberry and raspberry canes by egg punctures, and carries spores of ***cane-blight*** and other diseases (Figs. 72 and 73).

Adult.—Greenish white; head and pronotum black or barred with black; body black beneath and yellowish-green above; antennæ long, mostly black; wing-covers as in *Œ. niveus;* head, thorax and legs mostly black. Probably feeds on flies.

Eggs.—Similar to those of *Œ. niveus;* laid in a row of punctures

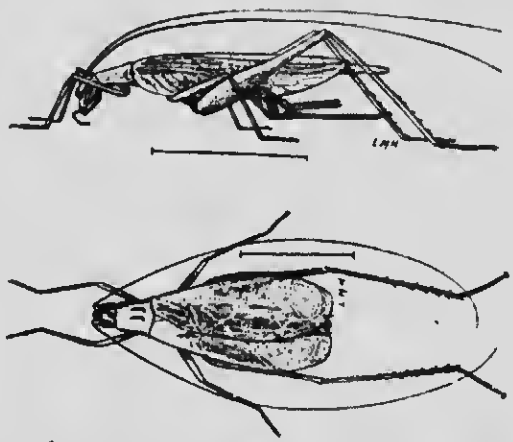


FIG. 72.—Black-horned tree cricket (*Œcanthus nigricornis*). Female above, male below. (*After Lugger.*)

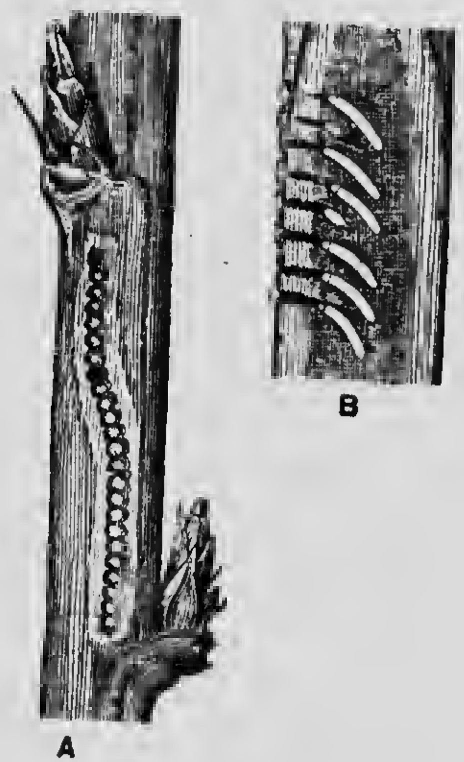


FIG. 73.—Egg punctures and eggs in raspberry by the black-horned cricket (*Œ. nigricornis*).

often 2 inches long, each row containing about 30 eggs; hatch in May and June.

Nymphs.—Feed on plant-lice and other insects; full grown late July and August.

Control.—Prune out infested twigs and burn them.

Other species of Œcanthus deposit eggs in galls on willows, and in the stems of *Helianthus*, *Solidago*, etc.

FIG. 74.—Œcanthus niveus ovipositing. (*After Parrott.*)

ORDER THYSANOPTERA (THRIPS)

(Consult Tech. Ser. No. 12, Pt. III, and No. 21, Bur. Ent., U. S. Dep. of Ag.)

A. Female with a saw-like ovipositor, last segment of abdomen of female conical, that of male broadly rounded; wings usually present, the fore pair the stronger.
  - B. Ovipositor curved upward; antennæ 9-jointed; fore wings broad and rounded. *Æolothripidæ.*—Genus *Æolothrips.*
  - BB. Ovipositor curved downward; antennæ 7- to 10-jointed; wings usually narrow and pointed.—*Thripidæ.* Genera: *Thrips, Euthrips, Heliothrips, Anaphothrips.*

AA. Female without a modified ovipositor, last segment of abdomen tubular in both sexes; wings often absent, but when present similar in structure.—*Phlæothripidæ.* Genera: *Phlæothrips, Trichothrips, Cryptothrips.*

THRIPIDÆ (THRIPS)

Grass Thrips (*Anaphothrips striatus* Osborn).—Feeds by sucking the juices of various grasses such as timothy, Kentucky blue, couch grass and oats.

Adult.—Small, 1/16 inch long, yellowish or brownish-yellow; four narrow wings fringed with hairs; feet bladder-like; parthenogenetic; May–June. Hibernate.

Eggs.—First hrood laid in spring, hatching in 10 to 15 days; summer eggs hatching in 4 to 7 days.

Nymphs.—Become full grown in spring in about 2 weeks, summer forms in 4 days. Life-cycle in 12 to 30 days.

"Thrips injury on the leaves shows as minute dots or lines usually running parallel with the leaf veins and remaining white."

Pear Thrips (*Tæniothrips inconsequens* Uzel).—(Consult Bull. 80, Part 4. U. S. Bur. Ent., 1909; Bull. 343, N. Y. Ag. Exp. St., 1912; Bull. 15, Ent. Br. Dept. Ag. Can., 1918.) A pest in central California and British Columbia, along Hudson River and in Pennsylvania to pear, apple, cherry and plum. Chief injuries done by adults to the buds in spring (Fig. 75).

Adult.—Minute, slender, dark brown, 1/25 inch long; wings fringe-like and flat along the back. Enters fruit buds in early spring. One brood a year.

Eggs.—Laid by a sharp, curved, saw-toothed ovipositor beneath epidermis of fruit and leaf stems as the trees come into bloom, causing "bleeding," and giving the bud a shrivelled, scorched appearance when infestation is heavy.

Nymphs.—Hatch out in blooming time and become full grown in about 2 weeks. They then drop to the ground and form a pupal cell some distance below, where they hibernate. The pupal stage is an inactive stage and lasts about 2 months hefore the adult appears.

Control.—Spray early with kerosene emulsion or soap solution, or distillate oil emulsion, to which is added nicotine extract.

Greenhouse Thrips (*Heliothrips hæmorrhoidalis* Bouché).—This insect injures the leaves of many greenhouse plants which first become spotted, then blotched and finally wilted. Drops of a reddish fluid, turning black, cover the leaves. (Consult Bull. 64, Pt. 6, Bur. Ent., U. S. Dept. of Agriculture.)

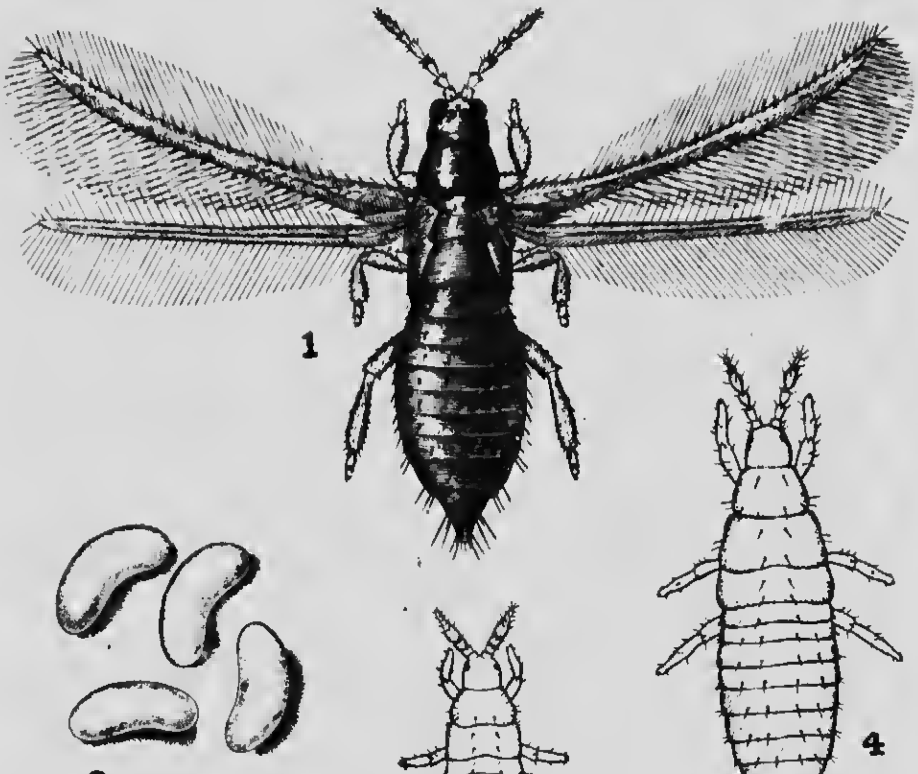


FIG. 75.—Pear thrips (*Tæniothrips inconsequens*): 1. Adult; 2, eggs; 3 and 4, larvæ; 5 and 6, nymphs or pupæ; 7, head (side view). All greatly enlarged. (*After Moulton, U. S. Bur. Ent.*)

Adult.—One-fifteenth inch long; head and thorax dark brown, abdomen yellowish brown; antennæ with 8 segments; 3 to 4 weeks for a generation; fore-wings with two, hind-wings with one longitudinal vein.

Eggs.—Hatch in 5 to 8 days; laid singly in leaf tissue; colorless and bean-shaped.

Nymphs.—Mature in 20 to 25 days.

Onion Thrips *or "White Blast"* (*Thrips tabaci* Lind.).—Attacks a large variety of garden plants. Found on bulbs of onion in loose soil and at axils of leaves. Punctures the tissues and sucks the sap, giving the field a whitish appearance. Produces also scullions or thick necks.

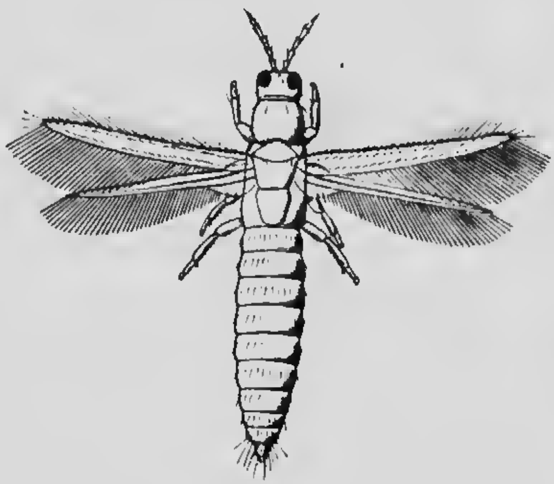


FIG. 76.—Wheat thrips (*Euthrips tritici*). Greatly enlarged. (*After Folsom.*)

Adult.—One-twenty-fifth inch long, active, slender, yellowish tinged with black, two pairs of bristly narrow wings which fold along the back. Probably winters over in the rubbish on the ground; life-cycle about 3 weeks, hence several generations in a season.

Eggs.—Laid singly in spring or early summer within the leaf tissue, 1/100 inch long, elongate and curved; hatch in about 4 days.

Nymphs.—Transparent at first, later greenish-yellow; mature in 11 or 12 days.

Control.—Spray with solution of nicotine sulphate and whale oil soap (4 oz., 4 lb., 40 gal.)

Wheat or Strawberry Thrips (*Euthrips tritici* Fitch).—The most common thrips and found on many cultivated plants. Injurious to strawberry, apple, peach and wheat. Several generations in a season (Fig. 76).

Adult.—Small, $\frac{1}{20}$ inch long, brownish yellow.

Eggs.—Small, whitish, curved oblong; laid singly in lower part of calyx and in flower stalk of strawberry; hatch in 3 days.

Nymphs.—Three moults; mature in 9 or 10 days.

This thrips produces "button" strawberries.

Control.—Spray with nicotine or kerosene emulsion.

ORDER HOMOPTERA[1]

Chief Economic Families

A. Tarsi 1 or 2-jointed; antennæ usually prominent; beak apparently arising from sternum.—*Group Sternorhynchi.*
- B. Tarsi 1-jointed; adult male with beak and 2-winged; female wingless with body scale-like, or gall-like, or grub-like, and covered with waxy secretion.—*Coccidæ* (Scale Insects), p. 123.
- BB. Tarsi 2-jointed; wings usually 4.
  - C. Wings white, opaque.—*Aleyrodidæ* (White-flies), p. 151.
  - CC. Wings transparent.
    - D. Legs long and slender; antennæ 3–7-jointed.—*Aphididæ* (Plant-lice), p. 136.
    - DD. Hind legs fitted for leaping; antennæ 9 or 10-jointed.—*Psyllidæ* (Jumping Plant-lice), p. 152.

AA. Tarsi 3-jointed, antennæ minute; beak evidently arising from mentum.—*Group Auchenorhynchi.*
- B. Ocelli 3; males with musical organs.—*Cicadidæ* (Cicadas), p. 156.
- BB. Ocelli 2 or wanting; males without musical organs.
  - C. Antennæ inserted on side of cheek beneath the eyes.—*Fulgoridæ.*
  - CC. Antennæ inserted in front of and between the eyes.
    - D. Prothorax prolonged into a horn above the abdomen.—*Membracidæ* (Tree Hoppers), p. 157.
    - DD. Prothorax not prolonged above the abdomen.
      - E. Hind tibiæ armed with two stout teeth and tip crowned with short stout spines.—*Cercopidæ* (Spittle Insects), p. 153.
      - EE. Hind tibiæ with a double row of spines below.—*Cicadellidæ* or the *Jassoidea* (Leaf Hoppers), p. 154.

[1] The old order *Hemiptera* is here broken up into three orders viz.: *Homoptera*, *Hemiptera* and *Siphunculata* (see p. 94).

1. Coccidæ (Scale Insects)

Chief Sub-families and Genera

Chief Sub-families:

A. Abdominal spiracles present on each segment; males with compound eyes; adult females with white waxy lamellæ.—*Orthezinæ.*

AA. Abdominal spiracles absent; males with simple eyes.

B. Concealed beneath a "scale," formed partly of larval exuviæ, partly of secretion; abdomen ending in a "pygidium."—*Diaspinæ* (Fig. 79).

BB. Naked or covered with a waxy secretion, but not beneath a "scale;" abdominal pygidium absent.

C. Extremity of abdomen cleft; anal orifice closed above by a pair of triangular plates, anal ring fringed with setæ; waxy scale not separable from the insect.—*Coccinæ.*

CC. Extremity of abdomen not cleft; no anal triangular plates, anal ring without setæ.—*Dactylopinæ* (Fig. 81).

Chief Genera of the Diaspinæ:

A. Scale of female circular to oval with central, sub-central, or sub-marginal exuvia.

B. Scale of male resembling scale of female in color and texture; only slightly elongated.

C. Pygidium with 6 groups of circumgenital gland-orifices.—*Comstockiella.*

CC. Pygidium with less than 6 groups of gland-orifices.

D. Chitinous processes much elongated.—*Chrysomphalus.*

DD. Chitinous processes smaller and shorter or wanting.—*Aspidiotus* (Fig. 79).

BB. Scale of male white, delicate and carinated.

C. Dorsal spinnerets irregular; exuvia usually sub-central.—*Diaspis.*

CC. Dorsal spinnerets in distinct bands; exuvia terminal in 2d stage female and marginal in adult.—*Aulacaspis.*

AA. Scale of female elongated with exuvia at one extremity.

B. Scale of male similar to scale of female, but smaller; five groups of gland-orifices.—*Lepidosaphes.*

BB. Scale of both sexes white, that of male small, with parallel sides and carinated.—*Chionaspis.*

BBB. Scale of female brown, that of male white and carinated.—*Hemichionaspis.*

Chief Genera of the Coccinæ:

A. Naked or covered only by a filmy secretion.

B. Flat or slightly convex; dermis alveolate.—*Coccus.*

BB. Very convex, usually hemispherical; hard when mature.

C. Dermis with coarse polygonal pitted areas.—*Saissetia.*

CC. Dermis microscopically tesselate, or appearing smooth.—*Lecanium.*

AA. With a strong cottony secretion; secreting an ovisac; body more or less chitinous without dorsal patches of secretion.—*Pulvinaria*.

Chief Genera of the Dactylopinæ:

A. Female globular or reniform, in a hard shell; larva fringed with spines.—*Kermes*.

AA. Female not as above; anal ring with eight hairs.

B. Adult surrounded by secretion but dorsally naked.—*Gossyparia*.

BB. Adult forming a cottony sac; caudal lobe long.—*Eriococcus*.

AAA. Female with soft powdery oval unarmored body; anal ring with six hairs.

B. Antennæ normally with 8 segments, sometimes 7; tarsus not toothed. *Pseudococcus* (Fig. 81).

BB. Antennæ normally with 9 segments; tarsus toothed.—*Phenacoccus*.

Scale insects are typically bark-lice, being minute sucking insects covered with a mealy or cottony waxy secretion. Some, like the Mealy Bugs, secrete a cottony material; some, like the Lecaniums, secrete a waxy hard continuous layer which forms a protection for the back; while others, like the San José Scale and the Oyster Shell Scale, possess true scale-like coverings, composed partly of a waxy secretion and partly of moulted skins, beneath which the insect lives.

For a short time after birth Scale insects crawl about, but soon they settle on the bark or leaf and begin sucking the sap. After a few moults the females lose their legs, eyes and feelers. The male adult insect is, as a rule, an active 2-winged insect with legs, eyes, feelers, but no mouth. In most species the females lay eggs (oviparous), but in a few the young scale insects are born alive (viviparous), *i.e.*, the eggs hatch within the body of the mother.

(Consult Comstock's republished papers, Bull. 372, Cornell; the "Coccidæ of Ohio" by Sanders; "Some Scale Insects of Mississippi" by Herrick; "The San José and other Scale Insects" by Lochhead; "Coccidæ of Indiana" by Dietz and Morrison; and Bull. 6, Tech. Series, Div. Ent., U. S. Dept. Agr.)

Hard Scales (DIASPINÆ)

Following are the most common economic orchard forms:

Oyster Shell Scale (*Lepidosaphes ulmi* Linn.).—(Consult Farmers' Bulletin 723, U. S. Dep. Ag.) A cosmopolitan insect of European origin and one of the most common pests of the orchard and of shade trees and shrubs. Single-brooded in the North but double-brooded in the Middle and Southern States (Fig. 79).

Adults.—Female scale oyster-shell shaped, narrow, 1/8–1/10 inch long, brownish-black; male scale smaller and ovate.

Eggs.—Yellowish-white, laid in September-October under the female scale (50–60). Destroyed by a mite *Hemisarcoptes malus.*

Nymphs.—The eggs hatch in late May or early June, or shortly after the apple blossoms fall, into active 6-legged pale yellowish larvæ, the females moulting twice and the males once. The exuviæ are yellowish.

Parasites.—Parasitized by *Aphelinus, Mytilaspidis, Anaphes,* and *Chiloneurus* and preyed upon by lady-birds, mites and birds.

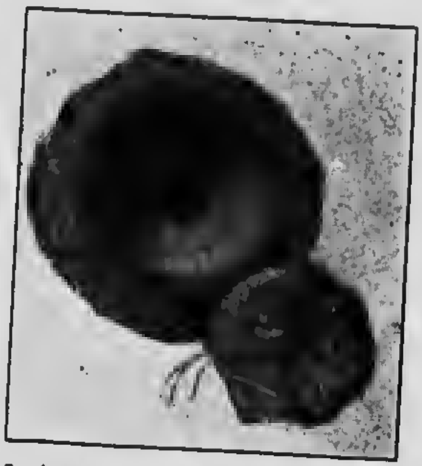


FIG. 77.—Female San José scale, mature female insect removed from beneath it. Greatly enlarged. (*After Alwood.*)

Scurfy Scale (*Chionaspis furfura* Fitch).—A native insect, occurring on pear, apple, gooseberry, and black currant.

Adult.—Scales white; female scale ovate, 2–3 mm. long, male scale smaller (1 mm.) and 3-ridged with parallel sides (Fig. 80).

Eggs.—Purplish-colored; laid in the early fall and found under the female scale in winter.

Nymphs.—These hatch about the middle of June and the female larvæ moult twice. The male has one moult. As in the case of the Oyster Shell Scale there is but one brood a season in the North and two in the South.

Parasites.—Parasitized by *Ablerus clisiocampæ* How., a chalcid and preyed upon by *Tyroglyphus malus* and *Chilocorus bivulnerus.*

San José Scale (*Aspidiotus perniciosus* Comst.).—China is probably the home of this scale. It became established at San José, Cal., about 1870, and was introduced into Eastern nurseries in the U. S. about 1886–7, and into Ontario about 1896. Occurs on orchard trees, bush fruits, and many perennials and annuals. On badly infested branches the scale presents the appearance of dark-grey scurfy patches, and on fruit there is often a purplish discoloration about the scale.

Adult.—The female scale is circular, $\frac{1}{15}$ inch in diameter, with a central exuvium surrounded by a yellowish ring. The male scale is

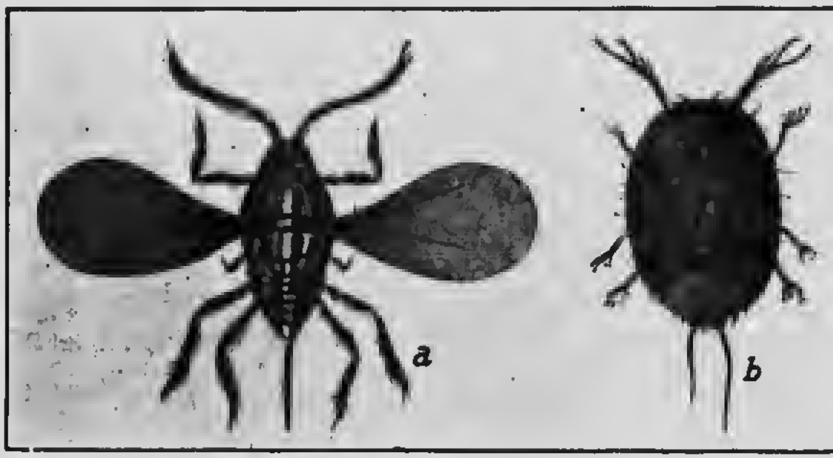


FIG. 78.—*a*, Winged San José scale (much enlarged); *b*, young scale insect (enlarged 125 times).

oval, twice as long as broad, with [illegible] exuvium showing a nipple toward the small end of the [illegible] José scale winters in the half-grown state. Early in spring the [illegible] males appear, and the females resume growth. The male moults thrice and the female twice. In early June the females begin to produce living young. The period of production lasts about six weeks during which time each female produces on an average 400 young. The females mature in 35 to 40 days, and the males in about 25 days after their birth. There are three or four broods in northern orchards (Figs. 77 and 78).

Nymphs.—The half-grown scale is black, and shows a central nipple surrounded by one or two depressed rings.

Parasites.—The following Lady-birds feed on the San José Scale: *Chilocorus bivulnerus*, *Pentilia misella* and *P. suturalis*.

The chief Chalcid parasites are *Prospaltella perniciosa* Tower, *Aphelinus fuscipennis* How., and *A. diaspidis* How., but the percentage of parasitism is too low for effective control.

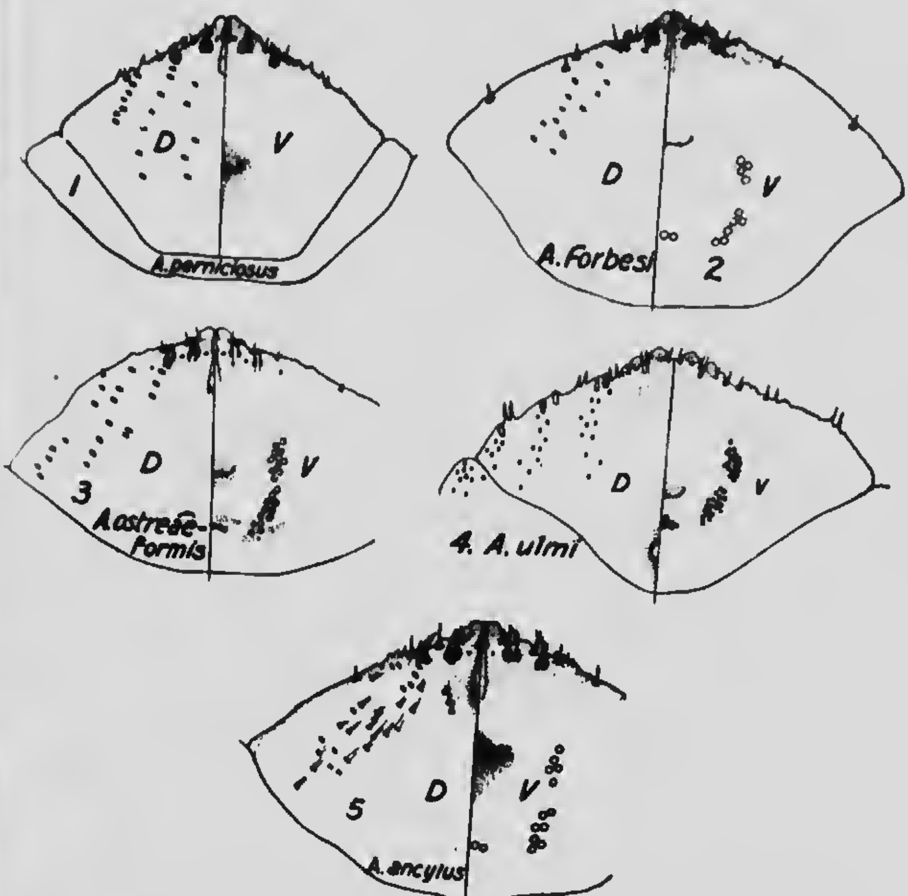


FIG. 79.—Pygidia of *Aspidiotus*. Showing the characteristic differences in five common species. Greatly enlarged. *D*, dorsal surface; *V*, ventral surface. (*After Sanders.*)

Control.—Plant fumigated nursery stock; spray with lime-sulphur wash (sp. gr. 1.03) before the buds burst; spray with certain miscible oils (see Part IV).

The three closely related species, **Putnam Scale** (*A. ancylus* Putn.) wintering in nearly full-grown condition and oviparous, the eggs hatching in June–July, the **Forbes Scale** (*A. forbesi* John.), and the **Curtis Scale** (*A. ostreæformis* Curtis) (Fig. 79), are difficult to distinguish from the San José Scale, and are also found in orchards. A comparison of the *pygidium*, or the fused posterior abdominal segments, under the microscope enables one to identify the adults of these species. On the dorsal surface of the pygidium are the anal opening and the glands that secrete the wax of the scale. On the ventral surface are the vaginal opening and 4 or 5 groups of spinnerets (wanting in the San José Scale). The margin of the pygidium is modified into

A B C

Fig. 80.—Three common orchard scales. *A*, San José scale; *B*, oyster-shell scale *C*, scurfy scale.

lobes with thickenings, dorsal and ventral spines, and plates characteristic of each species (Fig. 79).

Euonymus Scale (*Chionaspis euonymi* Comst.) is a common pest of Euonymus in the Eastern United States. Two broods a season. Female scale elongate-oval, brown, with yellow exuvia, convex; male scale white, parallel-sided, 3-ridged, with yellow exuvia, much smaller than female scale.

Rose Scale (*Aulacaspis rosæ* Bouché).—Attacks rose, raspberry, blackberry, etc.

Female scale snow-white, nearly circular, thin and flat, 1/12 inch in diameter; with two light yellow exuviæ at margin; oviparous. Male scale shorter, narrower, 3-ridged. Hibernates in all stages, hence all stages may be found on one infested plant. Two or three broods a year. Infested canes may become covered as if white-washed. Parasite: *Aphelinus diaspidis* How., a chalcid.

Control.—(1) Trim out all badly infested canes before spring; (2) spray with whale-oil soap (1 lb. to 1 gal. water) or lime-sulphur in early spring.

Soft Scales (Coccinæ)

Plum Scale, or European Fruit Lecanium (*Lecanium corni* Bouché).—This scale, also called the New York Plum Scale, is sometimes abundant in plum orchards. It occurs also on peach, apricot, pear, quince, currant, blackberry, ash, elm, etc.

Adult.—Female scales conspicuous brown objects, "like small halved peas," adhering to branches and twigs. Full grown in June. Male scales much smaller, flatter, more elongate, and of a whitish color; male insect delicate, with two whitish wings; emerges in May from scale.

Eggs.—Deposited under the scale in early June; white; hatch in about a month.

Nymphs.—Emerge from beneath the mother scale and crawl to the leaves in July; secrete much honey-dew. About the end of August or in September they begin to migrate from the leaves to the twigs and branches where they hibernate. In early spring (April) they begin feeding again and grow rapidly, maturing in June.

Parasite.—*Comys fusca.*

Control.—Spray with a miscible oil (1 to 15) before buds burst; spray about July 1st with Black leaf 40 and soap.

Terrapin Scale (*Lecanium nigrofasciatum* Perg.).—(Consult Bull. 351, Bur. Ent. U. S. Dept. Agr., and Circ. 88.) Attacks shade trees, such as maple, basswood and birch, and orchard trees, such as apple, plum and peach. A native insect.

Adult.—Female nearly hemispherical, reddish, 1–7 inches long, mottled with radiating streaks of black conspicuous about the margin. The presence of a double mid-dorsal row of 25–40 low subconical appendages appearing like pores, extending from near the anal lobes to nearly above the sucking mouth-parts is quite characteristic. Adult of male a minute, delicate 2-winged insect with rose-red body marked with dark and with heavy brown thoracic band, appearing early in August;

male scale smaller than female, elongate, slightly convex, and greenish white. Viviparous, young born June–July. One brood a year.

Nymphs.—Female scales nearly full grown by autumn, and winter as such. Mature early in spring.

Control.—A 20-25 per cent. kerosene emulsion or miscible oil applied in dormant seasons destroys the hibernating females, or flour-lime sulphur just before the young migrate to the leaves. *Coccophagus sp.*, a chalcid, is an important parasite.

Cottony Maple Scale (*Pulvinaria vitis* L.).—Occasionally becomes a serious pest of shade trees, such as the soft maple, box-elder, basswood, etc.

Adult.—Conspicuous on account of the cotton-like waxy masses projecting from beneath the brown scale of the female. Female scale "elliptical, convex on the back with a low rounded median ridge; pale green or whitish yellow, marked with black or brown." Male insect winged, with two long caudal filaments, and long antennæ.

Eggs.—Minute, oval, pale yellowish; enclosed in the secretion of waxy threads; about 3000 eggs laid by each female, in June and July.

Nymphs.—At first active and crawling, with six legs; later they settle and secrete a thin waxy covering on their backs. Females fertilized by the males in late summer. In autumn they migrate from leaves to twigs where they remain all winter.

Parasites.—*Coccophagus lecanii* Sm., *C. flavoscutellum* Ashm.—chalcids.

Control.—Spray in early spring with Black Leaf 40 and whale-oil soap.

Golden Oak Scale (*Asterolecanium variolosum* Ratz).—A small, yellow, round, convex scale often coating twigs of oak. The nymphs appear in May–June.

Cottony Grass Scale (*Eriopeltis festucæ* Fonsc.).—Often abundant on stems of grasses in the maritime provinces; forming conspicuous compact oval tufts of cotton wool, the egg-sacs. The eggs hatch in spring and the scales become full grown in July. Toward the end of July the eggs are laid in the cottony sacs.

Elm Bark-louse (*Gossyparia spuria* Modeer).—The females are dark red, bordered with white wax; $\frac{1}{10}$ inch long; arranged irregularly along cracks or fissures in the bark of trunks or limbs. The young appear in late June or early July and settle along the mid-veins of the leaves and on the green tips of twigs. In Sept.-Oct. they migrate back to the twigs. Winter is passed as partly grown insects.

Mealy Bugs (DACTYLOPINÆ)

Greenhouse plants are often injured by Mealy Bugs, which are mealy in appearance and are able to move about freely. The *scale* is

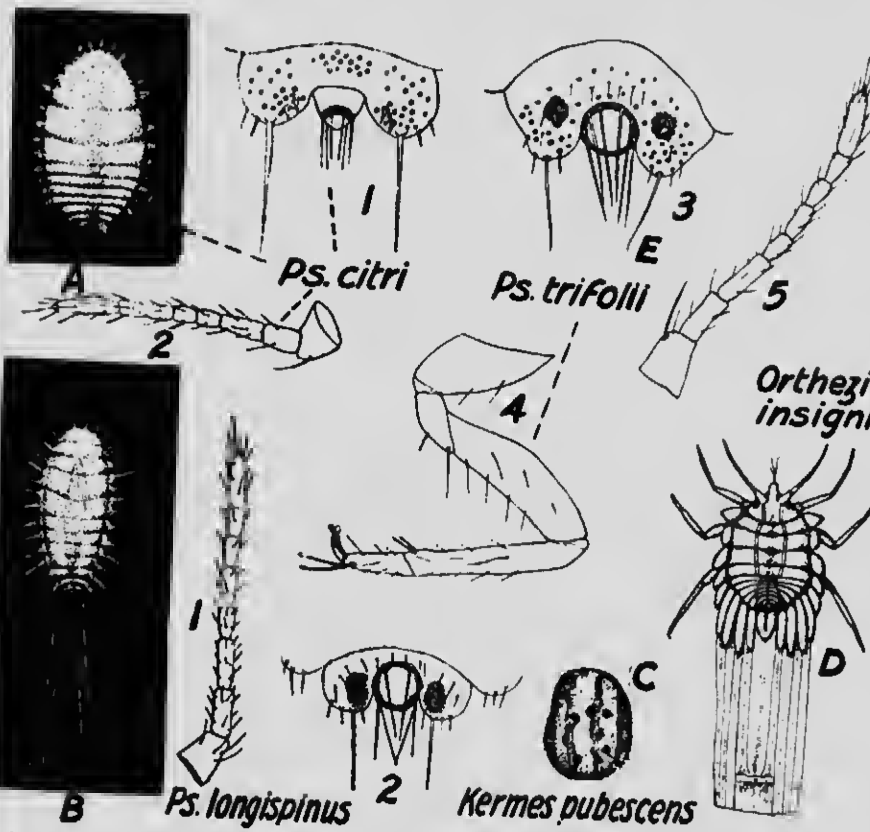


FIG. 81.—*A, Pseudoccus citri* showing adult female, anal ring and penultimate segment (1), antenna of adult female (2). *B, Pseudococcus longispinus*, showing adult female, antenna (1), anal ring and penultimate segment (2). *C, Kermes pubescens. D, Orthezia insignis. E, Pseudococcus trifolii*, showing anal ring and penultimate segment (3), anterior leg of adult female (4), and antenna of adult female (5). (*After Sanders.*)

absent and at maturity they secrete a cottony sack within which are deposited the cream-colored eggs. The following species are common:

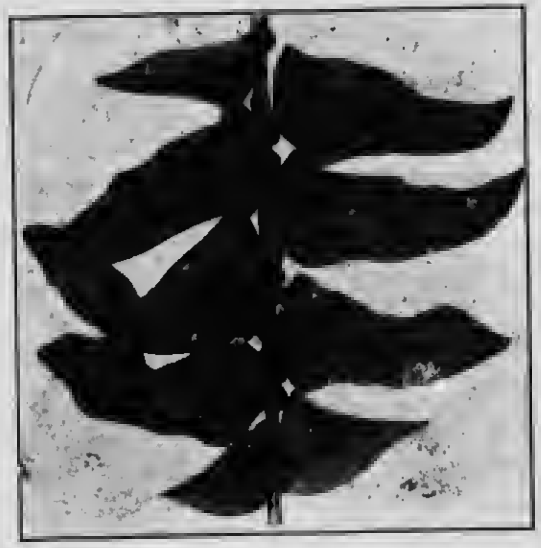


FIG. 82.—*Hemispherical scale* (Saissetia hemisphærica) on fern. Natural size. (*After Forbes.*)

FIG. 83.—Hemispherical scale, enlarged. (*After Forbes.*)

Long-tailed Mealy Bug (*Pseudococcus longispinus* Targ.).—A small mealy coated insect, viviparous, occurring on Coleus, ferns, croton, Poinsettia and citrous plants (Fig. 81).

Citrus or Greenhouse Mealy Bug (*Pseudococcus citri* Risso).—Oviparous; occurs on Coleus, ferns and citrous plants. Common (Fig. 81).

Clover Root Mealy Bug (*Pseudococcus trifolii* Forbes).—Occurs near the crown of second year red and white clovers in clusters, often accompanied by ants. Two forms exist—*winter females*, hatched from eggs in the fall, producing larvæ in the spring, some feeding on the roots and

FIG. 84.—*Aspidistra scale* (Hemichionaspis aspidistræ). Female scale, enlarged. (*After Forbes.*)

FIG. 85.—Male scale of the Aspidistra scale, enlarged. (*After Forbes.*)

others on the leaves; and *summer females*, producing several generations. Oviparous females lay eggs in the fall after mating with males (Fig. 81).

Woolly Maple Leaf Scale (*Phenacoccus acericola* Walsh and Riley). —A pest of maple trees, often confused with the Cottony Maple Scale. Oviparous, 1/6 to 1/5 inch long, yellow, rounded-oval.

Other Greenhouse Scales

Lemons, crotons, oleanders, ivies, etc. in greenhouses are frequently attacked by species of *Coccus*, *Saissetia*, *Aspidiotus*, *Chrysomphalus*, *Orthezia* and *Hemichionaspis* in addition to the Mealy Bugs already described.

Soft Brown Scale (*Coccus hesperidum* Linn.).—An oval, flat scale, straw colored to dark brown; viviparous. Occurs on oleander, Cycas, ivy, rubber plant, box elder.

Hemispherical Scale (*Saissetia hemisphærica* Targ.).—An oval, polished, rich brown scale; oviparous. Occurs on palms, orchids, ferns, asparagus, oleanders (Figs. 82 and 83).

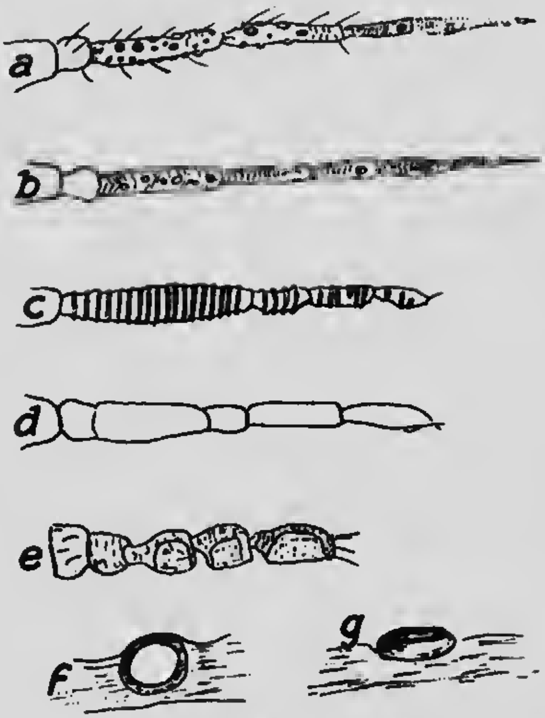


FIG. 86.—Types of antennæ of aphids: *a*, *Chaitophorus; b*, *Aphis; c*, *Schizoneura; d*, *Pemphigus* (apterous); *e*, *Chermes; f*, *g*, *sensoria.*

Oleander or Ivy Scale (*Aspidiotus hederæ* Vall.).—A circular, flat, grey or white scale, with a pale orange-colored centre. Occurs on oleander, ivy, box wood, orange, palm, cycad.

Circular Scale (*Chrysomphalus aonidum* Linn.).—A circular dark brown scale with a grey nipple in a reddish brown ring. Occurs on Araucaria, citrus, oleander, begonia, and rubber plant.

Greenhouse Orthezia (*Orthezia insignis* Dougl.).—An ochreous to green insect, covered with plates of waxy secretion. Occurs on many plants (Fig. 81).

Aspidistra Scale (*Hemichionaspis aspidistræ* Signoret).—Female scale 1/10 inch long; oviparous; light or dark brown with exuviæ brighter; thin and delicate; somewhat oyster-shell shaped. Male

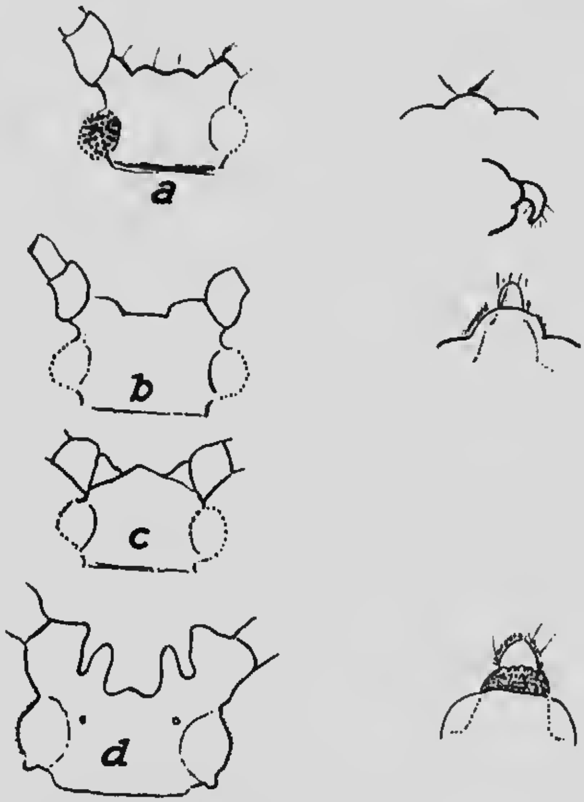


FIG. 87.—Front of head and cauda of aphids: *a*, *Microsiphum cratægi*; *b*, *Myzus* (apterous); *c*, *Myzus* (alate); *d*, *Phorodon*.

scale white, 3-ridged, slender, edges parallel. Occurs on Boston fern, aspidistra, orange, orchids, Davallia (Figs. 85 and 86).

Control.—On indoor plants for Mealy Bugs use Black Leaf 40 (1 to 400) and soap (4 lb. to 50 gal.); for Hard and Soft Scales use whale-oil soap (1 lb. to 2 gal.) or a dilution of some good miscible oil to which Black Leaf 40 has been added.

Spray with lime-sulphur, whale-oil soap, kerosene emulsions, miscible oils or whitewash when outdoor plants are infested.

APHIDIDÆ (APHIDS OR PLANT-LICE)

CHIEF ECONOMIC GENERA (Figs. 86–94)

A. Front wings with four oblique veins; antennæ generally 6-segmented.
  B. Media of fore wings twice forked (except *Lachnus* in part).
    C. Antennæ of winged female 5-segmented.—*Sipha.*
    CC. Antennæ of winged female 6-segmented.
      D. Cornicles mammiform; filament of sixth segment of antennæ not developed.
        E. Fore wing with stigmal shading appearing as the stigma, extending to tip of wing. Large aphids occurring commonly on *Quercus*, *Tilia*, and *Platanus*.—*Longistigma.*
        EE. Venation normal, except in *Lachnus* where media is sometimes unbranched or only once forked. Occurring usually on conifers, never on *Tilia* or *Platanus*.
          F. Flocculent species. Never on conifers.—*Phyllaphis.*
          FF. Not conspicuously flocculent as in F. Occurring on conifers.—*Lachnus.*
      DD. Cornicles variously shaped, seldom mammiform but if so the filament of sixth antennal segment developed.
        E. Large aphids with cornicles usually vasiform, body and appendages hirsute. Occurring on *Populus* and *Salix.*—*Pterocomma.*
        EE. Not as above.
          F. Cornicles short or wanting, usually tuberculate; cauda bluntly rounded or knobbed.
            G. Cornicles appear as mere rings; wings held horizontal when at rest.—*Monellia.*
            GG. Cornicles usually distinct; wings held slanting or roof-shaped over back when at rest.
              H. Body and appendages hirsute in which respect it approaches *Pterocomma* but smaller and mostly leaf-feeders; hairs not knobbed; antennæ noticeably shorter than body; gregarious on host.—*Chaitophorus.*
              HH. Body not conspicuously hirsute; antennæ varying in length often

noticeably longer than body; hairs on antennæ and body usually knobbed; most species living solitary or scattered on host.—*Callipterini* (includes *Myzocallis*, *Callipterus*, *Euceraphis et al.*).[1]

FIG. 88.—Types of cornicles among the aphids. Beginning from left, *Aphis avenæ*, *A. brassicæ*, *A. gossypii*, *Chaitophorus negundinis*, *Hyadaphis* sp., *Liosomaphis* sp.

FF. Cornicles short to very long but not tuberculate; cauda not globular or knobbed.

G. First antennal segment gibbous on inner side.

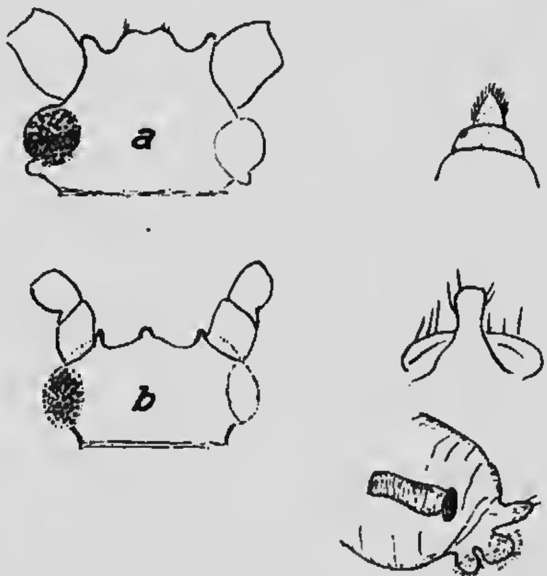


FIG. 89.—Front of head and cauda of two aphids: *a*, *Rhopalosiphum*; *b*, *Aphis*.

H. Frontal or antennal tubercles with a prominent tooth-like projection on inner side; cauda tapering.—*Phorodon*.

[1] See *Can. Ent.*, Vol. 42, No. 8.

HHH. Frontal tubercles without the prominent tooth-like projection; cauda more or less sickle shaped.—*Myzus.*

GG. First antennal segment not conspicuously gibbous on inner side.

H Head with distinct and more or less prominent frontal tubercles.

I. Cornicles clavate; antennæ seldom longer than body; cauda tapering and knobbed.—*Rhopalosiphum.*

II. Cornicles cylindrical or inconspicuously swollen; antennæ usually longer than body; cauda ensiform.—*Macrosiphum.*

HH. Head with frontal tubercles absent or slight.

I. Cornicles distinctly clavate.—*Siphocoryne* (Hyadaphis).

II. Cornicles usually cylindrical and of moderate length; if clavate they are only slightly swollen and quite small.

J. Cornicles very short, much shorter than cauda, slightly swollen; beak short; antennæ shorter than body.—*Hyalopterus.*

JJ. Not as above, *i.e.*, cornicles moderately long, usually longer than cauda, cylindrical; antennæ usually as long as or only slightly shorter than body.—*Aphis.*

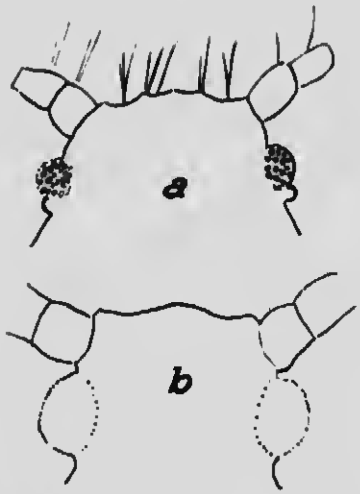


FIG. 90.—Front of head of aphids: *a*, *Chaitophorus*; *b*, *Hyadaphis*.

BB. Media of fore wings once forked or simple.

C. Media simple.

D. Hind wings with two oblique veins.—*Pemphigus.*

DD. Hind wings with but one oblique vein.

E. Antennæ 6-segmented.—*Tetraneura.*

EE. Antennæ 5-segmented.—*Hamamelistes.*

EEE. Antennæ 3-segmented.—*Hormaphis.*

CC. Media once forked.

D. Cornicles present, an Aphis-like species.—*Toxoptera.*

DD. Cornicles vestigial or wanting.

E. Hind wings with two oblique veins.—*Eriosoma.*

EE. Hind wings with one oblique vein.—*Colopha.*

AA. Front wings with three oblique veins, the media simple (unbranched), radial sector merged with margin of stigma; antennæ never more than 5-segmented.

B. Antennæ 5-segmented; wings at rest folded upright; galls on conifers. —*Chermes*.

BB. Antennæ 3- or 4-segmented; wings at rest flat on back; galls on grape, hickory, etc., never on conifers.—*Phyllaxera*.

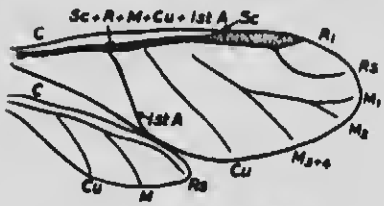


FIG. 91.—Venation of *Macrosiphum*. (*After Patch.*)

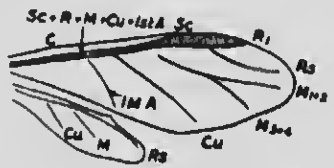


FIG. 92.—Venation of *Toxoptera*. (*After Patch.*)

Plant-lice or Aphids are gregarious sucking insects, often abundant on many varieties of plants, and doing much injury. Three forms occur: 1. sedentary wingless viviparous agamic females, 2. migratory winged viviparous agamic females, 3. sexual males and females —the females oviparous and wingless and the males winged or wingless.

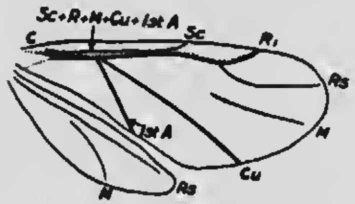


FIG. 93.—Venation of *Tetraneura*. (*After Patch.*)

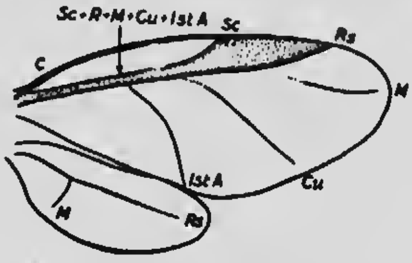


FIG. 94.—Venation of *Chermes*. (*After Patch.*)

Reproduction among the aphids may be represented diagrammatically as follows:

$$O-P-P-P-P-P-P-P-P\begin{matrix} \diagup\ \text{♂}\ \diagdown \\ \diagdown\ \text{♀}\ \diagup \end{matrix}O$$

$$=P=P-P-P-P-P\begin{matrix} \diagup\ \text{♂}\ \diagdown \\ \diagdown\ \text{♀}\ \diagup \end{matrix}O$$

where *O* represents the overwintering egg, *P* the viviparous agamic wingless form, and =*P*= the viviparous agamic winged form, and ♂ and ♀ the sexual forms (Fig. 95).

In general, plant-lice are soft-bodied and green, sometimes brown or black. The winged forms have four delicate wings with a few simple veins—the front pair much larger than the hind pair. The sucking beak is 3-jointed; the legs and antennæ are long and the eyes prominent. In autumn the sexual females deposit eggs that hatch in the spring into females which are often termed "stem-mothers." These produce living females which in turn produce living females, and so on for several generations. As each female produces several young, and these mature in a short time, reproduction is very rapid. When autumn approaches and food supply becomes scarce a brood of winged males and wingless females is produced. The females produce the winter eggs. Sometimes agamic females hibernate.

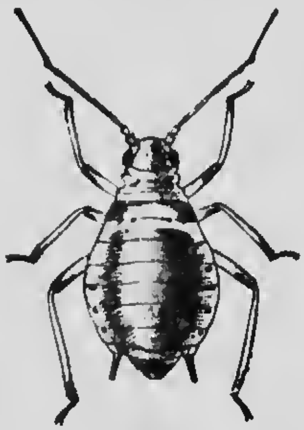


FIG. 95.—An apterous viviparous female aphid.

There are many species of plant-lice, some feeding on one variety of plant, but many are capable of feeding on two or more varieties. Some feed for a time on one host plant, then migrate to another for the summer, finally returning to the first one in autumn. Some produce abnormal growths called galls, such as the grape phylloxera gall, the cockscomb gall on the elm, the cottonwood gall, the poplar gall, etc.

Most plant-lice excrete a sweet liquid called "honey-dew," which is attractive to ants, bees, wasps and other insects. On account of this honey-dew aphids are often attended by ants who guard them. Forbes has shown that the little brown ant (*Lasius niger*) has domesticated the Corn Root Aphis, which is cared for and controlled in all stages of its development. (Consult Bull. 110, 112, 276 and Farmers' Bull. 804, U. S. Dept. Agr., and Bulletins by Parrott, Patch, Forbes, Herrick and Matheson.)

Fecundity.—Regarding the powers of reproduction of aphids Webster and Phillips (Bull. 110, U. S. Bur. of Entom.) cite the estimates of Huxley and Buckton. The former estimated that the tenth generation alone of a single Rose Aphis, were there no deaths, would contain more substance than 500 million stout men; the latter computed that in 300 days, or 15 generations of 20 each, there would be 20^{15} individuals, equal in weight to 1,638,400,000 men, supposing that 1000 aphids weigh 1 grain and 1 man weighs 2,000,000 grains. Another computer makes the possible number of individuals very much higher, viz., 210^{15}. It is believed that in the case of the Spring Grain Aphis or "Green Bug" (*Toxoptera graminum*) reproduction would not fall short of the figures given above as the average number of young produced in Indiana by each viviparous female for 1907-8-9 was 28.2. It is conceivable, therefore, how this pest is able to devastate vast areas of grain fields within a few weeks.

Professor Forbes of Illinois (Bulletin 130) also computes the fecundity of the Corn Root Aphis on the basis of a generation of 12 to 15 young in 2 weeks. If all the progeny lived and multiplied at this rate for a season they would reach 9,500,000,000.

In the case of the Green Apple Aphis (*Aphis pomi*) A. C. Baker reports the average reproduction per insect for the entire season as about 40. As the stem-mother becomes mature about May 1st in Virginia, and there are from 9 to 17 generations, or an average of 13, reproduction is very rapid. The potential number of green apple aphids in September from a single stem-mother would be 40^{13} = 670,088,-640,000,000,000,000.

J. J. Davis reports for the Oat Aphis (*Aphis avenæ*) 15 generations for Indiana with an average of 30 young for each female. The progeny of one stem-mother at the end of the season would be 30^{15}.

The same writer gives for the Pea Aphis (*Macrosiphum pisi*) the average number of young borne by female of 16 consecutive generations as 65. The progeny of a stem-mother at the end of the season would in this case be 65^{16}.

Natural Enemies.—Lady-bird beetles, syrphid maggots, lace-wing larvæ, many parasitic hymenoptera, nymphs of tree-crickets, harvest-spiders, birds.

Control.—Spray with kerosene emulsion, whale-oil soap, tobacco extract, etc.

Chief Economic Species

COMMON CEREAL AND FARM CROP APHIDS

Apple Bud or Oat Aphis (*Aphis avenæ* Fab.).—Sometimes called the European Grain Aphis; is often injurious to apple buds and appears before the other apple aphids. Stem-mothers appear early in May and are yellowish-green with three dark lines on back; progeny winged and blackish; migrate to grains and grasses in the second and third generations, winged and wingless generations. Migrate back to apple in September where mating occurs. Males produced on the secondary host and females on the primary host. Beak short and stout; thoracic shield dark; cornicles short and flanged; cornicles, antennæ and feet black.

Clover Aphis (*Aphis bakeri* Cowan).—Sometimes attacks the apple in the middle West. Eggs are laid on the apple, the pink stem-mothers appear early and give rise to green winged and wingless forms. The former migrate to clovers and give rise to several wingless generations. In late autumn the winged forms fly back to the apple and hawthorn where the eggs are laid. Cornicles are short.

Corn Leaf Aphis (*Aphis maidis* Fitch).—Bluish-green, with black legs, antennæ and cornicles; a row of black dots on each side of back.

Corn Root Aphis (*Aphis maidi-radicis* Forb.).—Bluish-green lice on corn roots; attended by brown ant (*Lasius niger*).

Spring Grain Aphis or Green Bug (*Toxoptera graminum* Rond.).—Infests cereals in spring; wingless form yellowish-green, with faint dark line along back; eyes black. Winged form larger, with darker thorax. Migrates to other regions and to grasses. Parasitized by *Lysiphlebus tritici*.

Western Grain Aphis (*Brachycolus tritici* Gillette).—Is injurious to winter wheat in Montana.

English Grain Aphis (*Macrosiphum granarium* Kirby).—Occurs on wheat, barley and the grasses, *Agrostis*, *Bromus*, *Dactylis*, *Poa* and *Phleum* and Cat-tail, widely distributed in the U. S.

COMMON FRUIT APHIDS

Apple Bud or Oat Aphis (*Aphis avenæ* Fab.).—See above.

Green Apple Aphis (*Aphis mali* Fab. = *A. pomi* DeG.).—This aphis collects usually on the tips of tender shoots, on the under surface of the leaves, and when abundant attacks the developing fruit. Winters on twigs as black shining eggs which hatch just before leaf buds open; 1/12 inch long, pear-shaped; bright green; black, slender cornicles; inhabits the apple throughout the season; winged females occur during summer. Causes curling of the leaves to some extent, those of young trees suffering most. Several (10–15) generations

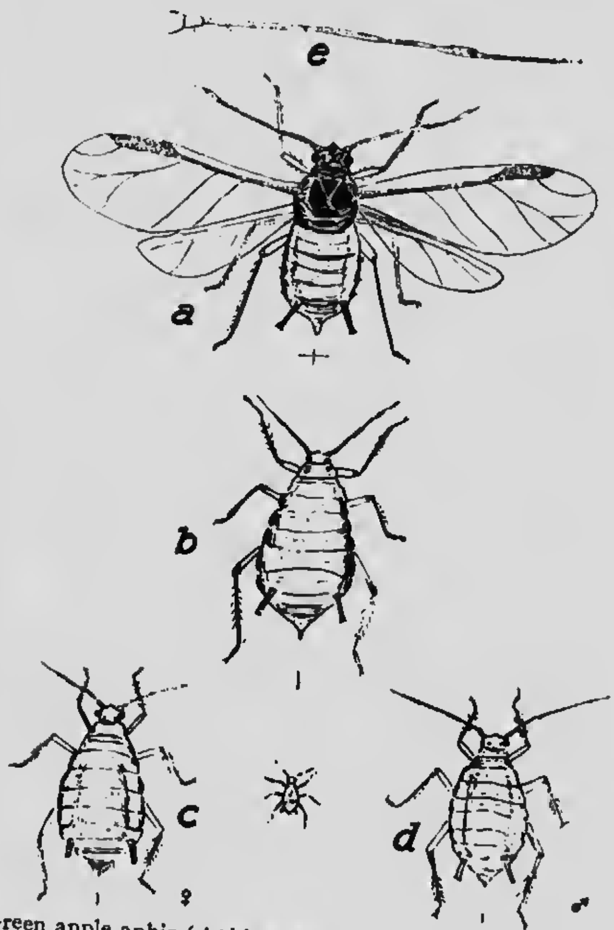


FIG. 96.—Green apple aphis (*Aphis pomi*): *a*, alate or winged form; *b*, apterous or wingless form; *c*, oviparous female; *d*, male; *e*, antenna of winged form.

a season, and each generation shorter than 3 weeks; each mother roduces about 70 young (Fig. 96).

Rosy Apple Aphis (*Aphis sorbi* Kalt. = *A. malifoliæ* Fitch = *A. yri* Boyer).—This shade-loving aphis collects around the flower buds, e developing fruits and on the under side of the leaves. It causes early all the curling of the leaves and the "cluster-apples." Larger an preceding; 1/9 inch long. Wingless females blue; honey-tubes yellow tipped with black, long and tapering; body covered with a powdery substance. Winged females with black thorax and red abdomen, honey-tubes long and black. Two small tubercles at end of abdomen; the late winged forms are migrants and have a black patch on abdomen, black bands across last segments of abdomen, and black spots on sides. Egg-laying females lemon-yellow, mate with migrant winged males. In this species also the males are produced on the secondary and the females on the primary host. After the third summer agamic generation this species deserts the apple for the plantain, but returns in autumn. (Consult "Apple Tree Insects of Maine," Circ. 31, Bur. Ent., U. S. Dept. Agr.)

Sweet Cherry Aphis (*Myzus cerasi* Fab.).—Eggs oval and black, laid around the buds and on bark of twigs and branches, hatching in late April. Stem mother globose and glossy black. First brood wingless viviparous, later broods winged and wingless viviparous; the winged form with head, thorax, cornicles and cauda black, and abdomen dark green to dark brown migrate to *Lepidium* where several broods of dark brown, wingless viviparous forms and darker winged forms are produced. The latter return to cherry when they and other resident winged forms produce viviparous females which are fertilized by migrant winged males from *Lepidium*. No males are produced on the cherry. Six to 14 generation are produced during the season in the Niagara district. Controlled most successfully in early spring, just before the buds burst, by spraying with lime sulphur and Black Leaf 40 (Ross, 48*th Rep. Ont. Ent. Soc.*, 1917).

Clover Aphis (*Aphis bakeri* Cowan).—See above.

Green Peach Aphis (*Myzus persicæ* Sulz).—This general feeder is our most common greenhouse species. Under glass it reproduces viviparously from year to year. At first the young lice are pink, but next generation is bright green. Migration in third generation to garden crops (where it has been known as *Rhopalosiphum dianthi* Schr.) returning in autumn to peach.

Currant Plant-louse (*Myzus ribis* L.).—A small yellowish plant-louse causing a curling and blistering of the leaves of currants with red discoloration of the upper surface. Wingless female light green and mottled; body covered with capitate hairs, and with two rows of spots on mid-dorsal surface. Winged forms darker and abdomen crossed by several bands. Migrates to *Stachys* and *Galeopsis* (Gillette).

Hop Plant-louse (*Phorodon humuli* Schrank).—Migrates from plums to hop in the third generation; yellowish-green, with a prominent tubercle on head at base of each antenna, and another smaller tubercle on the base of each antenna.

Apple Woolly Aphis (*Schizoneura* (= *Eriosoma*), *lanigera* Haus, *americana* Riley in part).—(Consult Bull. 256, Maine Agr. Expt. Stn.,

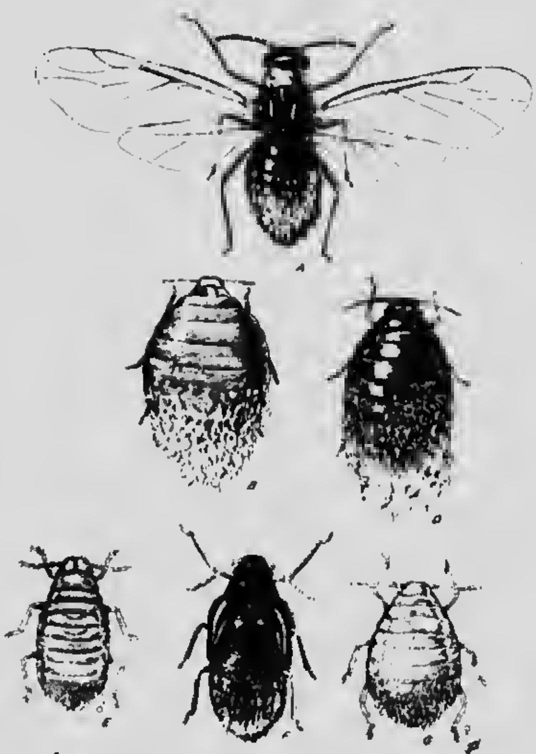


FIG. 97.—Forms of the woolly apple aphis: *A*, winged viviparous female; *B*, stem-mother; *D*, wingless viviparous female, summer form; *E*, male; *F*, pupa of fall migrant; *G*, oviparous female. All much enlarged. (*After Baker, U. S. Bur. Ent.*)

1916.) This native woolly aphis is frequently injurious to many varieties of apple trees, causing deformations both on the stems and leaves and on the roots. It occurs also on pear, hawthorn and mountain ash, and passes part of its life on the elm. The injury to the roots consists in the formation of hard fibrous enlargements resembling knots or clubs, often causing the death of the affected part. Nursery stock is liable to infestation and severe injury. The injury to the branches is not so serious, but in cases of severe infestation it causes stunted growth and yellowing of the leaves. Colonies often collect at the axils of leaves, on water-sprouts, and at abrasions and wounds.

The common form seen on roots and limbs is wingless, 1/10 inch long, reddish-brown, and covered with a woolly waxy excretion (Fig. 97).

The life-history of the trunk forms is as follows:

Some winter near the base of the apple tree as immature nymphs; but those in the elm as eggs in crevices of the bark. The hibernating nymphs on the apple migrate to the branches in early spring, and a succession of parthenogenetic generations of apterous viviparous females appears throughout the season. From the eggs on the elm hatch out apterous viviparous stem-mothers in early spring about May 15th, the second generation is also apterous viviparous, but the third is winged and migrates to the apple, hawthorn and mountain ash where three generations are developed, two being apterous, and the third part apterous and part winged. The winged form migrates back to the elm, and produces the wingless sexual forms. Each female lays one large yellow egg which winters on the tree. The wingless forms remaining on the apple give rise to another generation which winters over as immature nymphs.

The injury to the elm leaves is characteristic—the formation of terminal leaf clusters or rosettes. *S. americana* produces leaf-curl.

The winged forms are nearly black, the abdomen being rusty brown, the wings are clear and the antennæ have annulations and are 6-jointed. The sexual forms are wingless, beakless, smaller than the agamic forms; the female 1/20 inch long, reddish-yellow, is larger than the olive-yellow male; the antennæ are 5-jointed, and without annulations as in other apterous forms. The root colonies ordinarily remain underground throughout the year, and do less injury northward.

Parasites.—*Aphelinus mali*, a chalcid; *Pipiza radicum*, a syrphid; lady-bird beetles.

Control.—Spray thoroughly the aerial forms with kerosene emulsion, soap solution or tobacco decoction; dip roots of suspected nursery stock in same solution or fumigate with HCN; add tobacco dust to the soil.

Black Peach Aphis (*Aphis persicæ-niger* Er. Sm.).—Black; lives on roots, twigs and leaves. No migration. Of no economic importance in Ontario (Fig. 98).

Mealy Plum Louse (*Hyalopterus arundinis* Fab.).—Has long narrow light green body with three longitudinal stripes; covered with a mealy powder; honey-tubes short and thick; winged females migrate in June to grasses and cat-tail and return in autumn.

Variable Currant Aphis (*Aphis varians* Patch).—Infests currants, gooseberries and flowering currants, causing curling of the leaves. The winged summer forms migrate to some unknown host, and return

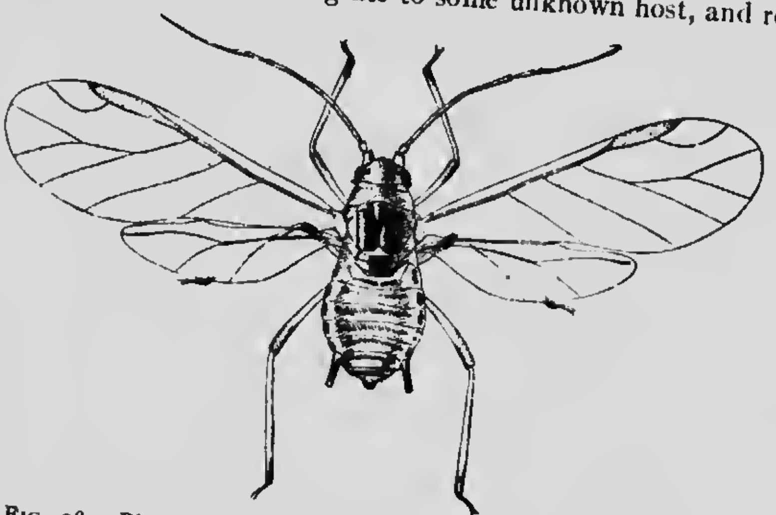


FIG. 98.—Black peach aphis (winged female). (*After Quaintance.*)

in the fall. The eggs are deposited on the twigs. The stem-mother is purplish-green with white honey-tubes. The winged form has a black head and body, with a dark green abdomen marked with black, while the wingless form is dark green, tan or dark brown.

Green Gooseberry Aphis (*Aphis sanborni* Patch).—Green; honey-tubes white.

Grape Phylloxera (*Phylloxera vitifoliæ* Fitch = *vastatrix* Planchon).—Four forms are recognized: (1) wingless leaf-gall form; (2) wingless root form; (3) winged form; (4) sexual form.

1. Adult leaf-gall form is a wingless female, plump, orange-yellow. Fills gall with many yellow eggs which hatch in 3 days into females. Several generations during summer. The feeding puncture stimulates the growth of the leaf tissue so that a hollow gall is produced, opening on the upper surface.

2. Root form similar to that on leaf; often derived from leaf form several generations in a season; yellowish and wingless, and forms nodules which break down and decay, often destroying the root. Yellowish oval eggs are laid on the roots. Larvæ moult three times. Leaf-galls are most common on American grapes while root-galls are most common on European grapes.

3. Some of the root forms in late summer develop elongate long-legged winged females that fly to neighboring vines and lay 2–4 eggs beneath loose bark.

4. These eggs are of two sizes—the smaller producing males, the larger sexual females. These are wingless and minute. Each female lays one large egg from which hatch the following spring the leaf and root forms. Not destructive on sandy soils.

Control.—Spray in early spring with lime sulphur; use American varieties as stock.

COMMON GARDEN APHIDS

Cabbage or Turnip Plant-louse (*Aphis brassicæ* L.).—Often abundant on the under surface of leaves of cabbages and turnips, and very destructive in warm dry weather. A greenish, soft, pear-shaped insect covered with a whitish bloom. Mature forms have black head and eyes and dark cornicles; nymphs are pale green with black legs and antennæ. Parasite, *Aphidius rapæ*, a braconid.

Aphis pseudobrassicæ Davis.—Also occurs on turnip, radish, cabbage, rape, mustard, etc., and is often mistaken for *A. brassicæ*.

Melon Plant-louse (*Aphis gossypii* Glov.).—Occurs on the under surfaces of the leaves of melon, cucumber, squash etc., and also on other crops and weeds. Winter eggs have been found on purslane and strawberry. A blackish-green insect. Apterous females with legs and antennæ whitish, cornicles black and short; winged forms with a row of black spots on sides of abdomen, and spots on head and thorax.

Bean Aphis (*Aphis rumicis* L.).—Occurs on the tips of horse and broad beans at time of flowering. When the lice are abundant the plants assume a sooty sticky appearance. Also on apple, dahlia, dock, shepherd's purse, pigweed, snowball and burning bush. This aphis is slaty blue or black, with white bands on the legs and often with waxy tufts. Called also the "black fly," "collier" and "black dolphin."

Strawberry Root Louse (*Aphis forbesi* Weed).—Bluish-green, on roots of strawberry; occurs also on leaves. Eggs laid on stems and leaves. Ants carry lice to roots. Of no economic importance in Ontario.

Pea Plant-louse (*Macrosiphum pisi* Kalt.).—Green; eyes red; legs long; migrates in August to clover fields where eggs are laid and first spring generation feeds. Parasites—*Aphidius fletcheri* Ash., *Megorismus fletcheri* Crwd., a chalcid.

Potato Plant-louse (*Macrosiphum solanifolii* Ashmead).—Green or pink; migrates to the rose, where winter is spent. Feeds on a large number of plants.

Green Rose Aphis (*Macrosiphum rosæ* Linn.).—A large pale green aphis with dark antennæ and the cornicles long and black. Occurs on roses.

Black Chrysanthemum Aphis (*Macrosiphum sanborni* Gill.).—Occurs on chrysanthemums in greenhouses. A brownish-black pyriform plant-louse.

COMMON SHADE AND FOREST TREE APHIDS

Negundo Plant-louse (*Chaitophorus negundinis* Thos.).—A serious pest of the ash-leaved or Manitoba maple in the West. Infested trees soon become covered with honey-dew in which a sooty fungus develops.

Woolly Apple Aphis (*Schizoneura lanigera*).—See above.

Poplar Leaf Gall Louse (*Pemphigus populicaulis* Fitch).—Produces a deformity at the junction of petiole and blade of cottonwood and aspen.

Alder Blight (*Pemphigus tessellatus* Fitch).—A Woolly aphid, occurs on branches of alder. Winged forms migrate to the maple.

Beech Tree Blight (*Pemphigus imbricator* Fitch).—A similar form on the twigs and leaves of beech.

Sitka Spruce Gall Aphis (*Chermes cooleyi* Gillette), **Western Hemlock Woolly Aphis** (*Chermes funitectis* Dreyfus), **Sitka Spruce Green Aphis** (*Aphis abietina* Walk.).—Are important economic forms on the Pacific Coast of British Columbia.

Spruce Gall Aphis (*Chermes abietis* Chol.).—Abundant locally on White and Norway spruces, producing pine-apple-like galls at base of terminal shoots. Each gall, ¾ inch long, contains about 50 cells each holding from 8 to 12 nymphs. The life-cycle is briefly as follows:

"Galls open about mid-August and fully grown pupæ emerge and moult within a few hours becoming the winged form which deposits a cluster of 40 to 50 yellow eggs on a spruce needle. The eggs are extruded from the abdomen but the parent Chermes remains over them until dislodged after her death by wind or rain. The winged form often oviposits near the gall from which it emerges. A different species of host plant is never sought by this *Chermes*. In about two weeks the young "stem-mothers" hatch from these eggs and seek a protecting crevice in the surface of the spruce bud where they can spend the winter. These wingless forms develop in the spring and become full grown about the last of May when they lay a cluster of 140 or more eggs. From these eggs hatch the young that inhabit the gall and are known as the "gall generation" with which we started the cycle" (Patch).

Spruce Gall Aphis (*Chermes similis* Gill.).—(Consult Bull. 173, Maine Agr. Exp. Stn.). Abundant locally on black, red, white and Norway spruces, producing loose terminal galls and scraggly deformed twigs. The galls open about July 1st and the winged flocculent migrants oviposit on spruce.

Control.—Spray in early spring while trees are dormant with whale-oil soap (1 lb. to 2 gal. water). Black Leaf 40 (1 to 800) added to soap (1 lb. to 4 gal. water).

Pine Bark Aphis (*Chermes pinicorticis* Fitch).—A common enemy of cultivated pines, appearing as flocculent white masses upon the green bark of the more tender parts.

Control.—Spray in late April or May with fish-oil soap or kerosene emulsion.

DOUBLE-HOST APHIDS

Following is a partial list of double-host Aphids:

Chermes abieticolens on spruce	= Chermes pinifoliæ on white pine.
Pemphigus tesselatus Fitch on alder	= Pemphigus acerifoliæ Riley on maple.
Pemphigus balsamiferæ on cottonwood	= Pemphigus betæ on beets.
Eriosoma pyricola on pear	= Eriosoma pyricola on elm.
Eriosoma lanigera on apple	= Eriosoma americana in part on elm.
Eriosoma americana on plum	= Eriosoma americana on Juneberry.
Eriosoma ulmi on English elm	= Eriosoma fodiens on currant.
Hyalopterus arundinis on plum	= H. arundinis on reed grass, cat-tail.
Phorodon humuli on plum	= P. humuli on hop.
Aphis avenæ on apple	= A. avenæ on oats, cat-tail, etc.
Aphis sorbi on apple	= A. sorbi on plantain.
Aphis pruni on plum	= Aphis cardui on thistle.
Aphis perii on oleander	= A. lutescens on milkweed.

Aphis bakeri on apple and hawthorn	= Aphis bakeri on clover.
Aphis brevis on apple and hawthorn	= Aphis brevis on clover.
Aphis euonymi on snowball and burning bush	= Aphis rumicis on bean and dahlia.
Macrosiphum illinoiensis on Viburnum prunifoliæ	= M. illinoiensis on grape.
Macrosiphum solanifolii on rose	= M. solanifolii on potato.
Macrosiphum granarium on grains, rose, etc.	= M. granarium on cat-tail.
Aphis prunorum Dob. on plum, Ribes	= Rhopalosiphum nymphææ on Nymphæa, Alisma, Sagittaria, Typha.
Rhopalosiphum ribis on Ribes	= R. lactucæ on Sonchus.
Rhopalosiphum capreæ on willow	= R. capreæ on Umbelliferæ.
Myzus ribis on Ribes	= M. galeopsidis on Galeopsis, Stachys and Leonurus.
Myzus cerasi on cherry	= M. cerasi on Lepidium.
Myzus persicæ on peach	= Rhopalosiphum dianthi on garden plants.
Rhopalosiphum pastinaceæ on Lonicera	= R. pastinaceæ on Pastinaca.
Hormaphis hamamelidis Fitch on witch hazel	= Hormaphis hamamelidis on birch.
Hamamelistes spinosus Shimer on witch hazel	= Hamamelistes spinosus Shimer on birch.
Tetraneura graminis on Ulmus	= T. graminis on Leersia.
Thecabius populiconduplifolius on poplar	= T. californicus on Ranunculus.
Chermes floccus on white pine	= Chermes floccus on Red and Black spruce.
Chermes cooleyi on Blue and Engelmann spruces	= Chermes cooleyi on Douglas fir.

ALEYRODIDÆ (WHITE FLIES)

White Fly (*Aleyrodes vaporariorum* Westw.).—(Consult Bull. 140, Conn. Agr. Exp. Stn.) Injurious both in adult and nymph stages sucking the juices from the under surfaces of the leaves.

Often abundant in greenhouses, and difficult to control.

Adult.—Wings pure white, covered with minute particles of wax; body yellow, 1/16 inch long; antennæ 6-jointed; beak 3-jointed; tarsus 2-jointed; eyes brown, in two pairs.

Eggs.—Elongate-oval, 1/100 inch long, laid on the leaves; light green or white to dark; hatch in 11–14 days. Unfertilized eggs produce males only; each female usually lays several dozen eggs.

Nymphs.—Three-one-hundredths inch long, yellowish when full grown; long waxen rods on back of "pupa." Life-cycle about 5 weeks.

Control.—Fumigate at night with hydrocyanic acid gas (½ oz. potassium or sodium cyanide, 1 fl. oz. sulphuric acid, 3 fl. oz. water, for every 1000 cubic feet of space); spray or wash repeatedly infested leaves with whale-oil soap (1½ oz. to 1 gal. water).

Citrus White Fly (*Dialeurodes citri* Ashm. = *A. citri* Riley & Howard).—A most serious pest of oranges and other citrous plants of the South. (Consult Tech. Ser. No. 12, Pt. V and No. 27, Bur. Ent., U. S. Dept. Agr.)

PSYLLIDÆ. (JUMPING PLANT-LICE)

Pear Psylla (*Psylla pyricola* Fuerst).—A European pest introduced about 1832, and now widely distributed over the Eastern states and Canada.

Adult.—A dark reddish-brown bug, 1/10 inch long; abdomen with black bands; wings clear with dark veins and laid roof-like over the body; when disturbed it hops and flies away. Eyes bronzy; hibernates on trunk in crevices, etc.; 4-5 generations each year.

Eggs.—Orange-yellow, minute; 1/18 inch long, pear-shaped; deposited in crevices of bark or along midrib of leaf; hatch in 2-3 weeks.

Nymphs.—Broadly oval, flattened, yellowish bodies with crimson eyes; later reddish with black markings and conspicuous black wing pads; secrete honey dew; 4-5 moults.

Natural Enemies.—Lady-birds, protracted periods of wet cold weather in spring, and long spells of hot dry weather in summer.

Control.—Clean cultivation; bark scraped; spraying with Black Leaf 40 (1 pint in 100 gal. water) during warm days in early spring, late fall or after blossoming; spraying with lime-sulphur just before opening of blossoms.

Bramble Flea-louse (*Trioza tripunctata* Fitch).—Occurs on blackberry, causing curling of the leaves and dwarfing of the shoots.

Adult.—A small reddish-brown, jumping plant-louse, ⅛ inch long; wings with three yellowish-brown bands. October–May or June.

Eggs.—Light yellow, deposited in June–July on blackberry.

Nymphs.—Mature in September–October; young nearly pure white to a greenish white; older nymphs yellowish.

CERCOPIDÆ (FROGHOPPERS OR SPITTLE INSECTS)

(Consult Bull. 254, Maine Agr. Expt. Station)

These insects commonly occur in meadows and are often conspicuous by the large number of frothy masses resembling spittle on the leaves of grass, clover and weeds. The injury done is difficult to estimate but it must be considerable in the aggregate. *Philænus spumarius* and *P. lineatus* are common in meadows, and *Aphrophora parallela* Say on pines.

Meadow Froghopper (*Philænus spumarius* Linn.).—This insect feeds on oats and a wide range of plants, many of them weeds, but not on grasses. The injury is apparent in the formation of withered or dwarfed seeds.

Adult.—Body elongate-oval, head bluntly angular, wing-covers extending well beyond the end of abdomen. Color pale grey to black, and the markings quite irregular in form.

Eggs.—Elongate-elliptical, one side straight, the other curved. Shell tough and hard; hibernate in dead stems or leaves in meadows.

Nymphs.—Almost colorless; three instars; antennæ 9-jointed. The viscid frothy masses excreted from anal opening and certain lateral glands on seventh and eighth abdominal segments. The masses are believed to be protective.

Control.—Rotation of crops; early mowing to kill the nymphs; burning the surface dead grass to kill the eggs.

Grass-feeding Froghopper (*Philænus lineatus* L.).—This spittle insect is found almost exclusively on grasses, especially on timothy and red top, and undoubtedly does considerable injury. It causes withering of the stems and blasting of the heads.

Adult.—Distinguished from *P. spumarius* by its longer head, and narrowed body with more nearly parallel sides. Front of head rounded-angular and as wide as thorax. Color grey with a whitish costal margin and a blackish border line.

Eggs.—Hibernate; hatch late in spring.

Nymphs.—Three or more instars; mature in July.

FAMILY CICADELLIDÆ (LEAF-HOPPERS)

(Consult Bull. 108, Bur. Ent., U.S. Dept. Agr. and Bull. 238, 248, Maine Agr. Exp. Stn.)

The Leaf-hoppers are divided into four fairly distinct sub-families, separated by means of the venation of the wings and by the head parts: (1) *Bythoscopinæ* occurring mainly on trees or shrubs, and including *Idiocerus alternatus* and the Clover Leaf-hopper (Fig. 99); (2) *Cicadellinæ*, including the Sharpshooter (*Oncometopia undata*) and *Dræculacephala mollipes* occurring in grass land; (3) *Jassinæ*, including the Shovel-nosed Leaf-hopper (*Dorycephalus platyrhynchus*) on wild rye

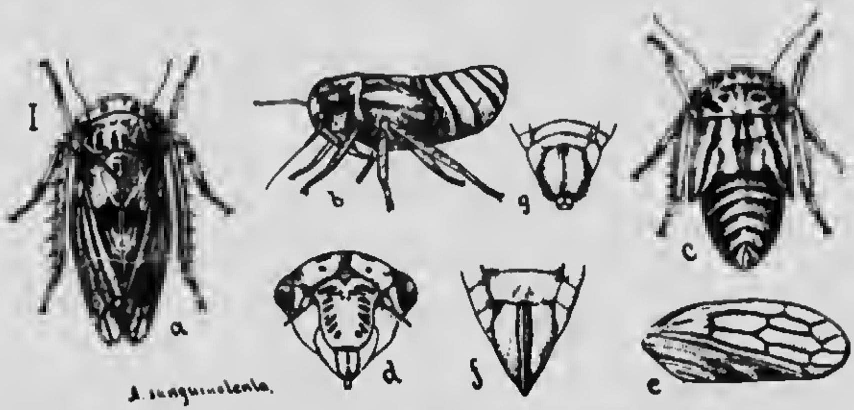


FIG. 99.—The clover leaf-hopper (*Agallia sanguinolenta*): *a*, adult; *b*, nymph, side view; *c*, nymph, dorsal view; *d*, face; *e*, elytron; *f*, female genitalia; *g*, male genitalia. All enlarged. (*After Osborn and Ball.*)

(*Elymus*), the Inimical Leaf-hopper (*Deltocephalus inimicus*) on blue grass, the Destructive Leaf-hopper (*Athysanus exitiosus*) in grain fields, and the Six-spotted Leaf-hopper (*Cicadula 6-notata*) in oat fields; and (4) *Typhlocybinæ* including the Apple Leaf-hopper (*Empoasca mali*) the Rose Leaf-hopper (*Empoa rosæ*) and the Grape Leaf-hopper (*Erythroneura comes*).

The presence of leaf-hoppers in very large numbers in meadows and pastures in late summer indicates that considerable injury is being done, and that they must be reckoned among insects of economic importance.

Six-spotted Leaf-hopper (*Cicadula 6-notata* Fallen).—A small yellow form 4 mm. long with six black dots on the vertex and a double series of black arcs on the front. Occurs on oats, timothy, etc., producing spots on the leaves, whitish at first, then turning to brown or black.

Black Apple Leaf-hopper (*Idiocerus fitchi* Van D.).—A common pest in the Annapolis Valley but the injury is small. The eggs are laid in August and hatch from May 22d to June 13th. The duration of nymphal stage (5 moults) is about 50 days.

Beet Leaf-hopper (*Eutettix tenella* Baker).—(Consult Bull. 66, Pt. IV, U. S. Bur. Ent.; Utah Bull. 155.) This native leaf-hopper causes the "curly-leaf" disease of sugar beets in the Western States and is therefore responsible for much loss. Found also on *Atriplex*, Russian thistle, Sea-blite and *Sarcobatus*. One brood a year.

Adult.—Small, ⅛ inch long, pale yellowish-green to white, often straw-colored. June–August. Hibernates.

Eggs.—Pale greenish-white, elongated, tapering at the end; inserted in the stems or large veins of leaf; hatch in about 2 weeks.

Nymphs.—White at first, becoming like the adult but wingless. Active. Duration 20–25 days. July–September.

Grape Leaf-hopper (*Erythroneura comes* Say).—(See Bull. 215, Cornell Ag. Exp. St., 1904.) This bug is a very common pest in vineyards, and occasionally does considerable injury to the leaves which curl and turn brown. During the summer the nymphs feed on the under surface of the leaves and give them an unnatural spotted appearance. The adults, mature in August, also do much harm. Feeds also on Virginia Creeper, Strawberry, etc.

Adult.—One-eighth inch long; wings and back variably marked with yellow and red. Hibernates in nearby grass and wood-lands, and emerges about May 1st.

Eggs.—Three-one-hundredths inch long, semi-transparent, slightly curved and faintly yellow; deposited in June beneath the lower skin of grape leaves; hatch in 9–14 days.

Nymphs.—Light yellowish-green with lemon-yellowish stripes on each side of the body; pass through 5 stages in 20–23 days; mature in July–August.

Control.—Spray thoroughly with Black Leaf 40, tobacco extract or kerosene emulsion when young nymphs appear; clean culture.

Apple Leaf-hopper (*Empoasca mali* Le Baron).—(Consult Bull. 108, Bur. Ent., U. S. Dept. of Agriculture, and Journ. Econ. Entomology, Vol. 2, p. 54; Vol. 11, pp. 144–148.) Occurs also on beans, alfalfa, clover, potatoes, currants and gooseberries.

Adult.—Slender and cylindrical, ⅛ inch long; brilliant grass-green;

white lines and dots between the eyes; a series of six whitish spots on front margin of prothorax, two whitish lines on mesothorax forming a letter H; three dots on scutellum; strongly convex above; front rounded; wings thin and uniform, folded close about the body; legs slender, hindmost larger; three or four generations each year. Adults may live 14–30 days. Hibernates.

Eggs.—Autumn eggs laid in September under epidermis of apple, summer eggs under epidermis of petioles of apple, clover, etc.; hyaline, cylindrical.

Nymphs.—Light green; feed on under side of leaves causing white spots, most injurious in May–June; five nymphal stages covering 12 days.

Control.—Spray in spring with a mixture of Black Leaf 40 and whale-oil soap; collect adults by driving tanglefoot screens along the rows in bush-fruits.

Rose Leaf-hopper (*Empoa rosæ* Linn.).—Leaves of rose bushes and apple trees are often badly infested with the Rose Leaf-hopper, and all stages of growth may be readily found. Eggs are laid in July, and eggs are again laid in the fall beneath the bark of young wood of roses, blackberry, and strawberry runners, where they stay over winter. Migration from the roses occurs in June. Controlled by lime-sulphur and Black Leaf 40 during the early nymph stages (Consult Bul. 148 Oregon Ag. Exp. St.)

Cicadidæ

Periodical Cicada (*Cicada septendecem* Linn.).—(Consult Bull. 71, Bur. Ent., U. S. Dept. of Agr.) Often called the Seventeen-year Locust. Adults damage orchards and nurseries by making egg punctures in the twigs.

Adult.—One and one-fourth inches long, black; abdomen banded with red; eyes red; veins red at base and along front margin; June; duration about 30 days. Dwarf forms also occur.

Eggs.—Each female lays 300 to 500 eggs in punctures made by ovipositor in twigs and stems; eggs hatch in 6 to 8 weeks.

Nymphs.—Burrow in the ground, feeding on juices of roots and humus of soil; moult probably 4 or 6 times at intervals of 2 to 4 years. In the spring of the seventeenth year they emerge and moult, changing to adults. A race or sub-species having a 13-year period occurs mainly in the South. Over twenty *broods* have been recognized and delimited.

Control.—Prune off affected twigs in July and burn before the hatching of the eggs; allow hogs the run of infested land during April and May; avoid pruning the orchard the year before a cicada year.

Natural Enemies.—A digger wasp (*Megastizus speciosus*), egg parasites (cecidomyiid and chalcid); mites; the English sparrow, catbird, robin, etc.

The Dog-day Harvest-fly (*Cicada tibicen* Linn.).—Often occurs but is not of much importance economically. It is black and green, and white powdered underneath.

FIG. 100.—Twigs showing egg punctures of the Buffalo tree-hopper.

MEMBRACIDÆ (TREE-HOPPERS)

Buffalo Tree-hopper (*Ceresa bubalus* Fab.).—(Consult Circ. 23, Div. Ent., U. S. Dept. Agric.) This bug is a common pest of orchards and shade trees feeding on the sap of apple, maple, etc. It injures the trees by making longitudinal incisions in the bark, which become points of weakness (Fig. 100).

Adult.—A grass-green bug, 3/8 inch long, with the pronotum greatly enlarged, and expanding laterally into two horns and posteriorly into a long point. July–September.

Eggs.—Dirty-whitish, cylindrical, slightly curved, tapering toward outer end; 1/16 inch long. Laid in the bark in batches of 6–12 in two curved slits made by ovipositor. Egg-laying occurs in August and September; hatching the following May and June.

Nymphs.—Covered along the centre of the back with numerous forked or barbed spines or projections, a pair to each segment. General feeders in or near orchards.

Control.—Thorough cultivation of the orchard and destruction of weedy borders in May and June.

ORDER HEMIPTERA (= FORMER SUB-ORDER HETEROPTERA)

Chief Economic Families[1] (after Comstock) (Fig. 101)

A. Antennæ with 3–4 segments.

B. Beak 3-jointed.

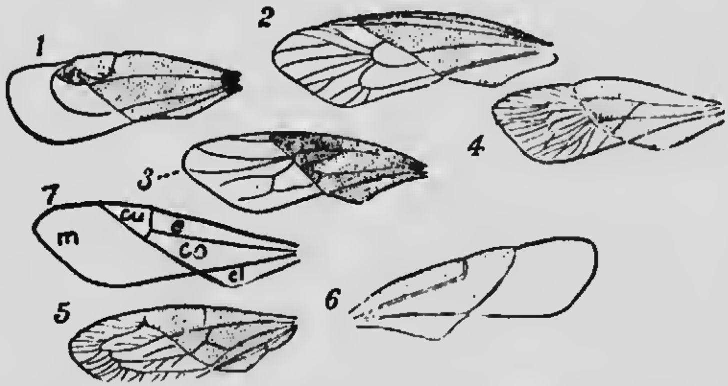


FIG. 101.—Fore wings of Heteroptera 1. Capsidæ; 2. Pyrrhocoridæ; 3. Lygæidæ; 4. Coreidæ; 5. Nabidæ; 6. Acanthiidæ; 7. Typical wing showing parts: *m.*, membrane; *cu.*, cuneus; *e.*, embolium, *co.*, corium; *cl.*, clavus. (*After Comstock.*)

[1] Other Hemiptera Families are of frequent occurrence, especially in or about water. For convenience of reference the common families (old Hepteroptera) are synopsized as follows:

A. *Short-horned Bugs.*—Live in or near water; antennæ short and concealed beneath the head.

Families: Corisidæ, Notonectidæ, Nepidæ, Belostomatidæ, Naucoridæ, and Galgulidæ.

AA. *Long-horned Bugs.*—Antennæ at least as long as the head.

B. *Semi-aquatic Bugs.*—Saldidæ, Veliidæ, Hydrobatidæ, Limnobatidæ.

BB. *Land-bugs.*

C. Antennæ 4-jointed. Emesidæ, Reduviidæ, Nabidæ, Phymatidæ, Aradidæ, Tingitidæ, Acanthiidæ, Capsidæ, Pyrrhocoridæ, Lygæidæ, Berytidæ, Coreidæ.

CC. Antennæ 5-jointed. Pentatomidæ, Cydnidæ, Corimelænidæ, Scutelleridæ.

C. Front legs with thick femora.—*Phymatidæ* (Ambusb-Bugs) p. 43.

CC. Front legs normal or slightly thickened.

D. Body not flattened.—*Reduviidæ* (Assassin Bugs), p. 43.

DD. Body flattened.

E. Tarsus with 2 segments.—*Aradidæ* (Flat Bugs).

EE. Tarsus with 3 segments, dorsum flat, beak short.—*Acanthiidæ* (Bedbugs), p. 167.

BB. Beak 4-jointed.

C. Ocelli absent.

D. Membrane of front wings with about eight branching veins; cuneus absent and with two large cells at base.—*Pyrrhocoridæ* (Red Bugs).

DD. Membrane of front wings with no branching veins; cuneus present and with one or two closed cells at base. —*Miridæ* or *Capsidæ* (Leaf Bugs), p. 163.

CC. Ocelli present.

D. Front legs fitted for grasping.—*Nabidæ* (Damsel Bugs), p. 43.

DD. Front legs normal.

E. Membrane of front wings witb 4 or 5 simple veins arising from its base.—*Lygæidæ* (Chinch Bugs), p. 161.

EE. Membrane of front wings with many forked veins arising from a transverse basal vein.—*Coreidæ* (Squash Bugs), p. 159.

AA. Antennæ with 5 segments.

B. Scutellum flat, narrowest behind; tibiæ usually without spines.—*Pentatomidæ* (Stink Bugs), p. 166.

BB. Scutellum convex, covering nearly the whole abdomen; tibiæ strongly spinose; prothorax rounded in front and straight behind; scutellum margin furrowed.—*Corimelænidæ* (Negro Bugs), p. 167.

BBB. Scutellum convex; prothorax not as above; scutellum with lateral margin unfurrowed.—*Scutelleridæ*.

Coreidæ (Squash Bugs)

Box-elder Plant Bug (*Leptocoris trivittatus*). Leaves attacked turn yellow and drop. Occurs in the West and is spreading eastward.

Adult.—A blackish bug 1/3 inch long, with three broad red lines on the black thorax; veins of wings red, also edges of harder parts of wings; mature in autumn. Hibernates under rubbish or in crevices.

Eggs.—Laid in spring and early summer on box-elder trees.

Nymphs.—Also show bright red markings of adult. Very young forms are bright red; mature in less than 2 weeks.

Control.—Collect bugs in sunny days in winter from trunks of trees, spray young forms with tobacco-soap solution.

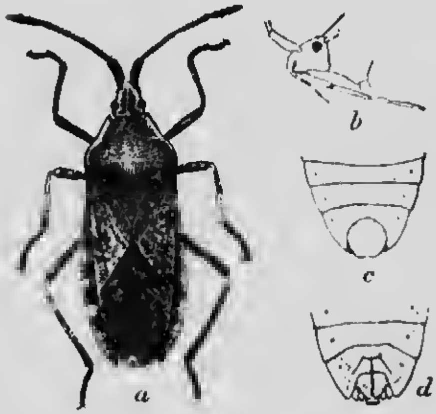


FIG. 102.—Squash bug (*Anasa tristis*): *a*, mature female; *b*, side view of head showing beak; *c*, abdominal segment of male; *d*, same of female. (*After Chittenden.*)

Squash Bug (*Anasa tristis* DeG.).—(Consult Cir. 39, Div. Ent., U. S. Dept. Agr.) Infests pumpkins and squashes. A sucking insect which should not be confused with the cucumber or squash beetle.

Adult.—Dirty blackish-brown above and mottled-yellowish beneath; ¾ inch long; wings folded diagonally across the back; beak 4-jointed; ill-smelling (Fig. 102).

Eggs.—Laid in clusters on the underside of leaves; red or bronze, smooth and shining; slightly flattened on two sides; 1/25 inch long. Hatching in 8–13 days.

Nymphs.—When newly hatched they are red and green but later they become black like the adults but without wings and with propor-

FIG. 103.—Nymphs of squash bug, showing five stages. (*After Chittenden, U. S. Bur. Ent.*)

tionately longer legs and antennæ, later developing wing pads and becoming more and more like the adult. Five moults occur (Fig. 103).

Life-history.—It hibernates as an adult under rubbish, in outbuildings, etc. In spring the adult injures the young squash plants by sap punctures, and at that time lays eggs; nymphs reach maturity in July–August. Two broods in a season in the South.

Control.—Spray with kerosene emulsion; trap the adults under bits of board; destroy the egg-masses; destroy the vines in fall; plant early squash plants among the cucumbers and melons as traps.

LYGÆIDÆ (CHINCH BUGS, ETC.)

Chinch Bug (*Blissus leucopterus* Say).—(Consult Bull. 95, Ill. Agr. Exp. Stn.; Bulls. 15, 69; Circ. 113; Farmers' Bull. 132, Div. Ent., U. S. Dept. Agr.) A serious native American pest, especially in the Central States to cereals and corn crops and to timothy meadows; widely distributed in the Eastern half of the Continent from the West Indies to Canada.

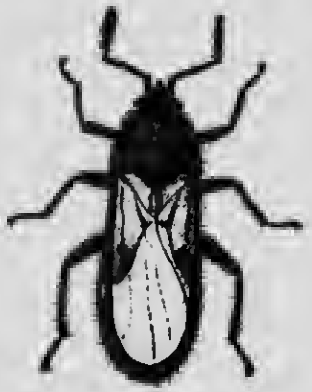


FIG. 104.—Chinch bug: adult. (*From Webster.*)

Adult.—A black bug, 1/8 inch long; wings white and marked by a small black triangle on their outer margins; bases of the antennæ and the legs are red. Short winged forms in the East and along the sea coast and Great Lakes. April–May, and August (Figs. 104 and 105).

Eggs.—Cylindrical, 3/100 inch long; squarer at one end; whitish at first, becoming amber-ed. Hatch in 2–3 weeks in May, but in 10 days in August.

Nymphs.—Four moults, the successive instars showing changes in size and markings, the first three often called the red stages. In the first stage it is pale red throughout with a yellow band across the base of abdomen; in the second stage the head and prothorax become darker, the abdomen vermilion with pale yellow band; in the third stage the color is decidedly darker throughout, and in the fourth the red has disappeared, general color varying from black in front to dusky grey behind (Fig. 106).

Life-history.—The bugs hibernate under rubbish, in thickets and in clumps of grass. In April and May females lay their eggs on the roots or the bases of the stems of wheat and grasses. Eggs hatch in 2 or 3 weeks or less. The nymphs reach maturity in 6 or 7 weeks, when a migration occurs on foot to other plants. Eggs are laid on the stems and leaves of corn and the nymphs attain maturity in autumn. There are, therefore, two broods in a year.

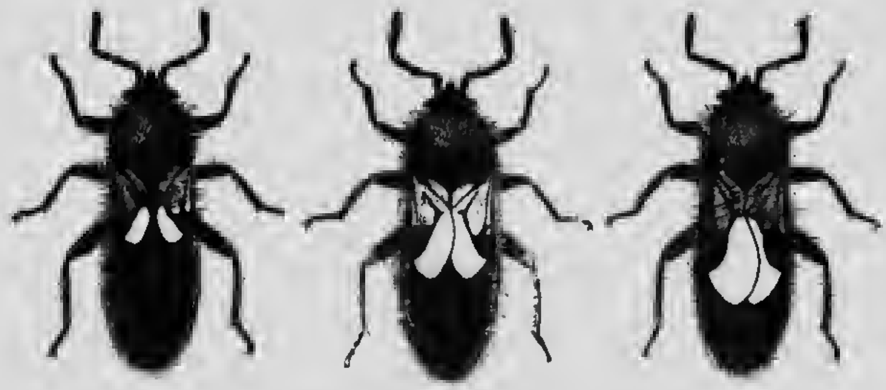


FIG. 105.—Chinch bug: adults of short-winged form. Much enlarged. (*After Webster.*)

Control.—Clean up rubbish and burn the dried grasses in which the pest winters in late fall or early spring; place barriers of dust or oil or tar lines; plow furrow about fields to be protected; the use of muscardine fungus.

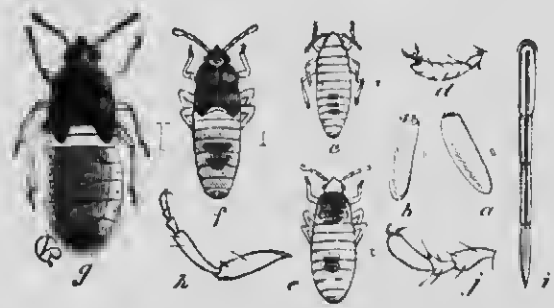


FIG. 106.—The chinch bug: *a*, *b*, eggs; *c*, newly hatched larva, or nymph; *d*, its tarsus; *e*, larva after first molt; *f*, same, after second molt; *g*, last-stage larva, the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same, still more enlarged; *i*, proboscis, or beak, enlarged. (*From Riley.*)

Parasites and Enemies.—*Triphleps insidiosus* Say, *Milyas cinctus* Fab., *Agonoderus pallipes* Fab., coccinellids, *Reduviolus ferus*, *Pagasa fusca*, *Blechrus*, *Chrysopa*, quail, frog, *Sporotrichum globuliferum* Speg.

Miridæ = Capsidæ (Leaf Bugs)

Four-lined Leaf Bug (*Pœcilocapsus lineatus* Fab.). (Consult Bull. 58, Cornell Agr. Exp. St.) This bug is one of the most common insects found during summer on field and garden vegetation. It is occasionally destructive in flower gardens.

Adult.—A greenish-yellow bug with two black spots on the thorax and four black stripes down the back; 3/10 inch long; abundant in June and July.

Eggs.—White, laid on terminal twigs of currant and other bushes in the fall; hatch in the spring.

Nymphs.—Red when young, but blacker when older, mature in about 20 days. They injure the tips of shoots and cause the leaves to curl up and become brown spotted. Currants, gooseberries, mint and sage are especially liable to injury.

Control.—Spray with nicotine sulphate or other tobacco extracts, or kerosene emulsion.

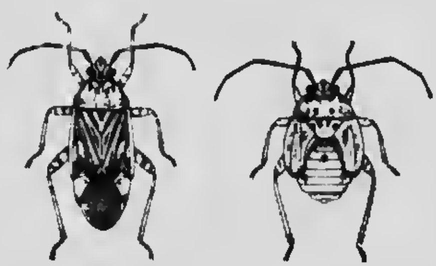


Fig. 107.—Tarnished plant bug (*Lygus pratensis*). (*After Chittenden.*)

Tarnished Plant Bug (*Lygus pratensis* L.).—(Consult Bulls. 346 and 391, Agr. Exp. Sta., Cornell.) A very common insect, feeding on a wide range of plants. It causes the well-known injury to the buds of aster, dahlia and chrysanthemum, and to the buds and blossoms of orchard trees (Fig. 107).

Adult.—Brownish, mottled with yellow and reddish. Head yellowish-brown, usually with three lines; prothorax bronzy brown, usually with four blackish spots in a row; scutellum brownish, usually with a Y-shaped spot. Wings bronzy brown mottled with yellowish-brown and reddish. Antennæ dark brown; legs brown, tibiæ banded near base and tarsi dusky. Under surface dark at centre with a lighter lateral stripe and a marginal brown band with yellow spots. Length 1/5 to 1/4 inch. Hibernates.

Eggs.—One-twenty-fifth inch long, flask-shaped, and obliquely truncate; deposited in stems, etc.; duration 10 days.

Nymphs.—Five stages; active; feeding on juices of plants.

Life-history.—Cycle completed in 25 to 30 days in late summer with probably four or five generations each year. Adults winter in sheltered situations; eggs laid in early spring and first nymphs appear in May. Broods not well distinguished, and insects to be seen from spring until fall.

Control.—No effective remedy; spraying with nicotine sulphate, kerosene-soap emulsions and fish-oil soap is fairly satisfactory if applied in early morning.

False Tarnished Plant Bug (*Lygus communis* Knight).—(Consult Can. Ent. 48, 10 and Bull. 8, Nova Scotia.) A serious pest in pear orchards in New York State, causing knotty deformed and gritty fruit. Plum and quince are also injured. The Var. *nova scotiensis* injures apple.

Adult.—Pale green to light brown; ¼ inch long; two black rays on disk of pronotum; membrane of upper wing with three brown spots near tip of areole; legs and antennæ long. Most commonly breeds on *Cornus* spp.

Eggs.—Smooth and cylindrical, elongated, 0.8 mm. long; yellowish-white, translucent. Inserted in the bark of small branches July–Aug.; hibernate, hatching during blossoming time.

Nymphs.—Pale yellow at first, becoming greenish; feeding on the leaves; five stages, maturing about middle to end of June. They puncture the young fruits, often several punctures on one fruit, causing the fruit to fall or depressions and deformities in apples and grittiness in pears. Leaves, stems and blossoms are freely attacked. Duration about 32 days. Carrier of European Canker and Fire Blight (Brittain).

Control.—1. Spraying with Black Leaf 40 (1 part to 1000 water) just after the petals fall.

2. Banding the trunks to prevent the bugs from crawling up.

3. Cultivation of soil up to July to keep down all plant growths.

The Var. *nova scotiensis* (Green Apple Bug) occurs abundantly as an apple pest in Nova Scotia. It is more slender and much paler than the typical *communis*.

Lygus invitus Say, according to Knight, breeds only on elm, and is not responsible for injuries to pear and apple.

A very common capsid of meadows is *Miris dolobratus* L., a form long and narrow, ⅖ inch long; greenish, yellow with black markings; two black stripes extending from the eyes over the thorax.

Clouded Apple Capsid (*Neurocolpus nubilus* Say).—A widely distributed capsid, injuring apple trees and fruit in Ontario.

Adult.—One-fourth inch long, larger and narrower than *Lygus pratensis.* Color variable, but dorsally mostly cinnamon brown to reddish-black; has a dull felty appearance; ventrally light green. Basal joint of antennæ stout, dark, and with clavate dark brown hair; second segment slender, elongate; legs slender with reddish bands.

Eggs.—Curved, nearly colorless, with a glistening white cap. Inserted into tissues of new growth; egg-laying period July 15th–Sept. 1st; eggs usually laid singly behind buds. Hibernate. Hatch about first week in June.

Nymph.—This stage lasts from 3 to 4 weeks. At first nearly colorless, but later is green with dull reddish marks on back and sides.

Control.—Clean cultivation, until end of June; spray the leaves thoroughly with soap and Black Leaf 40 soon after the nymphs hatch.

Apple Red Bugs (*Heterocordylus malinus* Reuter *and Lygidea mendax* Reuter).—(Consult Cornell Bull. 291.) These bugs cause spotting of the leaves, and they puncture the fruit in June, causing deformation.

Adults.—One-fourth inch long; *Heterocordylus* varies from red to black; wings red, black along inner edge and with an ovate black spot near outer margin; scutellum, legs and antennæ black, dorsum covered with white, scale-like hairs; *Lygidea* is lighter colored and without hairs on back; head and prothorax orange-red, scutellum orange-red in front and blackish posteriorly; wings with a band of orange-red along outer edges, legs darker yellow.

Eggs.—Dull whitish, curved and slightly compressed, inserted into the bark of smaller branches; hatch soon after opening of leaves of fruit-buds.

Nymphs.—At first red; five stages; *Heterocordylus* has dusky markings on thorax and no fine short hairs on thorax.

Control.—Applications of Black Leaf 40 (1 pt. to 100 gal.) just before blossoms open, and just after falling of the petals.

Hop Red Bug (*Paralacoris hawleyi* Knight).—This capsid is a pest of hops in New York. It stunts and deforms the vines and perforates the leaves.

Adult.—One-fourth inch long, black with hemelytra hyaline or pale yellowish, and cuneus reddish. July.

Eggs.—One-fifteenth inch long, dirty white, curved and with two prominent white incurving hooks at micropylar end; smooth and glossy. Inserted in the bark or wood of hop poles, Aug.-Sept. Duration of 9½ months. Hatch throughout June.

Nymphs.—Five stages; duration about 30 days. Active.

Enemies.—*Apeteticus maculiventris*, a Pentatomid; *Reduviolus subcoleoptratus*, a nabid; and a species of *Trombidium*.

PENTATOMIDÆ (STINK BUGS)

Harlequin Cabbage Bug (*Murgantia histrionica* Hahn). A native of Mexico and Central America. Injurious in the Southern states but its ravages do not extend much farther north than New Jersey and Long Island. Also known as "calico bug" "fire bug," and "terrapin bug." Attacks cabbage, radish and turnip.

Adult.—A moderate sized red and black plant bug, the markings running more or less transversely and alternating. In South active throughout the year; in North hibernates as adult.

Eggs.—Resemble "miniature white barrels bound with black hoops and with black spots set in for bung-holes." Usually laid in two rows, fastened by one end to under surface of leaf. Hatch in 2-11 days.

Nymphs.—Like adults in markings; antennæ with 4 joints, 5 instars, first instar glossy yellow; duration 2-10 weeks but shorter in the South. Probably 4 or 5 generations in the South and 2 or 3 in the North.

Control.—Trap-crop of kale, rape, mustard, radish or turnip, clean farm practice; bounties for collections.

Green Soldier Bug (*Nezara hilaris Say*).—(Consult Ohio Bull. 310.) In N. E. parts of U. S. and Canada; a general feeder, and a serious pest of the peach industry in Ohio.

Adult.—Oblong-oval; bright green, finely punctate; edges of head, thorax and abdomen white-yellowish or rufous; ⅔ inch long. Hibernates.

Eggs.—Light yellow; oval; circular cap with a row of short spine-like processes. Laid in clusters on leaves or fruits in June-July. Hatch in 7 to 8 days.

Nymph.—Five instars; mature in 50-75 days. Injures by puncturing the fruit.

Parasites. A Proctotrypid *Trissolcus euschisti* Ash.

In addition to the foregoing forms, among the more common northern plant-sucking species of this family are *Nezara pennsylvanica* a large green, flattened bug, $^3/_4$ inch long; *Cosmopepla carnifex*, shining black and spotted with red and orange, $^1/_3$ inch long; *Leioderma ligata*, a large broad form with a red margin and a red spot on the middle of its back.

Among the blood-sucking species are *Podisus spinosus*, recognized by the conspicuous spine on each side of prothorax, and *Brachymena* spp. mostly large grey tree bugs; *Perillus circumcinctus* which attacks the Colorado potato beetle.

Corimelænidæ (Negro Bugs)

Negro Bug (*Corimelæna pulicaria* Germer).—Feeds on strawberries, blackberries, raspberries and celery, imparting an unpleasant odor.

Adult.—A small shiny black bug $^1/_8$ inch long, with a white stripe on each side of body.

Eggs.—Orange-yellow, oval; laid singly on the leaves; hatch in about 16 days.

Nymphs.—Feeding on leaves and fruit.

Acanthiidæ (Bed Bugs)

Bed Bug (*Cimex lectularius* L.).—*Adult.* Reddish-brown, $^1/_5$ inch or less in length; never fully winged but with wing pads; flattened; hiding in day-time in cracks but active at night; "buggy" odor.

Eggs.—White, oval, $^1/_{20}$ inch long; laid in cracks and crevices; each female lays about 200 eggs, 50 at a time.

Nymphs.—White at first but red after feeding; resemble adults but body more slender and head larger; 11 weeks to mature; one generation in a season.

Control.—Fumigate with sulphur or carbon bisulphide; wash floors thoroughly with soapsuds and spray with benzine.

ORDER SIPHUNCULATA (SUCKING LICE)

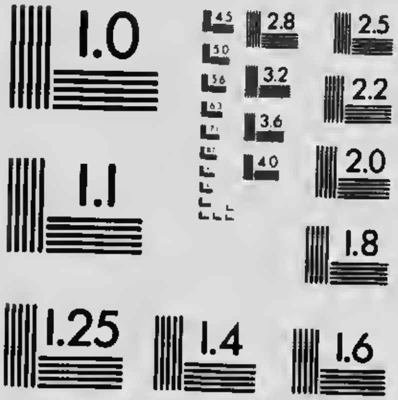
Chief Families

A. Eyes large, convex, distinctly pigmented; beak short.—*Pediculidæ.*

AA. Eyes very indistinct or wanting; beak long.—*Hæmatopinidæ.*

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



Pediculidæ

(Consult Bull. 5, Div. Ent., U. S. Dept. Agr.; Bull. 48, Minn. Agr. Exp. St.)

Most domestic animals at some time or other are liable to become infested with sucking lice which cause considerable irritation. The eggs or "nits" are attached to the hairs, and the lice by means of a beak suck the blood of their victims.

Treatment consists in the application of tobacco water or Black Leaf 40 (1 part to 1000 water), dilute carbolic acid, kerosene emulsion, sulphur and mercuric ointment, or an infusion of 4 oz. stavesacre and 1 oz. hellebore, or creolin solution.

Fig. 108.—Head louse (*Pediculus capitis*). Enlarged.

Two genera are of importance economically *Pediculus* occurring on man, and *Hæmatopinus* on domestic animals.

Head-louse of Man (*Pediculus capitis* De Geer).—Whitish with faint dark markings on sides. Eggs (50) glued to hairs, whitish, hatch in 6 days and young become mature in about 3 weeks (Fig. 108).

Body-louse of Man (*Pediculus vestimenti* Leach).—Similar in shape to preceding, but larger and at maturity with upper surface transversely banded with black. Eggs laid in the folds in clothing. Bacot (*Parasitology*, 1917) states that *P. capitis* and *P. vestimenti* may cross-pair with fertile offspring. He found that the average number of eggs per day was 3.7 for *capitis* and 6.4 for *vestimenti*. The egg period for the latter was estimated at 12 days, and 12 days more for the maturity of the female. "Allowing an average of 8 eggs per day, spread over a fertile period of 40 days we find that during her life a single female may have 4160 offspring." A carrier of typhus fever. A common pest of army camps.

Control Measures.—Change clothing as often as possible; wash infested clothing with a cresol soap made as follows: water 10 gal., Jeyes' Fluid 1½ oz., soft soap 1½ lb.; bathe body using cresol soap; place N.C.I. powder in shirt and trousers (naphthaline 96 per cent., creosote 2 per cent., iodoform 2 per cent.).

Crab-louse of Man (*Pediculus pubis* = *Phthirius inguinalis* Leach).—Body as wide as long, with strong legs. Eggs glued to hairs. Mouth-parts form a fleshy, extensible, unjointed beak. Tarsi with a strong curved claw.

Control.—Cleanliness, sulphur and mercurial ointments.

Hæmatopinidæ

Hog-louse (*Hæmatopinus urius* Nitzsch).—One-fourth inch long; broad abdomen, long head; grey with sides black.

Horse-louse (*Hæmatopinus asini* Linn.).—One-sixth inch long, half as wide, long and slender head with parallel sides.

Short-nosed Cattle-louse (*Hæmatopinus eurysternus* Nitzsch).—One-sixth inch long, half as wide; head rounded in front, as wide as long. Infests the neck and shoulders chiefly. Eggs white, hatching in 7–8 days; life-cycle 22–24 days. Each female lays from 35–50 eggs.

Long-nosed Cattle-louse (*Hæmatopinus vituli* Linn.).—One-eighth inch long, one-third as wide; long slender head. Life-cycle from 25–27 days.

Dog-louse (*Hæmatopinus piliferus* Burm.).—One-tenth inch long, abdomen wide, yellowish.

VI. LEPIDOPTERA (BUTTERFLIES AND MOTHS)[1]

Common Families (Figs. 109–121)

A. Antennæ club-shaped at apex; wings at rest held erect; day-fliers.—*The Butterflies* (*Rhopalocera*).
- B. Butterflies with cubitus apparently 4-branched.—*Papilionidæ* (Swallow-tails), p. 174.
- BB. Butterflies with cubitus apparently 3-branched.
  - C. Fore-legs normal.—*Pieridæ* (Pierids), p. 175.
  - CC. Fore-legs reduced in size.—*Lycænidæ* (Gossamer-wings).
  - CCC. Fore-legs aborted, mere tippets.—*Nymphalidæ*[2] (Four-footed Butterflies), p. 176.

AA. Antennæ clubbed but terminated by a hook; wings at rest usually held erect.—*Hesperidæ* (Skippers).

AAA. Antennæ not clubbed at apex; wings at rest held flat or folded like a roof over the body.—*The Moths* (*Heterocera*).
- B. Hind wings with one or two anal veins.—(*Macrolepidoptera* in part).
  - C. Frenulum present.
    - D. Subcosta and radius of hind wings connected by a strong oblique vein.—*Sphingidæ* (Hawk Moths), p. 177.

[1] Handlirsch groups the orders Mecoptera (Panorpatæ), Trichoptera and Lepidoptera under the Sub-class *Panorpoidea*.

[2] The *Danaidæ* family is now separated from the Nymphalidæ on the basis of the bare antennæ and forked base of subcostal vein.

DD. Subcosta and radius of hind wings not connected by a cross-vein.

E. Cubitus of fore wings apparently 3-branched.

F. Basal part of subcosta of hind wings joined to radius for a distance then bending sharply toward costal margin.—*Geometrina* (Geometrids), p. 2

FF. Basal part of subcosta of hind wings not as in F *Notodontidæ* (Prominents), p. 198.

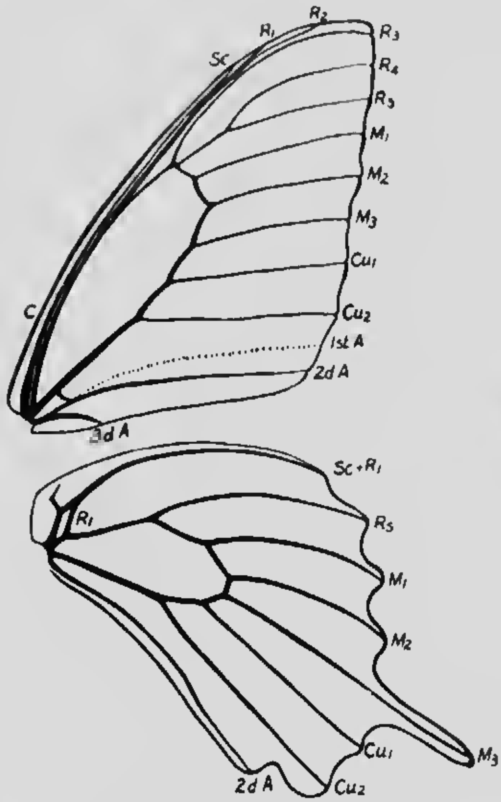


FIG. 109.—Venation of a papilionid (*Papilio*). (*After Comstock.*)

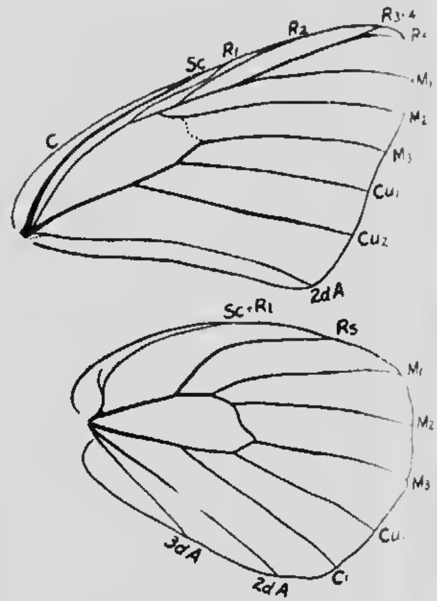


FIG. 110.—Venation of a pier (*Pieris*). (*After Comstock.*)

EE. Cubitus of fore wings apparently 4-branched.

F. Subcosta of hind wings either separate from or joined for a short distance to radius.

G. Ocelli absent; antennæ pectinate; cubitus of hind wings apparently 4-branched.—*Liparidæ* = *Lymantriidæ* (Tussock Moths), p. 200.

GG. Ocelli present; antennæ mostly simple;

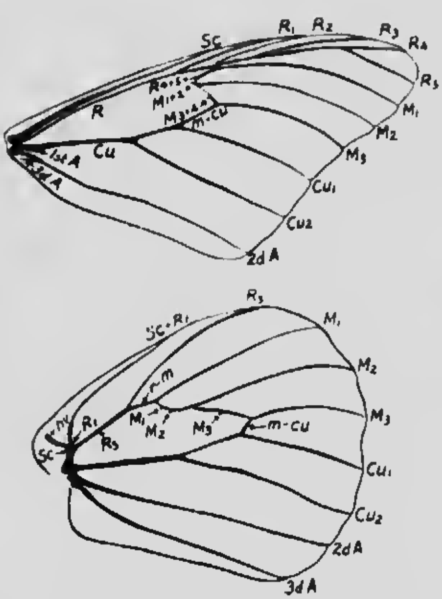


FIG. 111.—Venation of a danaid (*Danais*). (*After Comstock.*)

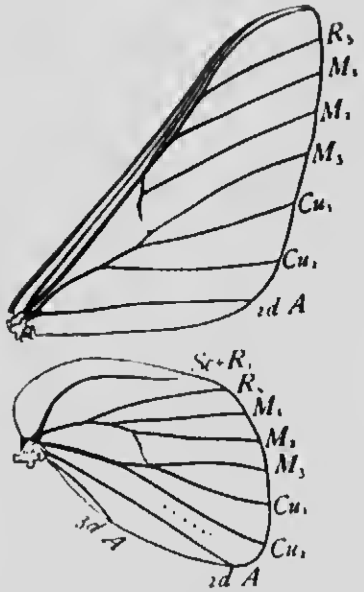


FIG. 112.—Venation of a saturniid (*Anisota*). (*After Comstock.*)

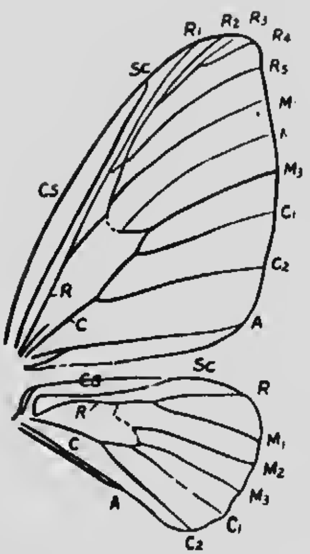


FIG. 113.—Venation of a geometrid (*Dyspteris*). (*After Comstock.*)

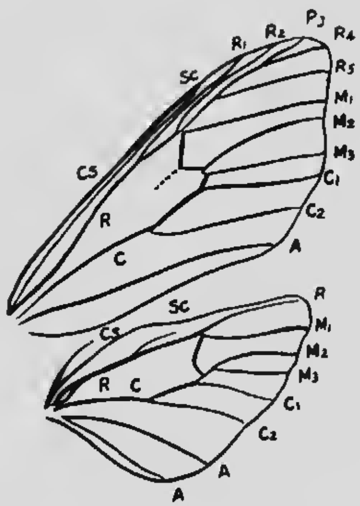


FIG. 114.—Venation of an arctiid (*Halisidota*). (*After Comstock.*)

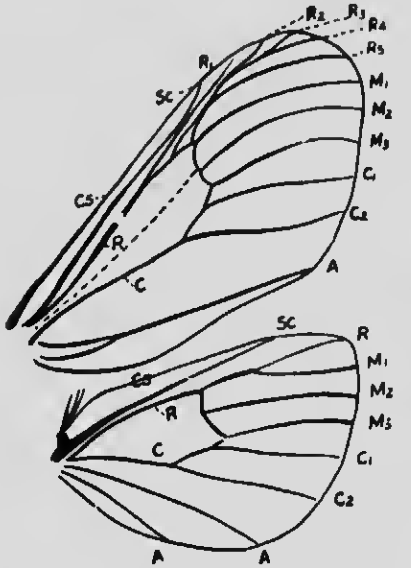


FIG. 115.—Venation of a notodontid (*Notodonta*). (*After Comstock.*)

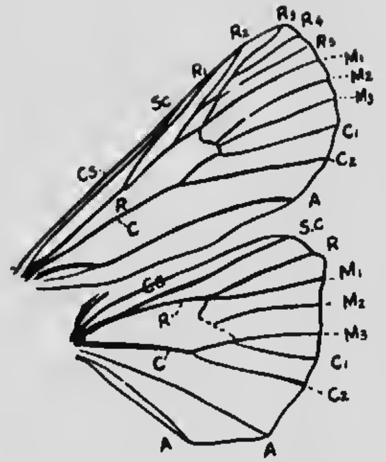


FIG. 116.—Venation of a noctuid (*Agrotis*). (*After Comstock.*)

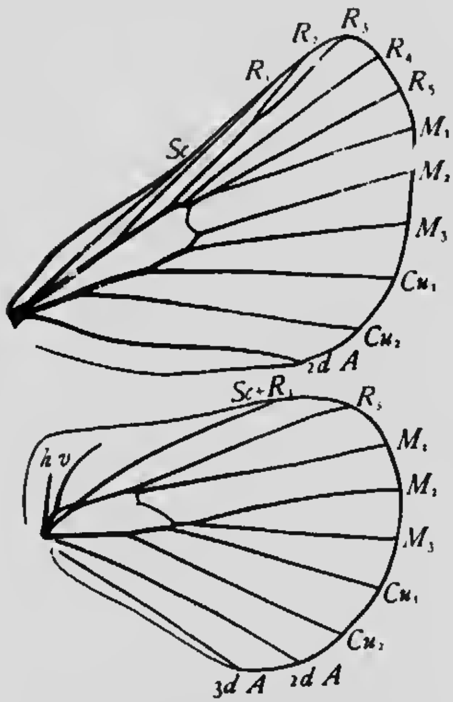


FIG. 117.—Venation of a lasiocampid (*Malacosoma*). (*After Comstock.*)

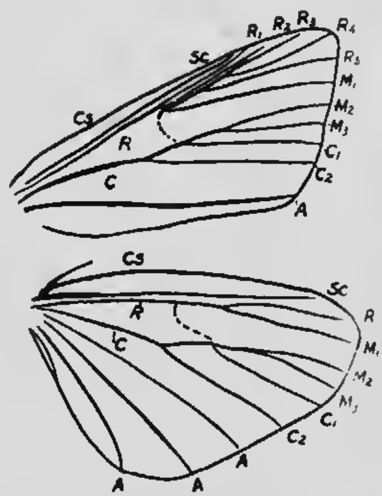


FIG. 118.—Venation of a pyralid (*Pyralis*). (*After Comstock.*)

cubitus of hind wings apparently 3-branched.—*Noctuidæ* (Owlet Moths), p. 184.

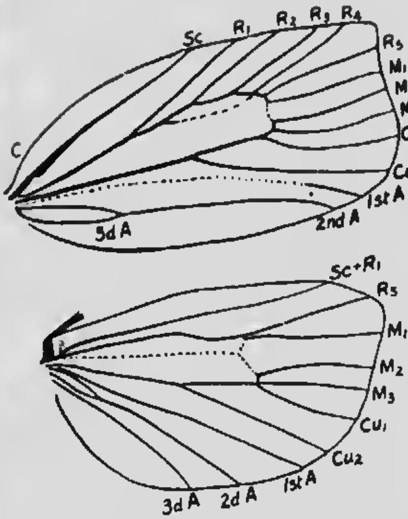


FIG. 119.—Venation of a tortricid (*Cacoecia*). (*After Comstock.*)

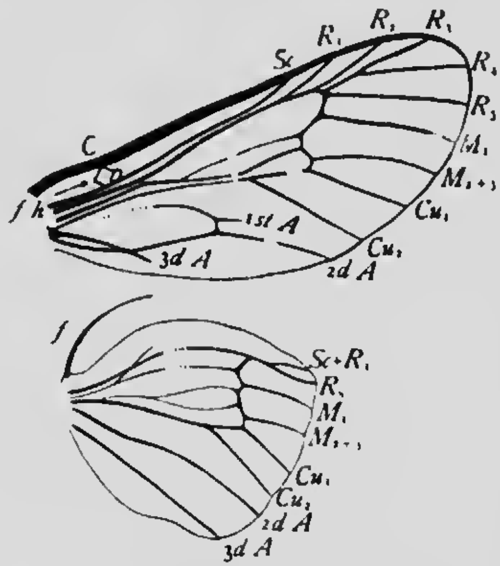


FIG. 120.—Venation of *Thyridopteryx*. (*After Comstock.*)

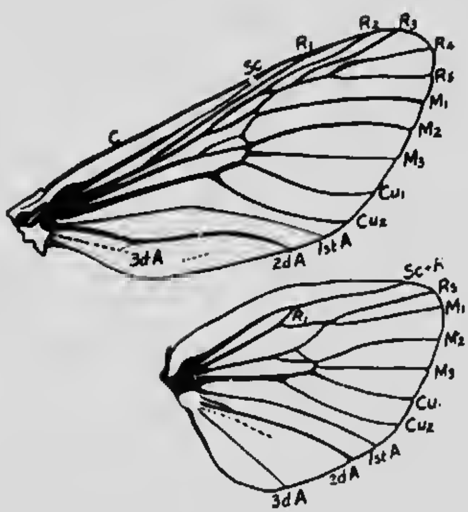


FIG. 121.—Venation of a cossid (*Prionoxystus*). (*After Comstock.*)

FF. Subcosta of hind wings united with radius for a considerable distance; cubitus of hind wings apparently 4-branched.—*Arctiidæ* (Tiger Moths), p. 181.

CC. Frenulum absent.

D. Cubitus of both wings apparently 4-branched. Hind wings with humeral veins. *Lasiocampidæ* (Tent caterpillar Moths), p. 203.

DD. Cubitus of both wings apparently 3-branched; tongue absent; tibia without spurs. *Saturniina* (Silkworm Moths), p. 179.

BB. Hind wings with usually three complete anal veins. (2 to 4 anal veins in hind wings of Ægeriidæ).

C. Wings transparent; free from scales; fore wings narrow.—*Ægeriidæ* (Clear-winged Moths), p. 216.

CC. Small moths; wings covered with scales.—(*Microlepidoptera*).

D. Subcosta and radius of hind wings fused or approximate —*Pyralidina* (Pyralids), p. 207.

DD. Subcosta and radius of hind wings far apart.

E. Second anal vein of hind wings forked at base. *Tortricina* (Tortricids), p. 218.

EE. Second anal vein of hind wings not forked at base. *Tincina* (Tineids), p. 236.

CCC. Large or medium-sized moths; wings usually covered with scales.—(*Macrolepidoptera* in part).

D. Anal veins of fore wings partially fused; hind wings sometimes with two anal veins.—*Psychidæ* (Bag-worms), p. 20[illegible].

DD. Anal veins of fore wings not fused.—*Cossidæ* (Carpenter Moths), p. 237.

Note.—The *Geometrina* includes the following families: Ennomidæ, Geometridæ, Hydriomenidæ, Sterrhidæ and Monocteniidæ.

The *Pyralidina* includes the Pyraustidæ, Pyralididæ, Galeriidæ, Crambidæ, Phycitidæ, Pterophoridæ and Orneodidæ.

The *Tortricina* includes the Eucosmidæ, Conchylidæ and Tortricidæ.

The *Tincina* includes Tineidæ, Yponomentidæ, Plutellidæ, Gelechiidæ, Haploptiliidæ, Lyonetiidæ, Nepticulidæ, Tischeriidæ, Gracilariidæ. (Consult Comstock's Manual and Barnes and McDunnough's Checklist of Lepidoptera.)

PAPILIONIDÆ

These butterflies are called "Swallow-tails" and are readily recognized. The more common forms are the *Tiger Swallow-tail* (*Papilio turnus*, two forms), the *Zebra Swallow-tail* (*Papilio ajax*, three forms), the *Green-clouded Swallow-tail* (*Papilio troilus*) and the *Black Swallow-tail* (*Papilio polyxenes*) which feeds on celery and other members of the carrot family.

Black Swallow-tail (*Papilio polyxenes* Fab.).

Adult.—Wings black with two transverse rows of yellow spots on the hind wings; between the rows of yellow spots are several flashes of blue. Two broods, May and July. Wing expanse 3–4 inches.

Eggs. Nearly spherical; honey-yellow changing in parts to reddish-brown; laid singly on leaves of food-plant; hatch in 5 to 9 days.

Larva.—The Celery Caterpillar; mature form 2 inches long; green, each segment with a black band and spotted with yellow. Scent-horns orange.

Chrysalis.—Dull grey, mottled with dull brown, roughened with larger projections pointing forward; swung in a loop of silk; summer chrysalis lasts from 9 to 18 days; hibernates.

Control.—Hand-picking, or the application of arsenicals for large infested areas.

PIERIDÆ

The more common butterflies of this family are the Cabbage Butterfly (*Pieris rapæ*), the Grey-veined White (*P. napi*), the Checkered White (*P. protodice*) the Clouded Sulphur (*Eurymus philodice*) and the Alfalfa Caterpillar (*Eurymus eurytheme*).

Cabbage Butterfly (*Pieris rapæ* Linn.).—Introduced from Europe *via* Quebec about 1860. Occurs throughout United States and Canada.

The caterpillars first injure young plants, riddling the outer leaves, later they attack the tender inner leaves where they are hard to poison, and which they render unsightly by reason of the abundant dark green excrement. Sometimes they eat into the centre of the head of cabbage where it is impossible to deal with them.

Adult.—Wing expanse 2 inches, dull white above; fore wings with black tips and two spots in the female and one spot in the male. Two full broods and a partial third in the North, and more in the South. Life-cycle 3 to 6 weeks.

Eggs.—Oval, yellow, ribbed, lengthwise and crosswise; laid singly on end on the leaves; hatch in 4 to 8 days.

Larva.—The Green Cabbage worm; 1¼ inches long, velvety green with a narrow greenish-yellow band on back and on each side. A row of yellow spots. Matures in 10 to 14 days; feeds also on mustard and other crucifers.

Chrysalis.—Three-fourth inch long, light brown; attached and swung by a girdle of silk. Winters in this condition. Duration in summer 7 to 12 days.

Enemies.—Apanteles glomeratus, Pteromalus puparum, paper wasps, ambush bug.

Control.—Spray every week with arsenical solution; 1 lb. Paris Green, 4 lb. whale-oil soap, 40 gal. water before heads form and with hellebore or pyrethrum after; spray with salt-tobacco solution (1 lb., 1 lb., 5 gal. water).

Pieris napi Linn. is a native species, but not so abundant as *P. rapæ.* Wings nearly all white.

Alfalfa Caterpillar (*Eurymus eurytheme* Boisd.).—(Consult Bull. 124, U. S. Dept. Agr.) Common, and a serious pest of alfalfa in the West.

Adult.—Yellow with the outer margins of wings black, dotted with white in the female. A black dot in the middle of the fore wings and a pale yellow spot in the middle of the hind wings. Two or more broods, March–April.

Eggs.—Minute, ribbed and cross-lined, spindle-shaped; laid on the new growth.

Larva.—Dark green, with a faint white line on each side; 1 inch long. Spiracles black and red. Strips the leaves leaving bare stalks.

Pupa.—Yellowish-green, 3/4 inch long, suspended, head up, by two threads to the stalks of alfalfa, weeds and grasses.

Parasites.—Tachinids—Phorocera and *Forntina;* also *Apanteles, Pteromalus* and *Trichogramma.* A bacterial disease.

Control.—Pasture infested fields or cut when larvæ appear in numbers; irrigate after cutting; disk in the fall; co-operation.

NYMPHALIDÆ

This family includes a large number of common butterflies such as the Fritillarias or Argynnids; the Angle-wings or Vanessids, including the beautiful Red Admiral (*Vanessa atalanta*); the Painted Beauty (*Vanessa virginiensis*); the Cosmopolitan Butterfly (*Vanessa cardui*); the Mourning Cloak (*Aglais antiopa*); the Comma Butterflies (*Polygonia faunus, P. comma*, the "Hop Merchant," *P. progne* and *P. interrogationis*); the Purple Butterflies (*Basilarchia arthemis, B. astyanax, B. archippus*). Of these the larvæ of the Comma and the Red Admiral feed on the hop.

The "Hop Merchant Caterpillar" often called the "Spring Currant Caterpillar," attacks currants, gooseberries, hop, elm, basswood, etc. Generally two broods a year. They are brownish-yellow and marked with black and yellow lines. On the body are numerous branched black tipped spines. The wings of the adult butterfly are reddish brown bordered with a darker brown. A silvery comma mark on surface of hind wings.

The larvæ of the Mourning Cloak Butterfly feed upon the leaves of willow, poplar, elm and dogwood and are interesting objects. There are two generations a year, the adults wintering over and appearing in early spring. The adults of the second brood appear in July.

DANAIDÆ

The monarch butterfly (*Danais archippus* Fab.) is a common insect but not of economic importance. Its larva feeds on milkweed.

SPHINGIDÆ (HAWK MOTHS)

The Hawk Moths are readily recognized both in the adult and the larval forms. The adults are strong fliers and are beautifully colored. They usually fly about dusk. The larvæ are large and often ornamented with stripes, and usually have a horn near the hind end of the body. They feed on a great variety of foliage. Ordinarily they are kept under control by parasites and birds. When occasioning damage they are readily controlled by spraying with arsenicals and by hand-picking.

Tomato Sphinx (*Protoparce quinque-maculata* Haw.). *Adult.*—Expands to 4 to 5 inches; wings ashy-grey with black markings; hind wings crossed by four blackish lines; abdomen with a black middle line with five yellow spots on each side; appears in June and July. Two breeds in the south.

Eggs.—Laid singly on under surface of leaves; hatch in 4 to 8 days.

Larva.—Three to 4 inches long; naked, dark-green with 8 V-shaped white lines on side; a black horn on tip of abdomen; feeds on leaves of tomato and tobacco.

Pupa.—Dark-brown, about 2 inches long, sheath of proboscis forming a handle-like process; in the soil several inches below the surface.

The **Tobacco Sphinx** (*P. sexta*) is very similar to the preceding, feeding on the same plants. It is more abundant in the South. The adult is brownish-grey instead of ashy-grey, with a distinct discal spot on the fore wings, and six spots on sides of abdomen instead of five. The larva has only seven oblique markings instead of eight V-shaped ones.

Plum Sphinx (*Sphinx drupiferarum* Sm. and Abb.). *Adult.*—Expands 3 to 4 inches; body brown, wings purplish brown; fore wings with a whitish stripe on costal margin, a fawn colored stripe on outer margin and several black streaks; hind wings with two whitish wavy and an outer fawn colored stripe. June.

Eggs.—Laid singly on the leaves of plum; smooth, oval, 1/15 inch long; pale yellowish-green. Hatch in 8 days.

Larva.—Three and one-half inches long, apple-green, with dark brown lateral stripe. On each side are seven oblique white bands. Feeds on plum leaves.

Pupa.—Reddish-brown, 1½ inches long, with a short tongue case; in ground all winter.

Grapevine Sphinx (*Ampelœca myron* Cram.). *Adult.*—Expands 2¼ inches; fore wings olive-grey with a curved oblique greenish-grey band, a discal point and a triangular spot. Body green. Two broods —June and August.

Eggs.—Round, 1/20 inch in diameter; yellowish-green.

Larva.—A "Hog Caterpillar," green with yellow dots; oblique yellowish stripes along sides; a white stripe with green margin from head to horn and seven pink spots along the middle; 2 inches long. Spine near tip of abdomen. Feeds on leaves of grape and Virginia creeper. Often infested with braconid parasites.

Pupa.—Formed in a loose cocoon of silk, spun under leaves at the surface of the ground.

White-lined Sphinx (*Celerio lineata* Fab.). *Adult.*—Body and fore wings olive-brown; thorax with three parallel lateral white stripes; fore wings with a buff stripe from inner margin to apex; hind wings black with a reddish middle band. Probably two-brooded adults appearing in June and September.

Larva.—About 3½ inches long; color variable, yellowish-green with black spots or black with yellowish spots, with horn at tip of abdomen. Feeds on grape, apple, plum and on purslane, chickweed, etc.

Pupa.—Light brown pupa formed in a smooth cavity in the ground.

Other common Hawk Moths are: Abbott's Sphinx (*Sphecodina abbotti*), Apple Sphinx (*Sphinx gordius*), Achemon Sphinx (*Pholus* *achemon*), Pandorus Sphinx (*Pholus pandorus*) on Virginia creeper, Twin-spotted Sphinx (*Smerinthus geminatus*), Thysbe Clear-wing (*Hæmorrhagia thysbe*) on *Viburnum*, snowberry and hawthorn.

SATURNIINA (GIANT SILK-WORM MOTHS)

This super-family includes the following families: *Bombycidæ*, *Hemileucidæ*, *Citheroniidæ* and *Saturniidæ*. The larger number of commonly occurring forms belong to the third and fourth families which may be distinguished by the presence of two anal veins in the former and only one in the latter.

CERATOCAMPIDÆ (CITHERONIIDÆ)

This family contains such magnificent forms as the *Regal Moth* (*Citheronia regalis*) and *Imperial Moth* (*Basilona imperialis*), and the economic *Oak-worm* moths (*Anisota*) and the *Green-striped Maple-worm* moth (*Anisota rubicunda*).

Green-striped Maple-worm (*Anisota rubicunda* Fab.).—The caterpillar of this moth injures maples of all kinds, box-elder and oak. Usually two generations in a season.

Adult.—A pale yellow moth with a delicate shade of pink; wing expanse of female $1\frac{3}{4}$–2 inches; her body yellow and woolly and her head small with thread-like antennæ. Male is smaller with plumose antennæ.

Eggs.—Pale green turning yellowish; $\frac{1}{25}$ inch in diameter. Each female may lay 150 eggs on the under side of leaves; hatch in 8–10 days.

Larva.—A naked pale yellow green caterpillar, striped with dark green; armed back of the head on second thoracic segment with two long black horns, and along the sides and anal extremity with short black spiny projections. Two inches long in a month, when full grown. Four moults. Goes into ground to pupate.

Pupa.—Dark brown, armed with little spines on margin of abdominal segments and on thorax; anal segment ends in a forked projection. Duration two weeks.

BOMBYCIDÆ

Silk-worm Moth (*Bombyx mori* L.).—An Asiatic species, domesticated for its silk for many hundreds of years in Europe and Asia. Many races have been developed by selection differing in the color of the cocoons and larvæ as well as the number of broods produced in a year.

The main food plants are the white mulberry and the Osage orange. The moth is creamy white in color, and has a wing-expanse of about 1¾ inches.

The lack of cheap labor in America has prevented the development of the silk-worm industry.

SATURNIIDÆ

The members of this family are often called the *Giant Silk-worms* and include several conspicuous forms such as the *Io Moth* (*Automeris io*), the *Polyphemus Moth* (*Telea polyphemus*), the *Luna Moth* (*Tropæa luna*), the *Promethea Moth* (*Callosamia promethea*) and the *Cecropia Moth* (*Samia cecropia*).

A. Wings bluish-green with four eye-like spots; hind wings with long tails; front border of fore wings purple-brown; larva pale bluish-green with a pearl-colored bead and two yellow stripes along the back; feeding on walnut, hickory, etc.—*Tropæa luna* L. (Luna moth).

AA. Wings not green.

B. Wings yellowisb or brownish.

C. Witb four oval, window-like spots, one near centre of each wing; a dusky band edged with pink along margin of wings; larva light green with an oblique yellow line on side of eacb abdominal segment, feeding on many forest and orchard trees.—*Telea polyphemus* Cram. (Polyphemus moth).

CC. With eye-like spots on hind wings only; ground color of wings of female purplish-red; that of male brigbt yellow; larva yellowish-green, edged with white on side, with many black-tipped branched spines; feeding on cherry, apple, elm, oak, etc.—*Automeris io* L. (Io Moth).

BB. Wings brown, never yellowish.

C. With eye-like spots near apex of fore wings, and 4 crescent-shaped discal spots, one near the centre of eacb wing, white surrounded by reddish and black lines; tborax red, abdomen red and banded with black and white lines; larva bright green with four prominent coral-red and two yellow tubercles on thoracic segments, and smaller yellow tubercles on abdominal segments; feeding on fruit and shade trees.—*Samia cecropia* L. (Cecropia Emperor Moth).

CC. Witb eye-like spots near apex of fore wings, discal spots angular; in male color blackish and discal spots faint; larva bluish-green with rows of black tubercles, excepting tbose on second and third thoracic segments which are coral-red, and a yellow one on eighth abdominal segment; cocoon in a folded leaf. Feeds on leaves of fruit and forest trees.—*Callosamia promethea* (Promethea Moth).

These handsome moths are not of much importance economically. Their larvæ are large, conspicuous and brilliantly colored, consequently are readily destroyed by birds. Many also are killed by parasites. Some attempts have been made to manufacture the silk of the cocoons of some species but it has been found that the cocoon cannot be profitably unwound on account of the large number of breaks in the thread.

ARCTIIDÆ (TIGER MOTHS)

Woolly Bears.—Several interesting and common caterpillars may be conveniently grouped as "Woolly Bears," on account of their hairy appearance. A few common forms are here considered.

Yellow Bear (*Diacrisia virginica* Fab.).—Color of caterpillar variable; frequently yellow or straw color with a black interrupted line along each side of back, and a black transverse line between each segment; hairs long and yellow; uneven in length and not gathered into pencils. Cocoon is light and composed of hairs in which pupa passes the winter. Moth snowy-white; wings marked with a few black dots; three rows of black spots on abdomen.

Hedge-hog Caterpillar (*Isia isabella* Sm. and A.).—An "evenly clipped furry caterpillar, reddish-brown in the middle and black at either end." Passes winter as larva. Moth (Isabella Tiger Moth) has wings and body orange-buff, hind wings tinted with rose. Body with 3 rows of black dots.

Salt Marsh Caterpilar (*Estigmene acræa* Drury).—Body and head blackish with pale longitudinal stripes on the back; hair is dark brown; passes winter as pupa. Abdomen of moth orange; both wings white in female, hind wings orange in male; both marked with black dots. Six rows of black spots on abdomen, one on back, one on venter, and two on each side.

Fall Web Worm (*Hyphantria textor* Harris).—Conspicuous by their webs or nests in autumn on orchard, shade and forest trees (Fig. 122).

Adult.—Quite variable in markings; pure white, sometimes spotted with black; expands 1¼ inches; femur of forelegs orange and legs and feet with touches of black.

Eggs.—Laid in a flat cluster of about 400 on under side of leaf; golden-yellow, globular and pitted; hatch in about 10 days.

Larva.—When young is pale yellow with two rows of black marks along the body, head black; hairs sparse; and when full grown is covered with long whitish hairs arising from black and yellow warts; 1 inch long; spins webs and feeds within them; about five moults.

Pupa.—Cocoon of silken web interwoven with hairs; pupa dark brown. Winter passed as pupa.

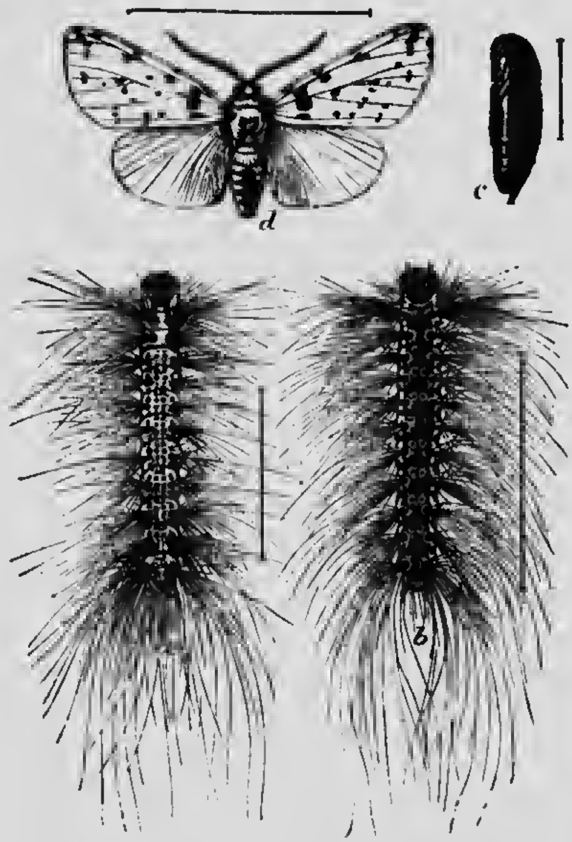


FIG. 122.—Fall web worm (*Hyphantria textor*): *a* and *b*, caterpillars; *c*, pupa; *d*, adult moth. (*After Howard, U. S. Bur. Ent.*)

Life-history.—Hibernates as a pupa under rubbish, in crevices under walls, etc. Moths emerge in June; eggs hatch in about 10 days and caterpillars mature in August and September. Two broods in some localities.

Parasites.—*Telenomus bifidus* Riley, *Meteorus hyphantriæ* Riley, *Apanteles hyphantriæ* Riley, *Limneria pallipes* Prov., *Tachina* sp.

Control.—Prune off and burn the webs; spray with arsenical; collect and destroy the cocoons.

Hickory Tiger Moth (*Halisidota caryæ* Harris).—(Consult Bull. 598, U. S. Dep. Ag.) *Adult.*—A yellow and brown moth, 2 inches wing expanse; fore wings long, narrow and pointed, ochre-yellow with five irregular transverse incomplete rows of spots. June–July. One brood a year. Distributed over the Northeastern States and the Eastern provinces of Canada.

Eggs.—Blue and nearly globular a brown ring on upper surface; laid in patches of 100 or more on under side of leaf in early summer. Duration 15–16 days.

Larva.—One and one-half inches long; gregarious at first; feeds on the leaves of hickory, butternut, apple and other trees; covered with dense and spreading tufts of *white* hairs, has a row of 8 black tufts on the back and two long slender black pencils on the fourth and tenth segments; head, feet and under surface of body black; upper surface of body white with black dots. Eight to nine feeding stages, and about a week as larva in the cocoon. Larvæ feed gregariously during the first four stages. Duration 70–90 days.

Pupa.—Cocoon *greyish*, oval, hairy, ¾ inch long, found under boards and rubbish on the ground; pupa reddish-brown, caudal end with a transverse row of spines.

Checkered Tiger Moth (*Halisidota tessellaris* Sm. and A.).—Like preceding species but tufts are *yellow;* two orange colored pencils on second and third segments; two white pencils on sides of third and eleventh segments.

Spotted Halisidota (*H. maculata* Harris).—Larva with yellow tufts in the middle and black tufts at either end, and a row of black spots down the centre. Occurs on apple, maple, birch, alder, poplar, oak, etc. Cocoon is *yellowish*, oval and hairy.

Parasites of Cocoons.—Scambus pedalis, Theronia melanocephala, Amblyteles malacus.

AGARISTIDÆ (WOOD MOTHS)

Eight-spotted Forester (*Alypia octomaculata* Fab.).—A frequent feeder on the leaves of wild and cultivated grapes, and Virginia creeper in eastern U. S. and Canada, sometimes doing considerable injury.

Adult.—General color a deep velvety blue black. Fore wings with two large circular pale yellow spots, and hind wings with two smaller white spots. Wing expanse 1¼ inches. May–July. Single brooded.

Larva.—One and two-fifth inches long; bluish-brown; head and cervical shield bright orange with black spots. Each segment crossed with black, white and orange bands; eleventh segment with a prominent hump; legs black; base of prolegs orange. Full grown in early August.

Pupa.—A chrysalis within a slight cocoon just below the surface of the ground. Hibernates.

Parasites.—*Winthemia 4-pustulata* Fab.—A tachinid.

Control.—Spray the larvæ with arsenate of lead or pyrethrum.

NOCTUIDÆ (OWLET OR MILLER MOTHS)

According to their manner of feeding on plants the larvæ of Noctuids may be classified roughly into: (*a*) *Cutworms* proper, feeding on roots

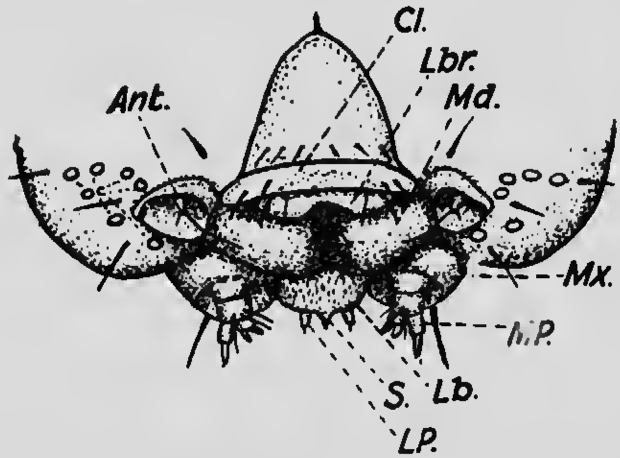


FIG. 123.—Mouth parts of a caterpillar, the striped cutworm (*Euxoa tessellata*): Ant., antennæ; Cl., clypeus; Lb., labium; Md., mandible; Mp., maxillary palpus; Lbr., labrum; Mx., maxilla; S., spinneret.

of grasses and cutting off young plants at surface. (*b*) ***Army-worms***, eating the leaves of cereal and other crops. (*c*) ***Climbing cutworms***, feeding on buds of fruit trees. (*d*) ***Loopers*** and ***caterpillars***, feeding on leaves of turnip, cabbage, celery and other plants. (*e*) ***Ear-worms***, feeding on kernels of corn in the field. (*f*) ***Stalk-borers***, feeding in tunnels made in stems. (*g*) ***Green Fruit-worms***, feeding on the surface of apple, etc. (*h*) *Dagger Caterpillars*, feeding on the leaves of many shrubs and trees. (*i*) *Underwing Moths*, some feeding on the leaves of trees (Fig. 123).

(*a*) Cutworms Proper

(Consult Bull. 95, Ill. Agric. Exp. Station, 1904; Bull. 10, Div. Ent. Can., 1912)

There are many species of cutworms that feed upon economic plants. They are mostly "plump, soft-bodied, cylindrical caterpillars, dirty greyish or whitish, and variously spotted and striped" (Forbes). They are the larval stages of species of Noctuid moths, commonly termed "millers," and are night feeders. "They are essentially grass and clover insects, and by far the greater part of them are bred in pastures and meadows."

Life-history.—The majority of the species hibernate as partly grown larvæ, and enter the ground to pupate in late June and early July. The adults—usually greyish nocturnal moths—emerge in early August and lay their eggs in grass lands. Each moth may lay from 200 to 500 eggs, either in masses or singly. The larvæ that hatch from these eggs feed on the roots of grasses until winter sets in. Feeding is resumed in the spring, when most serious injury is done, until their larvæ pupate in June-July.

Control of Cutworms.—Plow grass land in midsummer or early fall to prevent the female moths from egg-laying; late fall plowing of grass lands will destroy many of the hibernating cutworms; allow poultry and hogs upon cutworm land; use poison bait: bran 20 lb., molasses 1 qt., paris green or white arsenic ½ lb., water 2½-3 gals.

Natural Enemies.—*Calosoma calidum*, *Ammophila luctuosa*, *[illegible]n-themia 4-pustulata.*

The following species are most commonly met with:

Spotted Cutworm (*Agrotis c-nigrum* Linn.).—General color grey to brownish; a row of triangular black spots along each side of back; a pale line down the middle of back, a conspicuous whitish-yellowish stigmatal band, and a pale intermediate line; head and shield yellowish-brown; front feet pale brown and shiny, 1½ inches long. Active in April and May in vegetable gardens (Fig. 124).

W-marked Cutworm (*Agrotis unicolor* Wlk.).—General color pale brown; four rows of dark spots and often also with lighter lines along the back, resembling the letter W; sides of W-marks bordered with pale yellow; head pale brown with a wide black dash on each side; shield dark brown. Active in April and May in gardens and orchards (Fig. 125).

Greasy Cutworm (*Agrotis ypsilon* Rott.).—General color dark greasy grey to black above and greenish-yellow below; a pale yellow line down centre of back, and three others on each side; tubercles black and shiny; head and shield dark brown; 1½ inches long. Active in May and early June on corn and garden vegetables (Fig. 125).

Variegated Cutworm (*Lycophotia margaritosa* Haw.).—One and three-fourth inches long; color variable from grey to brown; body mottled with dark brown; a yellowish band along each side; a series of

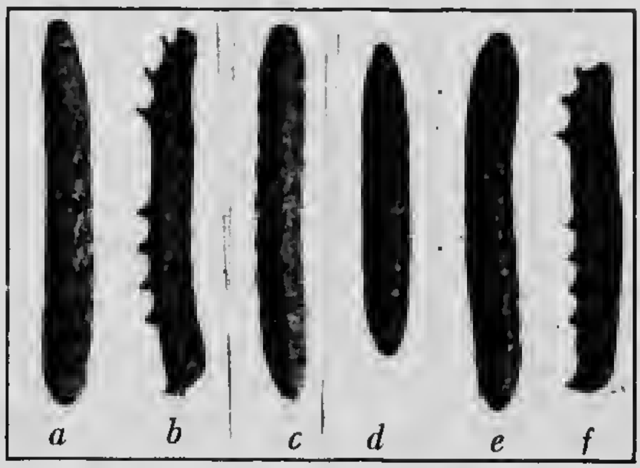


FIG. 124.—*a*, Spotted Cutworm, dorsal aspect; *b*, Spotted Cutworm, lateral aspect; *c*, White Cutworm; *d*, Dingy Cutworm; *e*, Black Army Cutworm, dorsal aspect; *f*, Black Army Cutworm, lateral aspect. (*After Gibson, Bul. 10, Ent. Br. Can.*)

yellow dots or spots along the middle of back; two stripes of velvety black blotches bordered with orange and black curved dashes between the lateral yellow band and the middle of the back; head reddish-yellow and marked with black bands resembling slightly the letter H. Practically an omnivorous feeder, its food plants including cereal root, forage, vegetable flowers and orchard trees. Active in May and early June in gardens. The eggs are laid in irregular masses upon the stems of plants; they are small, white, hemispherical and ribbed. The pupæ are reddish-brown and about ⅔ inch long.

Dark-sided Cutworm (*Euxoa messoria* Harris).—General color greyish; sides darker than rest of body; a dark line down middle of back; tubercles blackish, each with a single hair; head and shield shiny and grey. Active in May and June on fruits and garden vegetables. Sometimes called the "onion cutworm."

Common Striped Cutworm (*Euxoa tessellata* Harris).—This cutworm is 1¼ inches long, grey, with a pale median dorsal line and three pale lines on each side. It feeds on most vegetable crops. One brood a year; passes the winter as half-grown larva, and is most destructive in June. The moths appear in July and August.

Red-backed Cutworm (*Euxoa ochrogaster* Gn.).—With a broad reddish stripe down the back; head and shield yellowish-brown, the

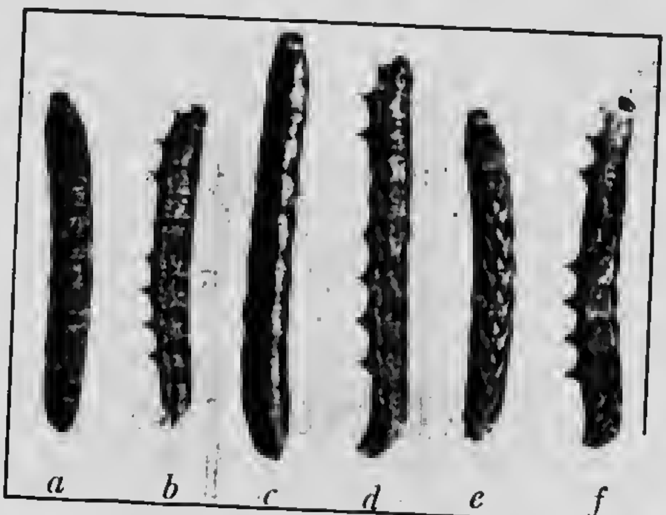


FIG. 125.—*a*, Red-backed Cutworm, dorsal aspect; *b*, Red-backed Cutworm, lateral aspect; *c*, Greasy Cutworm, dorsal aspect; *d*, Greasy Cutworm, lateral aspect; *e*, W-marked Cutworm, dorsal aspect; *f*, W-marked Cutworm, lateral aspect. (*After Gibson, Ent. Br. Can.*)

former with two distinct black marks toward the centre. Along middle of back a pale stripe, and at each side a dark stripe borders the red of the back. Tubercles small and dark, each bearing a single hair. Moth variable in color and markings. Ground color of wings pale yellow to dark red; fore wings crossed by four or five irregular lines and marked with black; body grey or dull brown; active in May, June and July on corn (Fig. 125).

Army Cutworm (*Chorizagrotis auxiliaris* Grote). (Consult Bull. 13, Entom. Branch, Ottawa.) Three varieties: *C. auxiliaris*, *C. intro-*

ferens, and *C. agrestis* are recognized as destructive to grain, alfalfa, beets and flax in the West in Montana and Alberta. The larvæ begin to mature about the middle of May but pupation in earthen cells does not occur until the middle of June. The moths fly from June 15th Sept. 30th and the eggs are laid from August 24th–October 15th in the soil in weedy summer-fallows.

Porosagrotis delorata Sm. is injurious to wheat in June. In British Columbia *Euxoa excellens* Grote injures market gardens, and *Neuria procincta* Grote injures farm crops (Fig. 127).

Glassy Cutworm (*Sidemia devastator* Brace).—Translucent whitish, tinged with bluish-green and without spots; tubercles brown, each with a single hair; head reddish-brown; neckshield brownish. Active in

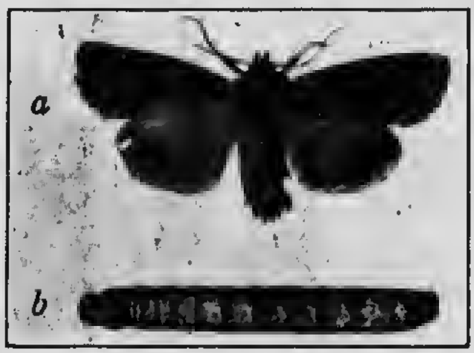


FIG. 126.—*a*, Moth of Glassy Cutworm (*Sidemia devastator*); *b*, larva. (*After Gibson, Bul.* 10, *Ent. Br. Can.*)

May and early June on hay and garden vegetables. Difficult to kill by poison bait on account of its underground feeding habit (Fig. 126).

Yellow-headed Cutworm (*Septis arctica* Bdv.).—Pale smoky grey, with head and neck shield tawny-yellow; without spots, 1½ inches long. Active in July on cereal crops and vegetables (Fig. 127).

Bronze Cutworm (*Nephelodes emmedonia* Gn.).—Large, 1¾ inches long, with alternate stripes of olive-bronze and yellowish, a pale stripe along the middle of the back, and two others on each side. Active in grass lands in April and May.

Zebra Caterpillar (*Ceramica picta* Harris).—"Velvety black on the back; beautifully ornamented with two golden-yellow stripes on each side of the body, which are connected by narrow lines of the same color;

the head and feet reddish-brown" (Fletcher). Two broods, on cabbages and turnips (Fig. 128).

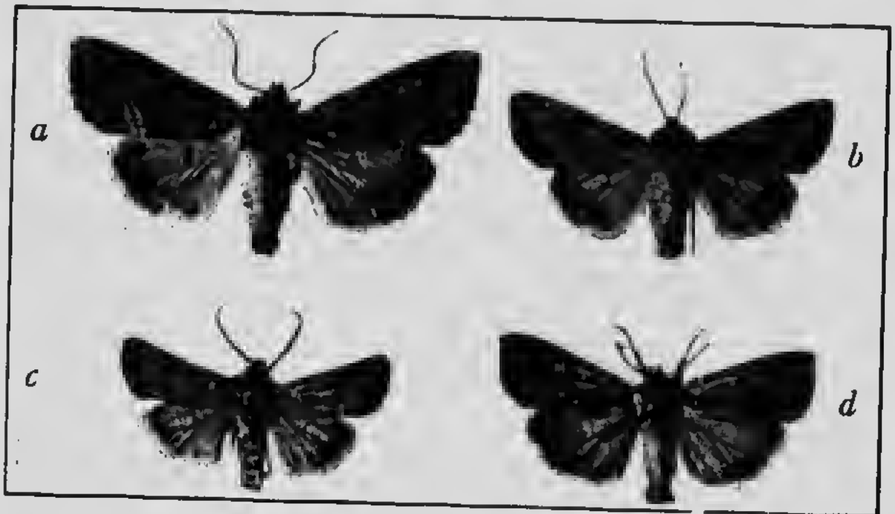


FIG. 127.—*a*, Moth of Yellow-headed Cutworm (*Septis arctica*); *b*, moth of Clover Cutworm (*Scotogramma trifolii*); *c*, moth of Pale Western Cutworm (*Porosagrotis orthogonia*); *d*, moth of Dingy Cutworm (*Felia ducens*). (*After Gibson, Bul. 10, Ent. Br. Can.*)

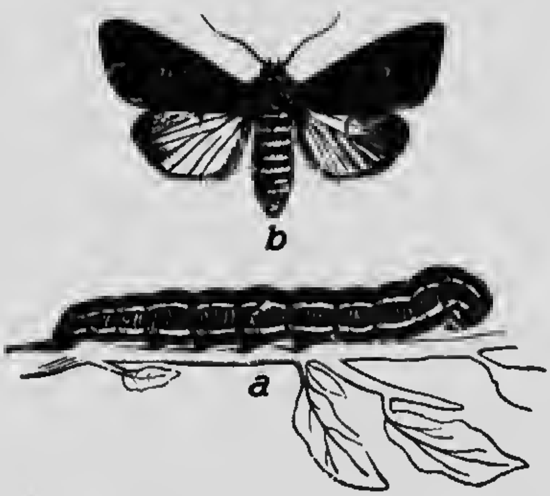


FIG. 128.—The zebra caterpillar and moth (*Ceramica picta*).

Clover Cutworm (*Scotogramma trifolii* Esp.).—Color varying from green to dark; a pale yellowish line along middle of back, a pinkish band bordered with white or pale yellow along each side, and between these a broken yellow stripe; head pale yellow or green with white mottlings; under side greenish grey with spots and streaks. Damages peas, clover, root crops, lettuce, etc. August (Fig. 125).

(*b*) Army Worms

The Army Worm (*Cirphis unipuncta* Haw.).—(Consult Farmers' Bull. 731, U. S. Dep. Agr.; Bull. 9, Ent. Br., Dep. Agric., Can.) Army worms appear to be more abundant in a wet spring or summer following a dry season. Injurious in 1895–1896 and in 1914. Probably a native of North America (Fig. 129).

Adult.—A dingy yellowish-brown moth with a white spot on the centre of each front wing; wing expanse 1½ inches, a row of small black spots near outer margins of wings with dark streaks.

Eggs.—Minute white eggs laid in bead-like strings on grass leaves in the folded blades or under the leaf-sheaths. Hatch in 8–10 days.

Larva.—A dark-colored cutworm, 1¾ inches long; body striped with black and yellow lines; a narrow white stripe or line along middle of greenish-black back; lower stripe dark greenish-yellow; next, just above the spiracles, black; the lowest, just below the spiracles, light greenish-yellow, edged with white. Head greenish-brown with coarse black mottlings and with two curved blackish-brown bars; under surface greenish mottled with brown; looping gait until after second moult; duration 20–30 days. Parasitized by *Winthemia 4-pustulata*, *Apanteles militaris*, *Ichneumon canadensis*, *I. lactus*, *I. jucundus* and others; by a bacterial disease; and preyed upon by *Calosoma.*

Pupa.—A brown chrysalis in the ground; duration 12–15 days.

Life-history.—There are two broods of the Army Worm moth each season. The insects usually pass the winter as half grown caterpillars. In the spring these mature and change to pupæ, the moths appearing early in June. The May brood of caterpillars seldom does much harm. The female moths lay their eggs (about 700) on grass leaves from which caterpillars hatch in about 10 days. The caterpillars of this brood do most injury. The worms usually feed at night, consequently whole fields may be ruined before they are discovered. This July brood of caterpillars reaches maturity in about 25 days, and changes to pupæ in the ground, the moths appearing again in about 2 weeks. These lay eggs for a brood of worms which appear in September, but are seldom injurious.

FIG. 129.—Stages and work of the true army worm (*Cirphis unipuncta*) and some of its insect enemies: *a*, parent or moth; *b*, full-grown larva; *c*, eggs; *d*, pupa in soil; *e*, parasitic fly, *Winthemia quadripustulata*, laying its eggs on an army worm; *f*, a ground beetle, *Calosoma calidum*, preying upon an army worm, and, at right, Calosoma larva emerging from hurrow; *g*, a digger wasp, *Sphex* sp., carrying an army worm to its burrow; *h*, *Enicospilus purgatus*, a wasplike parasite of the army worm. natural size. (*U. S. Bur. Ent.*)

Control.—Plow the fields in late fall; plow three or four furrows in front of the advancing army and kill the worms that fall into the furrows; poison a narrow strip on the threatened side of field with Paris green or the poisoned bran mash.

Black Army Cutworm (*Agrotis fennica* Tausch).—General color brown; a series of velvety black marks along middle of back; a white line along each side, and a spiracular white band, reddish-brown in the centre; head yellowish-red; shield black; feet pale brown. May and early June. Attacks peas, clover, trees and some garden vegetables (Fig. 125).

Fall Army Worm (*Laphygma frugiperda* S. and A.).—(Consult Farmers' Bull. 752, U. S. Dept. Agr.) Injurious mainly in the South but periodically appearing in the North. Feeds on grasses and cereal crops, cotton, alfalfa, cowpeas and other crops.

Adult.—Wing expanse 1½ inches; front wings dark grey, mottled, and with a light grey spot near tips; hind wings white, with a pearly lustre, and edged with a brown line. Body ash grey.

Eggs.—Light grey and minutely ribbed. Laid in clusters of 50-200 on grass blades. Hatch in 2–4 days in South, but as long as 10 days in the North.

Larva.—Newly hatched larvæ with jet-black heads and white bodies. Full grown in 2 to 3 weeks; then striped, nearly naked and about 1½ inches long. Front of head marked with an inverted Y. Assumes the Army Worm habit when food becomes scarce.

Pupa.—Golden-reddish at first but black later, living in an underground cell. Duration 10 to 14 days.

In the Gulf States there are 5 to 6 broods annually, but in the northern probably not more than one.

(*c*) Climbing Cutworms

(See Bull. 104, Cornell Agr. Exp. Stn., 1895; Bull. 10, Ent. Br. Dept. Agr., Can.)

Some species of cutworms are known to have a climbing habit, ascending not only fruit trees but also currants, gooseberries, tomatoes etc., to feed upon the leaves and fruit. Among these are:

White Cutworm (*Lycophotia scandens* Riley).—One and three-fourths inches long, yellowish-grey with whitish spots; spiracles black.

Spotted-legged Cutworm (*Porosagrotis vetusta* Walk.).—One and one-half inches long; black spots on legs; feeding on peach buds.

Dingy Cutworm (*Feltia ducens* Walk.).—Common; with wide buff-grey dorsal stripe; head and thoracic and anal shields dark brown. Feeds on garden crops (Fig. 124).

(*d*) Noctuid Loopers

Cabbage Looper (*Autographa brassicæ* Riley).—(Consult Bull. 33, Div. Ent., U. S. Dep. Ag., 1902, pp. 60–69.) Larva feeds on cabbage and related plants (Fig. 130).

FIG. 130.—Cabbage looper (*Autographa brassicæ*). Showing *a*, adult; *b*, larva and pupa. Natural size. (*After Chittenden, U. S. Bur. Ent.*)

Adult.—A brownish-grey "miller" moth; front wings transversely mottled with grey, white and black, and bearing a small silver-white spot on inner half; expanding $1\frac{1}{2}$ inches; borders of wings scalloped.

Egg.—Silvery-white or pale green, semi-globular, with radiating vertical ribs.

Larva.—A pale green translucent looping caterpillar, obscurely marked longitudinally; prolegs absent from 6th and 7th segments; 2 to 4 weeks.

Pupa.—Invested in a white gauzy silken cocoon spun on any convenient object; one to three weeks. Winters as a chrysalis.

Life-history.—Probably two broods a year in Canada and northern States.

Celery Looper (*Autographa simplex* Guen.).—(Consult Bull. 33, Div. Ent., U. S. Dept. Ag.) Slightly larger than the preceding species.

Adult.—A "miller" moth with fore wings marked with grey and seal brown, *silver mark hooked;* wings expanded 2 inches; borders not scalloped.

Egg.—Milky-white, flattened, globular; upper half grooved vertically.

Larva.—A pale yellowish-green looping caterpillar; markings similar to those on *A. brassicæ;* supra-spiracular spots black.

Pupa.—Resembles that of *A. brassicæ.*—(Consult Bull. 33, Div. Ent., U. S. Dept. Ag.).

Alfalfa Looper (*Autographa californica* Speyer).—Widely distributed over Western North America from Alaska and the Yukon south through B. C., Alberta, Saskatchewan, Manitoba to California, Nevada, Utah, Wyoming, Idaho, and Montana. Larvæ destructive to the leaves and blossoms of alfalfa, clover, garden peas, cabbage, etc.

Adult.—A brownish-grey moth, 1½ inches wing expanse; fore wings light bluish-grey with rose and light markings—one shaped like the letter Gamma near the middle; hind wings dull brown. An active flier.

Eggs.—Hemispherical, rounded at base, apex with rounded depressions; finely creased vertically; pale yellow. Duration 5–7 days. Probably laid on the leaves.

Larva.—One and one-fourth inches long, dark green, cylindrical tapering toward the head; subdorsal line fine and wavy; two other lines in this area and a wide whitish stigmatal band. Tubercles white, setæ white. Spiracles pale, black rimmed. Thoracic feet black, shiny. Three pairs of pro-legs on segments 9, 10, 13.

Pupa.—Dark brown, ⅔ inch long. The cocoon is a thinly woven web of whitish silk spun among the leaves. Duration 10–14 days. Hibernates as pupa and adult. Probably two broods in B. C. and Washington.

Green Clover Worm (*Plathypena scabra* Fab.) (Consult Farmers' Bull. 982, U. S. Dept. Agric.). A pest of alfalfa and the leguminous crops of eastern U. S. and southern Canada.

Adult.—Variegated dark brown to black; wing expanse 1¼ inches. 2–4 generations a season. Hibernates.

Eggs.—Circular, slightly flattened; green; about the size of a pin head. Female lays between 200–600 eggs in a few days singly on the underside of the leaf. Hatch in about four days.

Larva.—Green, with a narrow white stripe and second fainter white line on each side; 1¼ inches long; only four pairs of pro-legs; 5 moults; restless and drops off the plant when disturbed. Mature in about 4 weeks.

Pupa.—Yellow-brown or black, formed in a loose oval base or cocoon of debris webbed together; duration about 8 days. Sometimes hibernates.

Control.—Cut the crops when the caterpillars are most abundant; adopt clean culture; use hopperdozer in bad outbreaks.

Hop Vine Looper or Snout Moth (*Hypena humuli* Harris).—This noctuid sometimes does serious injury to the leaves of hop. Two broods a year.

Adult.—A dark brown moth, 1½ inches wing expanse, with irregular and variable transverse markings on fore wings; palpi long, flattened, and projecting horizontally like a snout. July and August–September; hibernates.

Eggs.—Pale green; laid on the under side of the leaves.

Larva.—A semi-looper, lacking the first pair of prolegs; green; with two longitudinal white lines along the back, a dark green line between and an indistinct whitish line on each side; head green spotted with black piliferous dots. Spins a thin silken cocoon before pupating.

Pupa.—Formed in the ground, in crevices in the poles, and in the leaves. Duration about 10 days.

Control.—Spray or dust vines with arsenate of lead.

(*e*) **Corn Ear Worm (Heliothis obsoleta Fab.)**

Adult.—An ochre-yellow moth with blackish markings, expanding about 1½ inches.

Eggs.—Small yellow circular flattened disks, prettily corrugated by ridges radiating from the centre.

Larva.—Variable in color, pale green or brownish caterpillar, $1\frac{1}{2}$ inches long, often dark striped; head amber-yellow; legs black.

Pupa.—In a small oval cell in the ground.

Life-history.—In Canada there is one brood, perhaps two in some southern localities. The insect hibernates as a pupa. The moth emerges the following July, when eggs are laid on the silk of the ears. The young caterpillars feed upon the young kernels until fully developed, when they descend to the ground and transform to pupæ in small oval cells. Known in the South as the Cotton Boll Worm.

(*f*) Stalk Borers

Several species of Stalk Borers are injurious to various cultivated plants, such as hop vines, columbines, corn, potatoes, tomatoes, raspberries, asters, dahlias, and also to burdocks. The caterpillar lives inside the stem and makes a burrow by devouring the interior. As a result the plant often withers and dies. Before maturity it works its way down to the root where it changes to a pupa. The Stalk Borers have been placed in the genera *Gortyna*, *Hydrœcia* and *Papaipema*. *Gortyna immanis* occurs in hop vines; *Papaipema purpurifascia* in columbine; *P. nitela* in corn, dahlia, aster, potatoes, etc; *P. cataphracta* in burdock; *Gortyna micacea* in rhubarb, corn, potatoes, etc.

Garden Stalk Borer (*Papaipema nitela* Guen.).—This borer tunnels the stalks of potatoes, tomatoes, and other garden crops, and many weeds. Sometimes feeds on strawberry. One brood a year.

Adult.—A mouse-colored noctuid moth, with outer third of fore wings paler and bordered within by a whitish cross-line. Late August.

Eggs.—Grey, circular, with radiating ridge, $\frac{1}{50}$ inch in diameter; hatch in late May or early June.

Larva.—Mines in the leaf at first, then enters the stalk and tunnels it. Full grown about August; 1 inch long, purplish to light brown and marked with white stripes except on first four segments of abdomen; head, neck-shield and anal-shield light reddish-yellow.

Pupa.—Brown, formed in lower part of stalk. Duration about 2 weeks.

Control.—Clean cultivation; removal and burning of old stalks.

Potato Stalk Borer (*Gortyna micacea* Esp.).—A European insect and a general feeder. Reported on rhubarb, corn, potatoes in N. S. and N. B.

Adult.—Ground color of fore wings light brown tinged with red, with a transverse darker median band. Hind wings dingy grey with a transverse light brown line. Aug.–Sept.

Eggs.—Circular, finely ribbed and sculptured; slightly pinkish; laid on stems of couch grass.

Larva.—One and three-fifth inches long; head chestnut-brown; tubercles pale brown with a stiff black bristle; spiracles shiny black; body color greyish tinged with pink.

Pupa.—Brown, 4/5 inch long. Duration about 3 weeks.

(*g*) Green Fruit Worms (Graptolitha spp.)

G. antennata Walker, *G. laticinerea* Grote, *G. cinerosa*, *G. bethunei* G. and R. and other species sometimes injure leaves and fruit of apple and forest trees in late May and early June.

Ash-Gray Pinion (*Graptolitha antennata* Walk.). *Adult.*—Dull ashy-grey; fore wings with darker grey or greyish-brown markings. April and September; hibernates.

Eggs.—Yellow, globular, ridged; laid singly on bark of smaller branches in early spring.

Larva.—Light yellowish or apple-green naked caterpillar, 1–1½ inches long, with a cream-colored stripe along the middle of the back, a similar but wider stripe along each side, and mottled markings or stripes above the lateral stripes. Head glossy green, with white mottlings; legs whitish, prolegs greyish. May–June.

Pupa.—Dark brown; often within a thin silken cocoon in an earthen cell in the ground. Duration 3 months, sometimes over winter.

Control.—Spray with dilute lime-sulphur and lead arsenate before the blossoms open.

Parasites.—*Meteorus hyphantriæ* and *Mesochorus agilis.*

Bethune's Green Fruit Worm (*Graptolitha bethunei* G. and R.).—This fruit worm is a pest in many parts, and has been reported as most destructive in the Annapolis Valley, Nova Scotia. The color of the moth is quite variable, some moths being nearly white with darker markings, while others are much darker.

Another species of Green Fruit Worm, *Orthosia hibisci* Guen., occurs at Geneva, N. Y.

(*h*) Dagger Moths

The larvæ of several species of Dagger Moths may be found feeding on the leaves of shrubs and trees. The more common forms are the

American Dagger Moth, the Raspberry Dagger Moth (*A. impressa* Walk.), the *Smeared Dagger Moth* (*A. oblinita* S. and A.), the *Grey Dagger Moth* (*A. populi* Riley), and the *Darkish Dagger Moth* (*A. morula* Grote). They may be distinguished from the arctiid woolly-bears by the mode of distribution of the hairs. The hairs of the latter arise from tubercles in clusters, while they are scattered over the surface of the body in the Dagger-larvæ.

American Dagger Moth (*Acronycta americana* Harris). *Adult.*—Fore wings light grey with faint dark lines and dagger-like markings. Hind wings smaller, dark brown. Body similar in color to hind wings.

Larva.—Two and one-half inches long when full grown; thickly covered with short pale yellow hairs, with a pair of long black hair pencils on first and third abdominal segments and a single one on the eighth; head black; body greenish-white above with a subdorsal and stigmatal black line; lower surface black. Common in September on elm, maple, oak, hickory, ash, poplar, alder and other trees.

(*i*) Underwing Moths

The Catocalas or Underwings are interesting Noctuids, the adult moths showing protective resemblance to the bark of trees. The larvæ of some of the species at least feed on the leaves of trees, *C. ultronia*, *C. grynea*, on apple, plum, cherry; and *C. relicta*, *C. cara*, and *C. concumbens* on poplar, willow and birch.

NOTODONTIDÆ (PROMINENTS)

Hand-maid Moths (*Datana* Spp.).—Several species of Datana occur on orchard and forest trees.

Yellow-necked Caterpillar (*Datana ministra* Drury).—The larvæ are gregarious, and are often injurious to the leaves of apple in late summer.

Adult.—A russet-brown moth nearly 2 inches expanse; head and large spot on the thorax chestnut brown; fore wings cinnamon brown crossed by 3–5 darker brown lines; hind wings pale yellow. Early summer, June–July. One brood a year.

Eggs.—In flat clusters of 70–100 on surface of leaf; white and round.

Larva.—Two inches long; head large and black; cervical shield dull orange; back and sides striped alternately with black and yellow lines; body thinly clothed with soft white hairs. Larvæ occur in clusters and at rest their bodies assume a characteristic bow-form. When young they are chestnut brown. At maturity they descend to the ground and burrow to a depth of 3 inches. Larval stage 5–6 weeks.

Pupa.—A naked brown object in the ground nearly an inch long.

Control.—Hand-pick the clusters of caterpillars; spray the caterpillars with an arsenical.

Walnut Caterpillar (*Datana integerrima* G. and R.) is often destructive on walnut, butternut, and hickory, and also on oak, beach, apple, and hawthorn.

Adult.—A buff-brown moth with darker bands across the fore wings; 1¾–2 inches wing expanse. July–August.

Eggs.—Laid in clusters of 100 or more on underside of leaves.

Larvæ.—Caterpillars feed in clusters devouring the leaves; when nearing maturity they separate. Body black, with a loose covering of soft whitish hairs 2 inches long; when at rest they assume a *bow-form.* At moulting times they gather in large numbers on the trunks and larger branches. When mature they descend and enter the earth.

Pupa.—A dark brown chrysalis; hibernates in this stage.

Control.—Spray caterpillars with arsenical; collect the clusters of caterpillars.

Red-humped Apple Caterpillar (*Schizura concinna* Sm. and Ab.). *Adult.*—Moth expanding 1¼ inches; body light brown, thorax dark brown; fore wings greyish on outer margin and dark brown on inner, with a brown dot near middle, a spot near each angle and several longitudinal streaks along posterior margin. Hind wings brownish. June and July. One brood in the North.

Eggs.—White, round, slightly flattened deposited in a cluster of 40 100 on the under side of leaf in July.

Larvæ.—Body striped with yellow, black and white lines; a double row of black spines on back; head coral-red; a red hump on fourth segment. Full-grown in late summer and fall, when they spin loose silken cocoons, mixed with rubbish, on the ground. Gregarious, attacking apple, pear, plum, cherry, and blackberry and some forest trees.

Pupa.—Formed in fall and pass the winter and early spring in or on the ground.

Control.—Spray with arsenate of lead; hand-pick or burn caterpillars with rag torch.

LYMANTRIIDÆ (TUSSOCK MOTHS)

Gypsy Moth (*Porthetria dispar* Linn.).—A European insect introduced into the U. S. (Mass.) about 1869, now found in all the New England States. The larva feeds on a very large variety of plants—forest, orchard and shade trees, especially oak, willow and apple, shrubs and even herbaceous plants. Conifers immune (Fig. 131).

Adult.—Male brownish-yellow, slender, with feathered antennæ; fore wings marked with zigzag darker lines; wing expanse 1½ inches; an active flier. Female white with zigzag dark lines and with slender black antennæ; body so heavy as to prevent flight.

Eggs.—Laid in July–August in irregular oval spongy masses of 400–500 in crevices and on convenient objects, and covered with tan colored hairs; hatching about May 1st following.

Larva.—A dark brown hairy caterpillar 2–3 inches long; 2 rows of red spots and 2 rows of blue spots along the back with a dim yellowish stripe between; body clothed with long black hairs. Full grown about July 1st.

Pupa.—Cocoon of silk loosely formed among the leaves; pupa conical and dark brown; 1 inch long. Duration 7–17 days.

Parasites.—The following have been introduced: *Anastatus bifasciatus* and *Schedius kuvanæ*—chalcid egg parasites; *Compsilura concinnata* and *Blepharipa scutellata* on the caterpillar; *Monodontomerus æreus*, a chalcid pupa parasite; and *Calosoma sycophanta.*

Control.—Treat the egg clusters with creosote; band the trees with burlap, etc. and spray; parasites.

Brown Tail Moth (*Euproctis chrysorrhœa* Linn.).—Larva destructive to orchard, shade and forest trees. Conifers immune. Probably introduced from Holland to Mass. about 1893 (Fig. 132).

Adult.—A white moth, except that the abdomen is tinged with brown and tipped with a tuft of brown hairs, most conspicuous in the female. Both sexes are strong fliers and active at night in July.

Eggs.—In brownish clusters of 150–300 on the leaves on the tips of the branches. Usually brown hairs are mixed with the egg mass. Eggs hatched by August 15th.

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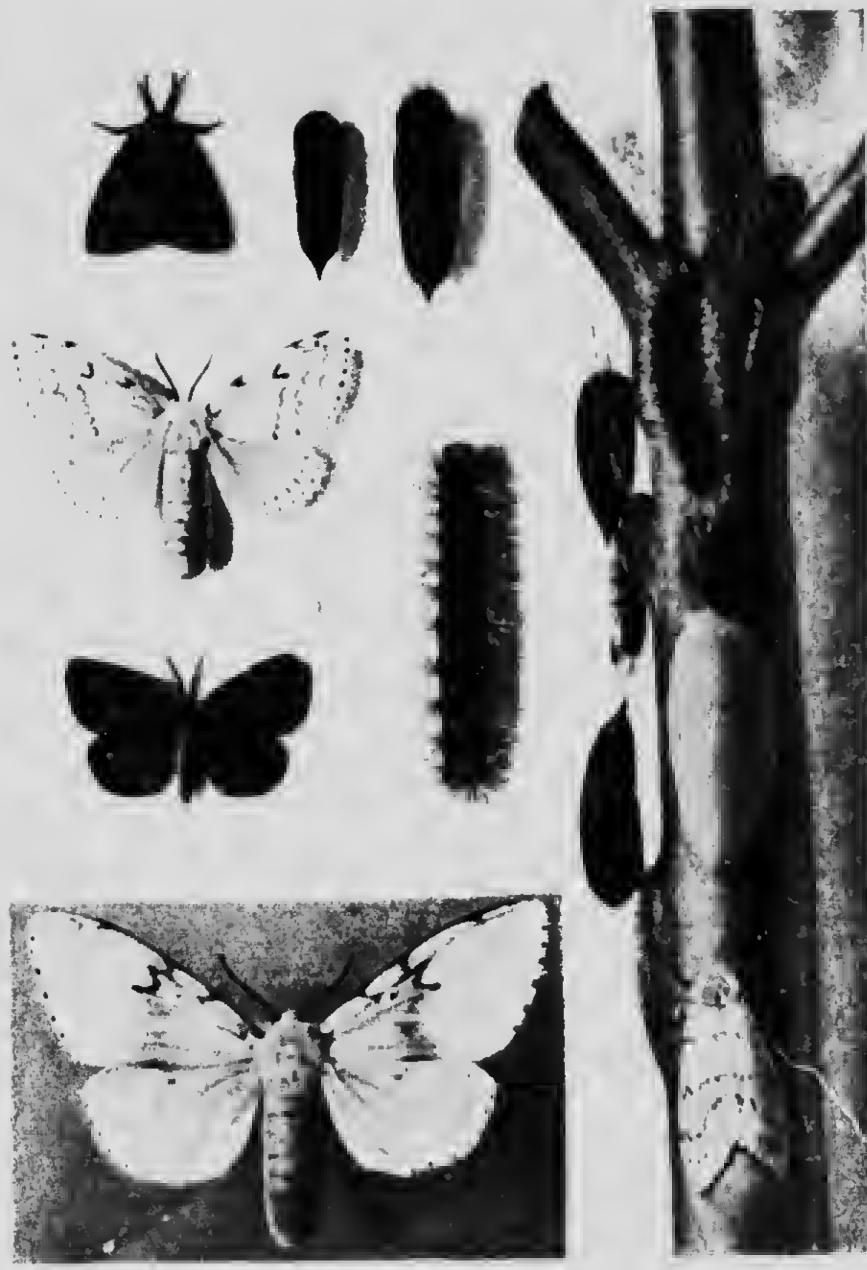

FIG. 131.—Different stages of the gipsy moth (*Porthetria dispar*). Egg m[illegible] on center of twig; female moth ovipositing just below; female moth, Japan[illegible] variety, lower left; male moth immediately above; female moth immediately abov[illegible] male moth with wings folded in upper left; male chrysalis at right of this; fem[illegible] chrysalis again at right; larva at center. All slightly reduced. (*After Howard a[illegible] Fiske.*)

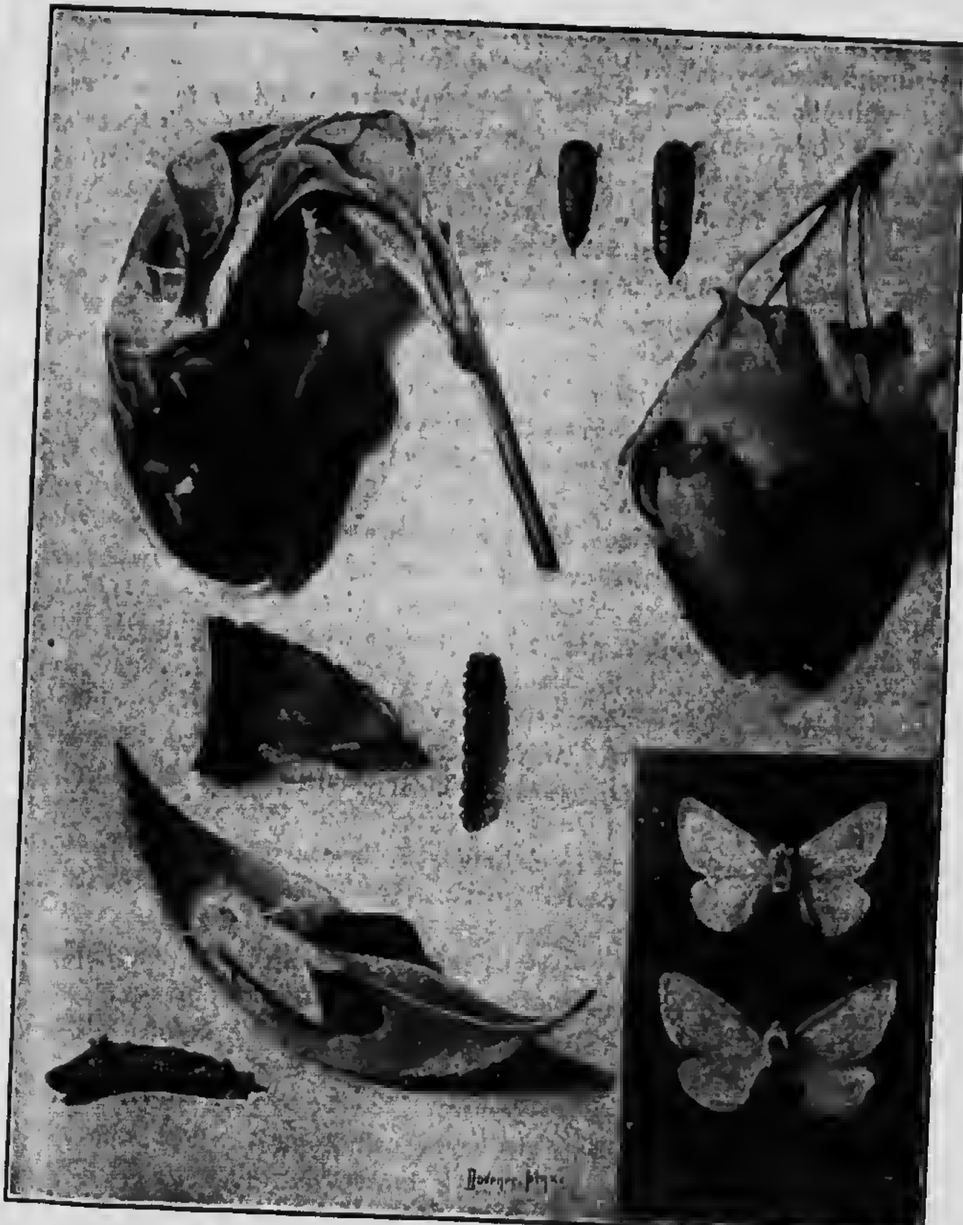

FIG. 132.—Different stages of the brown-tail moth. Winter nest at upper left; male and female adults at lower right; another winter nest at upper right; male and female chrysalides above, male at left; full-grown larva in centre, somewhat reduced; young larvæ at its left; egg-mass, the eggs hatching at lower left; female ovipositing on leaf; egg-mass also on same leaf. (*After Howard and Fiske.*)

Larva.—Dark brown caterpillar 1½ inches long with a sprinkling of orange; body covered with fine reddish-brown hairs; a row of conspicuous white hairs along each side; bright red tubercles on top of sixth and seventh abdominal segments. Full grown in June. Winter is spent as black quarter-grown larvæ in colonies or nests of leaves bound firmly together by a silken web. Barbed hairs irritating to human skin.

Pupa.—Loose cocoon attached to leaf; pupa brown, about ¾ inch long. Duration about 20 days.

Parasites.—Imported forms are: *Pteromalus egregius*, *Apanteles lacteicolor*, *Meteorus versicolor*, *Zygobothria nidicola*, *Compsilura concinnata*, *Pales favida*, *Monodontomerus æreus; Calosoma sycophanta.*

Control.—Cut off and burn the winter nests before the caterpillars emerge in April; poison the caterpillars with lead arsenate before the middle of June; parasites.

White-marked Tussock Moth (*Hemerocampa leucostigma* Sm. and Ab.).—A native insect whose larva is frequently injurious to fruit trees and shade trees.

Adult.—Male winged and ashen-grey in color; fore wings crossed by wavy bands of a darker shade, with a minute white crescent near outer hind angle, a small black spot near tip of outer edge and an oblique blackish stripe beyond it. Antennæ broad and feather-like. Females wingless with slender antennæ, and of a light grey color. July August.

Eggs.—White and nearly globular; 300–500 arranged in a three or four-layered mass and covered with a frothy substance. Hatch in May and June.

Larva.—One and one-fourth to one and one-half inches long, bright yellow; head and two small protuberances on hinder portion of back bright coral red; four creamy tufts on back; two black plumes at front and one at the rear; black and dusky yellow stripes along the back and sides.

Pupa.—Cocoons made of silk and hairs; pupa brownish, the male smaller than the female; 10–15 days duration.

Life-history.—Eggs are laid in July and August and hatch in late May and early June; caterpillars full grown in a month; pupal stage lasts about 2 weeks, and the adults emerge in July and August to lay their egg-masses. But one brood in Canada and Northern United States.

Enemies.—*Pimpla inquisitor, Chalcis ovata, Tachina mella;* certain birds; red ants; certain dermestid beetles; certain fungi and bacteria.

Control.—See under Antique Tussock Moth.

Antique or Rusty Tussock Moth (*Notolophus antiqua* Linn.).—A European species often injurious in Nova Scotia, New England, and the West.

Adults.—Male has rust-brown wings, with two deep brown cross bands and a conspicuous white spot near anal angle of fore wings. Female almost wingless with blackish body covered with yellowish-white hairs.

Eggs.—Egg-mass laid on cocoon, but *with no protective covering.*

Larva.—Head black; first two tussocks on back are black at first but whitish on later moults wnen an *additional pencil of long black hairs appears on each side of second abdominal segment.*

Pupa.—Female larger than the male.

Control of Tussock Worms.—Collect and destroy the egg-masses; paint the egg-masses with creosote; spray in June with an arsenical; band trees with burlap or tar to prevent females from ascending.

LASIOCAMPIDÆ (TENT-CATERPILLAR MOTHS)

Orchard Tent-caterpillar (*Malacosoma americana* Fab.).—Periodically a serious defoliator of orchard and forest trees and occurring as far west as the Rockies.

Adult.—A brown moth expanding 1½ inches; fore wings crossed obliquely by two pale lines; female larger than male.

Eggs.—A glistening brown mass (200–300) encircling the twigs, covered with a gluey froth. Each end of belt of eggs tapers; each egg 1/25 inch long, elongate, thimble-shaped.

Larva.—A hairy black soft velvety caterpillar, 2 inches long, with a white stripe down the back; on each side a row of blue spots; sides streaked with white or yellow lines; under side blackish. Caterpillars of a colony form silken tents at angles of branches and feed away from tents. Matures in 4–5 weeks.

Pupa.—Cocoons formed under bark, in crevices, etc., elongated-oval; outer silk delicate and loose, inner part firm and close; a yellow powder within. Pupal stage lasts 2–3 weeks.

Life-history.—Winters in the egg state; eggs hatch in May when the buds are beginning to open and the caterpillars reach maturity in June.

Adults appear and eggs are laid in July. There is but one brood each year.

Forest Tent-caterpillar (*Malacosoma disstria* Hbn.) differs from the preceding in the following particulars: egg-mass is nearly square at the ends; caterpillars do not construct tents; line along the back is broken with dots; transverse lines on the wings of moth are darker than ground color.

Parasites.—*Pimpla conquisitor, P. inquisitor, Tachina mella, Anomolon exile. Calosoma* and *Podisus* are predaceous enemies.

Control.—Destroy the egg-masses; spray caterpillars with arsenical; burn off the tents; band trees with burlap or tar to prevent the caterpillars from ascending.

GROUP GEOMETRINA (GEOMETERS)

Chief Families (after Comstock)

A. Media$_2$ of the hind wings wanting, being represented merely by a fold in the wing.—*Ennomidæ.*

AA. Media$_2$ of the hind wings present.

B. Media$_2$ of the hind wings arising much nearer to Media$_1$ than to Media$_3$.
Wings usually green.—*Geometridæ.*

BB. Media$_2$ of the hind wings arising nearly midway between Media$_1$ and Media$_3$ or nearer to Media$_3$ than to Media$_1$. Wings rarely green.

C. Subcosta and Radius of hind wings extending distinctly separate from each other, except that they are connected by a cross vein near the middle of the discal cell.—*Hydriomenidæ.*

CC. Subcosta and Radius of hind wings approximated or coalesced for a greater or less distance.

D. Subcosta and Radius of the hind wings closely approximated but not coalesced along the second fourth (more or less) of the discal cell.

E. Radius and Media$_1$ of hind wings separating at or before the apex of the discal cell.—*Ennomidæ.*

EE. Radius and Media$_1$ of hind wings coalesced for a considerable distance beyond the apex of the discal cell.—*Monoctenidæ.*

DD. Subcosta and Radius of the hind wings coalesced for a short distance near the beginning of the second fourth of the discal cell, thence rapidly diverging.—*Sterrhidæ.*

DDD. Subcosta and Radius of the hind wings coalesced to or beyond the middle of the discal cell.

E. Fore wings with one or two accessory cells.—*Hydriomenidæ.*

EE. Fore wings without an accessory cell.—*Monoctenidæ.*

MONOCTENIIDÆ

Spring Canker Worm (*Palæacrita vernata* Peck.). A widely distributed insect from Canada to Texas, and from Maine to Kansas and California.

Adults.—Male moth with thin brownish-grey silky wings, 1 inch expanse; fore wings with a row of light markings near outer margin and three transverse dark irregular bands; female moth wingless, ⅓ inch long, dull grey or brown with a dark brown stripe down the middle of the back. April May.

Eggs.—Yellowish-green, oval, 1/35 inch long; laid in irregular masses of about 50 under loose bark, in crevices. Hatch in a month about the time of unfolding of the leaves.

Larva.—Slender, cylindrical, 1 inch long, with only two pairs of prolegs, with narrow longitudinal yellow-white lines, and a yellow stigmatal stripe along each side; ventral surface white. Mature in 4 to 5 weeks, when it drops to ground by a silk thread and enters to a depth of 2 to 5 inches.

Pupa.—Cocoon an earthen cell lined with silk; pupa remains in it until following spring; light brown and pitted. Male pupa spined.

Parasites, Etc.—Hymenoptera, Diptera and birds.

Fall Canker Worm (*Alsophila pometaria* Harris).—Widely distributed—Eastern Canada, New England, New York, Ohio, California.

Adults.—Male moth with darker, stronger wings than that of the spring Canker Worm; fore wings crossed with two light bands; hind wings darker. Female moth wingless, ashy-grey, no markings, antennæ long. October–November.

Eggs.—Brownish-grey, flower-pot like, outer end with a dark spot surrounded by a dark ring; laid in clusters of 100, in rows, each egg fastened on end and to the bark. Hatch in May, about the time of unfolding of the leaves.

Larva.—Resembles in a general way that of the Spring Canker Worm, but has a broad dark stripe along the back and three pairs of prolegs near hind end of body. When disturbed full grown it drops to the ground by a silken thread. It forms a cocoon in the ground. Matures in 4 to 5 weeks.

Pupa.—Cocoon tough and contains more silk than that of Spring Canker Worm; pupa stouter and spine of male pupa forked.

Control.—Spray with arsenate of lead just after the leaves unfold; band trees with burlap in fall.

ENNOMIDÆ

Pepper-and-salt Currant Moth (*Amphidasis cognataria* Guen.).—Injures leaves of currant, gooseberry, plum, Spirea and maple.

Adult.—Body grey, with black dots; wing expanse 2 inches, grey with dark brown dots and two wavy brown cross bands on the outer third. May and August.

Eggs.—Cylindrical, with surface marked with rows of hexagonal depressions; 1/30 inch long.

Larva.—A geometrid or measuring caterpillar, 2 inches long; green to brownish-black in color, with indistinct green or yellow lines and spots. Full grown in July.

Pupæ.—Pupæ dark brown, 3/4 inch long, formed in the ground. Some change to moths in August, but others do not change until following May.

Lime Tree Winter Moth (*Erannis tiliaria* Harris).—Occasionally injurious to the leaves of elm, basswood, hickory, apple, etc.

Adult.—Male, with rusty-buff body and fore wings, and lighter hind wings. Female wingless, light brown to grey with markings. Oct.-Nov.

Eggs.—Cream colored, cylindrical with ends blunt-rounded. Hibernate.

Larva.—A bright-yellow looper, with rust-colored head, and ten crinkled black lines along the back. Full grown larva 1 1/4-1 1/2 inches. June.

Pupa.—July-Oct.

Currant Span Worm (*Itamera ribearia* Fitch). *Adult.*—A pale yellowish geometrid moth with brownish spots, 1 1/4 inches expanse; markings on wings variable and often with one or two cross bands. Mid-summer.

Eggs.—Laid on twigs about July; hatch the following spring when leaves are full grown.

Larva.—A yellow striped and black spotted looper, a little more than an inch long; full grown in 3 to 4 weeks.

Pupa.—Formed just beneath the surface of ground; duration 2 to 3 weeks. One brood each season.

Control.—Spray with arsenical or pyrethrum.

Mottled Umber Moth (*Erannis defoliaria* Clerck).—Destructive in plum and cherry orchards on the Pacific slope. A European insect, resembling the basswood or lime tree span-worm (*Erannis tiliaria*).

Adult.—Appears in November; female wingless, brown, with rows of brown spots; fore wings of male dull ochre-brown, crossed by two dark waved bands; hind wings pale and mottled with brown dots.

Larva.—Active in June–July; a span-worm, with black stripes separated by reddish-brown stripes; spiracles in reddish-brown blotches.

Bruce's Measuring Worm (*Rachela bruceata* Hulst).—Destructive in New York in 1886 and in Alberta in 1902–3.

Adult.—Female wingless, ⅓ inch long, light brownish-grey; male winged, expanding 1⅛ inches, pale brownish. Oct.–Nov.

Eggs.—Reddish-orange, oval, finely pitted; laid singly in crevices of bark; hatch in April.

Larva.—Three-fourths inch long, apple-green, with three narrow yellowish-white stripes along each side of body; head and thoracic shield black; feeds 4 or 5 weeks in April and May, especially on blossom buds.

Pupa.—Light brown in a slight silk-lined cocoon in the ground. One generation in a season.

PSYCHIDÆ (BAG-WORM MOTHS)

Evergreen Bag Worm (*Thyridopteryx ephemeræformis* Haworth).—Occurs on conifers, red cedar and arbor vitæ.

Adult.—Female wingless, naked and grub-like; male with transparent wings. September–October.

Eggs.—Deposited in a mass within a bag composed of silk mixed with bits of leaf and twig in September–October. They winter over and hatch in May–June.

Larvæ.—Feed on the leaves within bags which are gradually enlarged as they mature.

Pupæ.—Formed within the bags.

Control.—Spray foliage with arsenical solution; gather cocoons and bags.

PYRALIDINA GROUP

Families (After Comstock)

E. Wings not fissured.

  F. Hind wings without a fringe of hairs at base of Cubitus.

G. Fore wings with fourth and fifth branches of Radius separate, the latter arising from the discal cell.—*Pyraustidæ*.

GG. Fore wings with fourth and fifth branches of Radius united at base.—*Pyralididæ*.

FF. Hind wings with a fringe of hairs at base of Cubitus.

G. Radius of fore wings 5-branched.

H. Maxillary palpi more or less developed but not triangular as in HH.—*Galleriidæ*.

HH. Maxillary palpi well developed, appearing triangular; labial palpi long, straight and projecting forward.—*Crambidæ*.

GG. Radius of fore wings 4-branched.—*Phycitidæ*.

EE. Wings fissured.

F. Wings with less than five fissures.—*Pterophoridæ*.

FF. Wings with five fissures.—*Orneodidæ*.

PYRALIDIDÆ

Meal Snout Moth (*Pyralis farinalis* Linn.). *Adult.*—A pyralid moth, 1 inch wing expanse. Fore wings with base and tips dark brown, middle portion light brown, two wavy white lines crossing wings, bordering the middle portion; hind wings grey with two wavy whitish lines.

Eggs.—Laid in masses; irregular.

Larva.—Lives within a silken tube; dirty-grey, darker at both ends; head brownish-red.

Pupa.—Brownish-red, in a cocoon.

Clover Hay Worm (*Hypsopygia costalis* Fab.).—The caterpillars cause injury to stacked or stored clover, near the ground or floor, by webbing it together and contaminating it with excrement.

Adult.—Small; 4/5 inch wing expanse; wings silky, margined with orange and fringed with golden yellow; two large golden spots at the thirds of the fore wings, extending to hind margin as narrow lilac lines. Two straw colored lines on hind wing. Under surface of wings pale yellowish; head and legs straw colored; antennæ and palpi pale orange. Two broods. June–July; August.

Eggs.—Laid probably on growing clover heads. June and August.

Larva.—Three-fourth inch long, dull brown; head, shield and anal plate black after last moult; segments much wrinkled and provided with several smooth shining areas each bearing a fine white hair. Hibernates.

Pupa.—Honey-yellow; cocoon 1/2 inch long, oblong-oval, white, silky, intermingled with excrement and bits of hay.

Control. Remove old hay and if infested burn it; raise stack above ground a few feet on old rails, etc. Salt bottom of stack.

Grape Leaf Folder (*Desmia funeralis* Hbn.). Occurs on wild and cultivated grapes, and is widely distributed over the United States and Canada. Causes injury by skeletonizing the upper surface of leaves, while protected under their folds.

Adult.—Wings expanded, 9/10 inch, dark brown and bordered with white. Fore wings with two oval white spots; hind wings of male with one spot, of female spot divided. Body black, crossed by two white bands in female, one in male. Antennæ of male knotted near the middle. Two broods; May and July–August.

Eggs.—Minute, elliptical; laid singly on under side of leaf. Duration 8–10 days.

Larva.—One inch long when full grown; widest in middle; yellowish-green on sides; head and prothoracic shield light brown; sides of first two thoracic segments with light brown spots; six instars. Duration about 4 weeks. First brood matures in July, second in Sept. October.

Pupa.—Formed usually on the ground among fallen leaves. Dark brown; tapering posteriorly. Hibernates.

Parasites.—*Apanteles, Meteorus, Mesochorus, Exorista, Tachinophyto* and others.

Control.—Spray with arsenate of lead shortly after blossoms have fallen.

Purple-backed Cabbage Worm (*Evergestis rimosalis* Guen.).—Injurious in the Maritime Provinces and Southern States to turnips and cabbages.

Adult.—Small, wing-expanse 7/8 inch; fore wings pale satiny-yellow with a heart-shaped discal spot, two transverse wavy lines across middle of wings, a less distinct line near base and another near tip; hind wings silvery-white with a clear black margin. June and Oct. Nov.

Eggs.—Bright yellow; laid in masses of 20–40 on under surface of leaf; hatch in a week.

Larva.—Three-fourth inch long; bristly, slender, tapering to each end, back purplish; head, anal plate and two spots on second segment black. July and Sept.–Oct. Full grown in 2 to 3 weeks.

Pupa.—Winters as a chrysalis. Two broods in a season, the last brood being the more injurious. Probably three broods in the South.

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Control.—Same as for imported cabbage worm (*Pieris rapæ*), p. 176.

Sugar Beet Web Worm (*Loxostege sticticalis* Linn.).—Injurious in Manitoba, Saskatchewan and Alberta to alfalfa, turnips, rape, onions, peas, cabbage, and other garden plants; in the middle western states and the prairie provinces on sugar beets. A native of Europe and Northern Asia.

Adult.—A purplish-brown moth, with darker and paler bands; wing expanse 1 inch. May and June.

Eggs.—Broadly oval, 1/25 inch long, pale green; laid in clusters (3–10) on the leaves.

Larva.—One inch long, dark with a white stripe down the back and one on each side, marked with many black and white tubercles.

In Colorado the first brood of larvæ feed on pigweed and alfalfa in June; the second brood appears in July, and sometimes injures beets; the third brood about middle of August is most injurious. Most of the larvæ hibernate in the ground in long silken tubes.

Pupa.—The pupa is formed in early spring in the silken tube.

Greenhouse Leaf Tyer (*Phlyctænia ferrugalis* Hbn.).—A serious pest in greenhouses to violet, rose, carnation, and other plants; and outdoors to beet, celery, lettuce, sweet pea and other plants. It ties up contiguous leaves by webs and feeds within, skeletonizing the leaves. Widely distributed.

Adult.—A small moth, 3/4 inch wing expanse; fore wings light brown and with blackish cross lines; hind wings grey with darker margins.

Eggs.—Translucent, oval disks, 1/32 inch long; laid in clusters of 8 to 12; hatch in 19–20 days.

Larva.—Three-fourths inch when full grown; greenish white with a green line down the back and another on either side; head straw colored; mottled. Full grown in 3–5 weeks; feeds mostly at night.

Pupa.—Formed within the webbed leaves.

Control.—Spray or dip the plants in solution of arsenate of lead as soon as larvæ are observed; hand pick infested leaves.

Crambidæ (Close-wings)

Root or Sod Web Worms (*Crambus* spp.).—In July and August many small greyish moths with closely folded wings and with projecting mouth-parts (labial palpi) are common on grass lands and collect in large numbers about lights. The caterpillars of these moths live in the sod in silk-lined burrows among the roots of the grass, feeding upon them. Corn is sometimes injured.

Adults.—Several species; yellowish-white wings with silver stripes, bands, gold lines and other markings. Two broods. June–July.

Eggs.—Laid in grass land in June–July and again Sept.–Oct.; oval, yellowish, ridged, 200 by each female; hatch in 6–10 days.

Larvæ.—Color varying from yellowish-white to pink to reddish; surface tubercled with tufts of bristly hairs; form loose silken webs and feed on the roots; full grown in 5 to 7 weeks; ½ to ¾ inch long. Hibernate in webs partly grown.

Pupæ.—Cocoons formed often in the larval webs; 12 to 15 days.

Control.—Plow land early in autumn to prevent egg deposition; plow early in spring; use trap-lanterns to catch the moths.

Cranberry Girdler (*Crambus hortuellus* Hbn.).—(See Bull. 554, Bur. Ent. U. S. Dep. Agr.) An injurious pest of cranberry vines, widely distributed in United States and Canada. Its host plants are certain grasses, *Scirpus americanus*, and cranberry.

The moths appear in June, and eggs are laid on the trash covering the ground. These hatch in about 10 days. The larva feeds throughout the summer and fall; when full grown it is about half an inch long, with dark brown or black head, light amber colored thoracic shield and tip of abdomen, and sooty-white body bearing many long and short hairs black at the base. It forms cocoons in October–November, but pupates following spring. Duration of pupal stage about 3 weeks. The cocoon is composed of scraps of ground débris—bits of dead leaves, bark, twigs, fine roots, grasses and sand—held together by strands of silk. Its interior is lined with silk. Variable in shape, but usually enlarged at one end.

Control.—Fall flooding after picking the crop; sanding; pruning.

Larger Corn Stalk Borer (*Diatræa saccharalis* Fab.).—A serious pest of Southern corn fields, originally of sugar cane. The caterpillar feeds early in the season on the "throat" of the young corn, destroying the growing tip, and later feeds as a borer in the lower stalk, where it hibernates.

Adult.—A pale brownish-yellow moth, wing expanse of 1¼ inches, fore wings darker than hind wings and bear faint markings. Wings held close to body when at rest. First brood appears April 1st to May 15th; and second brood May 15th to July 1st.

Eggs.—Flat, scale-like, circular, $^3/_{100}$ inch long, placed in rows overlapping one another (2–25) on under side of a lower leaf; creamy white at first; hatch in 7 to 10 days.

Larva.—Robust, dirty-white caterpillar 1 inch long, thickly covered with roundish dark spots each with a single bristle; head and thoracic shield brownish-yellow. Hibernating larva is unspotted. Summer duration 20 to 30 days.

Pupa.—Light yellow changing to rich mahogany-brown, $^7/_8$ inch long. Pupation in the stalk; duration 7 to 10 days. (Consult Farmers' Bulletin 634, U. S. Dept. of Agr.)

PYRAUSTIDÆ

European Corn Borer (*Pyrausta nubilalis* Hbn.).—(Consult Bull. 178, Mass. Ag. Exp. St.) A pale yellowish or reddish brown moth of about 1 inch wing expanse, introduced from Europe into Massachusetts, whose larva bores into corn stalks. Its wild food plants are barnyard grass, foxtail, pigweed, and its cultivated food plants are corn, hemp, hops and millet. A possible serious enemy of corn.

GALLERIIDÆ

Bee-moth (*Galleria mellonella* Linn.).—Known also as *Wax-worm.* Often a serious pest of bee-hives feeding on stored combs and honey, and combs occupied by bees.

Adult.—Wings ashy-grey, hind part of fore wing bronze colored, body brown, about $^5/_8$ inch long. Appears April 15th to May 15th, and again in July; lays her eggs in hives in crevices at night.

Eggs.—Elliptical, $^1/_{50}$ inch long, pearly white—hatch in 12 days.

Larva.—White; 1 inch long; feeds at night, and makes silk-lined tunnels in the comb.

Pupa.—Formed in a tough cocoon on side of hive. Hibernates.

Life-history.—In the north two broods appear—the first in May, the second in July–August, and under favorable conditions it requires only 6 weeks from egg to adult.

Control.—Keep colonies strong; keep Italian bees; use well made hives, fumigate with carbon bisulphide.

Phycitidæ

Apple Leaf Crumpler (*Mineola indigenella* Zeller).—A widely distributed moth but injurious mainly in the Central States on buds in early spring.

Adult.—Wing expanse ¾ inch; fore wings brown with patches and streaks of silver. Emerges in June.

Eggs.—Laid in midsummer and hatch in about a week.

Larva.—Three-fifth inch long when full grown; greenish brown, head and thoracic shield dark brown; young larva brown, feeding on leaves of tender shoots; construct crooked cornucopia-like cases of fras and silk. Winters as half grown larva. Injures the buds in spring. Full grown in June.

Pupa. Reddish-brown.

Control. Early spraying with arsenate of lead.

Apple Leaf Skeletonizer (*Psorosina hammondi* Riley). Sometimes injurious in Mississippi Valley especially on nursery stock, but not common northward and eastward.

Adult.—A pyralid moth, ½ inch wing expanse; fore wings glossy, purplish-brown, marked with two transverse silvery grey bands. Two broods a season. May–June and August.

Larva.—Small, ½ inch long, greenish or brownish, with 4 black shining tubercles on back behind the head, and with a broad darker stripe along each side of back. Feeding singly, or in groups, in July and Sept.-Oct., on upper surface of leaves under a silken web, skeletonizing them and giving them a rusty blighted appearance.

Pupa.—Formed among the leaves in a slight cocoon; pale brown, ¼ inch long.

Mediterranean Flour-moth (*Ephestia kuehniella* Zeller). *Adult.*—A pyralid moth, ⅞ inch wing expanse. Fore wings grey with transverse black zigzag lines; hind wings greyish white with a darker border. Both wings fringed. New generation every two months; lives about a week (Fig. 133).

Eggs.—White, elongate oval; a female depositing as many as 200 eggs singly in flour, in cracks, and about machinery; hatch in about a week.

Larva.—One-half inch long; white with fine black dots, sparsely covered with hairs. Feeds within a silken tube and spins a silken web, matting the flour together and causing much damage Full grown in 40 days.

Pupa.—Formed in a cocoon; duration 11 days; cylindrical, reddish-brown above and lighter below; a cluster of small hooklets at tip of abdomen.

Control.—Fumigate with carbon bisulphide, carbon tetrachloride or hydrocyanic acid gas; or better still raise room to high temperature of 120–130° for 6 hours.

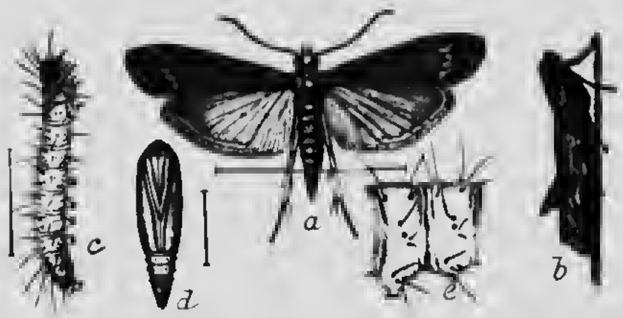

FIG. 133.—Mediterranean flour moth (*Ephestia kuehniella*): *a*, moth; *b*, same from side, resting; *c*, larva; *d*, pupa; *e*, abdominal segments of larva; *a–d*, enlarged; *e*, more enlarged. (*After Chittenden, U. S. Bur. Ent.*)

Indian Meal-moth (*Plodia interpunctella* Hbn.). *Adult.*—A pyralid moth, ¾ inch wing expanse. Fore wings with outer portion reddish-brown with fine transverse markings, the middle copper and the inner portion grey; hind wings grey. A new generation in about five weeks.

Eggs.—Small, whitish; as many as 350 eggs laid either singly or in clusters; hatch in 4 days.

Larva.—One-half inch long, whitish or pinkish, sparsely hairy.

Pupa.—Cocoon elliptical-cylindrical.

GELECHIIDÆ

Angoumois Grain Moth (*Sitotroga cerealella* Oliv.). *Adult.*—A small moth like a clothes moth; ¾ inch long; yellowish-grey. Hind wing dark grey, bordered with fine silvery fringe. Fore wing with a black dot between base and middle.

Eggs.—Milky-white to pale red; $\frac{1}{40}$ inch long; bottle-shaped; 60 eggs hatching in 4 to 10 days.

Larva.—Body white, densely covered with bristles, tapering slightly backward; head and antennæ brown. Feeds within the kernel of grain.

Pupa.—One-fifth inch long, brownish, ovate; eyes black. Formed within kernel.

Peach Twig Borer (*Anarsia lineatella* Zeller).—Destructive to grape roots, peach and other trees in California and British Columbia and troublesome also in the East.

Adult.—Dark grey; wings fringed with yellowish-grey, fore wing marked with blackish-brown spots or streaks; expands ½ inch; several broods each season.

Eggs.—Yellowish-white, elongate-oval; laid on bark of new twigs near base of leaves; duration about 10 days.

Larva.—One-half inch long; dull reddish-brown with dark-brown head; winters in silken cases beneath outer bark at base of new growth; first brood attacks young growth, second brood attacks tips and fruit, third brood the fruit.

Pupa.—Reddish-brown, ¼ inch long; duration 10-12 days.

Control.—Lime-sulphur just after buds begin to swell.

Palmer Worm (*Dichomeris ligulella* Hübner).—(Consult Bull. 187, Cornell Agr. Exp. Stn.) *Adult.*—A minute brownish-grey tineid moth, expanding ⅝ inch; fore wing sprinkled with black scales, and marked near middle with 4 black marks; hind wing fringed, dusky. July. Hibernates as adult.

Eggs.—Probably laid in May, and hatch in 2 weeks.

Larva.—Skeletonizes the leaf and eats holes in the young fruit of apple; a small caterpillar, ½ inch long; brownish-green; head light brown. Dorsal surface with two lateral and two dorsal whitish stripes. June.

Pupa.—A small brown object attached to leaf by a few silk threads, duration 10 days.

The **Lesser Bud Moth** (*Recurvaria nanella* Hbn.), a native of Europe, occurs in the eastern half of the United States and in Nova Scotia, and attacks the buds of apple trees.

Œcophoridæ

Parsnip Web Worm (*Depressaria heracliana* DeG.).—A European pest introduced about 1873, feeding on wild carrot and on wild and cultivated parsnips.

Adult.—Greyish buff or pale ochreous, marked with fuscous spots; 3/4 inch wing expanse; July–August.

Eggs.—Laid in May on leaves, stem and on sheath of inflorescence.

Larva.—Pale yellow or bluish grey, marked with black tubercles bearing bristles; head and thoracic plate bluish black; 1/2 inch long. Larvæ first web the flower-heads together and feed on the flowers and unripe seeds; they then enter the hollow stems and feed on the soft pith.

Pupa.—Formed within the hollow stem in a silken cocoon. Duration 2–3 weeks.

Control.—Spray carefully the flower-heads as soon as webbing is observed with an arsenical.

Ægeriidæ = Sesiidæ (Clear Wings)

Peach Tree Borer (*Synanthedon exitiosa* Say). (Consult Cir. 54, Div. of Ent., U. S. Dep. Ag.; Bull. 170, Cornell Ag. Exp. St.) A native insect occurring wherever peaches are grown east of the Rockies.

Adult.—A slender dark-blue clear-winged wasp-like moth. Male moth with wings transparent and bordered with steel blue; expands 1 inch. Female moth with fore wings blue and clothed with scales, hind wings transparent resembling the male; a broad orange band about middle of abdomen; expands 1 1/2 inches. July–September.

Eggs.—Minute, oval, yellowish-brown; and hexagonally sculptured; truncate at one end; deposited on the bark near surface of ground. Each female may lay from 300–400 eggs; hatch in about 10 days.

Larva.—One inch long when full grown, robust, yellowish-white, with head and first segment white. Young larva bores into sapwood at or below surface of ground, and continues feeding well into the fall, and after hibernating resumes feeding in spring, reaching full growth from July 1st–September. Exudation of gum mixed with bits of bark and excrement.

Pupa.—Cocoon-like cell elongated, made of grass and bits of bark attached with gum and threads of silk. Duration about 3 weeks. One generation each year.

Control.—Probe or cut out the caterpillar in fall or early spring; mounding up the earth about base of tree in spring; protect trunk with paper or wire covering or netting (see Ohio Bull. 329).

Lesser Peach Borer (*Synanthedon pictipes* G. and R.). This native insect occurs in most of the Northern States, in Ontario, and in some of the Southern States, and frequently does considerable injury. The larva bores as a rule above the soil level on the trunks and branches. Winter is passed as a larva, the pupa is formed in the canker or wound, and the moth emerges in June and July. About a month earlier than *S. exitiosa.* Attack by this insect usually follows mechanical and canker injuries.

Imported Currant Borer (*Synanthedon tipuliformis* Linn.). *Adult.* A small clear-winged moth, 3/4 inch expanse; body black with a yellow band about the neck, and three yellow bands across the tufted abdomen; fore wings with a margin of blackish scales and a band about one-third from the tip. June.

Eggs. Small, brown, globular; placed in axils of leaves, or in cracks of the canes.

Larva. Bores into pith of cane and makes a long black tunnel in it; when full grown 1/2 inch long, yellowish; head brown; numerous tubercles on body. Half grown by winter; hibernates at bottom of burrow; full grown in May.

Pupa.—Pupates in tunnel. Adult emerges in June.

Control. Cutting out and burning the old and affected canes in fall or early spring.

Maple Sesian (*Synanthedon acerni* Clem.). A serious borer in soft and hard maple shade trees.

Adult. A beautiful wasp-like moth, with transparent wings; body slender, yellow, banded trimmed with red, abdomen tufted. May June.

Eggs. Laid in rough places on trunk.

Larva.—A white caterpillar, 1/2 inch long; head yellow; thoracic shield light yellow. Burrows mainly just below the bark, often in developing tissue.

Pupa.—Formed at surface.

Control.—Apply soap-carbolic wash early in spring.

Squash-vine Borer (*Melittia satyriniformis* Hbn.). *Adult.*—A clear-winged moth, 1 1/4 inch wing expanse. Fore wings opaque, dark metallic olive-green. Hind wings transparent, veins and fringe black. Abdomen with orange or black and bronze marks; legs orange; tarsi black with white bands. June–July.

Eggs.—Oval, dull-red; $\frac{1}{25}$ inch long; laid singly on stems of plant; hatch in 1–2 weeks.

Larva.—Whitish, stout, 1 inch long; mature in 4 weeks; tunnels in the main stem. Hibernates in the north in a cocoon in the ground.

Pupa.—Formed in tough silken cocoons in ground, in spring in North; pupa dark brown with a horn on head and hook-like spines on abdomen; $\frac{5}{8}$ inch long.

Blackberry Crown Borer (*Bembecia marginata* Harris).—Occurs from Canada to New Mexico.

Adult.—A clear-winged moth, $1\frac{1}{4}$ inches wing expanse; fore wings with a transverse band on outer third; abdomen black, with four bright yellow cross bands; last segment of female yellow, of male black mixed with yellow. Aug.–Sept.

Eggs.—Oval, reddish-brown, $\frac{1}{16}$ inch long; laid singly on under side of leaves, about 140 by each female.

Larva.—At first white with a brownish head, hibernating under bits of bark or just below surface of ground. In spring bores into root girdling it; hibernating again in its burrow; in second spring bores upward, and becomes full grown in July.

Pupa.—Reddish brown, $\frac{3}{4}$ inch long, 25–30 days; formed in burrow near surface of cane. Empty pupal skin usually protrudes from opening when moth emerges.

Control.—Remove infested canes during spring and fall when thinning and pruning, and burn them.

Tortricina Group

Eucosmidæ

Apple Leaf Sewer (*Ancylis nubeculana* Clemens).—(Consult N. Y. State Mus. Bull. 124; Bull. 435, U. S. Dept. of Agr.) Generally distributed over the Northern States and Canada.

Adult.—A small white tortricid moth with brown markings; wing expanse $\frac{3}{4}$ inch. May–June.

Eggs.—Laid in June on under side of leaf; flat, oval-shaped, flanged, minute, yellow; hatch in 8 days.

Larva.—One-half inch long; yellowish-green; head yellow; thoracic shield darker with a black dot on each side; each body segment with pale tubercles bearing a single hair. Hibernates in folded leaves on the ground. Full grown in April. Total feeding period 5–6 months. Spends the first 3 or 4 weeks of its life under a silken covering on the under side of the leaf, afterward within a succession of folded leaves. It folds the leaf along the mid-rib and forms its nest within.

Pupa.—Dark yellowish-brown, but head, eyes and wing shields black mottled with yellow. Duration about 10 days.

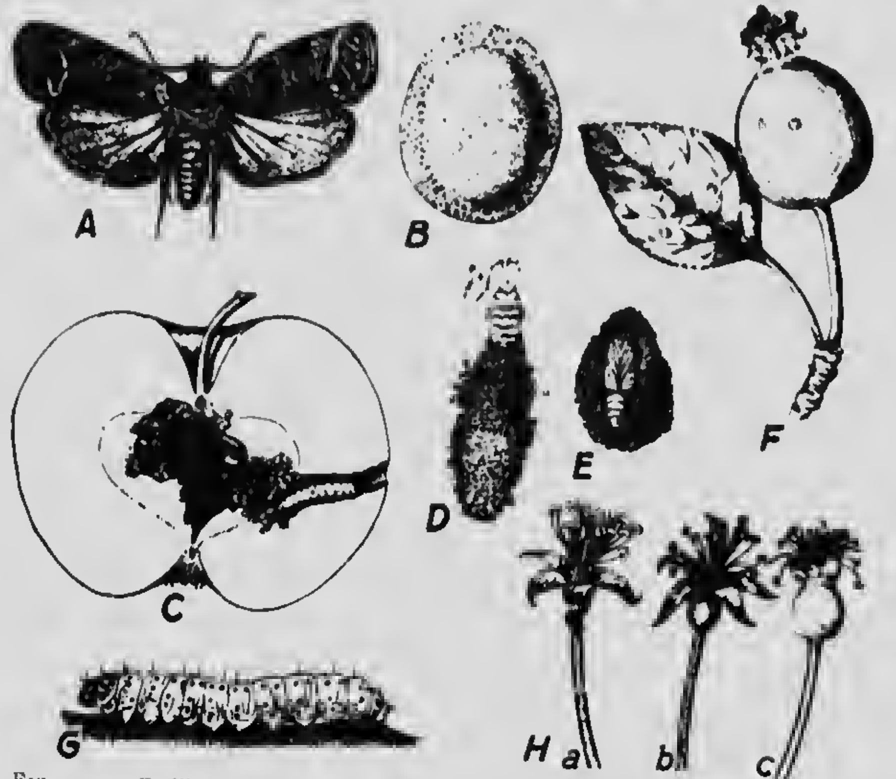

FIG. 134.—Codling moth. *A*, adult moth with wings expanded; *B*, egg much enlarged; *C*, half of worm-eaten apple; *D*, cocoon with empty pupa shell protruding; *E*, cocoon with pupa enclosed; *F*, leaf and apple showing eggs of a codling moth; *G*, caterpillar or "apple worm" enlarged; *H*, *a*, young apple just after petals fall; *b*, cup beginning to close; *c*, too late to spray. (*Montana Ag. Exp. St.*)

Codling Moth (*Carpocapsa pomonella* Linn.).—This European insect is probably the most destructive of apple insects and is practically cosmopolitan (Fig. 134).

Adult.—A small greyish-brown moth, ¾ inch expanse; fore wings crossed by alternate irregular transverse waxy bands of brown and grey, and with a large dark brown spot in the inner hind angle; hind wings light silky brownish-yellow, darker toward the fringed margin. Flies at night, about 1-2 weeks after the petals fall. Sometimes emerges as late as July 1st in northern districts.

Eggs.—A minute thin scale-like white object, 1/25 inch in diameter, at first transparent but later with a blackish streak. Each female deposits 60 to 75 eggs, mainly on the leaves 1 to 3 weeks after the blossoms fall; hatch in 5-10 days, or from 3 to 4 weeks after petals fall; 60 to 80 per cent. of larvæ enter the young fruit at the calyx end.

Larva.—At first whitish with distinct black tubercles on the body and black head; later the tubercles less distinct. When full grown larva

FIG. 135.—Larvæ and pupæ of the codling moth in the bark.

is 3/4 inch long, whitish or pinkish, head dark brown, tubercles indistinct, thoracic and anal shields light brown. Matures in 3–4 weeks. Winters as a larva within a white, tough, silken cocoon (Figs. 134 and 135).

Pupa.—Pale brown; 1/2 inch long, back armed with transverse rows of minute spines; within a cocoon; duration of spring pupæ about 21 days, of summer pupæ about 15 days (July 30th–August 14th in Maine).

Life-history.—Winters as a full grown larva within a cocoon on the trunk, under bark, etc.; about the time of apple blossoming the larva transforms to a pupa, and the moth emerges 15 to 22 days later. The eggs are laid singly on the leaves, stems, and even fruit, where they hatch in 7 to 10 days. The young larva feeds for a short time on the leaves, but finds its way to the fruit which it enters usually at the calyx end. It then makes its way to the core. When full grown in 3 to 4 weeks it makes its way out of the apple by a round hole and finds a place under bark, etc., to make its cocoon. When a second brood occurs

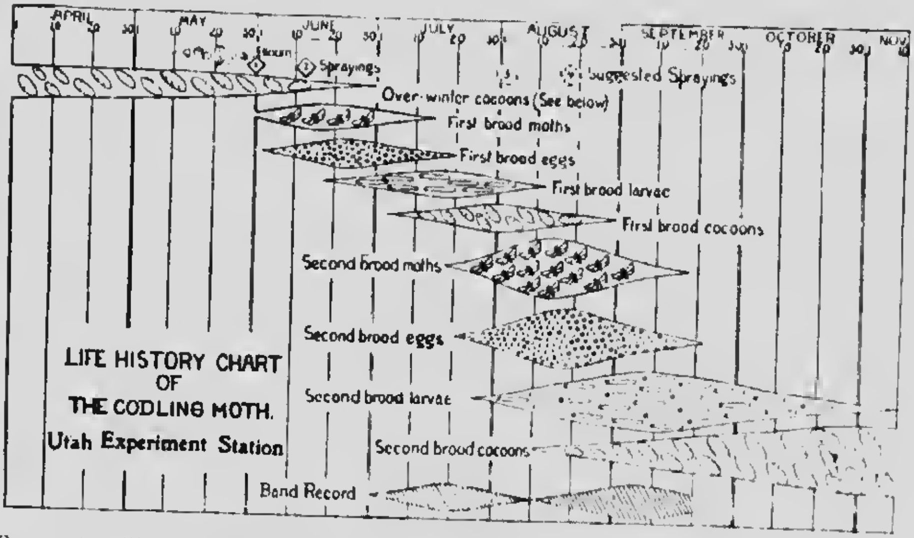

FIG. 136.—Chart showing life-history of the codling moth with suggested times of spraying and banding in Utah. (*After Hagan.*)

FIG. 137.—The proper time to spray for the codling moth.

the moths emerge throughout August, and the second brood larvæ enter the apples chiefly from the side. In Northern New England and

Codling Moth Records

Locality	Spring brood		Summer brood					Overwintering brood		Authority
	Pupation	Emergence of adults	Incubation of eggs	Larva in the fruit	Larva in cocoon	Pupation	Emergence of adults	Incubation of eggs	Larvæ in fruit	
Ottawa, Ont.		June 9					Aug. 17			Gibson, 1905
Guelph, Ont.	May 12 Apr. 22– July 3 (17 days)	June 12– July 25 May 29– July 22	June 12– July 31 (10 days)	June 21– Sept. 1 (25 days)	July 10– Sept. 9 (8 days)	July 22– Sept. 10 (18 days)	Aug. to Sept.	about 5%	emerge	Cæsar, 1909–1910
Niagara, Oot.		June 7	June 10	June 22	July 4 (7 days)	July 23 (12 days)	Aug. 1– Sept. 13			Cæsar, 1909–1910
Durham, N. H.	May 7– June 1 (16 days)	June 11– July 7	Juoe 14 (8 days)	June 22 (25–30 days)	July 10		Aug. 12–23	about 5%	emerge	Sanderson, 1907
Winthrop, Me.	May 15– July 5 (21 days)	June 4– July 26	June 7 (8 days)	June 15 (22–24 days)		July 25 (15 days)	Aug. 14– Sept. 14	1–2% (11 days)	pupate (46 days)	Siegler and Simanton, 1913–1914
North East, Pa.	May 22– Juoe 25 (22 days)	June 12– July 17	June 17– July 30 (7½ days)	June 25– Aug. 16 (26 days)	July 16 (7 days)	Aug. 23 (12 days)	Aug. 2– Sept. 6	Aug. 7– Sept. 22 (9½ days)	(40 days)	Hammar, 1909, 33–67% pupate
Ithaca, N. Y.	Apr. 27	May 7– June 22	May 28 (7 days)	(20–30 days)	2 to 3	weeks				Slingerlaod, 1896
Lincoln, Neb.			June 3	June 12			July 2			Card
Lansing, Mich.	May	May 22– June 4	June 5	June 12– June 22	July 2– July 11		July 20– July 30	July 25– Aug. 3	Aug. 13– Aug. 26	Pettit, 1903 Pettit, 1904
Douglas, Mich.	June 1– July 15			July 9– Sept. 13			July 28– Sept. 13		Sept. 1– Nov. 16 43%	Hammar, 1909

Douglas, Mich.	Apr. 15–June 3 (26 days)	June 13–July 27	June 19–July 14 (6–7 days)	June 29–Sept. 14 (25–29 days)	(7 days)	July 22–Aug. 16 (13.6 days)	July 26–Sept. 8	Aug. 3 (7½ days)	Aug. 12 Nov. 2 (34.2 days)	Hammar, 1910
Douglas, Mich.	May 9–June 26 (18½ days)	May 26–July 5	May 28–July 18 (8 days)	June 7–Aug. 7 (21¾ days)	July 6–Aug. 6 (7.2 days)	July 9–Aug. 16 (14 days)	July 8–Sept. 18	July 22– (10 days)	July 18–Oct. 3	Hammar, 1911
Pickens, W. V.				June 20					Aug. 10	Brooks and Blakeslee
Charlottesville, Va.				Apr. 28						
Ozarks, Ark.	Mar. 1–May 12 (23½ days) Full bloom apples March 31	Mar. 31–May 27	Apr. 19 (7.5–20 days)	Apr. 27 (23.8 days)	May 24–July 15 (7 days)	May 27 (10¾ days)	June 8–	June 13 (5 days)	June 21 (24.6 days)	Jenne, 1908 (3 broods)
Boise, Idaho		May 16	May 30 (11 days)	June 11 (20 days)	July 1 (22 days)		July 19	Aug. 3	Aug. 21	Simpson, 1902
Manhattan, Kans.		May 16–June 15		June 4	July 30	June 28–July 11	July 5–Aug. 21			Headlee, 1912

Canada, with the exception of Southern Ontario, there is but one brood a year, with a very small percentage transforming to make a partial second generation, but further south there are two or even three broods.

Parasites, Etc.—*Trichogramma pretiosa*, *Trombidium* on eggs; *Pimpla annulipes*, *Macrocentrus delicatus*, *Ascogaster carpocapsæ*, *Itoplectis marginatus*, *Hypostena variabilis* and *Tachinophyto* on larvæ;

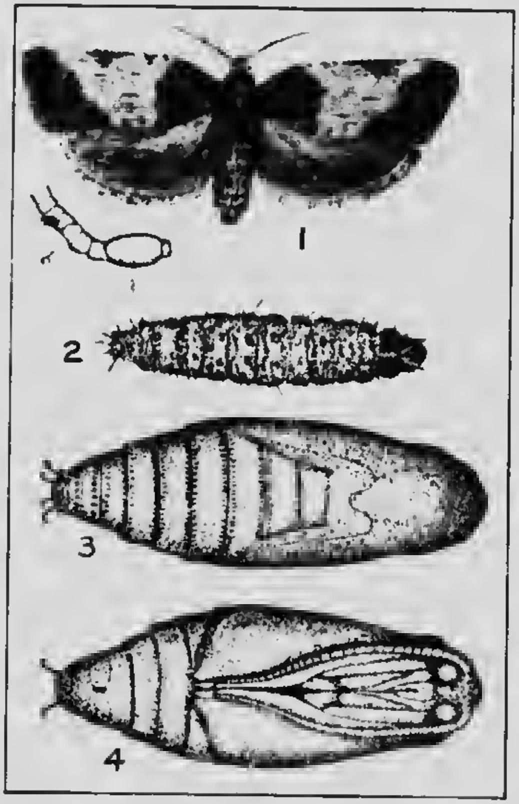

FIG. 138.—Bud moth. 1. Adult moth; 2. larva; 3. pupa (dorsal view); 4. pu (ventral view). (*After DuPorte.*)

some beetles (*Tenebroides corticalis*) two species of ants, *Lasius ni* and *Solenopsis molesta*, woodpeckers and chickadees. (Consult Bu 142, Cornell Ag. Exp. St.; Bull. 41, 80, 97, 115, 189, 252, n. s., D Ent., U. S. Dep. Ag.; Bull. 187, Ont. Dep. Agric.)

Control.—Spray with arsenical just after the blossoms fall, and ag in 3 weeks; destroy fallen fruit; band trees about July 1st; fumig fruit-houses with sulphur to kill the moth (Fig. 136 and 137).

Bud Moth (*Tmetocera ocellana* D. and S.).—(Consult Bulls. 50 and 107, Cornell).—The caterpillar of this moth sometimes does serious injury to the unfolding flower and leaf buds of the apple and other orchard trees. Introduced from Europe, and occurs from the Atlantic to the Pacific.

Adult.—A small moth with broad yellowish-white bands across ash colored fore wings; 3/5 inch expanse; lives 2–3 weeks. Emerges in June and July and deposits eggs (Fig. 138).

Eggs.—Flattened, disk-shaped, transparent; laid singly or in clusters on the under surface of the leaves; hatch in 7–10 days.

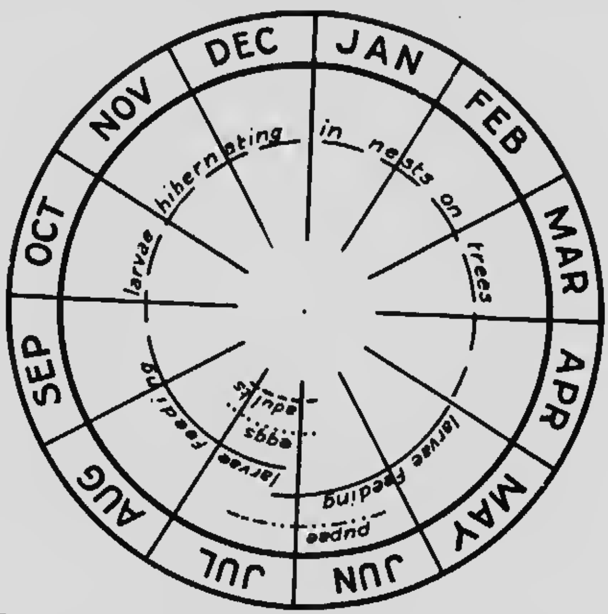

FIG. 139.—Seasonal history of the bud moth in Quebec.

Larva.—Full grown larva 1/2 inch long, chestnut brown sparsely clothed with light colored hairs borne on darker tubercles; head, legs and thoracic shield dark brown or black, smooth and shining. Full grown in June. Winters as half-grown larva in small oval silken cases on bark of twig. Emerges in spring when buds are expanding and bores into the bud and feeds for 6–7 weeks, latterly on the leaves tying them together.

Pupa.—Light brown; 1 1/4 inches long; two rows of short blunt backward pointing spines on back of abdomen; in a thin closely woven silk cocoon within a tube of tangled leaves. Pupal stage lasts about 10 days.

Life-history.—Hibernates as a half-grown larva, and matures in June; pupal stage lasts 10 days and moth emerges in July to deposit eggs. Young caterpillars feed on epidermis of under side of leaf and on green tissue within a silken tube for protection. Toward the end of September they leave their silken tubes and form oval silken cases on the smaller twigs near the buds, where they hibernate (Fig. 139).

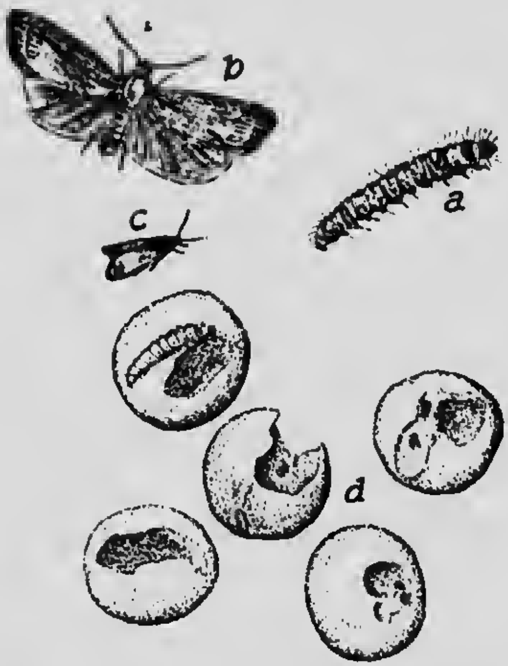

FIG. 140.—Pea moth: *a*, a full grown "worm" or caterpillar (enlarged); *b*, adult moth with wings expanded (enlarged); *c*, adult moth with wings closed; *d*, a group of five peas injured by the caterpillar of the pea moth.

Parasites.—Pimpla conquisitor, Bassus carinoides, Trichogramma pretiosa (Pentarthron minutum), Opius sp., Microdus lati ctus.

Control.—Spray with arsenate of lead when buds are expanding, when the leaves are expanded, and before and after blossoming.

Argyroploce consanguinana Walshm. is another bud pest of occasional importance.

Pea Moth (*Laspeyresia nigricana* Steph.). *Adult.*—A small grey moth ⅜ inch long. July (Fig. 140).

Eggs.—Laid in the growing pod; hatch in about 2 weeks.

Larva.—A small whitish slightly hairy caterpillar with pale brown head and thoracic shield; about 1/2 inch long when full grown, feeding within the pod on the green peas.

Pupa.—In a small oval cocoon in the ground near the surface.

Life-history.—Early in July the moths emerge from cocoons in the ground, and begin egg-laying; larvæ hatch out in about 2 weeks. About the end of July the larvæ emerge from the pods and spin small oval cocoons near the surface where they remain all winter.

Control.—Sow early varieties; sow very late; deep fall plowing of infested land; spray after blossoming with soap and Paris green and repeat in 10 days.

Lesser Apple Worm (*Laspeyresia prunivora* Walsh).—(Consult Bulls. 68, Part V, and 80, Part III, Bureau of Entomology.) The early work of this worm is similar to that of the Codling Worm, only nearer the surface on the flesh just under the skin; the young larvæ hatched in August often eat on the surface of the fruit. Two broods in the Northern States, and one in Quebec and northern Ontario.

Adult.—Ground color of fore wings brown with pale rusty-red patches, and with grey, yellowish-white and blue oblique lines; hind wings dusky grey at base, shading to black at apex. Appears in early June about the same time as the Codling Moth, and again in August.

Eggs.—Glistening white, minute, flat, oval, and covered with network of irregular ridges. Deposited on both sides of leaves, but on upper surface of fruit, stems, etc; hatch in 4–6 days.

Larva.—Full-grown larva 1/4–1/3 inch long; reddish flesh-colored above, lighter below; head brown; thoracic shield yellowish, transparent; anal plate brownish, with a brownish comet-like structure on the caudal curvature, and with an anal fork; mature in June and July. Many of the second brood larvæ enter the fruit on the side. Time in fruit 2–4 weeks; larva in cocoon before pupation 7–8 days. Larvæ of second brood winter over.

Pupa.—Pupation in spring; cocoon densely lined inside with whitish silk; pupa brown, 1/8 inch long; pupation stage about 10 days. Empty pupal case usually attached to cocoon.

Control.—As for Codling Moth but spray again in August; destroy hawthorns in vicinity.

Laspeyresia molesta Busck.—A new species found injurious to peach in District of Columbia.

Clover Seed Caterpillar (*Laspeyresia interstinctana* Clemens).—(Consult Bull. 134, Ill. Ag. Exp. St.) Injures heads of red clover, white clover and alsike.

Adult.—A silky dark brown moth, expanding about 1/3 inch; fore wings with 8 or 9 silvery markings along the front margin, and 2 curved markings on hind margin forming two crescents when wings are closed; hind wings dark brown with pale fringes. Probably three broods each season. May–June; July; Aug.–Sept.

Eggs.—At first green, later yellowish-white; slightly flattened orbicular; hatch in 5 or 6 days; laid on young clover heads, or on young stems and leaflets near the base.

Larva.—One-third inch long; dirty-white to orange; head dark brown and polished; thoracic shield yellowish or dark brown with a clear median line; dorsal tubercles arranged in 2 pairs and bearing hairs; body with several pale stiff hairs. Mature in 4 to 5 weeks.

Pupa.—Brown, 1/5 inch long. Cocoon oval, white, silken, usually with bits of flower tissue and excrement attached. Spun in a clover head or at surface of ground. Duration 14 to 30 days.

Control.—Cut and store the clover crop early in June; do not allow clover to run for more than 2 years.

Grape Berry Moth (*Polychrosis viteana* Clemens).—(Consult Bull. 223, Cornell and Bull. 293, Ohio). A serious grape pest causing wormy grapes.

Adult.—A purplish-brown tortricid moth, 1/2 inch expanse; wings leaden-blue with dark spots. Two broods.

Eggs.—Minute, whitish and scale-like, laid on stems of flower clusters or later on the green berries; hatch in 4–8 days.

Larva—Mature caterpillar, 3/8 inch long, dark green to purplish; head light brown; thoracic shield black; body covered with many faint spots bearing whitish hairs; 3 weeks.

Pupa.—Formed in a thin silk cocoon in a piece of leaf; light greenish-brown. Duration 10–14 days.

Life-history.—In June–July the moths appear and lay their eggs in the blossoms and on young grapes. The young larvæ feed on the blossoms and young berries, webbing the clusters together. They mature in 3 weeks and pupæ are formed in cocoons made from its of leaf and lined with silk. Moths emerge in 10 to 14 days in early August. The eggs of second generation are laid on the berries, and the larvæ feed on the pulp and seeds. Sometimes there is a third generation. Winter is passed in the pupal stage.

Control.—Spray with arsenate of lead, 4 lb., Bordeaux 2:3:50, and 2 lb. dissolved soft soap just after blooming; in August, when the berries are half-grown, or about 7 weeks after the grapes bloom, use 6 lb. arsenate of lead.

TORTRICIDÆ (LEAF ROLLERS)

Fruit Tree Leaf Roller (*Cacœcia argyrospila* Walker).—(Consult Bull. 311, Cornell, Bull. 250, Ont. Dep. Ag.) A serious enemy of the apple east of the Rockies. It attacks also pears and plums, and some shade and forest trees.

FIG. 141.—Egg-masses of fruit tree leaf roller. Natural size. (*After Caesar.*)

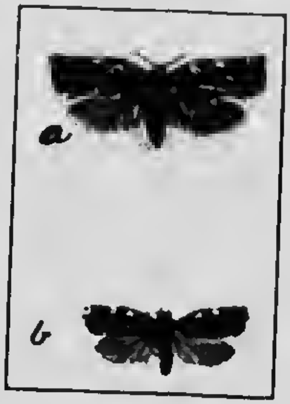

FIG. 142.—Fruit tree leaf roller: *a*, female; *b*, male. Natural size. (*After Caesar.*)

Adult.—Front wings mottled with a rusty-brown shade and silvery-white markings; hind wings light ashy brown without markings, ¾ inch wing expanse. Early July; one brood each year (Fig. 142).

Eggs.—Attached to upper side of twigs in small oval, flat, greyish varnish-covered patches, about 100 eggs in each egg-mass, in July. Hatch as buds are opening. Hibernate (Fig. 141).

Larvæ.—At first are black-headed and green; tie together the young leaves and blossoms with a silk web, later cut large irregular cavities out of young fruit. Injured fruit falls or is deformed. The leaves are also badly injured. Full grown in three weeks; about 1 inch long; light green; head, thoracic shield and legs brown to black.

Pupa.—Formed within a rolled leaf, brownish; duration about 10 days.

Control.—Spray with lime-sulphur (32°) and lead arsenate (3 lb. to 100 gal. water) about May 15, June 1 and June 15; use *Scalecide* (1 to 15) just before leaf-buds burst to destroy the eggs.

Cherry Tree Tortrix (*Cacœcia cerasivorana* Fitch).—A pest of cultivated and choke cherries.

Adult.—A tortricid moth, expanding about an inch; front wings ochreous yellow with irregular brownish spots and many transverse pale blue bands. July–August.

Eggs.—Laid in flat gluey-covered masses on twigs mainly near the ground; hibernate; hatch in spring.

Larvæ.—Lemon-yellow, ⅝ inch long; colony forms nest enclosed in silk web. Mature in July.

Pupæ.—Formed within the dirty ugly nest. Duration 10 to 14 days. Pupal skins project from nest.

Control.—Cut out and burn the nests before the moths emerge.

Oblique Banded Leaf Roller (*Cacœcia rosaceana* Harris).—Injurious to leaves and buds of orchard trees and small fruits; widely distributed.

Adult.—A yellowish-brown tortricid moth with three oblique dark bands across the fore wings; bell-shaped with wings folded; hind wings pale yellow. End of June.

Eggs.—Laid in flat patches on the bark where they winter.

Larvæ.—Roll up and fasten together the young leaves within which they feed; ¾ inch long; yellowish-green; head and thoracic shield brownish-black; two broods, one feeding in May–June, the other in July–August.

Pupa.—A dark brown object formed in its silken shelter in folded leaves.

Control.—Spray with arsenate of lead in early spring and July.

Cacœcia semiferana occurs on apple.

The **Large Aspen Tortrix** (*Cacœcia conflictana* Walk.) occurred in destructive numhers in Manitoba in 1916–17 on aspen poplars, although it is usually a rare insect. According to Criddle the adult emerges in July and lays flat masses of eggs on the leaves. The caterpillars eat holes in the leaves and spin much silk. About the end of July they go into hibernation resuming feeding in the spring and pupating in July. The natural means of control are hymenopterous parasites, birds, and sudden climatic changes in early spring.

Lesser Apple Leaf Roller (*Peronea minuta* Rob.).—Sometimes injurious in Eastern nurseries, causing the leaves to become folded and brown; also a pest of cranberry bogs.

Adult.—Small, 3/4 inch wing expanse; fore wings of summer brood bright orange colored; of the autumn brood slaty-grey. Two or three brooded. Hibernates.

Eggs.—Minute, disk-like, yellow; laid on unfolding leaves.

Larva.—Feeds within a folded leaf for 3 to 4 weeks. Broods work in May, July and September.

Pupa.—Small, 1/4 inch long, brown; head with a knob-like projection; within a silken web or cocoon. Duration 7 to 10 days.

Spruce Bud Worm (*Harmologa fumiferana* Clem.).—(Consult Bull. 210, Maine Ag. Exp. St. and Hewitt's Reports.) A destructive pest of spruces in Northern United States, Eastern Canada, Manitoba and Vancouver.

Adult. Fore wings brown, varied with short dark brown striæ; hind wings dark fuscous. July.

Eggs.—Pale green, scale-like, flat; laid in patches overlapping each other. Hatch in about 10 days.

Larva.—When young pale green with a yellowish tint; head dark brown, thoracic shield amber with two dots on posterior margin; hairs half as long as thickness of body 1/10 inch long. Just before last moult uniformly rust-red brown, and head and shield black. Full grown larva with thick stout body tapering from middle to end; head not quite so wide as body, and dark brown.

Feeds on needles of terminal shoots, often separating them at base and spinning a silk thread about them and the bud scales. Hibernates among the terminal shoots, becoming full grown the following June–July.

Pupa.—Thick; thorax swollen; pale brown color striped with brown; antennæ and legs dull tan color.

Parasites.—*Winthemia fumiferanæ*, *Pimpla inquisitor* and *P. conquisitor*, *Meteorus trachynotus*, *Conoblasta fumiferanæ*, *Mesochorus diversicolor*, *Epiurus innominatus*.

Strawberry Leaf Rollers (*Ancylis comptana* Fröhl and *Cacœcia obsoletana* Walker).—These two tortricids often do injury to strawberry leaves by rolling and destroying them. They may be controlled by spraying the plants with a solution of lead arsenate (5 lb. to 100 gal. water) within a week after the first appearance of the Moths.

HELIOZELIDÆ

Resplendent Shield Bearer (*Coptodisca splendoriferella* Clem.).—Sometimes a serious pest in orchards. Found from Maine to Minnesota.

Adult.—A small brilliantly colored golden-headed moth; fore wings leaden grey and lustrous at base, outer portion golden with silver and dark brown streaks; hind wings rich grey with long yellowish fringe; antennæ brown tinged with gold. May–June.

Eggs.—Laid on leaves.

Larva.—Small, 1/8 inch long, legless, light yellowish brown; head dark; makes an irregular dark blotch mine 1/4 inch in diameter, in the leaf. When full grown in July it cuts out a portion of the mine and forms a seed-like yellowish shield, which is attached to bark. A second brood in September, and in October the seed-like pupa case is formed.

Pupa.—In an oval, disk-shaped seed-like case. Hibernates.

PLUTELLIDÆ

Diamond-back Moth (*Plutella maculipennis* Curtis).—A widely distributed insect in U. S. and Canada. The caterpillar occasionally attacks the leaves of turnips and cabbages, and does considerable injury.

Adult.—A slender moth of a general ashy-grey color with white marks on the back, diamond-shaped when wings are closed; 3/5 inch wing expanse.

Eggs.—Minute, scale-like, greenish white or yellowish, laid singly on lower surface of leaves.

Larva.—A minute, active, dull green caterpillar with spindle-shaped body and with a wriggling motion when disturbed; mature form 3/10 inch long; feeds on the lower surface of the leaves; effects visible in July.

Pupa.—Slender, yellowish, 1/4 inch long, enclosed in a beautiful white lace-like cocoon on the surface of the leaves.

Probably two or more broods in a year in Canada; seven broods at Rocky Ford, Colorado.

Control.—Broadcast 2 to 3 cwt. ground lime per acre on appearance of moths on a dewy morning. Brush off caterpillars. Spray the caterpillars with kerosene emulsion, care being taken to get the solution on the under surfaces of the leaves.

Yponomeutidæ

Apple Fruit Miner (*Argyresthia conjugella* Zeller).—Occurs in western portions of Canada and the U. S.

Adult.—One-half inch spread; fore wings purplish-grey mottled with brown, with a row of small white and brown dots on front margins and a broad white interrupted band. May–June.

Larva.—Pinkish-white; ⅜ inch long; burrows in all directions through fruit. Also on wild crab.

Pupa.—In white cocoon with open pattern, under bark or leaves.

White Cedar Twig Borer (*Argyresthia thuiella* Pack.).—Causes a rusty appearance on white cedars along the Ottawa.

Adult.—A small pearly white moth with costal and apical brownish spots; head and thorax white; antennæ white with brown rings. Latter half of June.

Larva.—Slender, olive green, brownish at anal end; head black and shining; thoracic shield piceous; ⅛ inch long before winter sets in; hibernates in mines made in the young twigs; renews growth at end of May and is ¼ inch long when full grown in June.

Pupa.—No cocoon; formed in the mines.

The **Apple Ermine Moth** (*Yponomeuta malina*) and the **Cherry Ermine Moth** (*Yponomeuta padella* L.) are destructive orchard pests in Europe. They reached the U. S. in 1914 on nursery stock imported from France into New York State, and were discovered in shipments of ornamental shrubs and fruit seedlings into New Brunswick in 1917.

The moths are small, about ⅘ inch wing expanse; fore wings white with black dots; hind wings grey and broadly fringed. The caterpillars are about ⅗ inch long and vary in color from pale to greyish or greenish brown. The moths fly during July and August; the eggs hatch in the fall and the young larvæ hibernate beneath the scaly covering formed by the egg-masses.

HAPLOPTILIIDÆ

Case Bearers.—Two species of Case Bearers are found in apple orchards: the Cigar Case Bearer, and the Pistol Case Bearer. They do most injury to the young buds and blossoms.

1. **Cigar Case Bearer** (*Haploptilia fletcherella* Fernald).—(Consult Bull. 93, Cornell Ag. Exp. St.; Bull. 80, Pt. II, Bur. Ent., U. S. Dep.

FIG. 143.—*a*, Cigar case bearers and their work on apple leaves; *b*, pistol case bearer and its work on young fruit. Natural size. (*After Caesar.*)

Ag.) *Adult.*—A small greyish moth, expanding ½ inch; wings broadly fringed. June–July (Fig. 143, *a*).

Eggs.—Delicate light lemon-yellow; pitted; cylindrical; laid singly on under sides of leaves; hatch in 10–14 days, about July 15th.

Larvæ.—Orange colored; head black; feed as miners for 2–3 weeks within the leaf, then later in curved cases on the leaves. About

Septemher 15th they migrate to the twigs where they hibernate in their cases. About April 15th they attack the young huds, etc.; about the end of May they make their characteristic cigar-shaped cases, within which they feed on the leaves. About the end of June they change to pupæ.

Pupa.—Light brown; duration about 10 days.

2. **Pistol Case Bearer** (*Haploptilia malivorella* Riley).—(Consult Bull. 124, Cornell Agric. Exp. St.) The life history of this species is very similar to that of the Cigar Case Bearer, the habits of the larvæ differing to a slight extent (Fig. 143 *b*).

Adult.—A minute moth with brownish, heavily fringed wings and covered with white scales, head and thorax white; ahdomen whitish; all parts dotted with hrown scales. June–July.

Eggs.—Cinnamon-rufous; like inverted tea-cups with strongly ridged sides; July; egg stage lasts about a week.

Larvæ.—Never miners; make cases as soon as they begin to eat. In September they migrate to twigs where they pass the winter in small pistol-shaped cases. In spring they attack the buds and make irregular holes in the leaves. About the beginning of June they change to pupæ.

Pupa.—Pupal stage lasts about 2 weeks.

Control.—Spray with arsenate of lead in early spring just before the blossoms open and in July.

Tischeriidæ (Leaf Miners)

Apple Leaf Miner (*Tischeria malifoliella* Clemens).—The larva forms trumpet-shaped blotches under the surface of the leaves.

Adult.—A minute moth expanding 1/3 inch; wings broadly fringed. Fore wings shining dark brown with a purplish tinge; hind wings grey; head and antennæ dark brown. May.

Eggs.—Small, greenish-yellow, blister-like, elliptical, 1/50 inch long; attached to surface of leaf. Hatch in 8–10 days.

Larva.—A miner within the leaf; mature in 3 weeks. Larvæ of last generation hibernate in the fallen leaf.

Pupa.—Pupa formed within the leaf. Duration 8–10 days. Two or three generations each season.

LYONETIIDÆ (LEAF SKELETONIZERS)

Apple Leaf Bucculatrix (*Bucculatrix pomifoliella* Clemens).—(Consult Bull. 214, Cornell.) *Adult.*—A small moth, 1/4 inch expanse; fore wings whitish tinged with pale yellow and dusky brown. Hind wings broadly fringed. Appears when leaves unfold.

Eggs.—Laid in May, singly on under side of apple leaves; elliptical, 1/60 × 1/125 inch, greenish, iridescent; surface rough.

Larva.—One-half inch long, cylindrical, tapering at both ends; dark greenish-yellow, with reddish tinge on anterior segments, active. Full grown in July.

Pupa.—Cocoons dirty white, slender, 1/4 inch long; six prominent longitudinal ridges; oblong, tapering at both ends; fastened to twigs in groups, in September–October, etc. Hibernates in this stage.

Birch Leaf Skeletonizer (*Bucculatrix canadensisella* Chamb.).—A serious pest of birches, skeletonizing the leaves.

Adult.—A small brown moth, about 1/3 inch long; wings crossed with fine white bars.

Larva.—Slender, green; head brown; tapering slightly toward both ends.

It spins a small round white moulting cocoon on the twigs or leaf, and later spins a yellowish ribbed elongate cocoon within which it pupates.

Control.—By parasites and by spraying with arsenical solution.

TINEIDÆ (TINEIDS)

Clothes Moths.—Three injurious species of Clothes Moths are recognized in America:

(1) Case-making Clothes Moth, (2) Webbing or Southern Clothes Moth, and (3) Tapestry Moth.

1. **Case-making Clothes Moth** (*Tinea pellionella* L.).—So-called because the larva makes a true transportable case. (Consult Circ. 36, Bur. Ent., U. S. Dept. Agr.)

Adult.—A small tineid moth expanding 1/2 inch; head and fore wings greyish yellow; hind wings greyish white and silky. June–August.

Eggs.—Minute whitish, placed directly on food material; hatch in about 10 days.

Larva.—A dull white caterpillar with head and upper part of neck segment brown; living within its case; feeds on woolens, carpets, furs, feathers, etc.

Pupa.—Formed within larval case; duration about 3 weeks. One generation a year in the North.

2. **Webbing or Southern Clothes Moth** (*Tineola biselliella* Hum.).—Two or more broods in the North; more common than the preceding in the North.

Adult.—Fore wings pale ochreous. Female larger than the male; lays 40–50 eggs.

Eggs.—Laid among the threads of the cloth; hatch in 7 days.

Larva.—Constructs no case, but spins a silky cobwebby path wherever it goes; full grown in 10 or more weeks. Feeding all months of the year on woolens and furs. Not readily poisoned.

Pupa.—Cocoon stage 2 or more weeks.

3. **Tapestry Moth** (*Trichophaga tapetzella* L.).—Rarer and slightly larger than either of the preceding.

Adult.—Head white, basal half of fore wings black; outer half creamy and grey; hind wings pale grey. Expanse ¾ inch.

Larva.—Burrows in food materials, lining them with silk—no other protection than the galleries or burrows it makes. Feeds on carpets, horse blankets, tapestries, felting, furs, skins and woolen upholstering of carriages.

Control.—Give clothes or carpets a thorough beating, spray with benzine and expose to sun for some hours, and repeat frequently.

Cossidæ (Carpenter Moths)

Leopard Moth (*Zeuzera pyrina* Linn.).—A serious pest of shade trees in the East, especially of elm and maple. A native of the old world.

Adult.—A white moth with blue and black markings; female much larger than male and a feeble flyer. Male with pectinate antennæ; wings semi-transparent and white with black markings; thorax with six large and one small black spot.

Eggs.—Oval, salmon-colored, deposited either singly or in a large mass in crevices of bark; hatch in about 10 days.

Larva.—White or pinkish, over 2 inches long when full grown; numerous dark tubercles with hairs on body; head, thoracic and anal shields brown. Bores along the pith, eating the wood at intervals, with an occasional opening for the removal of fras, which is soon closed with a web of silk. Both large and small limbs when attacked frequently break off. Nearly full grown by second winter.

Pupa.—Formed in the burrow in May of second year.

Control.—Prune away and burn the smaller injured twigs or branches; inject carbon bisulphide into the openings of burrows and seal with wax or putty.

Carpenter or Goat Moth (*Prionoxystus robiniæ* Peck.).—The caterpillar bores into maple, oak, ash, willow and locust trees, often producing deformities.

Adult.—A large moth, wing expanse of female 3 inches, of male 2 inches. Color dark grey mottled with light grey. Front wings of male darker, and hind wings ochre yellow. June and July.

Eggs.—Oval, $\frac{1}{10}$ inch long; each female lays several hundred eggs; dirty whitish with one end black; finely reticulated, sticky. Laid in crevices about injuries. About July 1st.

Larva.—A large white caterpillar suffused with rose red, $2\frac{1}{2}$ inches long; head brownish, jaws prominent and black; thoracic shield dark brown in front; each segment with several minute brownish tubercles, each bearing a hair; spiracles brownish; a dark-colored dorsal line; under side of larva greenish white; bad smelling.

Pupa.—Brownish, $1\frac{1}{2}$ inches long; dorsal surface of abdominal segments with rows of tooth-like processes. Formed in a loose cocoon at ends of galleries. Duration 2 weeks or longer.

The life-cycle is believed to occupy 3 years.

Control.—Trim away deformities; inject CS_2 into borings and close holes with putty or cement.

NEPTICULIDÆ

Serpentine Leaf Miner (*Nepticula pomivorella* Pack.). *Adult.*—A minute, purplish-black tineid moth; head tufted; reddish-yellow; June.

Larvæ.—Small, dark-green caterpillars $\frac{1}{10}$ inch long. Make a narrow serpentine mine beneath surface of leaves of apple and pear, first half of mine broader than second half. In late autumn the larvæ find their way to twigs by means of silken threads, where they spin small oval brown cocoons $\frac{1}{8}$ inch long resembling Lecanium scales. In May they transform to pupæ.

Pupa.—Bright green.

ORDER DIPTERA (FLIES)

Sub-orders and Groups

A. Adults without a frontal lunule; pupa and adult escape from larval skin through a T-shaped opening at anterior end.—Sub-order *Orthorrhapha.*

B. Antennæ long, with more than five joints.—*Nematocera Group* (Fig. 144, *A*).

BB. Antennæ short, usually 3-jointed; first anal cell narrowed.—*Brachycera Group.* (Fig. 144)

AA. Adults with a frontal lunule; pupa and adult escape from larval skin through a circular opening at anterior end.—Sub-order *Cyclorrhapha.*

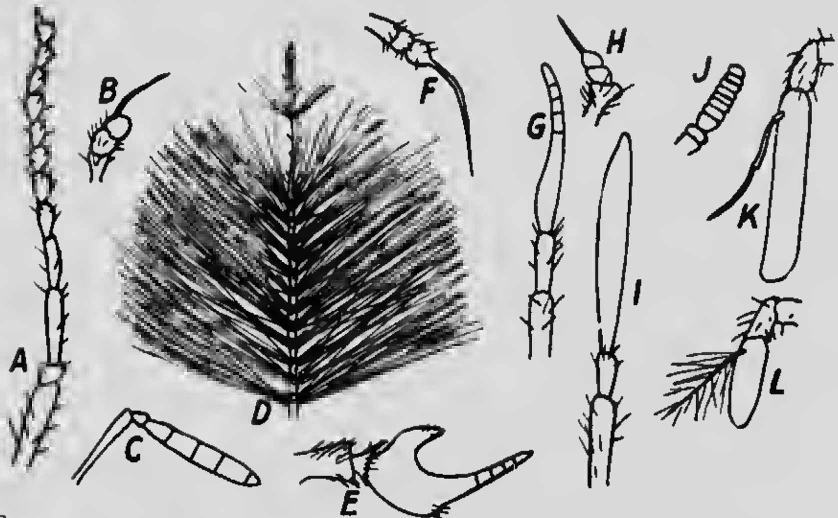

FIG. 144.—Antennæ of common *Diptera.* *A. Xiphuria* (Tipulidæ). *B. Sargus* (Stratiomyiidæ). *C. Stratiomyia* (Stratiomyiidæ). *D. Culex* (Culicidæ). *E. Tabanus* (Tabanidæ). *F. Leptis* (Leptidæ). *G. Chrysops* (Tabanidæ). *H. Anthrax* (Bombyliidæ). *I. Dasyllis* (Asilidæ). *J. Bibio* (Bibionidæ). *K. Gonia* (Tachinidæ). *L. Pollenia* (Muscidæ).

Chief Families of the Nematocerous Orthorrhapha:

A. A distinct V-shaped suture on back of thorax; legs long and slender. —*Tipulidæ* (Crane Flies) p. 242.

AA. No V-shaped suture on thorax.

B. Veins and margin of wings fringed with scales.—*Culicidæ* (Mosquitoes), p. 243.

BB. Margin of wings not fringed with scales.

C. Anal veins wanting; Media vein wanting; tibiæ without spurs. —*Cecidomyiidæ* (Gall Gnats), p. 245.

CC. Anal veins present and Media vein at least represented by a fold. Costal vein does not extend beyond tip of wing.

D. Abdomen slender; wings narrow; antennæ pulmose in the males; wing veins strong near costal margin.—*Chironomidæ* (Midges), p. 252.

DD. Abdomen short and thick; wings broad; antennæ short and non-plumose.—*Simuliidæ* (Black Flies), p. 251.

Chief Families of the Brachycerous Orthorrhapha (Figs. 146–149);

A. Antennæ of five or more segments, those beyond the second more or less united. (Fig. 144, *E*).

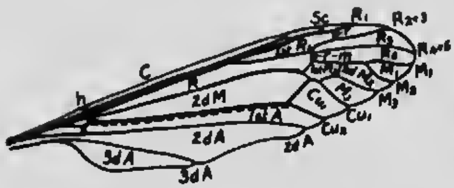

FIG. 145.—Venation of a tipulid (*Tipula*). (*After Comstock.*)

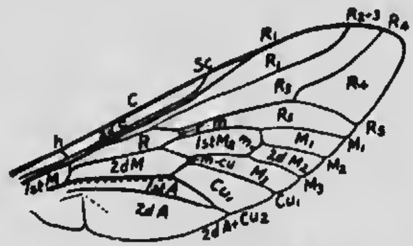

FIG. 146.—Venation of a tabanid (*Tabanus*). (*After Comstock.*)

B. Alulets large, third joint of antennæ without a style or bristle.—*Tabanidæ* (Horse Flies), p. 252.

BB. Alulets small; brancbes of Radius crowded togetber near the costal margin.—*Stratiomyiidæ* (Soldier Flies).

AA. Antennæ of four or five segments but the third joint not ringed.

B. Antennæ long, clavate, 4-jointed; brancbes of Radius curving toward costal margin.—*Midaidæ* (Midas Flies).

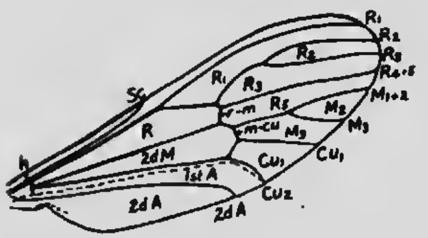

FIG. 147.—Venation of *Dixa*. (*After Comstock.*)

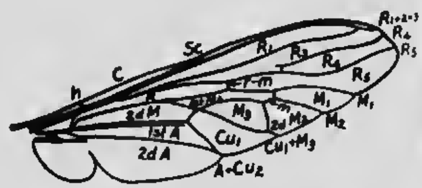

FIG. 148.—Venation of an asilid (*Erax*). (*After Comstock.*)

AAA. Antennæ of three segments; Radius four-branched.

B. Vertex of head hollowed out between the eyes; palpi present.—*Asilidæ* (Robber Flies).

BB. Vertex of head not hollowed out; alulets small; beak prominent.—*Bombyliidæ* (Bee Flies).

Chief Families of the Cyclorrhapha (Figs. 151 and 152):

A. Adults non-parasitic; maxillæ covered by upper lip; Radius 3-branched.

B. With a spurious longitudinal vein between Radius and Media; front convex between the antennæ.—*Syrphidæ* (Flower Flies), p. 250.

BB. With rudimentary mouth-parts; palpi wanting; antennæ with dorsal arista.—*Œstridæ* (Bot Flies), p. 254.

BBB. With well developed mouth-parts; palpi present; head with a suture above the antennæ.—Superfamily *Muscoidea.*

C. Alulets small; eyes of males not contiguous; thorax without complete transverse suture.—(*Acalyptrate Muscids.*)

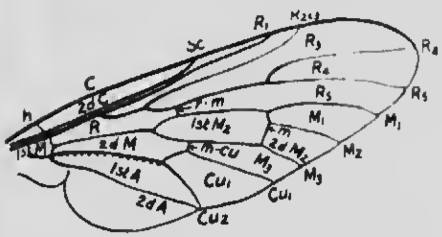

FIG. 149.—Venation of a leptid (*Leptis*). (*After Comstock.*)

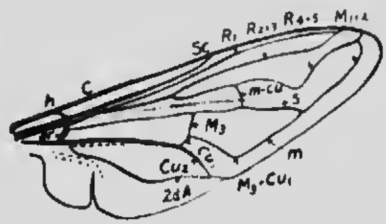

FIG. 150.—Venation of a syrphid (*Eristalis*). (*After Comstock.*)

D. Subcostal or auxiliary vein ending in the costa and distinctly separate from Radius I, or first longitudinal, which usually ends near the middle of the wing. Anal cell present.

E. Oral vibrissæ present; front bristly; R. nearly half the wing length; cross veins not close together; yellow or brown.—*Scatophagidæ* (Dung Flies).

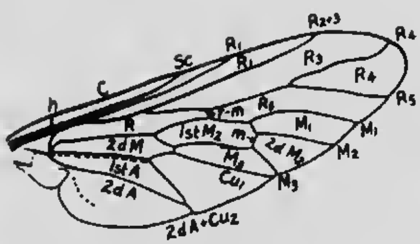

FIG. 151.—Venation of *Thereva*. (*After Comstock.*)

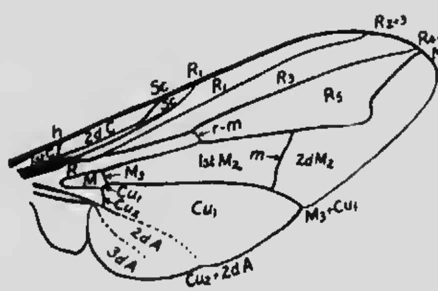

FIG. 152.—Venation of a muscid (*Musca*). (*After Comstock.*)

EE. Oral vibrissæ absent; eyes large; first posterior cell (R_5) closed or narrowed in the margin; proboscis and ovipositor greatly lengthened.—*Conopidæ* (Thick-headed Flies).

DD. Subcostal vein absent, vestigial or incomplete; Radius I usually ending in costa before middle of wing.

E. Discal and basal cells united; Anal cell absent.—*Oscinidæ* (Grass Stem Flies), p. 260.

EE. Discal and second basal cells separated; anal cell complete.
F. Oral vibrissæ present.
G. Arista long plumose or pectinate above.—*Drosophilidæ* (Pomace Flies), p. 260.
GG. Arista bare, pubescent or short plumose; front bristly as far as middle, usually light colored.—*Agromyzidæ* (Leaf-miner Flies), p. 262.
FF. Oral vibrissæ absent.
G. Subcostal vein abruptly bent forward before the tip of Radius I; anal cell angular. Wings pictured.—*Trypetidæ* (Fruit Flies), p. 264.
GG. Subcostal vein more or less fused witb Radius I; all three basal cells distinct, anal cell not produced; antennæ more or less elongate and decumbent.—*Psilidæ* (Rust Flies), p. 262.
CC. Alulets or calypters large; eyes of males often contiguous; thorax with complete transverse suture.—*Calyptrate Muscids.*
D. Cell Radius 5 closed or more or less narrowed at the margin of the wing.
E. Antennal bristle bare.—*Tachinidæ* (Tachina-flies), p. 278.
EE. Antennal bristle bare near tip.—*Sarcophagidæ* (Flesh-flies).
EEE. Antennal bristle pubescent or plumose to the tip.
F. Dorsum of abdomen bristly; legs elongate.—*Dexiidæ.*
FF. Dorsum of abdomen not bristly except at tip.—*Muscidæ* (House-flies), p. 268.
DD. Cell Radius 5 widely open.—*Anthomyiidæ* (Root-maggot flies), p. 273.
AA. Adults parasitic; upper lip enveloped by maxillæ as by a sheath.—*Pupipara* (Sheep-ticks, etc.), p. 279.

(Consult Tech. Series, No. 22, Bur. Ent., U. S. Dep. Ag. on "The Structure of Certain Dipterous Larvæ, etc.," by N. Banks, 1912)

TIPULIDÆ (CRANE FLIES)

Meadow Maggots (*Crane Flies or Leather Jackets*). *Adult.*—Large mosquito-like flies with very long thin legs, long slender bodies, narrow wings and thread-like antennæ. A transverse V-shaped suture on the back of middle portion of the thorax (Figs. 145 and 153).

Larva.—When full grown about an inch long, dirty brown, and footless; of a tough leathery texture; cylindrical; tapering in front and blunt behind.

Pupa.—No puparium; occupying small cells near the surface of the ground in a vertical position.

Broods.—There are two broods each season. Larvæ winter over and change to pupæ in late May. Adults soon appear and deposit eggs from which hatch the maggots. These change to pupæ and adults in September when eggs are laid for a fall brood. The maggots hatching from these eggs winter over.

Control.—Early fall plowing, draining, and rotation of crops.

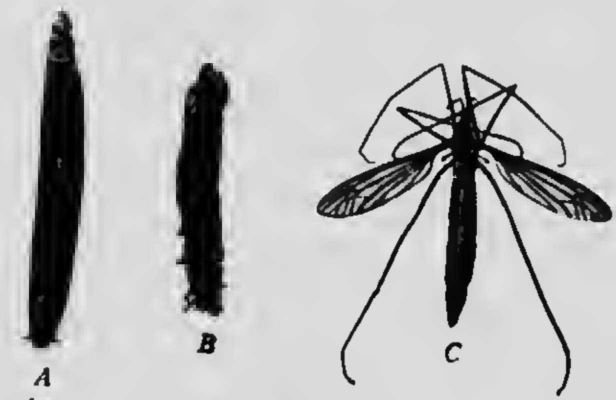

FIG. 153.—Tipula. *A*, Larva; *B*, cast pupal skin; *C*, imago. Slightly reduced. (*After Folsom.*)

CULICIDÆ (MOSQUITOES)

Key to The Common Genera

A. Palpi in both sexes at least almost as long as the proboscis.—*Anopheles.*
AA. Palpi in both sexes less than one-half as long as the proboscis.—*Aedes.*
AAA. Palpi in the male at least nearly as long as the proboscis; in the female less than one-half as long.—*Culex.*

This family includes several important economic genera, comprising many hundreds of species. The more important of these are *Culex pipiens*, *C. pungens*, *Anopheles maculipennis*, and *Stegomyia fasciata* = *Aedes calopus.*

House Mosquito (*Culex pipiens* Linn.). *Adult.*—A slender-bodied, delicate fly with gauzy wings, the veins bearing minute scales; deep yellowish to dark brown; legs and beaks not banded; abdomen with narrow whitish bands at the base of each segment. Hibernates as adult (Fig. 154).

Eggs.—Laid at night or early morning on the surface of standing water in masses of 50 to 400. Hatch in about 24 hours.

Larva.—Large head with a pair of mouth-brushes and a tube at opposite end of body for breathing, not over four times as long as broad: antennæ of moderate length with a branch about the middle, bearing a tuft of hairs. Full grown in a week; dirty white, or yellowish.

Pupa.—A hunched object, floating just below the surface of the water. Duration 1 to 3 days.

Number of broods limited only by conditions of temperature and moisture.

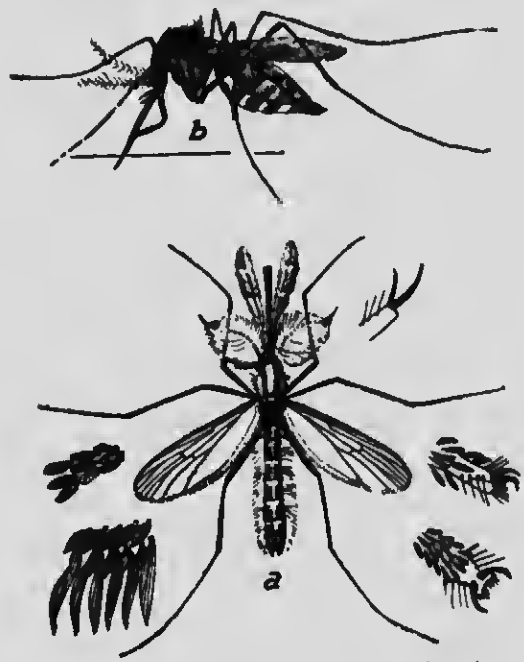

FIG. 154.—The common house mosquito: *a*, male; *b*, female. (*U. S. Bur. Ent*

Malarial Mosquito (*Anopheles maculipennis* Meign.). *Adult.*—Differs from *Culex* in being much larger, more slender and with larger legs; wings longer, and more or less spotted with brown or black, and carried flat on the back when not in use; palpi or mouth-feelers as long as the beak in both sexes. (In *Culex* the palpi are short in the female.) A common malaria carrier.

Eggs.—Laid singly on surface of water; hatch in 24 to 48 hours.

Larva.—Larva lies flat on surface; tube very short; at first black or grey, usually banded with white; later color harmonizes with surroundings. Full grown in 7 to 10 days.

Pupa.—Like that of *Culex* but with shorter, more trumpet-shaped breathing tubes; duration about 2 days.

Other species of Anopheles are: *A. punctipennis* and *A. crucians.*

The Salt Marsh Mosquito (*Aedes sollicitans* Walk.), the Swamp Mosquito (*A. sylvestris* Theo.) and the Irritating Mosquito (*Mansonia perturbans* Walk.) are commonly met with and are annoying.

On the western prairies the genus *Aedes* is most abundant. The eggs are laid in late summer and hatch out the following spring in the water of the melting snow. There is but one brood a year. The most common species are *A. spenceri* Theob., *A. fletcheri* Coq., and *A. curriei* Coq.

CECIDOMYIIDÆ (GALL MIDGES)

Hessian Fly (*Mayetiola destructor* Say). (Consult Ent. Bull. 11, Dep. Ag, Ottawa; Bull. 116, Ont. Dep. Ag.; Cornell Bull. 194; and

FIG. 155.—The hessian fly (*Mayetiola destructor*): 1, adult female; 2, mature larva; 3. puparium or "flax-seed"; 4. seed of flax. Enlarg . about 8 times. (*After Criddle, Ent. Bul. 11, Dep. Agric. Can.*)

bulletins by Webster and Marlatt.) An introduced pest from Europe and one of the most serious enemies of growing wheat. Distributed over the wheat regions of United States and Canada. Attacks also oats, barley, rye, *Agropyron* spp., *Bromus*, *Elymus* and *Agrostis* (Fig. 155).

Adult.—A small dusky 2-winged fly, $\frac{1}{8}$ inch long, about half the size of a common mosquito; the female with a dull reddish tinge and larger than the male; legs long; wings smoky-black, covered with fine black hairs and obscurely fringed.

Eggs.—Spindle-shaped, reddish and 1 to 50 inches long; hatch in 4 to 12 days.

Larva.—A footless maggot, clear-white except for a greenish stripe down the middle; last stage of larva passed in "flax-seed" covering, and having a peculiar "breast-bone," a horny forked structure.

Pupa.—Pupa case deep rich brown, like small "flax-seeds;" pupa rosy colored and with a pointed beak.

Broods.—Two generations in fall wheat regions, and one in spring wheat regions. Criddle reports a supplementary summer brood in Manitoba, the adults appearing from late June up to middle of August. Pupæ develop which winter over. Webster (640) is of the opinion that the Hessian Fly is two-brooded even in spring wheat sections. Female lays a few, to 50 or more, eggs on upper surface of leaf about last week in August, first week in September or later, according to latitude, altitude and longitude; maggots hatch in about 4 days and move down the leaf to the stem where they embed themselves within the leaf-sheath. In about 3 weeks they change to "flax-seed" but remain as larvæ until the following May, when they change to pupæ. The flies emerge a few days later to lay their eggs for a new spring brood on the leaves of spring cereals. The maggot stage lasts until the third week in June, and the "flax-seed" stage until the third week in August or later, when the flies emerge (Fig. 156).

Parasitized by *Polygnotus*, *Merisus*, *Eupelmus*, *Tetrastichus*, and *Entedon*, all Chalcids.

Control.—Late seeding in fall on well prepared seed-bed; trap-strips; destruction of all volunteer wheat; destruction of "flax-seeds" at threshing; co-operation. Plowing the wheat stubble deeply immediately after harvest. (See Part IV).

Clover Seed Midge (*Dasyneura leguminicola* Lintner).—(Consult Bull. 1 34, Ill. Agr. Exp. Stn.). A widely distributed pest of red and white clover fields. Alsike, mammoth and alfalfa are uninjured.

Adult.—A minute 2-winged fly, 1/12 inch long, with red abdomen and long reddish-brown legs and antennæ; head and thorax black; wings transparent with dusky hairs. April–May and July–August.

Eggs.—Very minute, orange, smooth and transparent. Laid in green flower-heads, hatch in about a week.

Larva.—A footless orange maggot, 1/10 inch long, and with nine pairs of respiratory tubercles and a sternal spatula.

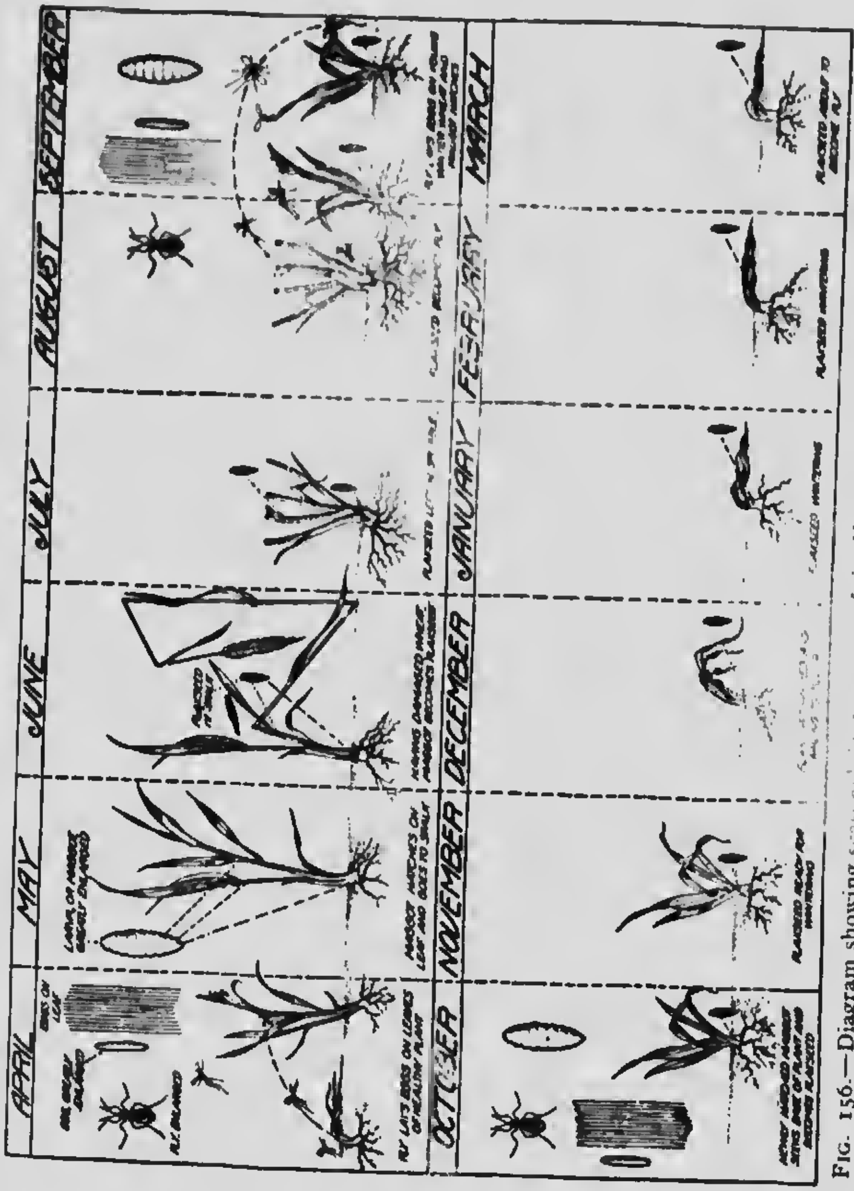

FIG. 156.—Diagram showing seasonal history of the Hessian fly. (After Walton, Bur. Ent. U. S.)

Pupa.—Cocoon oval, 1/12 inch long, made of silk threads; pupa pale orange; eyes brown; two short tubercles on front of head.

Life-history.—There are two broods each year. Eggs are laid in May in the forming flower-heads. At the end of June and early July (June 20 to July 8 in Illinois) the maggots mature and drop to the ground to pupate. The adult flies emerge when the second crop of clover comes into bloom (July 15–Sept. 1) and lay their eggs among the blossoms. The maggots leave the ripe heads in autumn, and pass the winter in the ground. In May the adult flies emerge to lay their eggs. Affected florets do not expand their petals and remain fresh and pink until after maggot leaves the bud, eventually fading and withering without opening.

Natural Enemies.—*Tetrastichus, Anopedius, Triphleps.*

Control.—Cutting or pasturing clover before the 20th of June.

Clover Leaf Midge (*Dasyneura trifolii* Low.).—A serious pest of white clover, affected leaves folding upon a midrib with maggots enclosed.

Adult. Smaller than the Clover Seed Midge, but very similar in color and markings. Abdomen is darker, due to the large dorsal bands of black scales.

Eggs.—Colorless soon becoming orange, cylindrical and slightly curved; very minute; several eggs usually placed together between folded leaflets near the ground.

Larva.—White at first, orange later; 1/25 inch long. Leaflet remains folded in half along the midrib.

Pupa.—Cocoon oval and about 1/15 inch long; pupa orange, with blackish eyes and a darker median ventral stripe.

Life-history.—Probably four broods, each requiring about a month.

Control.—Pasturing or cutting frequently.

Rose Midge (*Dasyneura rhodophaga*).—An introduced pest of greenhouse roses and often does serious injury. It is known also as the Reinberg Fly by florists. The larvæ "feed inside the flower and leaf buds, preventing and distorting their growth, and soon causing them to turn brown and then to blacken and die." Several generations.

Adult. A 2-winged fly with long delicate legs; 1/20 inch long.

Eggs. Cylindrical; laid at bases of the flower and leaf buds. Hatch in 2 days.

Larva.—One-twelfth inch long and legless; mature in one week;

drops to the ground, burrows beneath the surface and spins a silken cocoon.

Pupa.—Pupa within cocoon; duration one week. Hibernates.

Control.—Frequent fumigation with tobacco to kill the adults.

Grape Blossom Midge (*Contarinia johnsoni* Sling.).—A pest in the Chatauqua grape belt of New York.

Adult.—A midge 1/16 inch long, with yellowish body and straw colored legs. End of May.

Eggs.—Minute, grey, elongate, curved; about 25 laid in each bud which becomes swollen and yellowish and reddish when maggots begin to feed.

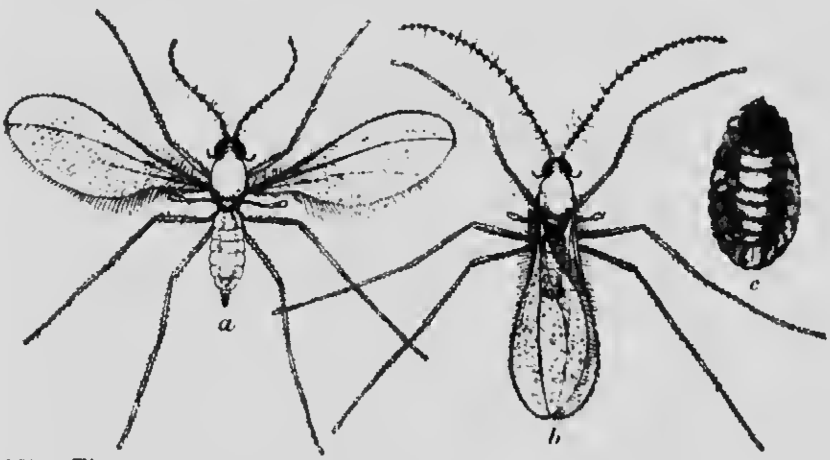

Fig. 157.—The wheat midge (*Diplosis tritici*): *a*, female fly; *b*, male fly; *c*, larva. Enlarged. (*After Marlatt, U. S. Bur. Ent.*)

Larva.—Whitish to yellow-orange; 1/12 inch long; passes the winter in a small oval silk-lined earthen cocoon about 6 inches below surface of ground.

Pupa.—Formed at end of April.

Control.—Spray with Black Leaf 40 just as buds of early varieties begin to open, and again a week later.

Wheat Midge (*Diplosis = Contarinia, tritici* Kirby).—A European pest, destructive to wheat, introduced probably by way of the Province of Quebec (Fig. 157).

Adult.—A minute orange-yellow fly 1/10 inch long, smoky-tinged on the back above the wings. June–August.

Eggs.—Minute, cylindrical, pale red; laid singly or in clusters in crevices of wheat heads in June and hatch in about a week.

Larva.—A short oval orange-yellow maggot, 1/12 inch long; as a rule it leaves the head after feeding for 3 or 4 weeks and goes into the ground where it remains in a mustard-seed-like cocoon.

Pupa.—Pupa case small, about the size of a mustard seed, in the ground; formed in June shortly before the emergence of the adult.

Broods.—At the end of June the adult flies lay their eggs in the crevices of the wheat head; the eggs hatch in about a week, and the larvæ feed on the milky juices of the developing kernels for about 3 or 4 weeks; some descend to the ground where they form minute puparia which remain until the following June; others remain and are carried out in the screenings at threshing time. Only one brood a year.

Control.—Burn or feed screenings; plow stubble deeply after harvest; rotation of crops; sow wheat early. Dry weather unfavorable and moist weather favorable for the development of the insect.

SYRPHIDÆ (SYRPHIDS OR FLOWER FLIES)

The Syrphids or Flower Flies are most valuable enemies of many injurious forms of insects. They are usually bright colored and they feed upon the pollen and nectar of flowers. Their maggots are often found in colonies of plant-lice, upon which they feed. Some syrphid larvæ live in filth and are known as "rat-tailed maggots."

C. L. Metcalf ("Syrphidæ of Maine," Bull. 253) notes five types of Syrphid larvæ:

1. The *Aphidophagous* type with body narrowed anteriorly, subcylindrical and flattened ventrally (*Allograpta* and *Syrphus*);
2. The *boring type*, with body nearly cylindrical (*Merodon*).
3. The *short-tailed filth-inhabiting* type (*Syritta*).
4. The *rat-tailed filth-inhabiting* type (*Eristalis*).
5. The *Microdon type*, with body hemispherical in form.

Aphid-feeding species are *Syrphus americanus*, *Allograpta obliqua*, *Sphæropnoria cylindrica*, *Didea fasciata*, *S. stanthostomus* (Fig. 150).

The following genera live, in larval condition, in decaying vegetable or animal matter: *Eristalis*, *Platychirius*, *Orthoneura*, *Criorhina*, *Syritta*. (Consult "Syrphidæ of Ohio" and "Syrphidæ of Maine" by Metcalf.)

A few forms are injurious in the larval stage. The *Corn-feeding Syrphid Fly* (*Mesogramma politus*) feeds on pollen grains and at the axils of the leaves of corn, producing a wilting and browning of the lower leaves. It has been reported from several states.

Merodon equestris and *Eumerus strigatus* are pests of the onion, narcissus and amaryllis. The larvæ burrow into the bulbs.

Certain species, *Eristalis* spp., produce myiasis in man and some of the domestic animals. The eggs are laid, singly or in masses, on or near the food upon which the larvæ feed, the exact location and number depending upon the habits of the species. "They are chalk-white, shiny, elongate-ovate or subcylindrical with rounded ends, 1/25 inch long and 1/75 inch wide. Under the microscope each egg may be seen to be delicately and beautifully sculptured "

The larvæ vary also according to the habits of the species. They are "headless, footless, blind creeping maggots." They breathe by spiracles near the fore and hind ends of the body. They are 1/2 inch long when full grown.

Narcissus Fly (*Merodon equestris* F.).—A serious pest of narcissus and daffodil bulbs in British Columbia.

Adult.—A fly resembling the house-fly; March–September, most common in May, when it begins to breed.

Eggs.—Laid in the centre of crown at surface of the ground.

Larva.—Found in centre of bulb which is often destroyed. Leaves bulb in February and pupates 1/2 inch below the surface of the ground. Three-fourth to 1 inch length.

SIMULIIDÆ (BLACK FLIES, BUFFALO GNATS, TURKEY GNATS)

Several species of *Simulium* are very troublesome pests in our northern woods, occurring in immense numbers in the vicinity of running water. The females have well developed piercing and sucking mouth-parts and their punctures are painful, with effusion of blood. Black Flies have stout black humped bodies and are small, not more than 1/6 inch in length. They are most numerous in early spring and are considered by travellers worse pests than mosquitoes. They are active in the day-time, especially in bright sunshine.

The eggs are laid in patches on stones or other objects under running water. The larvæ are aquatic and gregarious; they are long and slender, more or less cylindrical in shape, provided at the posterior end with a disk-like sucker fringed with hooks wherewith they attach themselves to the rocks. At the anterior end are two fan-shaped organs for securing food, and behind these on the ventral side is another sucker. The pupa is formed within a boot-shaped cocoon, and is provided with two tufts of respiratory filaments on the thorax.

As a rule there are two or three broods in a season. The most abundant species in the northeast are *Simulium venustum*, *S. vittatum* and *S. hirtipes*, on the western Canadian prairies *S. similis* Mall. *S. pictipes* is innoxious.

Control.—Smudges and fumes of pyrethrum as repellents; destruction of larvæ by phinotas oil.

CHIRONOMIDÆ (MIDGES)

(*Ceratopogon* spp. (*Punkies*).—These minute flies, known as "punkies," "no-see-ums" and "sand-flies," are also very troublesome pests in northern woods. They are blood-suckers and attack any exposed part of the body. The larvæ are thread-like and live in water or in moist places. Dr. Riley states that the following species bite: *Culicoides guttipennis*, the most common form; *C. cinctus*, *C. sanguisu*[illegible], *C. stellifer*, *C. variipennis*, and *C. unicolor*. Not much, however is known regarding the habits of the different species.

TABANIDÆ (HORSE FLIES, BULLDOGS, CLEGS, BREEZE FLIES)

Common Genera:

A. Hind tibiæ with spurs at tip; third segment of the antennæ with five ri[illegible] second segment but little shorter than the first; wings with dark markin[illegible] —*Chrysops*.

AA. Hind tibiæ without spurs; third segment of the antennæ with a w[illegible] developed process.—*Tabanus*.

(Consult "Tabanidæ of Ohio" by H[illegible]ne)

Black Horse Fly (*Tabanus atratus* Fab.). *Adult.* A large fly with broad and slightly flattened body and large and depressed head; l[illegible] segment of antennæ annulate and without stylet; females with powerful piercing mouth-parts (see p. 8); may transmit disease (Fig. 158).

Eggs.—Elongate, spindle-shaped; laid in large black masses of [illegible] on the leaves of grasses, sedges and other plants in marshy grou[illegible] Hatch in less than 9 days.

Larva.—Lives in the soil, mud or water; cylindrical, tapering, 2 inches long when full grown; yellowish-white with wide dark brown bands at union of each two segments; prothorax with 2 lateral grooves on each side; mesothorax with 4 longitudinal grooves on each side; metathorax and abdominal segments like mesothorax. Carnivorous. Hibernates (Fig. 159).

Pupa.—The pupal stage lasts only a few days; $1\frac{1}{4}$ inches long; brownish yellow; lives beneath surface of the soil.

Fig. 158. The black gad fly. Enlarged. (*After Garman.*)

Fig. 159. The larva or grub of the black gad fly. (*After Garman.*)

Treatment.—Protect work horses with fly-nets, smearing ears, with a repellent solution composed of pine tar 1 gal., fish oil or crude carbolic acid 1 qt., powdered sulphur, [illegible].

On the western plains horse flies are very troublesome pests. The most common forms are *T. septentrionalis* Loew, *T. [illegible] illotus* O. S., *T. [illegible]dus* Bigot, *Chrysops mœrens* Walk., and *C. fulvaster* O. S.

ŒSTRIDÆ (BOT FLIES)

Common Genera and Species:

A. Costal vein ends at tip of R_{4+5}, M_{1+2} is straight not reaching the margin, and cell R_5 wide open; squamæ small, arista bare; ovipositor elongate.—*Gastrophilus* (Fig. 160).

B. Wings with spots and smoky median cross band.—*G. intestinalis.*

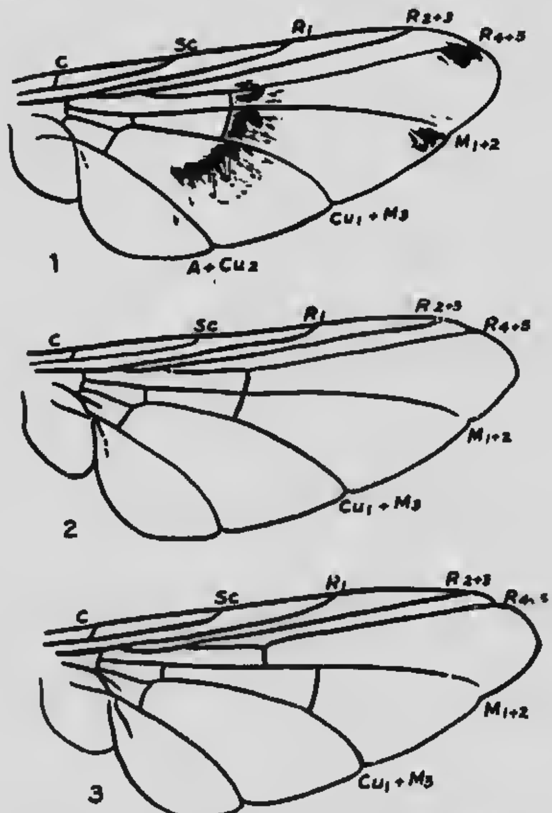

FIG. 160.—Venation of wings of horse bot flies (*Gastrophilus*). 1, *G. intestinalis;* 2, *G. nasalis;* 3, *G. hæmorrhoidalis.*

BB. Wings without spots.

C. Posterior cross-veins (M–Cu) beyond the anterior cross-vein (r–m); legs blackish brown.—*G. hæmorrhoidalis.*

CC. Posterior cross-vein opposite and nearer than the anterior cross-vein.—*G. nasalis.*

AA. Costal vein ends at tip of M_{1+2}; M_{1+2} with a bend; cell R_5 much narrowed or closed.

B. Facial grooves approximated below; cell R_5 closed and petiolate.—*Œstrus.*

BB. Facial grooves far apart; squamæ large, ovipositor elongate.—*Hypoderma* (Fig. 161).

C. Prothoracic band of yellow hairs, mesothoracic band of brownish black hairs; media 3 sinuate; legs black with black hair; tips of hind tibiæ and tarsi yellowish-brown.—*H. bovis.*

CC. Thoracic band of hairs brownish; media 3 rounded; tibiæ and tarsi yellow; femora black.—*H. lineatum.*

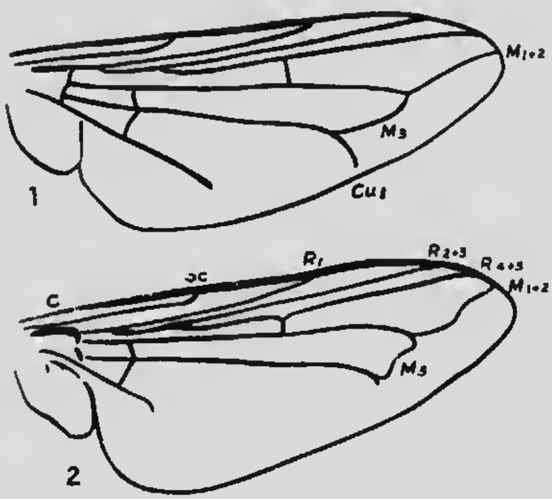

FIG. 161.—Venation of wings of warble flies. 1, *Hypoderma lineatum;* 2, *H. bovis.*

WARBLE FLIES

The Striped Warble Fly (*Hypoderma lineatum* Villers).—(Consult Bull. 5, Div. Ent., U. S. Dept. Agr.; Bull. 48, Minn. Agr. Exp. St.; Ont. Ent. Soc. Rep., 1915; Que. Soc. Prot. Plants, 1918.) Causes much loss to flesh and hides, and in lessened milk yield. Introduced from Europe.

Adult.—A hairy fly resembling a dark-colored bee; ½ inch long, with yellowish-white hairs; abdomen banded above with black and whitish stripes and terminated at apex with reddish-yellow hairs; thorax with four lines often seem as white by reflected light. Mouth-parts rudimentary and ovipositor blunt. Tibiæ and tarsi yellow, femora black. June–July (Fig. 162).

Eggs.—Attached in spring and summer to hairs of cattle by a peculiar clasping base, often several to a hair; 1/25 inch long; dull yellowish-white; narrow; ovoid.

Larva.—Dr. Cooper Curtice of Washington believed that the eggs were licked into the mouth and the maggots bored through the wall of the œsophagus, whence they gradually made their way to the tissues along the back, causing *warbles.*

Miss Ormerod, of England, on the other hand maintained the popular belief that the eggs were laid on the back, but Carpenter of Ireland, and more lately Dr. Hadwen of Canada, have proven fairly

FIG. 162.—The striped warble fly (*Hypoderma lineatum*). Enlarged. (After Hadwen.)

conclusively that the eggs may be laid on almost any part of the body of the animal, and that the maggots bore into the skin where lesions and swellings are produced. They finally make their way to the back where the warbles are formed.

Full grown maggots are greyish-white and nearly an inch long. When mature they make their way out through the minute opening, drop to the ground and bore an inch or so below the surface, where they change to pupæ. Four stages of larva; duration 9–10 months.

Pupa.—Puparium dark brown. Duration 3–6 weeks.

The Ox Warble Fly (*Hypoderma bovis* DeG.).—This bot-fly is also European and is found in several provinces of Canada and in several states. It is more dreaded by cattle than *lineatum*, and causes much panic due largely to the insect's persistence and manner of egg-laying. More robust than *H. lineatum*. Body hairs yellow, except those on scutellum and base of abdomen which are yellowish-white, and at apex

FIG. 163.—The ox warble fly (*Hypoderma bovis*). Enlarged. (*After Hadwen.*)

of abdomen which are bright lemon yellow (see Table given above for structural differences between *bovis* and *lineatum*) (Fig. 163).

The adults of *H. bovis* appeared in B. C. from May 31st to August 2d as extremes (Hadwen). Carpenter says that most of the maggots emerged from May 27th to June 17th. The pupal period has an average duration of about 35 days varying according to temperature. One egg is laid at a time, often when the cattle are running, besides not

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so many laid about the hoof as with *lineatum*. Swelling is more rounded and more raised than that of *lineatum*, and exudes less serum.

Control.—When practicable dip every 10 days and treat the larvæ with arsenic. Remove the larva from the warble in spring.

Larvæ of a species of *Hypoderma* have been obtained from the backs of horses.

Bot Flies

These flies are probably of European origin but little is known of their introduction.

Horse Bot Fly (*Gastrophilus intestinalis* DeG. = *equi* Fab.). *Adult.*—A large brownish hairy bee-like fly, ¾ inch long; head brown with

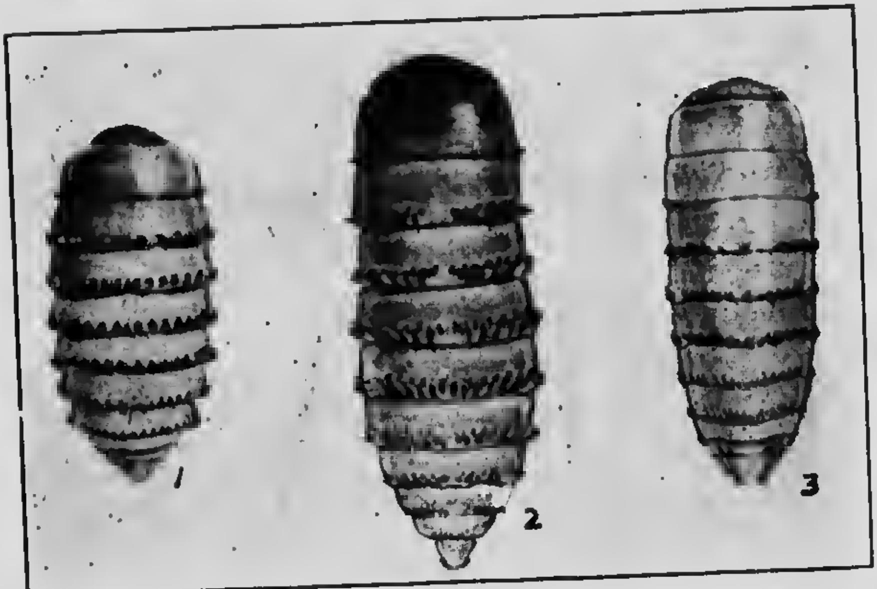


Fig. 164.—Larvæ of horse bot flies: 1, *G. hæmorrhoidalis;* 2, *G. intestinalis;* 3 *G. nasalis.* (*After Dove, Bur. Ent., U. S.*)

three rows of black spots; wings with dark spots or bands; abdomen brown with spots and conical. July–August.

Eggs.—Yellow, conical, attached by female without alighting to hairs of fore-legs, shoulders and under side of body; 1⁄16 inch long, hatch most readily 10 to 15 days after deposition, with the aid of warmth, friction and moisture.

Larva.—Licked into the mouth of the horse, thence into the stomach, where it attaches itself to the wall. Remains in stomach 8–10 months.

In spring it escapes in the droppings to the ground and bores an inch or two below the surface where it pupates (Fig. 164).

Pupa.—Duration 30-40 days.

Chin or Nose Flies (*G. nasalis* Linn. *and G. hæmorrhoidalis* Linn.).—These flies are a serious annoyance to horses in the West. They have bands of whitish, black and orange-red on the abdomen.

The eggs of *G. nasalis* are yellowish; laid on the hairs of the throat. Parker (1916) records the egg-laying of *G. hæmorrhoidalis*, the red-tailed bot fly. The egg is black, barnacle-like and stalked, and is in-

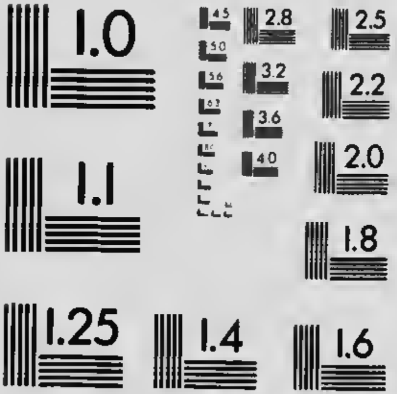
Fig. 165.—An effective leather fringe device to protect horses from the nose and red-tailed bot flies. (*After Dove.*)

serted on the hairs of the lip and nostrils by the stalk. The "striking" of the fly causes a sharp pain and excites a nervous uncontrollable fear in the horse.

Control.—Administer three or four 4-oz. doses of turpentine, followed finally by an ounce of powdered aloes; stable horses in day time; groom carefully so as to kill or remove the eggs; use fly-nets of loosely dangling cords for *G. equi*, and wire-screen muzzles, leather nosebands cut into narrow strips or provided with canvas flaps for *G. nasalis* and *hæmorrhoidalis* (Fig. 165).

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



Sheep Bot Fly (*Œstrus ovis* Linn.). *Adult.*—A dull-yellow fly a little larger than the House-fly and covered with minute spots; abdomen with five rings, velvety and variegated with dark-brown and straw color. Antennæ small; eyes purplish-brown; ocelli three on top of head; no mouth; wings transparent extending beyond body; alulets large covering the poisers. June–August.

Eggs.—Deposited in nostrils of sheep; hatch almost at once.

Larva.—Maggot works its way up the nasal passages until it reaches the frontal sinuses, the cavities between and above the eyes. There it attaches itself and feeds on the mucus present. Young is creamy-white, with two brown spots, spiracles on last segment; full grown maggot darker, particularly posteriorly; two small hooks on head; small rounded spots on sides of each segment. When mature, maggot passes down the nasal passages and falls to the ground, which it enters to pupate.

Pupa.—Puparium smooth, hard, and black, tapering toward head; duration 40–50 days.

Control.—Apply tar to the nose; furnish a shed for the sheep or a plot of plowed or dusty ground.

DROSOPHILIDÆ (POMACE FLIES)

Pomace Fly (*Drosophila ampelophila* Loew.).—This small fly breeds in decaying or over-ripe fruit, and is a common pest about fruit-stores. It is also suspected of being a typhoid-transmitter. The adult is a small light-brown fly with bright-red eyes; the maggot is white and about 1/4 inch long; the pupa is yellow or brown with two long horn-like breathing tubes at anterior end. The front tarsus of the male has a comb of black spines on its upper side near the tip.

OSCINIDÆ (GRASS STEM MAGGOTS)

Wheat Stem Maggot (*Meromyza americana* Fitch).—(Consult Bull. 42, Bur. Ent., U. S. Dep. Ag.) *Adult.*—A slender fly; yellowish-green, 1/5 inch long, with 3 dark stripes running down the back; femora of last pair of legs abnormally developed; eyes golden-green (Fig. 166).

Eggs.—About 1/40 inch long, and glistening white.

Larva.—A watery-green footless maggot, 1/4 inch long, tapering toward front end and broader posteriorly.

Pupa.—Pupa-case translucent pale green; pupa greenish and 1/6 inch long.

Broods.—Probably three generations occur each season. The eggs are laid in September-October on fall wheat. The maggots eat down into the stem where they remain all winter. In early spring they assume the pupal stage, and about the first of June the adult flies appear. This brood matures about August 1st, when flies again appear. This third generation matures at the end of September and the beginning of October, when the adult flies escape to lay their eggs. Besides wheat, rye, barley, and oats, this insect attacks timothy, couch grass, *Elymus*, *Poa*, and green foxtail.

Control.—Grain stacked or threshed; straw stacked or burned; burning of stubble when practicable.

Meromyza nigriventris Macq. and *Cerodontha femoralis* Meig. have been recorded as doing injury in Montana.

American Grass Stem Maggot (*Oscinis carbonaria* Loew.). *Adult.*—A black or yellowish fly, resembling a minute house-fly, 1/15 inch long.

Larva.—A yellowish-white slender maggot with two distinct hook-like jaws and two knob-like processes on the last segment of the body; 1/12 inch long.

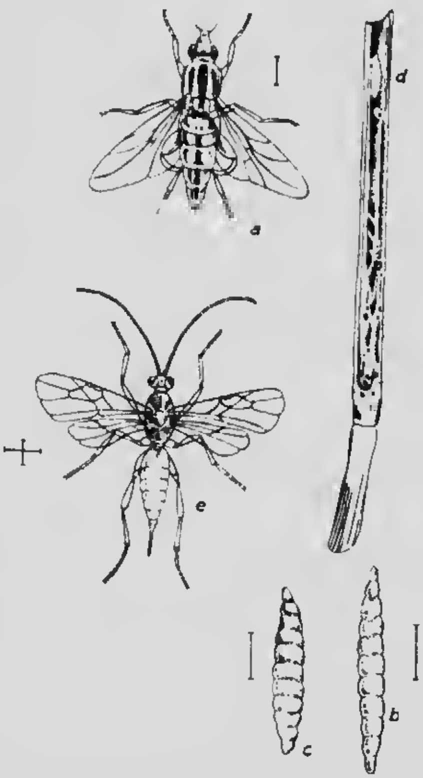


FIG. 166.—The wheat stem maggot: *a*, adult; *b*, maggot; *c*, pupa; *d*, pupa within the stem; *e*, parasite. (*After Lugger.*)

Pupa.—Pupa-case cigar-shaped and pale chestnut brown.

Broods.—Similar in life-history to Wheat Stem Maggot. The larva destroys the centre of the young shoot at the ground in the autumn.

Other Species.—*O. coxendix* Loew. and *O. dorsata* Loew. occur on prairie grasses, sometimes very abundant.

Control. Summer-fallow grass lands; prevent volunteer growth in autumn.

PSILIDÆ (RUST FLIES)

Carrot Rust Fly (*Psila rosæ* Fab.).—This fly is a native of Europe, and the larva frequently does considerable injury to the roots of carrots, celery and parsnips.

Adult.—One-sixth inch long, dark green, sparsely clothed with yellow hairs; eyes black, and head and legs pale yellow.

Eggs.—Deposited by female about roots of host through cracks in the ground.

Larva.—Maggot dark brown, $^3/_{10}$ inch long, slender, truncate at posterior end; segments well marked, head small.

Pupa.—Puparium dark brown; anterior segment obliquely truncate; $^1/_5$ inch long; pupation in the earth.

Life-history.—(Consult Fletcher's Reports and Bull. 33, U. S. Div. Ent.) Winters as larva or pupa; adults appear early in the season; summer generations develop in 3 or 4 weeks (Curtis); both flies and maggots found throughout the warmer months; number of broods uncertain.

Control.—Spray the carrots four or five times at intervals of a week or ten days with kerosene emulsion, the first application at the time of thinning; spread the earth in which carrots have been stored in the poultry yard; sow late and practice rotation of crops.

AGROMYZIDÆ (LEAF MINER FLIES)

Marguerite Fly (*Phytomyza chrysanthemi* Kowz.).—(Mass. Agricultural Experiment Station, Bull. 157.) Attacks co[illegible]itous plants and is especially injurious in the greenhouse. Occurs [illegible]he Northern States, and has done considerable injury in B. C.

Adult.—A small greyish fly $^1/_{12}$ inch long, with a yellow stripe on each side of abdomen; face yellow; antennæ black; legs black with yellow markings; rather inactive. Average length of generation about 33 days; several generations a season in greenhouse.

Eggs.—Laid singly in incisions between flesh and skin of leaf. Hatch in 5 days.

Larva.—Burrows in the leaf, producing irregular whitish lines or patches, often causing withering, also preventing flowering or reducing the number of blossoms. Matures in about 17 days.

Pupa.—Formed in larval mine. This stage lasts about 14 days; puparia dark brown.

Control.—A solution of Black Leaf 40 and Soap applied at intervals of 10 or 12 days, as soon as first signs of operation of the insect.

Asparagus Miner (*Agromyza simplex* Loew.).—(Consult Bull. 66, Part I, U. S. Bur. Ent.) Injures asparagus stalks, the maggot mining beneath the epidermis, sometimes girdling the stem.

Adult.—A black two-winged fly; eyes and head prominent; wings clear with 1/6 inch expanse. Probably two generations, June and August.

Eggs.—White; deposited just beneath epidermis of stalk.

Larva.—Milk-white; 1/5 inch long; footless, truncate posteriorly and tapering anteriorly.

Pupa.—Puparium flax-seed-like, red, 1/7 inch long; attached to slits in epidermis of asparagus stalk near ground.

Control.—Pull up and burn infested stalks in spring; destroy volunteer trap plants in late June.

Corn or Spike-horned Leaf Miner (*Cerodonta dorsalis* Loew.). (Consult Bull. 432, Bur. Ent., U. S. Dept. Agr.) This leaf-miner has a wide distribution in the U. S. and feeds on a wide range of cereal and grass plants. Three generations at least in Indiana.

Adult.—One-twelfth to 1/10 inch long; proboscis, palpi, front, antennæ, legs, mesonotum and abdomen mostly yellow. Punctures the leaves, in some of which an egg is laid. May in Indiana, but active throughout the year in Pasadena, Cal.

Eggs.—Elongate, kidney-shaped, rounded at each end. Color opaque white; 1/60 inch long. Hatch in 3–12 days.

Larva.—Dirty-white; 1/6 inch long; slender, nearly cylindrical; mouth-hooks black; body segments plain; posterior ends truncate; mines in the leaves and stem of host plant, frequently killing the parts affected. Full grown in 9–24 days.

Pupa.—White at first, turning yellow and dark later. Duration 9–24 days. Hibernates (in Indiana).

Control.—(1) Summer fallowing, (2) fall plowing, (3) burning dry grasses along fence lines, roadsides, etc. in late fall and early spring.

TRYPETIDÆ (FRUIT FLIES)

Common Genera (after Williston):

A. Bristle on each side of front with a terminal leaf-like appendage. *Ceratitis*

AA. Front without such bristles; wings with colored markings not reticulate; scutellum not with six bristles; fourth longitudinal vein not conspicuously curved forward at its extremity.

B. Distal portion of wings marked with two hyaline indentations. Separated by a curved or arched brown projection from the brown oblique cross-band; body short; abdomen as broad as thorax; antepenultimate section of fourth vein curved.—*Epochra*.

BB. Wings not marked as in B.

C. Coloring of body generally light, never black; cross-bands of wings nearly transverse; cross-veins but little oblique.—*Trypeta*.

CC. Coloring of body black; wings with four very oblique black cross-bands; cross-veins not approximated; scutellum with 4 bristles, yellow.—*Rhagoletis*.

Mediterranean Fruit Fly (*Ceratitis capitata* Wied.).—(Consult Circ. 160, U. S. Div. Entomology.) Probably a native of the East Indies. The appearance of this destructive insect in Hawaii has alarmed the fruit-growers of the Pacific coast, and quarantine restrictions have been enforced. It already occurs in Africa, Europe and Asia, in Australia and in Brazil, and attacks nearly all kinds of fruits.

Adult.—An active fly about size of house-fly, ochre yellow color, eyes reddish purple, a blackish blotch in centre of forehead where two stout black bristles arise; thickened basal antennal joints yellow, terminal segments black; dorsum of thorax convex, yellowish-white marbled with shiny black blotches. Wings broad and semi-opaque with extreme base blotched with ochreous or brownish yellow, the rest of the basal area marked with black; beyond a broad, irregular, transverse ochreous band blotched at extremity; another similar blotch inside of costal vein.

Abdomen oval, with fine scattered bristles on upper surface, and two rather broad transverse silvery white bands on basal half. Number of broods depends on temperature and food supply.

Eggs.—Glistening white eggs placed beneath skin of ripe fruit by sharp extensile ovipositor. Eggs not all deposited at once.

Larvæ.—Begin feeding at once on the pulp, when mature (2–3 weeks) they leave the fruit and enter the ground, changing to puparia.

Pupa.—Duration 12–21 days.

Control.—Cleaning up and destruction of all fallen fruits; covering trees with netting; using a poison bait spray (Berlese and Mally).

Currant Fruit Fly (*Epochra canadensis* Loew.).—(Consult Bull. 264, Maine Agr. Expt. St.) A common pest on currants and gooseberries in Canada and the Northern States, and confined to the Canadian, Transition and Upper Austral zones.

Adult.—Pale yellowish, slightly smaller and more delicate than the house fly; eyes green, legs yellow, wings cross-banded; active and restless. May and June. Mating period 33 days; preoviposition period 6–10 days. One brood a year.

Eggs.—Elongate, oval, whitish, $\frac{1}{25}$ inch long; placed under skin of fruit by long ovipositor. Female may lay about 200 eggs. Hatch in 4–7 days.

Larva.—Burrows within the fruit, destroying seeds and kernel. Infested berries show discolored spots, become deformed and usually fall early. Matures in 3 weeks; $\frac{1}{4}$ inch long, white with black mouth-parts. Leaves the fruit and enters the ground to pupate.

FIG. 167.—A female white-banded cherry fruit fly. Much enlarged. (*After Caesar.*)

Pupa.—Puparium broadly oval and straw colored, in the ground. Hibernates. Duration 10–11 months.

Control.—Allow poultry to run among the bushes to pick up fallen infested fruit; spray bushes with a sweetened poison of sodium arsenite and diluted molasses to kill adult flies at intervals of a week beginning early in May. A heroic but effectual method is to pick entire crop of fruit and destroy it before the maggots emerge.

White-banded Cherry Fruit Fly (*Rhagoletis cingulata* Loew.). *Adult.*—A small blackish fly, smaller than the House-fly, $\frac{1}{6}$ inch long, expanding $\frac{3}{8}$ inch; pale yellow spot on hinder part of thorax and a yellowish stripe along each side of thorax; head yellow, eyes gold-green; legs yellow, abdomen crossed with 3 or 4 white bands. Wings with four brown cross bands, and a black spot at tip. June (Fig. 167).

Eggs.—Egg-laying begins about 11 days after emergence of flies.

Eggs inserted under the skin of cherries; small, glistening white; elliptical; hatch in about 5 days.

Larva. One-fourth inch long, white or cream-colored, cylindrical, tapering. Twelve to 22 days in fruit; destroys the pulp. Leaves the cherry when full grown.

Pupa. Puparium formed just beneath the surface of the ground brown; hibernates.

Black-bodied Cherry Fruit Fly (*Rhagoletis fausta* O. S.). (Consult Bull. 227, O. A. C., 1915.) *Adult.* Larger than preceding; black without white cross-bands on the abdomen; head, eyes and legs similar to those of *cingulata* but bands on wings darker and differently arranged (Fig. 168).

FIG. 168.—A female black-bodied cherry fruit fly. Much enlarged. (*After Caesar.*)

Eggs and Larvæ.—Similar to those of *cingulata*.

Pupa.—Puparium cream or straw colored.

Control.—Spraying with sweetened arsenate of lead solution (2 to 3 lb. arsenate of lead (paste), 40 gal. of water and 1 gal. of cheap molasses) when the flies begin to emerge about June 10th, and again 10 to 12 days later.

Apple Maggot or Railroad Worm (*Rhagoletis pomonella* Walsh). (Consult Rep. Maine Ag. Exp. St., 1889; Cir. 101, Bureau of Ent. U. S. Dep. Agr.; Bull. 171, N. H. Ag. Exp. St.; Bull. 324, Cornell Ag. Exp. St.; U. S. Dep. Ag., Bull. 9.) This maggot is a serious pest of apples in N. E. districts. It is probably a native species, and occurs widely in both the United States and Canada on apple, crab-apple, haw, and huckleberry. Perhaps most common on sweet and sub-acid varieties of apple.

Adult.—A small fly, a little smaller than the house-fly; blackish with yellow head and legs, eyes green; 3–4 white bands (3 in male and 4 in female) across the abdomen; wings marked by four dark irregular bands. July and later, each female capable of laying 300 to 400 eggs; uses sharp ovipositor to puncture the skin of the fruit. Pre-oviposition period may be as short as one week or less, but usually longer than a week (Fig. 169).

Eggs. Elliptical, yellowish, pedicellate, 1/30 inch long; laid singly just under the skin of the apple; hatch in 4–10 days.

Larva.—A small plump white legless maggot, 1/3 inch long; mouth-parts with a pair of small black rasping hooks; caudal end truncate;

FIG. 169.—A female of the apple maggot fly (*Rhagoletis pomonella*). Much enlarged. (*After W. H. Brittain.*)

makes soft discolored trails and corky strands in the pulp; full grown in 4–6 weeks, or when the infested fruit is ripe. Infested apple usually falls, and larvæ leave the fruit 1 to 4 weeks later to enter the ground (Fig. 170).

FIG. 170.—A parasite of the apple maggot (*Biosteres rhagoletis*). Enlarged. (*After W. H. Brittain.*)

Pupa.—Puparium just beneath the surface of the ground in which the pupa rests all winter, and in some cases the following year. Some flies emerge in September from early pupæ.

Life-history.—Hibernates as pupa in the ground; adults begin to emerge in July, and appear irregularly later; maggots hatching from the eggs tunnel in the flesh of the fruit, sometimes close to the surface. They mature in 4–6 weeks, and make their way out of the apple to the ground, the time (1 to 4 weeks) depending on variety of apple, a short time (3 days) in early apples. Infested fruit usually falls. There is but one generation each year. "Some forms require an extra year for the pupal stage" (O'Kane).

Control.—Apply arsenical or poison-bait spray in early July for adults; collect fallen apples; allow hogs the run of the orchard.

RECORDS

Locality	Emergence of adults	Oviposition	Larval period	Second brood adults	Author
Ithaca, N. Y.	June 15	July 1	July 1 (12–32 days)	Some flies emerge in Sept.	Illingworth
Durham, N. H.	1910, July 9 1911, June 26 1912, June 28 1913, July 10	July 4–Sept. 18	30 days more or less	None	O'Kane
Bowmanville, Ont.	1912, July 6–Aug. 20	July 20	. . . .	. . . .	Ross
	1915, July 27–Sept. 20	July 27–Sept. 10	4 weeks ±	None	Brittain
Windsor, N. S.	1916, July 18–Sept. 18	July 25–Sept. 12			

MUSCIDÆ (MUSCIDS)

Common Genera (Figs. 171 and 172):

A. Proboscis long, slender, directed forward, adapted for piercing; arista pectinate (rays on one side only).
 B. Palpi nearly as long as proboscis.—*Hæmatobia* (*Lyperosia*).
 BB. Palpi much shorter than proboscis.—*Stomoxys*.
AA. Proboscis not elongate; labella fleshy and not adapted for piercing.
 B. Arista plumose; hypopleuræ with a vertical row of bristles; eyes bare; vibrissal angle distant and above oral margin.
  C. Thorax and abdomen with depressed yellow woolly hairs among the bristles; sternopleurals arranged 1 : 1.—*Pollenia*.
  CC. Thorax and abdomen without such hairs; sternopleurals arranged 2 : 1; mesonotum distinctly striped; bright metallic.—*Chrysomyia*.
 BB. Arista plumose; hypopleuræ without a row or tuft of bristles.

C'. Last section of fourth vein (M_{1+2}) with a rounded angle. *Musca.*

CC'. Last section of fourth vein curved forward, often slightly, beyond

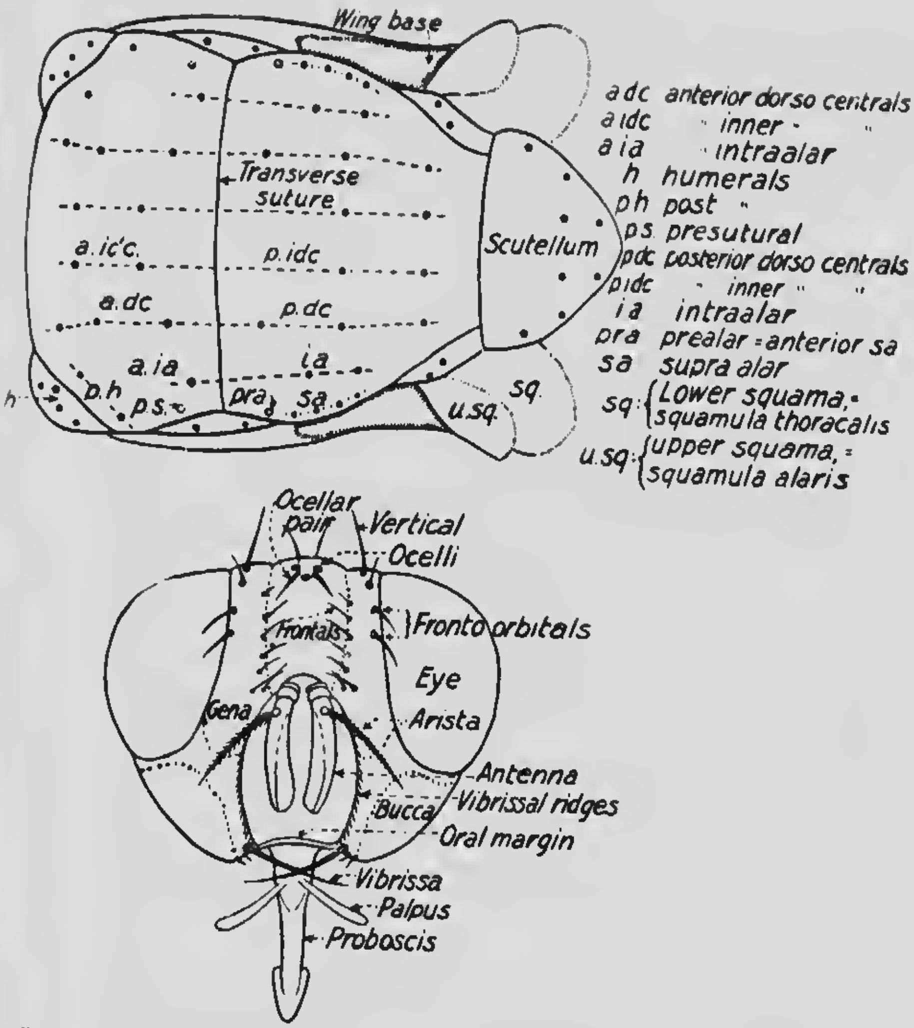


FIG. 171.—Dorsal aspects of the thorax, and frontal aspect of the head of a Muscoidean fly with designations of the parts commonly used in taxonomic work. (After Riley and Johannsen, Comstock Pub. Co., Ithaca, N. Y.)

its middle or at the tip, the cell broadly open; the first longitudinal vein (R_1) ending beyond the middle of the wing. *Muscina.*

BBB. Arista plumose; hypopleuræ and eyes as in B; vibrissal angle near oral margin.

C. Mesonotum flattened behind the transverse suture, posterior dorsocentral and acrostichal bristles inconstant and unequally developed. *Phormia.*

CC. Mesonotum not flattened behind the transverse suture; posterior dorsocentral and acrostichal bristles well developed and constant.

D. Cheeks hairy; third longitudinal vein (R_{4+5}) spinulose at base only. *Calliphora.*

DD. Cheeks bare; third longitudinal vein (R_{4+5}) spinulose. *Lucilia.*

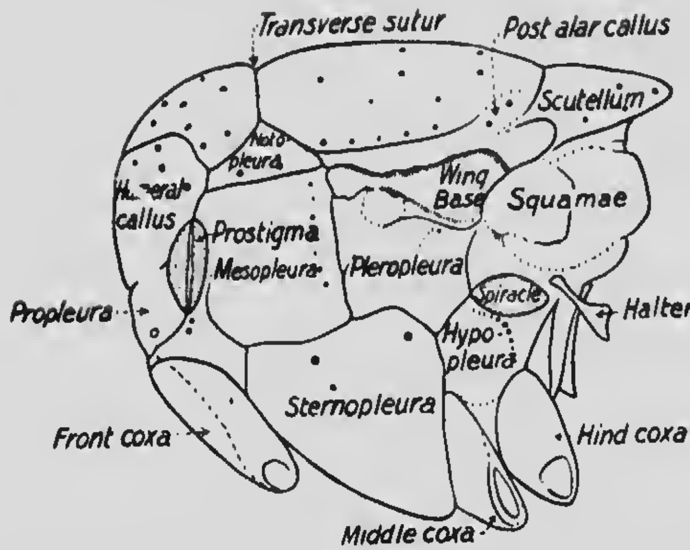


FIG. 172—Lateral view of the thorax of a muscoidean fly, with designations the parts commonly used in taxonomic work. (*After Riley and Johannsen.*)

House-fly (*Musca domestica* Linn.).—A cosmopolitan insect dangerous to human life. A carrier for typhoid fever, tuberculosis, dysentery and other diseases (Fig. 173).

Adult.—A two-winged fly with four black lines on back of thorax, bristle of antennæ feathered; vein ending near tip of wing distinctly elbowed; no bristles on abdomen except at the tip. Mouth-parts used for sucking not for piercing, retractile; mouth-parts and feet specially adapted for carrying micro-organisms. Each foot with two claws and two sticky pads. Egg-laying begins 10 14 days after adult emerges from puparium (Fig. 174).

Eggs.—Minute, glistening white, long ovoid, $\frac{1}{6}$ inch long. Laid in irregular small clusters. Each female lays about 120 eggs at a time and may lay several times; hatch in about 8 hours in mid-summer. Laid in horse manure, pig manure, and to a less extent in other manure, human excreta, in decaying grain moist bran, moist mixtures of hay and grain from feed troughs, in excreta-soil l straw, decaying kitchen refuse, rotting fruits, vegetables, in ensilage.

Fig. 173. The common house-fly (*Musca dom stica*). Puparium at left; adult next; larva and enlarged parts at right. All enlarged. (*After Howard.*)

Larva. —At first glist ing white; two moults; duration about 5 days; yellowish when full gr n, slender in front and truncate behind; a large hook above the mouth; active. Develops in horse manure and other filth in substances more or less alkaline.

Pupa. Puparium nearly cylind l, dark chestnut; duration 3 4 days.

Duration of life-cycle 10 14 days. Probably seven to ten generations develop between April 15th and October 10th. It hibernates as larva or pupa in the South but probably more commonly as adult in the North. (Consult Howard's and Hewitt's books on "House Flies.")

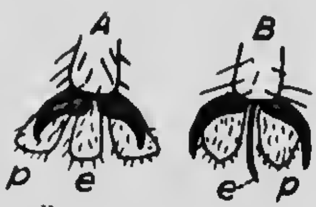


Fig. 174.—Extremity of tarsus: *e.*, empodium; *p.*, pulvillus in *A*, *Bibio*; *B*, *Musca*.

Stable Fly (*Stomoxys calcitrans* Linn.).

Occurs in stables, yards, shady groves, dwellings, etc.

Adult.—Resembles house-fly, but has piercing mouth-parts; bright golden tinge at front end of median, light stripe on thorax; six black lines on thorax; dorsal surface of abdomen with a number of nearly round dark spots. Bite severe but not poisonous. A carrier of disease; breeds in moist straw and hay.

Eggs.—Laid in an irregular heap of about 100 on manure and garbage; similar in form to those of House-fly; hatch in 2–3 days.

Larva.—Similar in form to that of House-fly, but more translucent in appearance. Duration 10–20 days.

Pupa.—Duration 6–20 days; puparium reddish-brown, elongate-oval, 1/5 inch long.

This fly occurs in the open, but often enters houses; breeds rapidly in oat-straw and other organic refuse. Winters as pupa or larva.

Control.—Apply 0.62 lb. borax to every 10 cu. ft. (8 bushels) manure, on removal from stables, with a flour sifter or fine sieve, particularly about the edges of the pile, and sprinkle 2 or 3 gal. water over the heated manure; use fly-traps. (Consult Farmers' Bulls. 540, 734 and 851, U. S. Dep. Agr., 1913.)

Horn Fly (*Hæmatobia serrata* Rob.-Desv., *Lyperosia irritans* Linn.).—(Consult Circ. 115, Bur. Ent., U. S. Dep. Agr.) Introduced into U. S. about 1886 from Europe, and has spread rapidly since.

Adult.—Similar in shape and color to House-fly, but about half as large. June–September.

Eggs.—Laid singly in fresh cow manure in day time, irregular, oval, light reddish brown. Egg-laying begins soon after adult emerges.

Larva.—White, 1/4 inch long; full grown in 4–6 days.

Pupa.—Puparium dark brown, ellipsoidal, 1/6 inch long; pupal stage lasts 5–10 days.

Probably 6–8 generations in a season.

Control.—(1) Killing the maggots by the introduction into the manure of lime and other drying and destructive agents; (2) application of creolin compounds in the form of spray, or kerosene emulsion solution, or a mixture of 1/2 gal. fish oil, 1/2 pint coal oil, 4 tbspfls. crude carbolic acid applied with a cloth rubbed over the parts attacked.

The main factors limiting the number of the common flies are:

(*a*) The destruction of the larvæ and pupæ by braconid and chalcid parasites;

(*b*) The lack of food for the larvæ;

(*c*) The enemies of the adults;

(*d*) Weather conditions—oppressive sultry weather; cold, wet and windy weather; acting on the adults, and preventing the emergence of adults from the pupæ.

The Screw-worm Fly (*Chrysomyia macellaria* Fab.) occurs as far north as Canada but is of importance economically in the southwestern States as a pest of stock. The adult is larger than the house-fly, of a dark bluish-green color, with three distinct black stripes on the thorax. The eggs are laid in irregular masses upon dead animals and in wounds. The maggots bore into the carcass or flesh, often causing death. (See Farmers' Bull. 857, U. S. Dep. Ag.)

Blue Bottle or Green Bottle Flies.—Two or three common species of these flies occur which are also known as Blow, Green or Blue Bottle Flies.

Meat Fly, or Blue Bottle, or Blow Fly (*Calliphora vomitoria* Linn.).—A large blackish fly with bluish abdomen and black spines on the thorax. Its eggs are laid on meat and dead animals, and each female may lay 400 to 600 eggs, which hatch very soon after deposition. Duration of a generation 22 to 23 days. *C. erythrocephala* Meig. is another common species with a pre-oviposition period of 12–17 days, an active larval stage of 3–4 days and a pupal stage of 7–9 days.

Green Bottle Fly (*Lucilia cæsar* Linn.).—Similar in habits to Meat Fly, with pre-oviposition period of 1–3 weeks, active larval stage of 2–5 days and a pupal stage of 5–16 days. Hibernates as larva and pupa.

Phormia regina Meig. is a large black fly seen in early spring in houses, and breeds in garbage.

Large Blue Bottle Fly (*Cynomyia cadaverina* Desv.) frequents pantries. Lays eggs on meats—smoked, uncured and cooked. Pre-oviposition period 1 to 3 weeks, larval period 5–40 days, and pupal stage 1–8 weeks.

The Cluster Fly (*Pollenia rudis* Fabr.) and *Muscina stabulans* Fall. are also dangerous as disease carriers (see Part I). The former is found in early spring and late autumn crawling sluggishly about, often collecting in large numbers in and about houses. It has short curly yellow hair on dorsum of thorax. Probably breeds in manure and garbage.

ANTHOMYIDÆ (ANTHOMYIDS)

Root Maggots (*Phorbia* spp.).—Three species of root maggots are commonly injurious to root crops—Cabbage Root Maggot, Onion Maggot and Seed Corn Maggot.

Cabbage Root Maggot (*Phorbia brassicæ* Bouché).—A widely distributed insect, introduced from Europe.

Adult.—Smaller than House-fly; 3/16 inch long; greyish, with three blackish, rather broad bands on back of thorax and a dark stripe along back of abdomen; a number of stiff hairs on body and legs; eyes red-

FIG. 175.—Male of the cabbage root maggot fly. Enlarged about 3 times. (*Photo by J. T. Wadsworth. After Gibson and Treherne. Bul. 12. Ent. Br. Dept. Agric. Ottawa.*)

FIG. 176.—Female of the cabbage root maggot fly.. Enlarged about 3 times. (*Photo by J. T. Wadsworth.*) *After Gibson and Treherne. Bul. 12. Ent. Br. Dept. Agric. Ottawa.*)

dish-purple. Hibernates sometimes as adult. Pre-oviposition period about 6 days (Figs. 175 and 176).

Eggs.—Elliptical, white, 1/25 inch long; 50–60 deposited separately on the surface of ground or on stem of plant; stage lasts about a week.

Larva.—A whitish, cylindrical, footless maggot, tapering toward the front, and abruptly terminated behind, where are 12 two-pointed fleshy tubercles and 2 conspicuous reddish-brown spiracles; ¼ inch long when full grown (3 to 4 weeks) (Figs. 177 and 178).

Pupa.—Puparium in earth, oval, ¼ inch long, chestnut-brown; 2 weeks in June; hibernates.

FIG. 177.—(*a*) Caudal end of cabbage root maggot; (*b*) of the imported onion maggot; and (*c*) of the seed-corn maggot; showing arrangement of fleshy tubercles and central spiracles. All much enlarged. (*After Gibson and Treherne, Ent. Bul.* 12, *Dept. Agric. Ottawa.*)

Life-history.—Adults appear in May, when cabbages are being set out, and deposit eggs. Maggots hatch in a week and feed on roots for 3 or 4 weeks when they change to pupæ within puparia in the soil. In 15 days or so the adults appear in late June and July to lay eggs for a second brood. The number of broods is uncertain, probably three or four, but the later broods do but little harm.

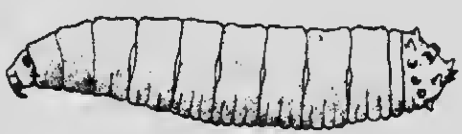


FIG. 178.—Cabage root maggot, side view. Enlarged 7 times. (*After Gibson and Treherne. Ent. Br. Can.*)

Control.—Use "single-ply tarred felt" paper disks when young plants are set out; use cheese cloth frames as screens; plant trap-crops; apply white hellebore or pyrethrum either as dust or as solution; use carbolic wash; use corrosive sublimate solution (4 oz to 50 gal. water). In the case of the last three insecticides, treatment should be made when the plants are set out and repeated once a week for 5 weeks.

Enemies.—*Baryodma ontarionis*, a Staphylinid; *Cothonaspis gillettei* Wash., a Cynipid; and *Trombidium* spp.—(Consult Bull. 12, Ent. Br.

Dep. Agr. Canada, 1916; Bull. 419, N. Y. Agr. Exp. Stn.; Cornell Univ Bull. 78.)

Onion Maggot (*Phorbia ceparum* Mg. = *Hylemyia antiqua* Mg. *Adult.*—Slightly larger than Cabbage Root Maggot Fly; body and legs with many black bristles; back of thorax of male with four indistinct dark colored bands; abdomen with a distinct blackish band down the middle; May–June. Probably three broods a year. Pre-oviposition period about 10 days (Fig. 180).

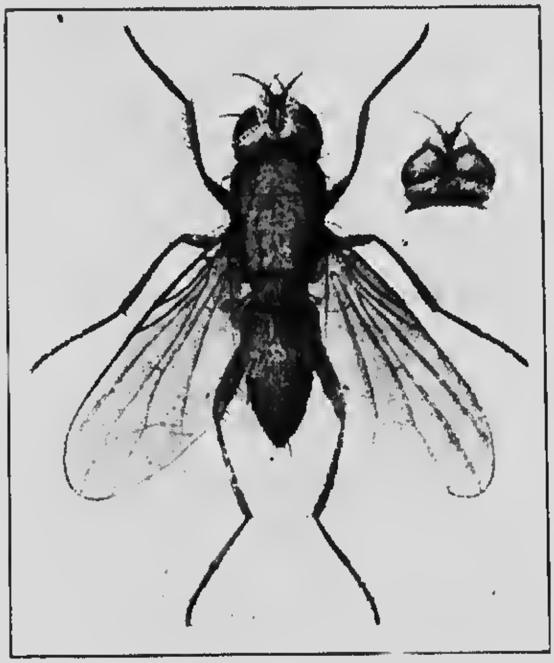


FIG. 179.—Onion maggot (*Phorbia ceparum*), female and head of male.

Eggs.—Cylindrical, white, distinctly ridged; groove not so deep or long as in *P. brassicæ;* duration 3 to 4 days.

Larva.—White, cylindrical, rounded, truncate at posterior end. $\frac{2}{5}$ inch long; central tubercles of blunt end single-pointed, with a pair of additional tubercles. Duration 2–3 weeks, occasionally 4–5 weeks. Young larva works its way down within the sheath of the plant to the forming bulb, in which it feeds.

Pupa.—Puparia formed in soil or in outer layers of onion. Found $1\frac{1}{2}$–3 inches below the surface. Summer duration about 2 weeks; hibernates.

The Barred-winged Onion Maggot (*Chaitopsis anea* Wied.) is also injurious to onions (Michigan).

Control.—Apply poisoned bait spray composed of sodium arsenite and molasses to kill adults; apply hellebore, pyrethrum and carbolic wash.

Seed Corn Maggot (*Phorbia fusciceps* Zett.).—(Consult Bull. 12, Ent. Br. Dep. Agric. Can.). Injurious frequently to beans, peas and corn.

Adult.—Smaller than Onion Maggot Fly, 1/5 inch long; bands on back of thorax indistinct, those on abdomen distinct; inner side of posterior tibiæ of male with a row of short bristly hairs. Body of female pointed, eyes widely separate. June–July.

Eggs.—Laid on or about the seed in the soil, or on the seedling.

Larva.—Smaller than Cabbage Root Maggot or Onion Maggot, 1/4 inch long; whitish, cylindrical, footless, blunt at caudal end and pointed at the head. Caudal tubercles simple, rather close together with a *trace* of additional tubercles. Feeds mostly on the seed.

Pupa.—Puparium 1/5 inch long, light brown to dark reddish-brown; duration 12 days.

Number of generations not yet known. Injury seems most severe when a wet period follows immediately after planting the seed.

Control.—Difficult. Use mineral fertilizers; carbolic acid emulsion.

Raspberry Cane Maggot (*Phorbia rubivora* Coquillet). *Adult.*—A grayish-black fly, smaller than the house-fly. April.

Eggs.—White, elongate, 1/15 inch long, laid in the axil of young leaves at the tip of shoot. Hatch in a few days.

Larva.—Maggot bores into the pith of the shoot, and tunnels downward, making a tortuous path. About halfway down it girdles the wood beneath the bark. It continues burrowing downwa... and becomes full grown in June. Wilting occurs in May.

Pupa.—Formed at lower end of burrow in June and July.

Control.—Cut off and burn the wilting canes as soon as observed.

Beet Leaf Miner (*Pegomyia vicina* Lintner). It is sometimes destructive to beets in late fall. Whitish blotches are formed on the leaves. There are several generations each year, and the winter is passed in the pupal condition under fallen leaves or in the soil. The eggs are placed on the lower side of the leaves, and the maggots mine in the leaves; life-cycle about a month.

Control.—Pick and burn infested leaves where practicable; use spinach as a trap crop; plow deep and harrow as soon as crop is removed.

Lesser House-fly (*Homalomyia canicularis* Linn.).—This fly is smaller than *Musca domestica*, and may be observed in houses in early summer. As an Anthomyiid it can be readily distinguished from the true muscids by the venation of the wings. In this species the middle tibiæ are without a tubercle.

The larva, 1/5 inch long, is markedly different from that of *Musca*. It has a flattened body with a double row of spiny processes. It lives in waste vegetables and animal matter, and no doubt is responsible

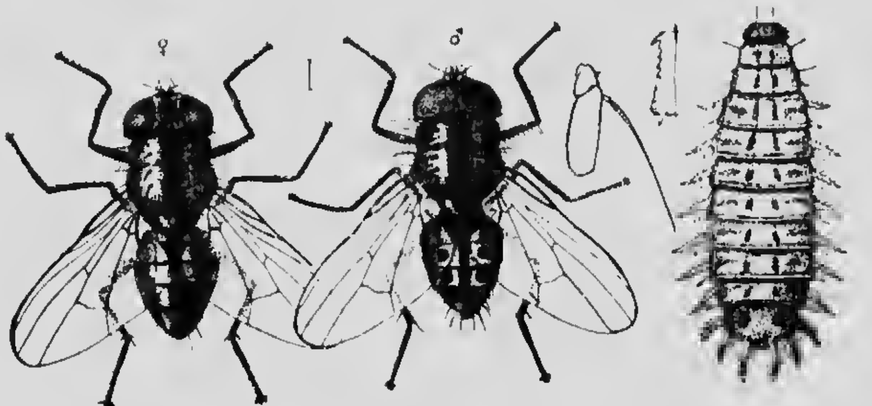


FIG. 180.—The little house-fly (*Homalomyia brevis*). Female at left; male next with enlarged antenna; larva at right. All enlarged. (*After Howard.*)

for the transmission of certain diseases. It becomes full grown in about a week, sometimes prolonged to 3 or 4 weeks.

The Little House Fly (*Homalomyia brevis* Rond.) occurs about outbuildings and breeds in human excrement. It acts, no doubt as a disease carrier (Fig. 180).

The Latrine Fly (*Homalomyia scalaris* Fab.) is also under suspicion as a carrier of contagion. Middle tibiæ with a tubercle.

TACHINIDÆ (TACHINA FLIES)

These flies are useful in that the larvæ or maggots are parasitic within the bodies of injurious caterpillars. The female tachina fly lays her eggs upon the caterpillar or upon the leaves of the food plant and the maggots on hatching bore their way through the walls and live within the body until full grown. Tachina flies resemble house-flies but are usually more bristly and hairy. The bristles of the antennæ are entirely bare. They are frequently found about flowers and rank vegetation. Besides caterpillars, such as army-worms and cutworms, locusts, leaf-eating beetles and other injurious forms are kept under control by tachina flies.

HIPPOBOSCIDÆ (SHEEP TICKS)

Sheep Ticks (*Melophagus ovinus* Linn.) are wingless, brownish, flattened blood-sucking insects belonging to the sub-order *Pupipara*. They are often very injurious to lambs in spring after shearing time. Sheep should, therefore, be dipped twice after shearing in some good "dip," of which several kinds are on the market. (See Farmers' Bull. 708, U. S. Dep. Agr.)

Life-history. Each female produces 5 to 8 nearly full grown larvæ which become brown puparia in about 12 hours. Eggs are not produced. The adult tick emerges in 19–24 days after the deposition of the pupa, and reaches sexual maturity 3 or 4 days later. In 8 to 10 days after fertilization the female deposits the larva.

ORDER SIPHONAPTERA (FLEAS)

Pulicidæ (*Fleas*).—(Consult Farmers' Bull. 897, U. S. Dep. Ag.) Two species of fleas are found infesting houses: the Human Flea (*Pulex irritans*) most commonly found on the Pacific Coast, the Cat and Dog Flea (*Pulex serraticeps*) in the eastern part of the continent. Fleas are most numerous in sandy regions and in rainy seasons.

Human Flea (*Pulex irritans* Linn.). Secretes itself in bedding and clothing, and attacks its human victims at night.

Adult.—Body compressed; wingless; legs long and stout; tarsi 5-jointed, and mouth-parts adapted for sucking; antennæ small, eyes simple.

Eggs.—Laid in dust or lint under carpets and other out-of-the-way places, whitish and ovoid; in summer hatching in 4 to 6 days. Each female lays 8 to 12 eggs.

Larva.—Lives and feeds in dust or litter; slender, worm-like, footless, sparsely haired; full grown in summer in about 11 days, but may be prolonged to several months.

Pupa.—Formed where larva lives, often enclosed in a small silk cocoon, covered with dust. Duration about 12 days in warm conditions, but may be more than a year under unfavorable conditions.

Cat and Dog Flea (*Pulex serraticeps* Gerv. = *Ctenocephalus canis* Curtis). *Adult.*—Like that of House Flea but with a comb of spines on border of head and pronotum. Adheres quite closely to its host.

Eggs.—Laid loosely among the hairs of host; small white and oval. hatch in about 2 weeks. Collect on mats.

Larva.—At first white, footless, maggot-like; head pale yellow; feeds on decaying particles of animal and vegetable matter; matures in summer in about 12 days.

Pupa.—Duration 12 to 16 days in summer in a cocoon. This flea may be found in winter in any of the stages. Several broods each season.

Control.—Bathe the animals frequently in a 3 per cent. creolin solution (4 teaspoonfuls to a quart of water); provide them with sleeping mats and have these mats beaten or shaken regularly once a week; keep the kennel clean; dust fresh pyrethrum thoroughly among the hairs of the animals and on the floors; remove carpets or mats and give floors a thorough cleaning with soapsuds and later with benzine; dust powdered alum upon the carpets, etc.

Treatment of bites with a 3 per cent. carbolic acid solution, menthol, camphor or carbolated vaseline will allay the irritation.

COLEOPTERA (BEETLES)

Chief Groups of Beetles

A. Head of the ordinary form, not prolonged into a narrow beak; maxillæ divided; palpus flexible, usually 4-jointed; larvæ rarely without legs *True Beetles* (Fig. 181).
- B. All tarsi with the same number of segments.—*Isomera.*
  - C. Fourth and fifth tarsal segments not grown together.—*Pentam[illegible]* (Fig. 182).
    - D. First three ventral segments of abdomen grown together, most with thread-like antennæ.—*Carnivora* or *Preda[illegible] Beetles.*
    - DD. First ventral segments of abdomen not grown togeth[illegible]
      - E. Antennæ club-shaped.—*Clavicornia* or *Club-h[illegible]* (Fig. 183).
      - EE. Antennæ serrate.—*Serricornia* or *Saw-horns* (Fig. [illegible]

EEE. Antennæ lamellate.—*Lamellicornia* or *Leaf-horns* (Fig. 183).

CC. Fourth and fifth tarsal segments grown together; antennæ bead-like.—*Phytophaga* or *Plant-eaters* (Fig. 184, *A*).

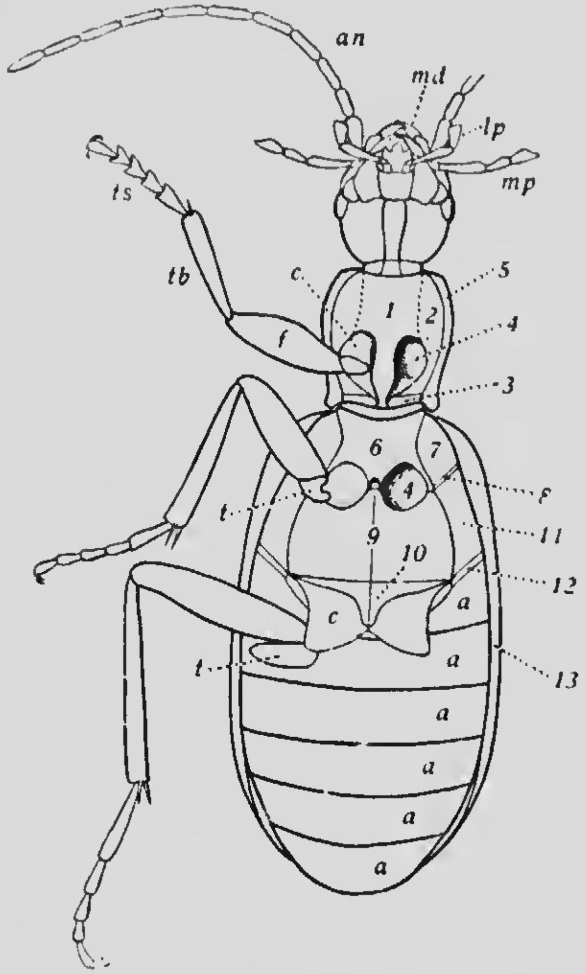


FIG. 181.—Ventral aspect of a carabid beetle (*Galerita janus*). 1. Prosternum; 2, proepisternum; 3, proepimeron; 4, coxal cavity; 5, inflexed side of pronotum; 6, mesosternum; 7, mesoepisternum; 8, mesoepimeron; 9, metasternum; 10, antecoxal piece; 11, metaepisternum; 12, metaepimeron; 13, inflexed side of elytron; [illegible]sternum; *an.*, antenna; *c.*, coxa; *f.*, femur. (*After Folsom.*)

CCC. Tarsi 3-jointed; antennæ clavicorn.—*Trimera Coccinellidæ*, p. 281.

BB. Fore and middle tarsi 5-jointed and hind tarsi 4-jointed.—*Heteromera.*

AA. Head often prolonged into a beak; maxillæ undivided; palpi rigid and not more than 3-jointed; larvæ legless.—*Rhyncophora* or *Snout Beetles*, p. 328.

Chief Families of the Carnivora Group:

A. Legs adapted for running; terrestrial; antennæ 11-jointed.
B. Antennæ inserted on front of head above the base of the mandibles.
Cicindelidæ (Tiger Beetles), p. 284.
BB. Antennæ inserted on sides of head between the base of the mandible and the eyes.—*Carabidæ* (Ground Beetles), p. 285.
AA. Legs adapted for swimming; aquatic.
B. With only two eyes.—*Dytiscidæ* (Diving Beetles).
BB. With four eyes.—*Gyrinidæ* (Whirligig Beetles).

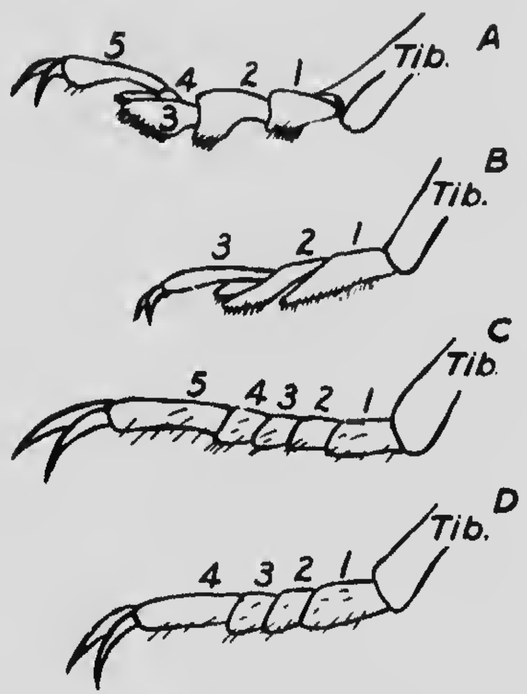


FIG. 182.—Tarsi of coleoptera. *A*, Leptinotarsa; *B*, *Coccinella*; *C*, *Tenebrio* fore leg; *D*, *Tenebrio*, hind leg.

Chief Families of the Clavicornia Group:

A. Legs fitted for swimming; aquatic.—*Hydrophilidæ* (Water-scavengers).
AA. Legs not fitted for swimming; terrestrial.
B. Elytra short.—*Staphylinidæ* (Rove Beetles).
BB. Elytra as long or nearly as long as body.
C. Abdomen with 5 ventral segments.—*Dermestidæ* (Larder Beet[illegible] p. 291.
CC. Abdomen with 6 or more ventral segments.—*Silphidæ* (Car[illegible] Beetles), p. 293.

Chief Families of the Serricornia Group (Fig 184):

A. Head inserted in thorax up to compound eyes.

B. First two segments of abdomen fused together on ventral side. *Buprestidæ* (Metallic Wood borers), p. 300.

BB. First two segments of abdomen not fused.—*Elateridæ* (Click Beetles), p. 293.

AA. Head not inserted in thorax up to compound eyes.

B. Head normal or bent, but partially covered by the margin of thorax.

C. Elytra flexible; body elongated and flattened.—*Lampyridæ* (Fire Flies).

CC. Elytra firm; body not much flattened.—*Cleridæ* (Checkered Beetles).

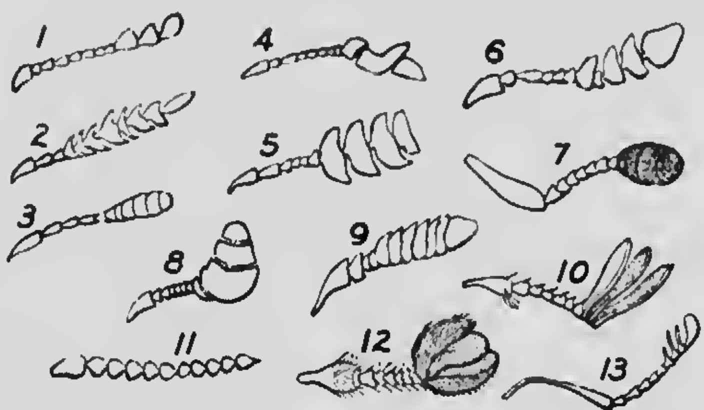


FIG. 183.—Forms of antennæ of beetles. 1–9, clavate; 10, 12, 13, lamellate; 11, moniliform. (*After Leconte and Horn.*)

BB. Head bent nearly at right angles to thorax; size small.—*Ptinidæ* (Death Watch Beetles, etc.), p. 327.

Chief Families of the Lamellicornia Group:

A. Antennæ elbowed; lamellæ fixed.—*Lucanidæ* (Stag Beetles), p. 318.

AA. Antennæ not elbowed; lamellæ not fixed.—*Scarabæidæ* (Leaf Chafers), p. 302.

Chief Families of the Phytophaga Group:

A. Body and antennæ short.

B. Front of head prolonged into a broad, quadrate, beak; elytra short; seed eaters.—*Bruchidæ* (Pea-weevils), p. 319.

BB. Front of head not prolonged into a beak; elytra long; leaf-eaters.—*Chrysomelidæ* (Leaf Beetles), p. 306

AA. Body and antennæ long.—*Cerambycidæ* (Long-horned Beetles), p. 320.

Chief Families of the Heteromera Group:

A. Head with distinct nec[illegible] soft and elytra flexible.—*Meloidæ* (Blister Beetles), p. 325.

AA. Head without distinct [illegible]k; body wall hard.—*Tenebrionidæ* (Darkling Beetles), p. 328.

Chief Genera of the Rhyncophora Group:

B. Beak short and broad; antennæ short, geniculate and clubbed; tibiæ often with several teeth externally; head narrower than prothorax, eyes oval, emarginate or divided; first tarsal joint much shorter than combined length of the others.—*Ipidæ* (Bark Beetles), p. 339.

BB. Beak usually long and well developed; palpi small and concealed antennæ usually clubbed; tibiæ without teeth externally; submentum produced into a gular peduncle.

C. Dorsum of last segment of male divided transversely.

D. Mandibles with a scar on anterior aspect.—*Otiorhynchidæ*, p. 336.

DD. Mandibles without scar on anterior aspect. *Curculionidæ* (Curculios), p. 329.

CC. Dorsum of last segment of both sexes undivided; tibiæ not serrated.—*Calandridæ* (Grain Weevils), p. 337.

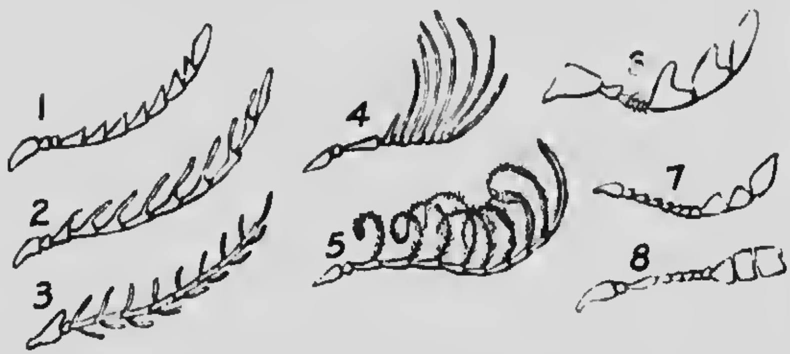


FIG. 184.—Serrate antennæ and modifications: 1, serrate; 2, pectinate; 3, bipectinate; 4, flabellate; 5, plumose; 6, 7, 8, irregularly serrate, approaching the clavicorn type. (*After Leconte and Horn.*)

CICINDELIDÆ (TIGER BEETLES)

Tiger beetles, both adult and larvæ, are predaceous, feeding upon caterpillars and other unwary insects. The adults are active, alert creatures, and are most commonly observed on sandy grounds and roads. They are brilliantly marked with metallic colors.

The larvæ live in vertical burrows and there lie in wait for their prey. They have strong jaws and large dirt-colored heads, and the fifth abdominal segment bears a hump with two backward-curved hooks which serve to anchor their owners in the burrows.

The majority of the species belong to the genus *Cicindela*, and the most abundant forms are *C. sexguttata* Fab., *C. vulgaris* Say, *C. repanda* Dej., *C. hirticollis* Say, and *C. punctulata* Oliv.

CARABIDÆ (GROUND BEETLES)

Common Genera (after Leconte and Horn):

A. Middle coxal cavities entirely closed by the sterna (Fig. 185).
  B. Head with two punctures above the eye, each bearing a single bristly hair.
    C. Margin of elytra interrupted at posterior end and with a distinct internal fold; three basal joints of antennæ glabrous.
      D. Last joint of palpi as long as or longer than the next to the last and cylindrical. *Pterostichus.*
      DD. Last joint of palpi shorter than the next to the last. *Amara.*
    CC. Margin of elytra not interrupted posteriorly and without an internal fold.
      D. Penultimate joint of labial palpi with but two bristly hairs, elytra truncate at tip; front tibiæ slender, tibial spurs short, head constricted behind the eyes. *Lebia*

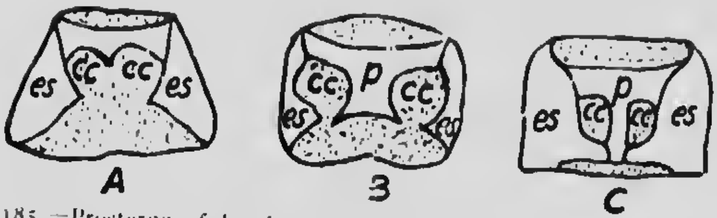


FIG. 185.—Prosterna of beetles. *A*, Coxal cavities (*CC*) confluent and open behind; *B*, coxal cavities separated and open behind; *C*, coxal cavities separated and closed behind. (*After Wickham.*)

      DD. Penultimate joint of labial palpi with a number of bristly hairs in front and always longer than last joint; first antennal joint elongate; head elongate-oval, prolonged behind the eyes.—*Galerita.*
  BB. Head with but one bristle-bearing puncture above the eye.
    C. Elytra truncate at apex; mandibles with a bristle-bearing puncture in outer groove; hind coxæ often separated.—*Brachinus* (Bombardier Beetle).
    CC. Elytra always entire; mandibles without a bristle-bearing puncture; hind coxæ contiguous.
      D. Antennæ with only two basal joints glabrous; black, front tarsi of male dilated and with two rows of small scales beneath; first joint of hind tarsus not longer than the two following.—*Harpalus.*

AA. Middle coxal cavities not entirely closed by the sterna (Fig. 185).
  B. Hind coxæ not separated; labrum not forked; third joint of antennæ cylindrical.—*Carabus.*
  BB. As in B, but third joint of antennæ compressed.—*Calosoma.*

Ground beetles are common insects and, with two or three exceptions, prey upon injurious forms and do not feed upon fruits, leaves or seeds. (See Part I, Beneficial Insects.) Following are the species most commonly met with:

Some Common Carabids

Murky Ground Beetles:

Pterostichus lucublandus Say.—Color usually green or bluish, not polished; length 10–14 mm.; thorax widened posteriorly; striæ of elytra

FIG. 186.—A carabid beetle (*Pterostichus lucublandus*). (*After Gibson and Treherne Ent. Bul. 12. Dep. Ag. Can.*)

smooth; 4 dorsal punctures; legs usually reddish; under surface punctured; three basal joints of antennæ distinctly carinate; basal impressions of thorax double (Fig. 186).

Galerita janus Fab.—Black, clothed with short hairs; length 17–22 mm.; legs, palpi, thorax and base of antennæ reddish-brown; head black, strongly constricted behind; prothorax half as wide as wing-covers; elytral striæ fine not punctured.

Lebia grandis Hertz.—Length 9 mm.; head and thorax reddish-y[ellow]

low; under surface and legs pale brownish-yellow; abdomen black; elytra dark blue and deeply striate; antennæ pale; head finely wrinkled; tarsal claws comb-shaped; tibial spurs short; thorax but little wider than head and much narrower than elytra.

Harpalus caliginosus Fab.—Pitchy black, length 21–25 mm.; antennæ and tarsi reddish-brown; legs black, thorax broader than long, narrow in front, as broad as base of elytra nearly square; elytra deeply striate and without a dorsal puncture on third interval, and sinuate at tip. A seed-eater.

Harpalus pennsylvanicus Dej.—Black, length 13–15 mm.; antennæ and legs reddish-yellow; under surface reddish-brown to piceous; sides of thorax gradually curved; region of basal angles strongly depressed, densely punctate; mentum toothed.

Metallic Ground Beetles:

Calosoma scrutator Fab.—(Searcher). Length 28–30 mm.; disk of thorax blue; margins reddish-bronzed, sides and angles rounded; legs blue, abdomen green and red; elytra metallic green with red margin, striate, punctured; third joint of antennæ compressed.

Calosoma calidum Fab.—(Fiery Hunter). Length 22 mm.; black above and below; elytra black with six rows of golden spots, deeply striate and finely punctate; head and thorax finely rugose; third joint of antennæ compressed.

Calosoma sycophanta Linn.—A European form imported to combat the Gypsy and the Brown-tail moths. Both larvæ and adults are predaceous and freely climb trees in search of their prey. The eggs are deposited in the earth and the mature larvæ seek the earth again and construct pupal cells. The adult beetles emerge late in the spring. They are about an inch long, and of a beautiful green color. (See Bull. 101, Bur. Ent., U. S. Dep. Ag.)

COCCINELLIDÆ (LADY-BIRD BEETLES)

(Consult Bull. 181, Conn. Agr. Exp. St. and "Coleoptera of Indiana.")

Lady-bird beetles are essentially feeders on plant-lice and scale insects; both as adults and larvæ; hence are of great economic importance. (See Part I, Beneficial Insects.)

Common Lady-birds:

Two-spotted Adalia (*Adalia bipunctata* Linn.).—Wing-covers red with a black spot in the centre of each; thorax black-margined with yellow; head black with two yellow spots between eyes; legs and under side of body black. Feeds on plant-lice. Common. Egg stage lasts about a week, larval stage about 3 weeks, and the pupal stage about a week. One-eighth to one-fifth inch long (Fig. 188).

Twice-stabbed Chilocorus (*Chilocorus bivulnerus* Muls.).—Wing covers black with a red spot near centre of each; head, thorax and legs black; under side of thorax black, and abdomen red. Larva spiny; pupa black and spiny. Feeds on scale insects and plant-lice (Fig. 188).

Two-spotted Hyperaspis (*Hyperaspis signata* Oliv.).—Wing-covers black with a red circular spot and a smaller yellowish spot on each; thorax

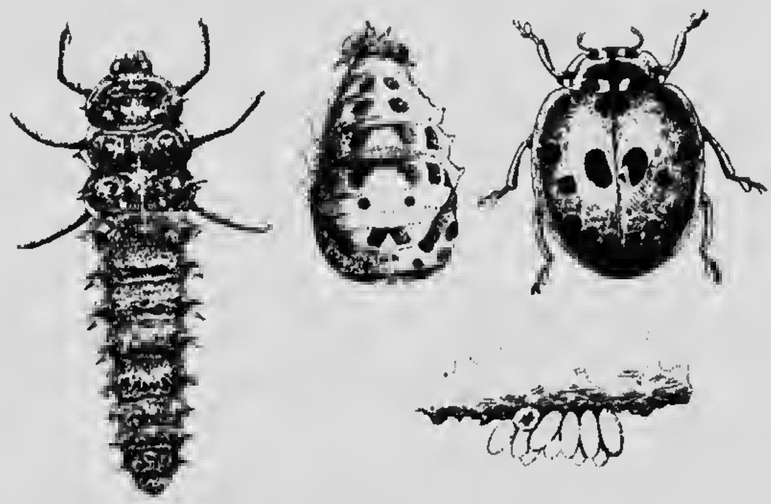


Fig. 187.—The 15-spotted lady-bird in all its stages. Enlarged about 3 times. (*After Britton.*)

and head black. In male the head and margins of thorax yellow. Larva white and woolly. Feeds on cottony maple scale.

Spotted Megilla (*Megilla maculata* DeG. = *Megilla fuscilabris* Muls.).—Wing-covers red with six black spots on each; thorax red with two triangular black spots; head black with a red median stripe; legs and under surface of body black. Larva blackish with white lines and black spots. Feeds on plant-lice. One-fourth inch long.

Pitiful Lady-bird (*Pentilia misella* Lec.).—Black, small. Feeds on San José Scale (Fig. 189).

Convergent Lady-bird (*Hippodamia convergens* Guer.).—Wing-covers reddish yellow with six black dots on each; thorax black with

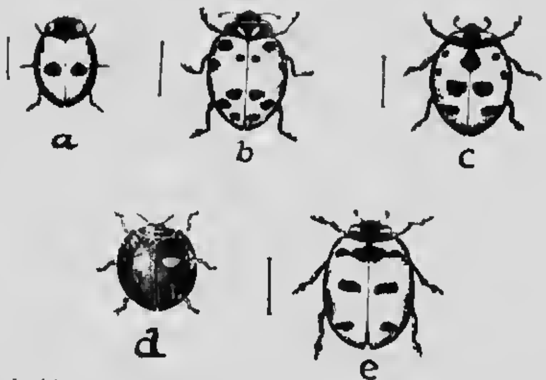


FIG. 188.—Lady-bird beetles: *a*, a 2-spotted lady-beetle (*Adalia bipunctata*); *b*, the convergent lady-beetle (*Hippodamia convergens*); *c*, the 9-spotted lady-beetle (*Coccinella 9-notata*); *d*, twice-stabbed lady-bird (*Chilocorus bivulnerus*); *e*, the 5-spotted lady-beetle (*C. 5-notata*). (*After Britton.*)

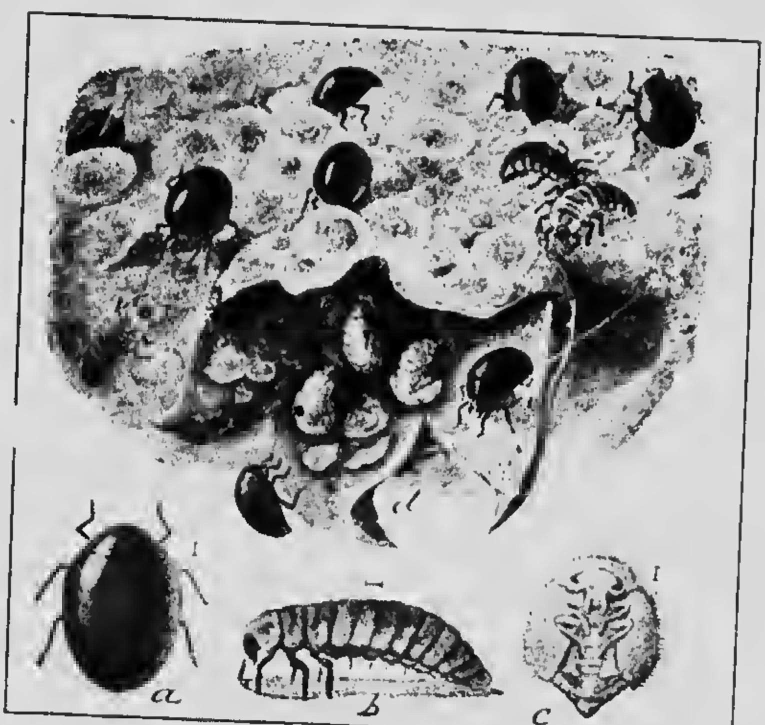


FIG. 189.—*Pentilia misella* LeC.; *a*, beetle; *b*, larva; *c*, pupa; *d*, blossom end of scale infested pear, showing beetles and their larvæ feeding upon the scales, all greatly enlarged. (*After Howard and Marlatt, Bull. 3 Div. Ent., U. S. Dept. Agric.*)

margins yellow and two oblique yellow dashes; head black with yellow between the eyes; legs and under surface of body black. Larva yellow with black spots and cross bands. Feeds on plant-lice, etc. One-fourth to one-third inch long (Fig. 188).

Thirteen-spotted Lady-bird (*Hippodamia 13-punctata* Linn.).—Wing-covers reddish-yellow marked with 13 spots; thorax black with yellow margins; head black with yellow mouth-parts. Under surface of body and femora black; tibiæ and tarsi yellow. Feeds on plant-lice.

Fig. 190.—The squash lady-bird beetle (*Epilachna borealis*).

Five-spotted Lady-bird (*Coccinella 5-notata*).—Wing-covers red with five black bands; thorax with front lateral margins yellow; head black with two yellow spots between the eyes; legs and under surface black. Feeds on plant-lice. One-fourth to three-eighth inch long (Fig. 189).

Nine-spotted Lady-bird (*Coccinella 9-notata* Herbst.).—Wing-covers reddish-yellow with 9 black spots; thorax black with front margin or red yellow; head red or yellow; legs and under surface black. Larva with black markings on thorax and white markings on abdomen. Feeds on plant-lice. One-fourth to three-eighth inch long.

Fifteen-spotted Lady-bird (*Anatis 15-punctata* Oliv.).—Wing-covers reddish yellow with 8 spots on each; thorax black with wide white lateral margins with a black spot in each, and two whitish spots at posterior margin; under surface of body black with yellowish margins; femora black, tibiæ and tarsi brown 2/5 inch long. Larva large, black with sharp spines on each segment. Feeds on plant-lice. Three-eighth inch long (Fig. 187).

Squash Lady-beetle (*Epilachna borealis* Fab.).—A native insect occurring in the east as far north as Canada. The adult and larva of this lady-beetle feed on the leaves of cucumbers. The adult is orange-yellow with four black spots on the thorax and seven on each wing-cover. The larva is yellow and armed with six rows of forked black spines. The adults hibernate in large colonies beneath leaves on the ground (Fig. 190).

DERMESTIDÆ (LARDER AND CARPET BEETLES)

Larder Beetle (*Dermestes lardarius* Linn.).—Sometimes a pest in meat pantries, and where skins and feathers are kept.

Adult.—Dark brown, 1/3 inch long, oval; a pale yellowish-brown black-dotted band across the front half of the wing-covers. Hibernates.

Eggs.—Laid on meat, or in crevices near the food.

Larva.—One-half inch long, brown above, white below and covered with long brown hairs; feeding on surface of meat at first, later burrowing into it and pupating there.

Control.—Trap or collect the beetles; clean the pantry thoroughly; wrap the hams very closely; fumigate the pantry.

Buffalo Carpet Beetle (*Anthrenus scrophulariæ* Linn.).—A serious pest of carpets and woolens. Introduced from Europe, where it is principally a museum pest (Fig. 191).

Adult.—A stout oval beetle, 3/16 inch long, with black, white and red mottled wing-covers. Winters normally out of doors, under bark of trees, and other shelters. In spring it visits the flowers of spiræas, cherries, etc. Probably two generations in the North.

Eggs.—Laid in convenient places on carpets or other woolens. Hatch in a few days.

Larva.—A stout active grub, 1/4 inch long, covered with stiff brown hairs, forming tufts at the sides and at the end of body. Develops rapidly, but may be retarded by cold weather or by lack of food Normally six moults; feeds on woolens.

Pupa.—Yellowish, formed within a larval skin.

Control.—Use rugs; remove and beat the carpets, and spray them with gasoline; scrub the floors with soap and water; spray floors with gasoline, and fill the cracks with putty.

Black Carpet Beetle (*Attagenus piceus* Oliv.).—Introduced from Europe. Injury done by the larva.

Adult.—A small black oval beetle, smaller than the Buffalo Carpet Beetle, 1/16 inch long.

Eggs.—White, broadly oval; laid about the edges of the carpet or on woolens.

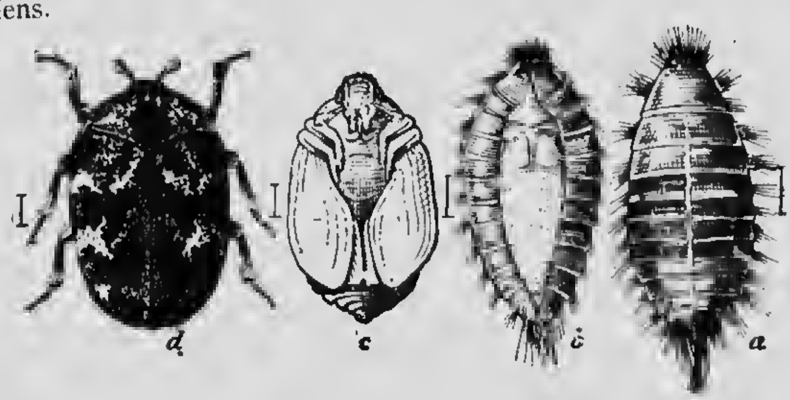


FIG. 191.—Buffalo carpet beetle (*Anthrenus scrophulariæ*): *a*, larva, dorsal view; *b*, pupa within larval skin; *c*, pupa, ventral view; *d*, adult. All enlarged. (*From Riley.*)

Larva.—A reddish-brown active grub, 1/3 inch long, with a long bushy tail of reddish hairs; body cylindrical with closely appressed hairs.

Pupa.—Duration 6–15 days; clothed with a coat of whitish hairs.

A museum pest; a house pest feeding on woolens, carpets and feathers. Probably requires 2 years for life-cycle.

Raspberry Byturus (*Byturus unicolor* Say). *Adult.*—A small brown dermestid beetle, 1/7 inch long; body covered with pale tawny hairs. May–July. Feeds on young leaves and buds.

Eggs.—Laid in June on the unripe fruit, one egg on a berry and attached by one side to one of the carpels.

Larva.—A small white plump cylindrical grub, 1/4 inch long; each segment marked crosswise with a broad yellow band and many short white hairs. Feeds on heads bearing the berries.

Pupa.—Yellowish, formed in an earthen cell in the ground, where it winters.

Control.—Spray with arsenate of lead, 3–4 lb. to about 40 gal., where beetles first appear.

SILPHIDÆ (CARRION BEETLES)

Spinach Carrion Beetle (*Silpha bituberosa* Lec.).—The shiny black active flattened larva of this dull black beetle destroys the leaves of spinach, pumpkin, squash, beet, etc. at night. Eggs are laid in June and the grubs mature four or five weeks later. The adult beetles winter under clods, etc.

S. opaca L. is also an injurious species in the West.

ELATERIDÆ (CLICK BEETLES, WIREWORMS)

Common Economic Genera (After Leconte and Horn):

A. Hind coxal plates suddenly dilated about the middle, the outer part much narrower than the inner.
- B. Prosternum very broad, sutures straight, side pieces of mesothorax reaching the middle coxæ.—*Cryptohypnus.*
- BB. Prosternum of moderate width; sutures double and not excavated in front; third joint of antennæ longer than second.—*Drasterius.*

AA. Hind coxal plates gradually dilated on the inner side.
- B. Clypeus or front convex and truncate, its edge higher than the labrum, mouth inferior and applied to the prosternum in repose. Side margins of thorax bent downward in front.—*Agriotes.*
- BB. Clypeus or front flattened; mouth horizontal or anterior.
  - C. Front margined; tarsal claws with comb-like teeth.—*Melanotus.*
  - CC. Front not margined.
    - D. Tarsi simple, filiform.—*Corymbites.*
    - DD. Tarsi with the second and third joints lobed beneath.—*Asaphes.*

Wireworms

The larvæ of click beetles are known as "Wireworms" of which several species are injurious to the roots of cereal crops. Perhaps the most common are *Agriotes mancus*, *Drasterius elegans*, *Asaphes de-*

coloratus, Melanotus communis, Cryptohypmus abbreviatus, and *Corymbites* spp. (Consult Bull. 156, Bur. Ent., U. S. Dep. Ag., 1915.)

Adults.—Slender oval hard beetles (the "click" or "snapping" beetles) with serrated antennæ, mostly brownish in color, sometimes black or greyish, or even metallic. In *Agriotes mancus* Say, the "wheat wireworm," the thorax is very convex, coarsely and densely punctate, and the front or clypeus convex. It is dull brownish yellow, dusky beneath, sparsely pubescent, and about 1/3 inch long. *Diasterius*

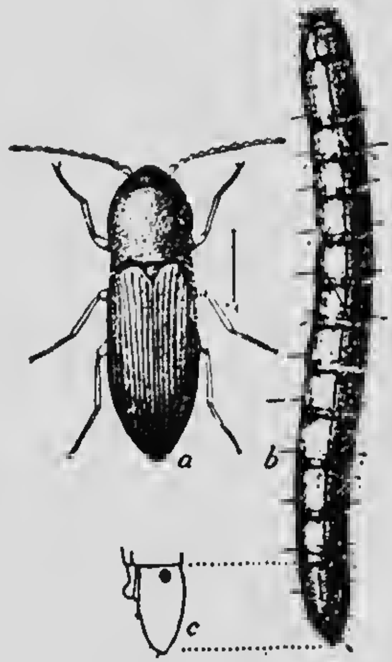


FIG. 192.—*Agriotes mancus.* (*After Forbes.*)

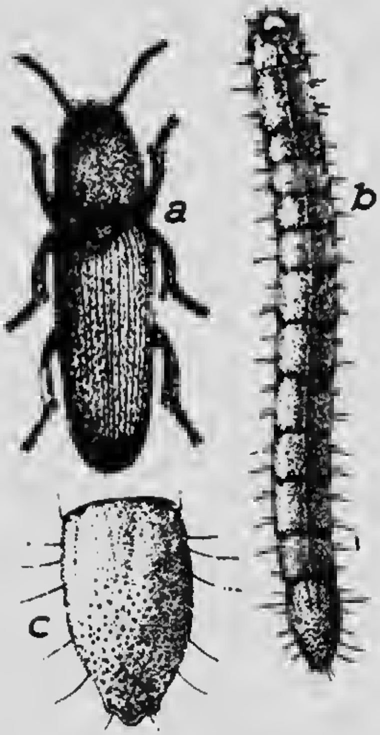


FIG. 193.—*Melanotus cribulosus.* (*After Forbes.*)

elegans Fabr. is dull reddish brown, about 1/3 inch long, sparsely pubescent, head black, a median black spot on thorax, a black spot in front of middle of each wing-cover, and a black cross-bar near the apex. *Asaphes decoloratus* Say is shining black, about half an inch long, with hind angles of thorax divergent. *Melanotus communis* Gyll. is about 1/2 inch long, dull brown, and with a more or less distinct median impressed line on basal half of thorax (Figs. 192–195).

Larvæ.—Slender, cylindrical, yellowish or reddish-brown, wire-like grub, mostly vegetable feeders, in the ground; more than an inch long when full grown. Require 2 to 5 years to reach maturity.

Pupa.—A soft white body resembling the adult in form, in a pupal cell in the ground.

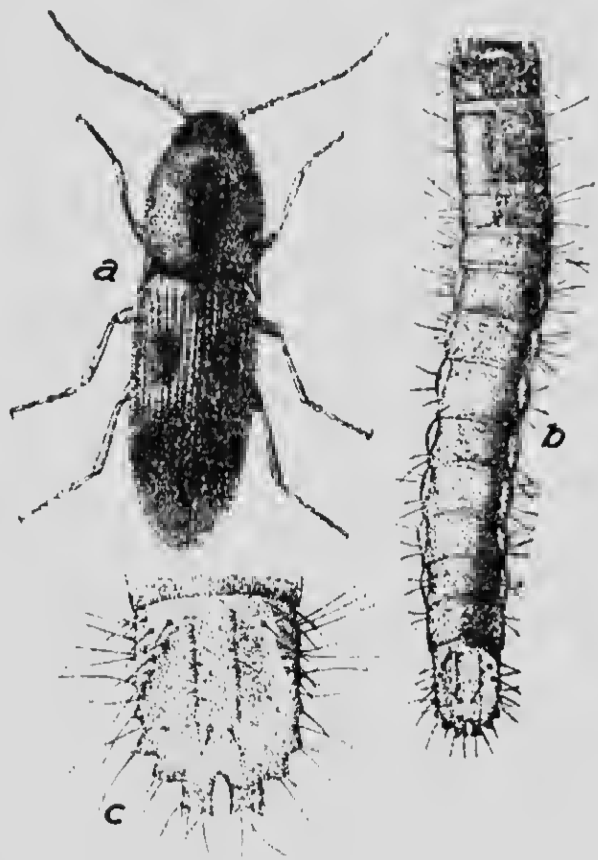


FIG. 194. *Drasterius elegans.* (After Forbes.)

Agriotes mancus Say (*Wheat Wireworm*).—Mating takes place in April and May, and eggs are laid immediately in grass lands. The larvæ feed for 2 full years, pupating in July. The pupal stage lasts from 2 to 3 weeks in the pupal cell about 5 inches below the surface. Larvæ have been reported feeding on the roots of wheat, corn, turnip, cabbage, cucumber and carrot; on potato tubers and on corn seed.

The grub of *Agriotes mancus* is cylindrical, pale brownish-yellow, highly polished, with two black pits on last segment which tapers gradually to a brown point, and about an inch long when full grown.

Melanotus spp. (*Corn Wireworms*).—The larvæ spend 2 to 5 years in the soil, and feed on corn, and other cereal and forage crops. Common species observed: *M. communis*, *M. fissilis*, *M. cribulosus*.

Hyslop reports that larvæ of *Melanotus* are largely confined to poorly drained and heavy sour soil. They spend 2 to 5 years in the

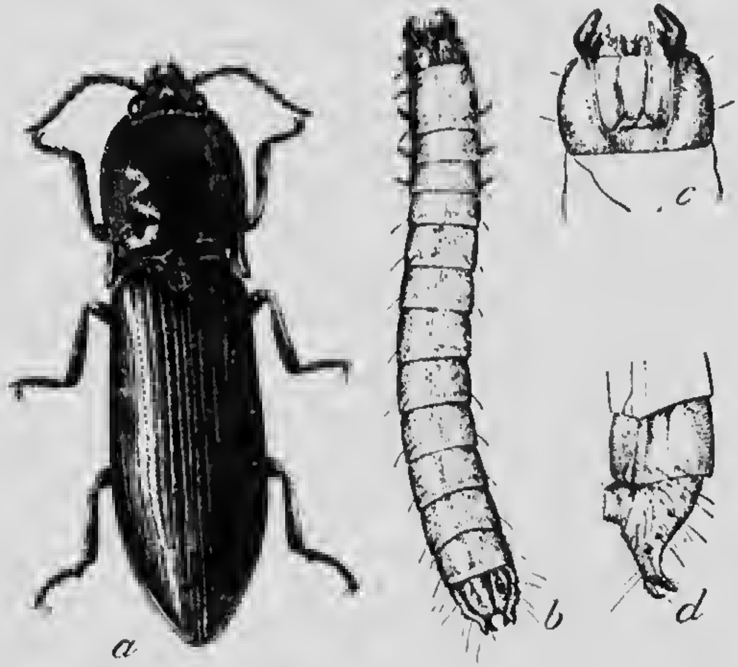


FIG. 195.—The dry-land wireworm (*Corymbites noxius*): *a*, adult; *b*, lar- *c*, under surface of head of larva; *d*, side of last segment of larva. All enlarge (*After Walton, U. S. Bur. Ent.*)

soil; pupate in July–August, adults transforming 12–22 days later, but emerging the following spring.

The grub of *Melanotus communis* is smooth and shining and of a light brown color; the last segment ends in a blunt tubercle.

The grub of *Drasterius elegans* is one of the smallest wireworms, being $\frac{1}{3}$ to $\frac{1}{2}$ inch long, and of a light waxy yellow color. The last segment has an acute apical notch, is nearly flat, and roughish above.

The grub of *Asaphes decoloratus* is above 3/4 inch long, with an oval apical notch on last segment; dark waxy yellow; matures in May-June. Pupal stage lasts about 3 weeks.

Cryptohypnus abbreviatus Say.—A common wireworm in Eastern United States and Canada. Adult is small, 3/16 inch long, broad and flattened; dark brown. Larva is 1/2 inch long, flattened, pale yellow, and its caudal segment furnished with a circular notch; resembles that

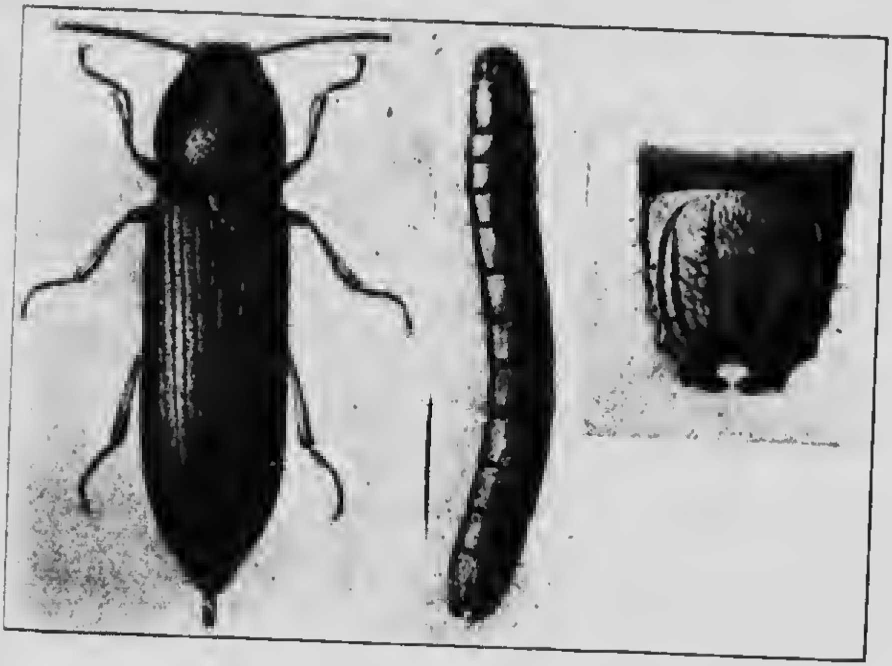


FIG. 196.—*Limonius confusus.* (*After Walton.*)

of *Drasterius elegans.* Pupates in August-September; adult emerges 9 days later.

Corymbites caricinus, C. tarsalis, C. cylindriformis feed on flower buds of apple and pear in Canada.

General Life-history of Wireworms.—The full grown larvæ change to pupæ in the soil in July and August. These become adult beetles in about a month, but remain in the ground until spring in their pupal cells. On emerging they lay their eggs in grass lands in the earth. It is probable that the larval stage of most species lasts 2 years, but in some species 3 or even 5 years.

Control.—Professors Comstock, Slingerland and Forbes several years ago carried on a long series of experiments in the hope of finding out a satisfactory method of treating wireworms. These experiments were carried out along three lines:

1. By the protection of the seed.
2. By the destruction of grubs by cultivation and clean fallow, and immune crops, and by the use of insecticides and fertilizers.
3. By trapping the adult click beetles.

The following substances were used as a protection for the seed:

1. A coating of Paris Green and flour.
2. A coating of tar.
3. Soaking the seed in a solution of salt.
4. Soaking the seed in a solution of copperas.
5. Soaking the seed in a solution of chloride of lime and copperas
6. Soaking the seed in a solution of kerosene oil.
7. Soaking the seed in a solution of spirits of turpentine.
8. Soaking the seed in a solution of strychnine.
9. Soaking the seed in a mixture of Paris green and water.
10. Soaking the seed in an alcoholic solution of arsenic.
11. Soaking the seed in a solution of arsenic and boiling water.
12. Soaking the seed in an alcoholic solution of corrosive sublimate
13. Soaking the seed in a saturated solution of potassium cyanide.

In almost every case the wireworms fed upon the grain or seed thus coated without injury to themselves, and the investigators were forced to the conclusion that it was not practicable to protect the seed by means of these substances even were it possible to use them without preventing or retarding the germination of the seed.

Buckwheat, mustard and rape, which are supposed by many to be immune crops, were found to be not entirely so, for the wireworms in some instances fed upon these plants almost as readily as upon cereal plants.

Insecticides were also used in the effort to destroy wireworms. The following were applied directly to the soil:

1. Kerosene emulsion, and pure kerosene.
2. Crude petroleum emulsion, and pure crude petroleum.
3. Poisoned dough.
4. Bisulphide of carbon.
5. Salt.

6. Muriate of potash.
7. Lime.
8. Chloride of lime.
9. Gas lime.

The results of these experiments showed that as insecticides most of these substances are of very doubtful value. Such a large amount would have to be used in many instances as to completely destroy all vegetation; and the cost would be so excessive as to make their application impracticable.

The following methods were found of value:

1. Trapping the wireworms and beetles by means of lanterns, and in some cases by means of poisoned dough placed under boards in infested spots.

2. Plowing late in fall and keeping the earth stirred more or less up to the time winter sets in. By this means large numbers of the newly transformed pupæ, which do not become fully hard until spring, are destroyed. It must not be supposed, however, that all of the wireworms are killed by such treatment, for the ordinary wireworms spend from 3 to 5 years in the ground feeding on the roots of plants before they appear as adult beetles. It is only when the wireworms are transforming into pupæ in the fall that they are very sensitive to disturbance of any kind. When the worms are numerous in small areas, especially in spots on low, poorly drained land, they may be easily trapped by placing under boards bunches of clover or sweetened bran poisoned with Paris green.

3. A short rotation of crops, in which the fields are not allowed to remain more than two seasons in grass land, will be found very effective. It is frequently observed that wireworms are more destructive during the second season after the sod is plowed up than the first. This is because there is sufficient vegetable matter in the soil during the first season to furnish a plentiful supply of food; but with the gradual rotting of the soil from another season's plowing the food is removed and wireworms then take to the roots of the growing plants. With the breaking up and thorough working over of grass land in the fall, much of the old vegetable matter may be destroyed (see Part IV).

4. By the application of mineral fertilizers, it is often possible to force the crops in the following season in spite of the wireworms. (Consult Bull. 33, Cornell; Bull. 44, Ill. Agr. Exp. Stn.)

BUPRESTIDÆ (METALLIC WOOD BORERS)

Common Genera (after Blatchley):

A. Hind coxal plates dilated near base.

B. Prosternal spine obtusely angulated behind the coxæ; epimera of metathorax triangular, uncovered.

C. Mentum entirely horn-like, elytra without yellow markings. *Dicerca.*

CC. Mentum membranous in front; elytra usually marked yellow. *Buprestis.*

BB. Prosternal spine acutely angulated behind the coxæ; epimera of metathorax partly covered by abdomen. Clypeus contracted, scutellum large, first joint of hind tarsi elongate.—*Chrysobothris.*

AA. Hind coxal plates scarcely dilated near base.

B. Hind tarsi with first joint as long as the three following; antennæ free; thorax truncate at base; clypeus not narrowed.—*Agrilus.*

Flat-headed Apple-tree Borer (*Chrysobothris femorata* Fab.).- (Consult Bull. 437, U. S. Dep. Agric.)

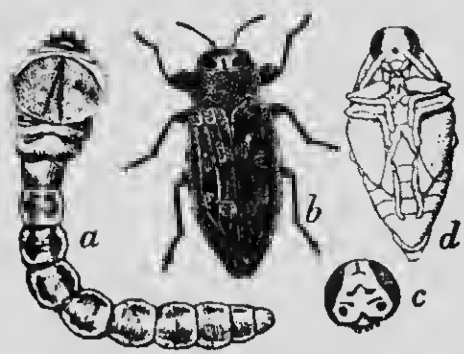


FIG. 197.—Flat-headed apple-tree borer (*Chrysobothris femorata*): *a*, larva; *b*, beetle; *d*, pupa. (*After Chittenden, U. S. Bur. Ent.*)

This borer attacks shade and forest trees as well as orchard trees, and is of common occurrence. It attacks unhealthy trees by preference (Fig. 197).

Adult.—A dark flattened metallic brown buprestid beetle, ½ inch long; wing-covers parallel, thin, tapering to a point behind, under surface greenish-blue; under surface of body coppery-bronze. June.

Eggs.—Yellowish, ribbed, 1/50 inch long; deposited in crevices of the bark, often several together.

Larva.—Light yellow, 1 inch long when full grown; thorax broad and flattened; abdomen flattened and often curved. Head small and concealed by thorax; tunnels formed immediately under the bark, sometimes girdling the trees. Matures in a year and winters as a full grown larva.

Pupa.—Yellowish; duration about 3 weeks, in spring.

Parasites.—Certain braconids, ichneumonids and chalcids.

Control.—Application of alkaline washes, of soap, washing soda and crude carbolic acid in May and June; wire netting as a protector; clean culture; digging out the borers.

Red-necked Blackberry Borer (*Agrilus ruficollis* Fab.). *Adult.*—Wing-covers velvety brownish-black; head small, wide, dark, bronze; front with a deep median furrow; prothorax bright coppery-red; under side black; 3/10 inch long. June–July. Native.

Eggs.—Laid in July on young canes.

Larva.—Thread-like, pale yellowish; anterior segment enlarged and flattened; head small, brown, jaws black; tip of abdomen with two slender dark-brown horns, each with three blunt teeth on inner edge; 6/10 inch long.

Makes spiral tunnels in sap-wood, often causing a swollen appearance called the gouty gall. Winters as full-grown larva in the burrow.

Pupa.—Formed in May.

Bronze Birch Borer (*Agrilus anxius* Gory).—(Consult Bull. 18, Div. Ent., U. S. Dept. Ag.) Bark of infested birch trees riddled with holes; wood showing a labyrinth of burrows made by the larvæ, the bark showing a number of ridges and the top the characteristic "stag-head."

Adult.—Olive-brown, 1/3 to 1/2 inch long; last ventral segment oval at tip; hind angles of thorax carinate. May–June. Emergence-holes semicircular.

Eggs.—Laid in crevices of the bark. Hatch in June.

Larva.—Creamy-white, 3/4 inch long; mouth-parts dark; tip armed with a pair of linear, serrate chitinous bars; head flattened. Winters in an immature state, becoming full-grown in April or early May.

Pupa.—White, 1/2 inch long, tapering to tip of abdomen.

Control.—Remove and burn tree before middle of June; at least cut well below dead portion. Pruning useless unless it is extensive, for when the top dies usually most of the tree is affected.

Two-lined Chestnut Borer (*Agrilus bilineatus* Oliv.).—Destructive to oaks in the N. W. States. The eggs are laid in the spring on the bark, and the grubs burrow beneath the bark in the growing layer, often girdling the tree.

SCARABÆIDÆ (SCARABÆIDS)

Groups:

A. Abdominal spiracles situated on the membrane; upper surface of head usually dilated.—*Scavengers, or Dung-eating and Skin Beetles.*

AA. Abdominal spiracles not situated on the membrane; upper surface of head rarely dilated.—*Leaf-chafers.*

Common Economic Genera of Leaf-chafers (after Blatchley):

A. Abdominal spiracles in part situated on superior portion of ventral segments; the rows of spiracles feebly diverging.
  B. Form slender, elongated; dull yellow; elytra densely covered with scales.—*Macrodactylus.*
  BB. Form robust, heavy; brownish; six ventral segments.
    C. Small, ventral segments free; elytra with regular indistinct grooves on disk.—*Serica.*
    CC. Medium sized, ventral segments connate; elytral disk without grooves.—*Phyllophaga = Lachnosterna.*

AA. Abdominal spiracles (excepting the three front ones) situated on dorsal portion of ventral segments, forming two rows which diverge strongly.
  B. Tarsal claws unequal in size.
    C. Elytra with membranous margin; antennæ 9-jointed.—*Anomala.*
    CC. Elytra without membranous margin; antennæ 10-jointed.
      D. Elytra with black spots.—*Pelidnota.*
      DD. Elytra without spots.—*Cotalpa.*
  BB. Tarsal claws equal in size.
    C. Front coxæ transverse; body above convex.
      D. Head and thorax unarmed in both sexes; mandibles narrow, brownish yellow.—*Cyclocephala.*
      DD. Head or thorax (or both) armed in both sexes; mandibles toothed on outer side; clypeus bidentate; dark reddish brown.—*Ligyrus.*
    CC. Front coxæ conical, prominent; body not convex; antennæ 10-jointed.
      D. Side-pieces of mesothorax visible from above; sides of elytra more or less sinuate; thorax triangular; never uniform black.—*Euphoria.*
      DD. Side-pieces of mesothorax not visible from above; sides of elytra not sinuate; hind coxæ contiguous.
        E. Body almost glabrous; size large; color uniform.—*Osmoderma.*
        EE. Body pubescent; size smaller; color variegated; thorax rounded at base.—*Trichius.*

White Grubs (*Lachnosterna = Phyllophaga*, spp.).—White grubs are the larvæ of May or June beetles, the majority belonging to the genus *Phyllophaga* or *Lachnosterna.* The following species: *L. fusca*, Frol., *L. anxia*, *L. calceata rugosa* Melsh, *L. futilis* (*gibbosa*), *L. fervida* (*arcuata*) Smith, *L. implicita* Horn, *L. hirticula*, *L. fraterna* Harr., *L. tristis* Fab., and *L. illicis* Knoch are perhaps the most abundant (Figs. 198 and 199).

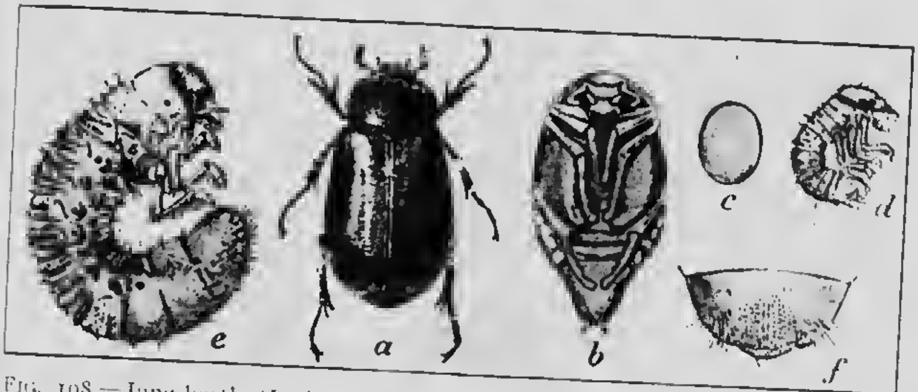


FIG. 198.—June beetle (*Lachnosterna arcuata*): *a*, adult; *b*, pupa; *c*, egg; *d*, newly hatched larva; *e*, mature larva. (*After Chittenden, U. S. Bur. Ent.*)

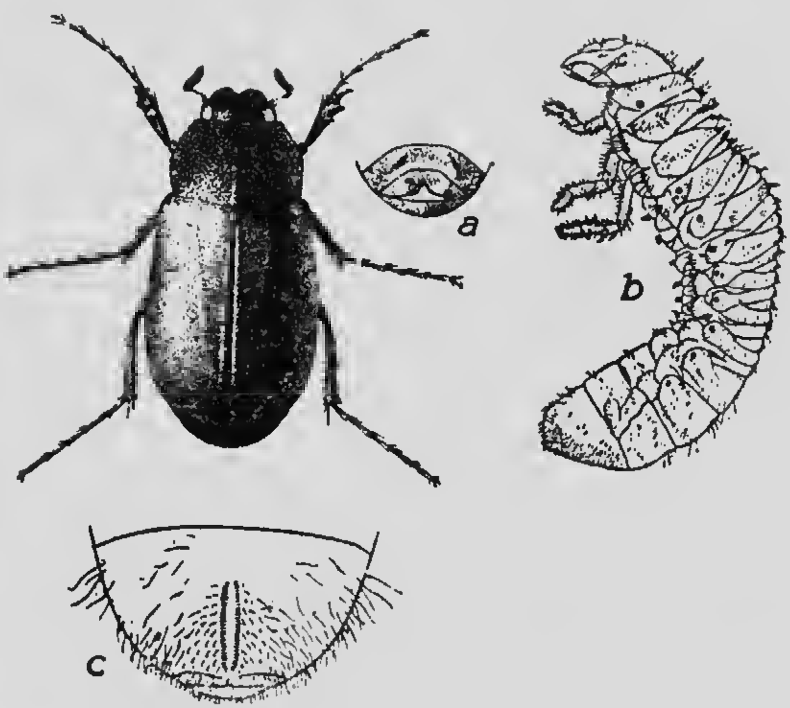


FIG. 199.—June beetle (*Lachnosterna rugosa*): *a*, adult; *b*, larva; *c*, last segment of larva. (*After Forbes.*)

Adults.—Robust, pale reddish, or yellowish-brown to piceous lamellicorn beetles, with long dense hairs on the sternum; about 3/4 inch long. On emerging from the ground they fly about at night in search of food, pair in the trees and retreat again to the earth by day and remain in hiding. Food plants various.

Eggs.—Oblong-oval, pearly white, translucent; about 1/8 inch long; deposited singly from 1 to 8 inches below the surface of the soil within oval cavities in the centre of balls of earth. Hatch in about 2 weeks.

Larvæ.—Large, soft, white grubs with brownish heads; hinder portion of body thick and smooth; ventral surface of anal segment with a triangular patch of brownish hooked hairs and with a median double row of coarse hairs; anal slit in the form of an obtuse angle.

Pupæ.—Whitish bodies in oval cells.

Life-history.—The eggs are laid in May and June; the grubs feed throughout the next two seasons and in June or July of the third year they change to pupæ. Two or three weeks later they change to adult beetles but remain in their pupal cells until the following spring. In other words, larvæ hatched in June, 1913 change to pupæ in July, 1915, and the beetles emerge in May and June, 1916. During the winter the grubs descend for protection. The life-cycle of *L. tristis* is 2 years longer for all forms in the North than in the South. Not known to breed in manure.

Control.—Fall plowing; utilizing hogs and poultry; rotation of crops; collecting the grubs and beetles; spraying trees upon which beetles feed (see Part IV).

Of related genera *Ligyrus gibbosus*, *L. relictus*, *Cyclocephala immaculata*, *Allorhina nitida*, and *Euphoria* have a 1-year life-cycle, while *Cotalpa lanigera* and *Polyphylla* require 4 or 5 years. *Cotalpa lanigera* is in some districts destructive to raspberry, strawberry, corn and grass.

Natural Enemies.—*Pyrgota undata*, *Tiphia*, Asilids, carabids; crows and blackbirds; annelids; skunks, *Cordyceps*.

Biological facts of importance have been obtained in recent years (see Bull. 116, 186, 187, Ill. Agr. Exp. Station, and Farmers' Bull. 543 U. S. Dept. Agric.) regarding the habits of White Grubs. These may be summarized as follows:

(*a*) Some species, *L. tristis* and *L. farcta* have a life-cycle of 2 years, but most others have a cycle of 3 or 4 years.

(b) The life-cycle tends to lengthen northward.

(c) The adult beetles feed on the leaves of oak, ash, elm, poplar, willow, maple, hackberry, plum and apple during the night and migrate to the soil in early morning. Mating occurs at night. They have been observed feeding on corn and grass.

(d) The eggs are generally deposited in the high grounds covered by vegetation near woodlands.

(e) Clover, alfalfa and buckwheat are not injured, and small grains are not so much injured as are corn, timothy, strawberries and potatoes.

(f) As the grubs change to pupæ about the end of July, disking infested land as soon after that date as practicable destroys large numbers of the tender pupæ and adults in the ground.

(g) As grubs are small the first year, and large the second year, plowing up to 1st of October destroys large numbers.

(h) White grubs are most abundant in the neighborhood of trees.

(i) The adult beetles prefer to lay their eggs on (1) pasture, (2) small grains, (3) fallow land grown up to weeds, (4) clover and corn, (5) meadow crops (Forbes).

Rough Osmoderma (*Osmoderma scabra* Beauv.).—*Adult.* A large, bronzy, purplish-black beetle; wing-covers with coarse punctures; thorax narrower than wing-covers. Nocturnal; July September.

Larvæ.—Resemble white grubs, with a hard, reddish head, and horny scales on prothorax. Live in decaying wood of apple, cherry, etc., mature in fall.

Pupa.—Within an oval cocoon made of fragments of wood.

Bumble-flower Beetle (*Euphoria inda* Linn.).—*Adult.*—A yellowish-brown beetle, with wing-covers covered with black spots; body covered with fox-colored hairs; under side of body black and hairy; legs black; hibernates.

Eggs.—Deposited in refuse heaps of decaying vegetable matter.

Larvæ.—Resemble white grubs; head small; mandibles and legs short; spiracles prominent; a yellow plate on each side of first thoracic segment; anal slit transverse; dorsal locomotion; live chiefly in rotten wood or decaying vegetables.

Rose Chafer (*Macrodactylus subspinosus* Fabr.).—(Consult Cir. 11, Div. Ent., U. S. Dep. Ag.) Frequently injurious to grapes, peaches, plums, roses, etc., destroying the blossoms and newly set fruit. A widely distributed pest.

Adult.—A long-legged yellowish-brown beetle, 1/3 inch long, covered with light hairs; legs spiny and long; end of June first half of July. Feeding for 3–4 weeks. Toxic to chickens and rabbits.

Eggs.—Smooth, white, oval; laid singly (24–36) a few inches below the surface of the ground; hatch in 2–3 weeks.

Larva.—Yellowish-white with a pale brown head; 3/4 inch long when full grown; white-grub like; matures in autumn and hibernates in the ground. Feeds on the roots of grasses in sandy areas.

Pupa.—Pupal stage entered in spring and lasts for 10–30 days. 3/4 inch long, yellowish brown.

Control.—Spray trees with arsenate of lead sweetened with molasses.

CHRYSOMELIDÆ (LEAF BEETLES)

Common Economic Genera (after Leconte and Horn):

A. Head produced; thorax narrower than elytra; mandibles simple, pointed. (Criocerini).
- B. Thorax cylindrical, not constricted.—*Crioceris.*
- BB. Thorax constricted.—*Lema.*

AA. Head inserted in the thorax to the eyes; thorax as broad as the elytra; mandibles with several teeth.
- B. Last dorsal segment of abdomen not exposed.
  - C. Antennæ widely separated at base.
    - D. Front coxæ transverse.—*Leptinotarsa* (Chrysomelini).
    - DD. Front coxæ rounded; 3d tarsal joint bi-lobed.—*Fidia* (Eumolpini).
  - CC. Antennæ rather close at base; front coxæ conical.
    - D. Hind thighs slender and front coxal cavities open behind.—(Galerucini).
      - E. All the tibiæ without terminal spurs.—*Galerucella.*
      - EE. Middle and hind tibiæ with terminal spurs.—*Diabrotica*
    - DD. Hind thighs thickened.—(Halticini).
      - E. Front coxal cavities open behind.
        - F. Thorax with a feeble transverse impression on basal half; hind tibiæ with a short terminal spur. —*Haltica.*
        - FF. Thorax without a transverse impression near the base.
          - G. First joint of hind tarsus short and rather broad; claws appendiculate.—*Disonycha*
          - GG. First joint of hind tarsus long and slender; claws simple; elytra usually with a yellow stripe or spots.—*Phyllotreta.*
      - EE. Front coxal cavities closed behind.
        - F. Antennæ 11-jointed; claws appendiculate.
          - G. Thorax with a distinct transverse impression near base.
            - H. Elytra without hairs.—*Crepidodera*

HH. Elytra with rows of stiff hairs.—*Epitrix.*

GG. Thorax without a transverse impression near base; elytral punctures confused.—*Systena.*

FF. Antennæ 10-jointed; hind tarsi inserted on the outer side of tibiæ above the apex; elytral punctures in rows.—*Psylliodes.*

Striped Cucumber Beetle (*Diabrotica vittata* Fab.).—(Consult Cir. 31, Bur. of Ent., U.S. Dep. Agr., 1909.) A native pest, destructive to squash, melon and cucumber, especially in early spring, both in adult and larval stages. Well distributed. Known also as the "Melon-bug" and "Striped Bug" (Fig. 200).

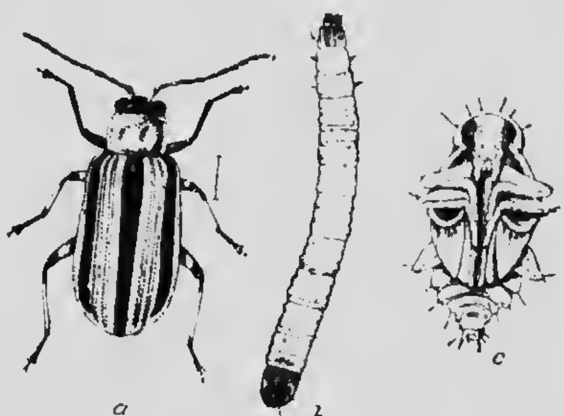


FIG. 200.—Striped cucumber beetle (*Diabrotica vittata*): *a*, beetle; *b*, larva; *c*, pupa; *d*, egg; *e*, sculpture of same; *a*, *b*, *c*, much enlarged; *d*, more enlarged; *e*, highly magnified. (*After Chittenden.*)

Adult.—A yellow beetle 2/5 inch long, with a black stripe on each side of each wing-cover; head black; under surface mostly black. Hibernates.

Eggs.—One-fortieth inch long, lemon to orange in color, oval; laid singly or in groups in the soil about the roots. Hatch in 9–10 days.

Larva.—A slender white worm-like grub with head, thoracic and anal plates dark brown; lives in the soil, feeding on or in the roots, and matures in about a month.

Pupa.—Formed in an earthen cell 2–3 inches below surface; 1/4 inch long; whitish; duration 1–2 weeks.

Life-history.—Probably two broods a year. The adults hibernate under rubbish, etc., but appear again in April or May. They attack cucurbits when set out or appear above ground and later deposit eggs in the soil or upon the plants. Beetles of the second brood appear in July.

Control. Spray the early and late beetles with arsenate of lead as summer beetles do not eat much. Keep vines well covered with Bordeaux; use trap squashes; place cheese-cloth screens over plants; dust plants frequently with lime, ashes, tobacco dust, etc., to which a little turpentine or crude carbolic acid has been added.

Twelve-spotted Cucumber Beetle (*Diabrotica duodecem-punctata* Oliv.).—This beetle is a pest of cucurbits and vegetable crops in the north and of corn in the south where it is known as the Southern Corn-root Worm, Budworm or Drill Worm. There are two broods in the north and probably more in the south.

Adult.—One-fourth inch long, bright green marked with twelve black spots; practically omnivorous; hibernates; May–July; October–November (Ky.).

Eggs.—Dull yellow, oval, 1/40 inch long; laid singly just beneath the surface of the soil; April–June; hatch in 7–10 days.

Larva.—Slender, thread-like, delicate and soft bodied; yellowish-white; matures in about a month. Injures the roots, crown and growing bud of the young stem. Breeds chiefly in grasses and corn and on weeds.

Pupa.—Formed in the soil; duration about a week.

Western Corn-root Worm (*D. longicornis* Say) is a corn pest in the northern Mississippi valley. The eggs of this species are oval and dirty white; they are laid in the fall just beneath the surface of the soil, winter over and hatch the following spring after the corn begins to grow. The larvæ feed on the roots and often kill the plant; they reach maturity by August 1st, and pupate. The greenish-yellow adults emerge in the autumn, and may be found feeding upon pollen and silk of the corn plants; also on clover, beans, cucumber, thistle, golden rod, sunflower, etc.

Colorado Potato Beetle (*Leptinotarsa decem-lineata* Say).—The most serious insect pest of potatoes. A native feeder on wild Solanums in Colorado, migrating eastward, reaching the Atlantic in 1874. Found nearly everywhere the potato is grown in United States and Canada.

Adult.—An oval, convex, robust ochre-yellow beetle with ten black longitudinal lines on wing covers and about 14 spots on thorax; 1/4–1/3 inch long; hibernates.

Eggs.—Orange, oval, laid in clusters of 12 or more on the lower surface of leaves; hatch in a week. Each female capable of laying 500 1000 eggs in the course of a month.

Larva.—At first dark colored; later, variegated red, soft bodied, hump-backed, with two rows of spots on each side; matures in 2 or 3 weeks.

Pupa.—Naked, yellow or orange colored, in a smooth oval cell below the surface of the soil; duration 10 14 days.

Life-history.—Adult beetles emerge from their winter quarters about the end of May, and soon eggs are deposited. The grubs require 2 or 3 weeks to mature, and the pupa remains about 2 weeks in the soil before the adult appears. There are two broods in a year, the summer adults appearing in July and the fall adults in September and passing the winter deep underground. There is also considerable overlapping of stages and broods on account of variation in times of development.

Control.—Spray with arsenical—Paris green or arsenate of lead.

Enemies.—*Lydella doryphoræ*, a tachinid; *Podisus spinosus* and *Perillus circumcinctus*; ground beetles; lady-birds; the crow and grosbeak.

Red Turnip Beetle (*Entomoscelis adonidis* Fab.). An injurious pest of turnip, cabbage and radish in the Prairie provinces.

Adult.—Scarlet, with three black stripes along the back; collar with a black patch; legs black; smaller than the Colorado potato beetle. July and August to October and November.

Eggs.—Bright red, laid beneath clods of earth, where they pass the winter.

Larva.—Nocturnal; slug-shaped; black; ½ inch long when full grown.

Pupa.—Formed about an inch below the surface of the ground.

Control.—Use arsenical.

Elm Leaf Beetle (*Galerucella luteola* Müller).—(Consult Felt's "Insects Affecting Park and Woodland Trees.") Introduced from Europe into United States about 1834. A serious pest in New England, and especially in the Hudson Valley, has not yet appeared in Canada. The adults eat irregular circular holes in the leaves, and the grubs skeletonize the under surfaces. Two broods.

Adult.—One-fourth inch long; head, thorax and wing margin reddish-yellow; median black line of wing-covers separated from lateral black stripes by greenish-yellow or white at the base; and elongated black spot in each wing-cover. Eyes and median spot on head coal black; a dorsal and two lateral black spots on thorax. Antennæ golden yellow with brownish markings; legs yellowish with tibiæ and tarsi marked with brown. Under surface of head and prothorax yellowish, that of metathorax and abdomen black. Hibernates under rubbish and in shelters.

Eggs.—Orange yellow, fusiform, attached by larger end; laid in irregular rows in clusters on under surface of leaf in June; second brood in July; hatch in 5–6 days.

Larva.—When full grown 1/2 inch long, somewhat flattened, striped dorsally and laterally with yellow stripes; tubercles prominent; under surface yellowish. Black dominates in young stages. Duration 15–20 days.

Pupa.—Bright orange yellow, 1/5 inch long; dorsal surface very convex. Duration 7–24 days according to temperature.

Control.—Spray when leaves are fully unfolded, and 3 weeks later with arsenate of lead (3 lb. to 40 or 50 gal. water).

Western Willow Leaf Beetle (*Galerucella decora* Say).—A serious pest of willows and poplars in some of the prairie provinces and states. Breeds chiefly in willows.

Adult.—Small, dark yellowish or brownish, rather flat; 3/16 inch long. Hibernates. May–June.

Eggs.—Laid on the leaves of willow and poplar.

Larva.—Both larva and adult feed on the leaves.

Control.—Spray the grubs with arsenical and lime. When adults occur in large numbers keep them from the most valuable trees with smudges of damp manure, etc., and spray with lead arsenate (4 lb. to 50 gal. of water).

The following four Chrysomelids also are injurious to willows and cottonwoods in the northern prairie sections:

Cherry Leaf Beetle (*Galerucella cavicollis* Lec.) did considerable injury in 1915 to cherry and peach trees in New York, Pennsylvania and West Virginia. The adults attack the leaves.

Streaked Cottonwood Leaf Beetle (*Lina scripta* Fab.) having dull reddish or greenish-yellow elytra with elongate black spots, and sides of thorax yellow and disk dark metallic green.

Unspotted Aspen Leaf Beetle (*Lina tremulæ* Fab.) with dull yellow elytra without spots, and thorax green.

Interrupted Cottonwood Leaf Beetle (*Lina interrupta* Fab.) having reddish-yellow elytra with rounded black spots, or transverse black bands.

Fruit Tree Leaf Syneta (*Syneta albida* Lec.). A small brown or yellowish-white leaf beetle, 1/4 inch long, is sometimes injurious to fruit trees in the spring in British Columbia and Oregon.

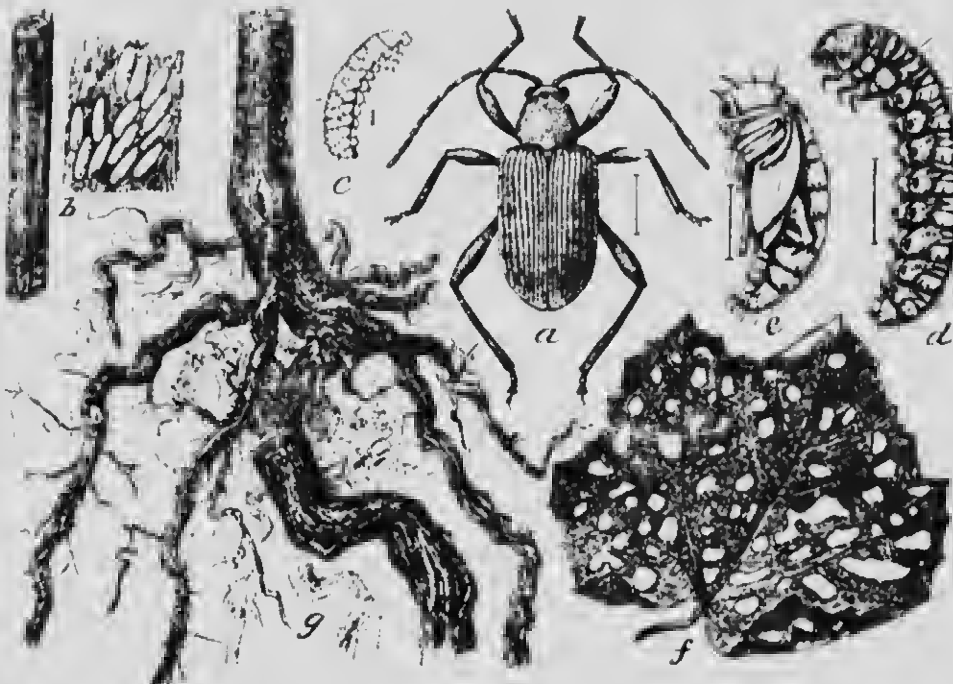


FIG. 201. The grape root worm (*Fidia viticida*). *a*, beetle; *b*, eggs natural size under fold of bark and much enlarged at side; *c*, young larva; *d*, full grown larva; *e*, pupa; *f*, injury to leaf by beetles; *g*, injury to roots by larvae. (*After Marlatt, U. S. Bur. Ent.*)

Grape Root Worm (*Fidia viticida* Walsh). A native American insect, and widely distributed (Fig. 201).

Adult.—A small brownish beetle, 1/4 inch long; covered with whitish hairs; body stout and legs long; June–July; eating holes in the leaves of grape.

Eggs.—Whitish-yellow, cylindrical, 1/25 inch long; laid in masses of 25–40 beneath old bark; hatch in 9–12 days.

Larva.—Young grub feeds on roots and becomes nearly full grown by fall. Winters deeper in the soil, but resumes feeding in the spring. Full grown grub 5/8 inch long, whitish.

Pupa. Formed in an earthen cell 2-3 inches below surface; 1/4 inch long; whitish; head, thorax, and tip of abdomen pinkish and spiny. Duration about 2 weeks in June.

Control. Spray with arsenate of lead and molasses in late June and early July; stir the soil in June.

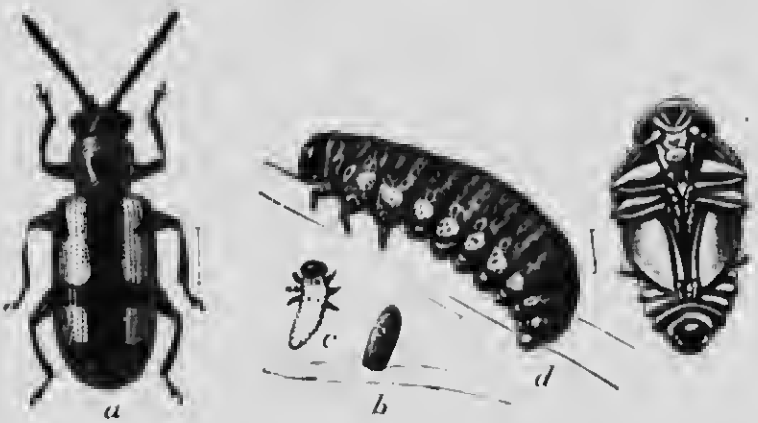


FIG. 202.—The common asparagus beetle: *a*, beetle; *b*, egg; *c*, newly hatched larvæ; *d*, full grown larvæ; *e*, pupa. All enlarged. (*After Chittenden.*)

Asparagus Beetles. The two species of Asparagus Beetles have come from Europe. They injure the tender shoots in the early season, rendering them unfit for market, and later they eat the leaves of the tall seedlings.

Steel-blue Asparagus Beetle (*Crioceris aspara*... *ull* A small beetle 1/4 inch long, blue-black; thorax ...d, ... yellow and black with orange margin. Feeds on the folia...

Eggs.—Dark brown, oval; 1/16 inch long; laid on end on the buds and stems of leaves in a row in early spring; hatch in 3-8 days (Fig. 202).

Larva.—Head and legs black; body dark grey or olive; 1/3 inch long, soft, fleshy, and wrinkled; matures in 10-14 days. Feeds on the foliage.

Pupa.—Yellowish in a rounded earth-covered cocoon in the ground just beneath the surface; beetle emerges in about a week.

Parasites, etc.—*Megilla maculata*, *Hippodamia convergens*, *Podis...* sp., and *Tetrastichus asparagi* Cwf'd, a chalcid.

Twelve-spotted Asparagus Beetle (*Crioceris 12-punctata*). *Adult.* Wings orange-red with 12 black spots. Feeds on the foliage.

Eggs. Laid singly on side, mostly near the ends of old shoots.

Larva.—Three-tenth inch long; head brownish and body yellowish. Feeds within the growing berry.

Pupa.—As in *C. asparagi.*

Control.—Allow chickens the run of the patch; keep all asparagus cut down except the marketable shoots and cut these every day or two; allow some shoots to grow as traps and spray these with arsenate of lead; dust air-slacked lime over the plants while they are wet with dew; beat or brush the larvæ from the plants to the bare ground, where many will die.

Strawberry Root Borer (*Typophorus canellus* Fab.). *Adult.* Small, 1/8 inch long; black to reddish-yellow; black spots on wing-covers. August. Hibernates under mulch. One brood a year.

Eggs.—Laid in spring (May June) on or near the surface of the ground.

Larva.—Full grown in July August; feeds on roots of strawberry.

Pupa.—Formed in a small smooth-lined earthen cell.

Other Strawberry Root Borers are *Graphops pubescens* Mels., a metallic copper-colored Chrysomelid, and *Colaspis brunnea* Fab.

Control.—Adopt short rotation; apply lead arsenate (4 6 lb. in 100 gal. water) to the leaves when beetles appear.

Bean Leaf Beetle (*Cerotoma trifurcata* Forst.). An injurious bean pest in the Eastern Middle and Southern States. The beetles eat large holes in the growing leaves, and the grubs feed on the roots and main stem just below the surface of the ground. One brood in the North but more in the South.

Adult.—A small yellowish-red beetle marked with black; 1/6 inch long; sluggish; hibernates.

Eggs.—Orange-colored; laid in clusters of 6 12 near the bean plant just below the surface; hatch in 5 8 days.

Larva.—Three-tenth inch long, cylindrical, milk-white; head and anal segment dark. Full grown in 6 7 weeks.

Pupa.—White, duration 5 8 days.

Control.—Lead arsenate spray.

Flea Beetles

(Consult Bulls. 19 and 33, U. S. Dept. Agr., Div. Ent.; 211 Maine: Circ. 2 Div. Ent., Can.)

Flea Beetles are minute beetles belonging to several genera of the Chrysomelidæ family. They are leaf-feeding insects, and are characterized by the large femora of the hind legs, which enable them to leap like fleas.

The following species are the most injurious to cultivated plants:

Potato Flea Beetle (*Epitrix cucumeris* Harris).—The adult often injures the leaves of potato, tomato, cucumber, etc. (Fig. 203).

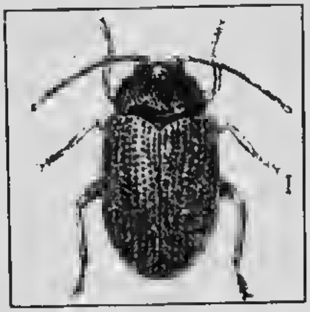


FIG. 203.—Potato flea beetle; line at side indicates natural size. (*After Chittenden, Bul. 19, N. S. Div. of Ent., U. S. Dept. of Agric.*)

Adult.—A shining black minute beetle, $1/15$ inch long; antennæ and legs reddish yellow; hind femora pitch black; thorax sparsely punctate; covered with short fuscous hairs; emerges in April and May; again from July–September.

Eggs.—Laid on roots of food plant in June and July.

Larva.—A slender whitish grub feeding on the tubers and roots, sometimes causing pimply potatoes; 3 weeks.

Pupa.—In small cells about the roots.

Life-history.—Adult beetles hibernate under rubbish, emerge in spring to lay eggs and to attack the leaves. Probably two or more broods.

Control.—Keep leaves covered with Bordeaux; dust with Paris green and land plaster (1–20) in early morning.

The **Western Potato Flea Beetle** (*E. subscrinata*) is quite injurious in B. C.

Turnip Flea Beetle (*Phyllotreta vittata* Fab.).—Also called the "Turnip Fly," frequently injurious to the seed-leaves of turnips and radish in June. Two or three broods a season (Fig. 204).

Adult.—An active shining black beetle, $1/10$ inch long; each wing-cover with a wavy yellow stripe; femora black; tibiæ and tarsi brownish yellow; fifth joint of antennæ broadened.

Larva.—A slender white grub, $1/8$ inch long, feeding on the roots of cruciferous plants.

Control.—Dust the plants with a mixture of 1 lb. Paris green and 20 lb. land plaster on first appearance of "fly."

Horse-radish Flea Beetle (*Phyllotreta armoraciæ* Koch).—An oval beetle, ⅛ inch long, with yellow wing-covers bordered with black and with a longitudinal black band through the middle. The larvæ bore into the petioles of horse-radish and the adults feed on the leaves and gouge deeply into the midribs, causing drying and death. Introduced from Europe about 1893 (Fig. 205).

Red-headed Flea Beetle (*Systena frontalis* Fab.).—Injures grapes, gooseberry, sugar beet, horse bean, potato, clover, and other plants.

Adult.—Shining black, with a red head; punctations on wing-covers dense but not coarse; ¼ inch long.

FIG. 204.—Turnip flea beetle. Enlarged 12 times. (*After Riley, U. S. Dept. Agric.*)

FIG. 205.—Horse-radish flea beetle. Enlarged 9 times. (*After Chittenden.*)

Banded Flea Beetle (*Systena tæniata* Say).—Injurious in beet fields, in vegetable gardens and in orchards.

Adult.—Black to brownish, with a whitish longitudinal stripe down middle of each wing-cover; ⅛ inch long; omnivorous.

Eggs.—Elliptical, opaque, light yellow; finely granulated, June–July.

Larva.—Slender, sluggish, ⅛ inch long, yellowish-white, narrowing toward the front; sutures of thorax with an X-mark; anal segment pointed with a crown of spines and four long hairs; winters.

Smartweed Flea Beetle (*Systena hudsonias* Forst.).—Sometimes feeds on leaves of sugar beets, young apple and pear trees.

Adult.—Bluish-black, $\frac{1}{5}$ inch long. Natural hosts are smartweed and dock.

Eggs.—Laid in autumn.

Pale-striped Flea Beetle (*Systena blanda* Mels.).—This Flea beetle attacks a large number of vegetable crops in June–July.

Grapevine Flea Beetle (*Haltica chalybea* Ill.).—(Consult Bull. 157. Cornell Ag. Exp. Stn., 1898.) The early adults injure the buds of grapes

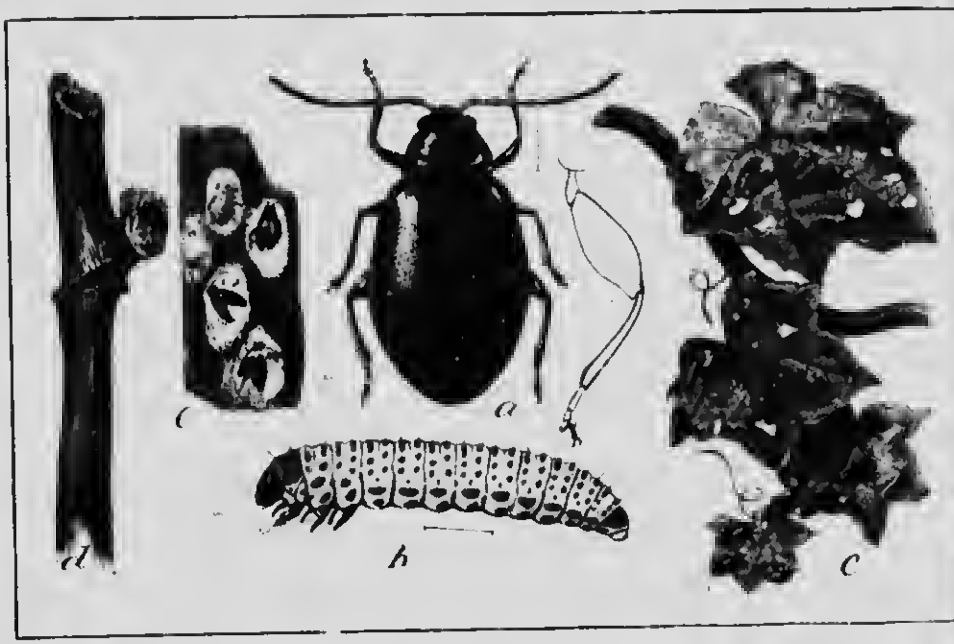


FIG. 206.—The grapevine flea beetle (*Haltica chalybea*): *a*, adult beetle; *b*, larva or grub; *c*, beetles and larvæ on foliage—natural size; *d*, beetle feeding on bud; *e*, diseased beetles. (*After Marlatt, U. S. Bur. Ent.*)

and Virginia creeper while the larvæ and late adults riddle the leaves. A native insect (Fig. 206).

Adult.—A polished steel-blue, or sometimes purplish, flea beetle. $\frac{1}{6}$ inch long; antennæ and legs brownish black or piceous; thorax distinctly wider at base. Hibernates.

Eggs.—Orange-colored, long-oval; laid in crevices of the bark near base of buds, or on the leaves. One-thirtieth inch long.

Larva.—Lightish-brown, $\frac{3}{10}$ inch long; head and thoracic shield black; 6–8 shining black dots on each segment, a brown hair on each dot;

an elongate middle dot on back; legs black; orange-colored proleg on last segment. Full grown in 2-3 weeks.

Pupa.—Dark yellow, in a smooth oval cell in the ground.

Life-history.—Adults hibernate under rubbish, and feed in April or May on the buds. Eggs deposited in May and hatch in a few days. Larvæ present in June-July and mature in 2-3 weeks; pupæ remain in the earth for 1-2 weeks, and transform to beetles in July. There is but one brood.

Control.—Spray early on the first appearance of the beetles in April with arsenate of lead (3-4 lb. to 40 gal. water); spray with arsenate of lead in June-July to destroy the grubs on the leaves.

Strawberry Flea Beetle (*Haltica ignita* Ill.).—A widely distributed pest, but most destructive in the South.

Adult.—A small beetle, 1/6 inch long, green, copper-colored or blue. Hibernates.

Eggs.—Laid on leaves of Evening Primrose.

Larvæ.—Feed on leaves and pods of Evening Primrose and allied plants.

Pupæ.—Formed in the ground.

One brood in the North, but more in the South.

Willow Flee Beetle (*Crepidodera helxines* Linn.) varies from brownish bronze to metallic blue or green. It eats holes in the leaves of willow, and has been reported as feeding on the leaves of young apple trees.

Red-legged Flea Beetle (*Crepidodera rufipes* Linn.).—A widely distributed beetle in Europe and America. Food plant is the black locust, but adjacent orchard trees are often injured.

Spinach Flea Beetle (*Disonycha xanthomelæna* Dalm.).—Injurious to sugar beets, spinach and lamb's quarters (Fig. 207).

Adult.—Shining black with a greenish lustre; prothorax and abdomen reddish yellow; legs and antennæ pale yellow; 1/4 inch long; October-May and July-September.

Eggs.—Orange, laid on end on bits of leaf; hatching from April-July and July-September.

Larva.—Gray, with rows of raised tubercles, each bearing a black hair, on segments. Full grown in June-July and September-October.

Pupa.—In the ground. Duration of first generation about a month.

The Alder Flea Beetle (*Haltica bimarginata* Say) occurs periodically in enormous numbers on alder, willow and poplar. (See Bull. 265, Maine Ag. Exp. St.)

Mangel Flea Beetle (*Psylliodes punctulata* Mels.).—Feeds on the leaves of mangels, beets, rhubarb, hops, radish, etc. Probably two broods in a season.

Adult.—Shiny black or dark brassy-green, upper surface finely punctulated or pitted in regular rows; 1/10 inch long; femora, tarsi, basal joints of antennæ pale obscure yellowish; hibernates.

Eggs.—Minute, oval, yellow.

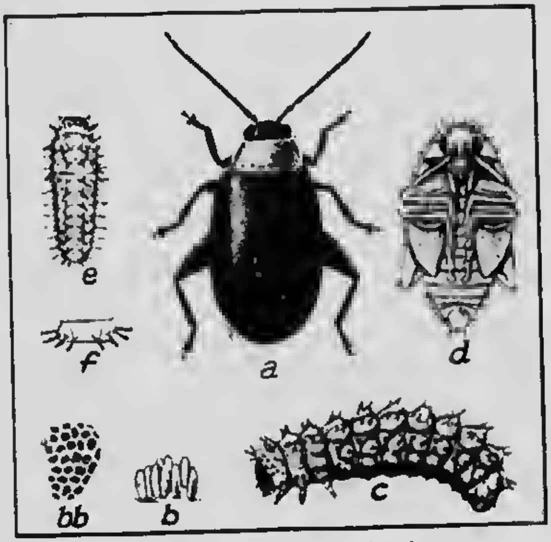


FIG. 207.—Spinach flea beetle: *a*, adult beetle; *b*, egg mass; *bb*, sculpture of egg; *c*, full grown grub; *d*, pupa; *e*, newly hatched grub; *f*, abdominal segment of same; *a*, *c*, *d*, 5 times natural size; *b*, *e*, more enlarged; *bb*, *f*, more enlarged. (*After Chittenden, Bul.* 19, *N. S. Div. of Ent., U. S. Dept. of Agric.*)

Larva.—Slender, white, with dusky markings; 3/16 inch long; lives in the ground feeding on roots of various plants.

Pupa.—White.

Control.—Spray hop vines with whale-oil soap solution (1 to 5); collect by means of tarred shield and feather duster.

LUCANIDÆ (STAG BEETLES)

Stag Beetle (*Lucanus dama* Thunb.). *Adult.*—A large brown lamellicorn beetle; male with large sickle-shaped mandibles and a smooth broad head; the female with smaller mandibles and a narrower, rough head. July–August.

Eggs.—Large, globular, white; laid in crevices of the bark near the roots.

Larvæ.—Like white grubs; live in decaying wood.

Pupa.—In an oval cocoon made of fragments of wood.

BRUCHIDÆ (PEA AND BEAN WEEVILS)

Pea Weevil (*Bruchus pisorum* Linn.). *Adult.*—A small brownish black beetle, 1/5 inch long, with characteristic black and white markings; sides of thorax notched; abdomen projects beyond the wing-covers. Two black spots on uncovered portion of abdomen; antennæ 11-jointed; hind femora thickened and prolegs with two spines. A native of the old world (Fig. 208).

Eggs.—Yellow, 1/20 inch long, spindle-shaped.

Larva.—White fleshy wrinkled grub, about 1/4 inch long when fully grown; 3 pairs of minute legs.

Pupa.—White, becoming brown after threshing or fumigating; thorax with notched sides; formed in the pea.

Life-history.—Adult winters over and eggs are laid on the forming pods. The larva bores through the wall of the pod and enters the seed, where it feeds and grows. The pupal stage lasts about a week. Mature adults develop in August, the majority remaining in the mature seed all winter. Several grubs may inhabit a single seed.

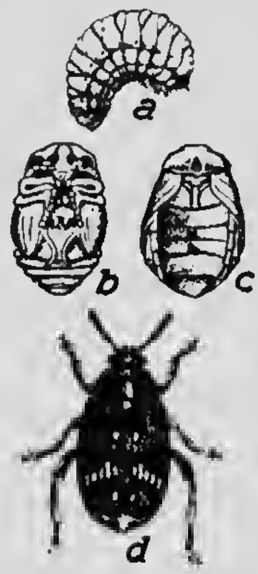


FIG. 208.—Pea weevil: *a*, the grub; *b*, the pupa, under surface; *c*, the pupa, upper surface; *d*, the adult weevil.

Control.—Fumigate peas with carbon bisulphide; drench seed with kerosene; store the peas over for a season in tight sacks before planting; raise the temperature to 145°F. to kill the weevils.

Bean Weevil (*Bruchus obtectus* Say). *Adult.*—A small brown beetle, about 1/8 inch long, with wing-covers shorter than the body, and "marked with ten impressed and dotted longitudinal lines which are broken up into pale yellow dashes and dark brown spots" (Fletcher); body covered with short silky hairs; tips of abdomen, antennæ and legs of a reddish tinge; antennæ enlarging toward the tip. Probably a native of Central or South America.

Eggs.—Cylindrical oval grey objects, $\frac{1}{50}$ inch long; laid on or in the young pods or stored beans; hatch in 5–20 days.

Larva.—A small whitish fleshy wrinkled grub; matures in 11–42 days.

Pupa.—White and delicate; enclosed in an oval pupal chamber within the bean; duration 5–18 days.

Life-history.—The larva enters the seed, where it feeds and grows until autumn when it changes to a pupa, and a little later to the beetle. Propagation may take place for several generations in the dry beans.

Control.—Fumigate with carbon bisulphide or superheat as for pea weevil.

CERAMBYCIDÆ (LONG-HORN BEETLES)

Common Economic Genera:

A. Thorax margined; labrum united with clypeus; body broad and depressed —*Prioninæ.*
- B. Antennæ 11-jointed; body elongate, parallel.—*Orthosoma.*
- BB. Antennæ 12–20-jointed; body stout, broad.—*Prionus.*

AA. Thorax not margined; labrum free; body oblong and cylindrical.
- B. Front tibiæ obliquely grooved on inner side; last joint of palpi pointed at tip.—*Lamiinæ.*
  - C. Elytra spined; size small.—*Psenocerus.*
  - CC. Elytra not spinose; large size.
    - D. Scape of antennæ with an apical scar; body elongate.—*Monohammus.*
    - DD. Scape of antennæ without apical scar.
      - E. Tarsal claws divaricate and simple.—*Saperda.*
      - EE. Tarsal claws divaricate and cleft.
        - F. Eyes not divided; thorax cylindrical.—*Oberea.*
        - FF. Eyes divided; thorax with blunt tubercle on each side and marked with four black spots.—*Tetraopes.*
- BB. Front tibiæ not grooved; last joint of palpi not pointed at tip—*Cerambycinæ.*
  - C. Base of antennæ partly enveloped by the eyes; front coxæ not conical; eyes finely granulated; scutellum rounded behind; tibial spurs large.
    - D. Head small; process between hind coxæ rounded.
      - E. Thorax transversely excavated at sides and with three yellow cross bands.—*Cyllene.*
      - EE. Thorax not excavated at sides and without yellow cross bands.—*Plagionotus.*
    - DD. Head large; process between hind coxæ acute.—*Clytus.*
  - CC. Base of antennæ not enveloped by the eyes, front coxæ conical.—*Desmocerus.*

Round-headed Apple-tree Borer (*Saperda candida* Fab.).—This beetle is a common native pest of the mountain ash, apple, quince and pear in orchards east of the Rocky Mountains (Fig. 209).

Adult.—A pretty beetle, ¾ inch long, with long grey antennæ; head and under side of body silvery white, upper surface light yellowish-brown and with two longitudinal white stripes extending through thorax and wing-covers; legs grey. Appears mostly in May, June and July, usually in day-time.

Eggs.—Embedded singly in incisions in the bark, near the base of the trunk, and covered with gummy substance; pale rust-brown, oval, ⅛ inch long; hatch in 2–3 weeks. A female may deposit 15–30 eggs.

Larva.—Full-grown larva is a yellowish fleshy cylindrical legless

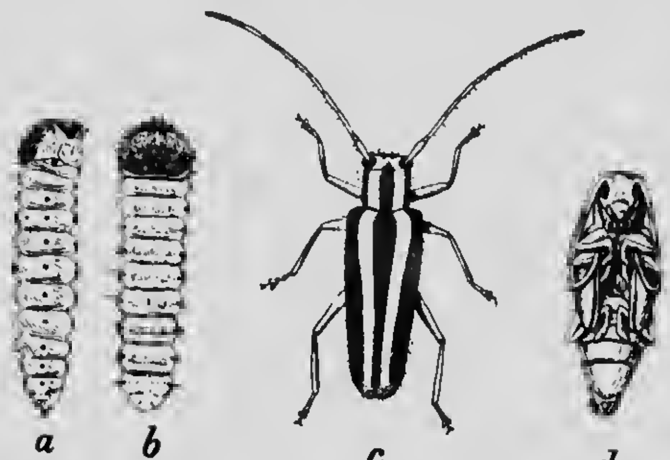


FIG. 209.—Round-headed apple-tree borer: *a, b,* larvæ; *c,* female beetle; *d,* pupa. (*Chittenden, Cir. 32, Bur. Ent., U. S. D. A.*)

grub, ¾ to 1¼ inch long; head small and dark; body tapering from the thorax backward. Matures in 3 years. Works in bark and sapwood the first year forming broad, irregular, circular galleries beneath the outer bark; bores deeper in the second year, and in the third year bores upward into the solid wood and outward to the bark, and in May of the fourth year transforms to a pupa, the winter being spent in the pupal chamber.

Pupa.—Lighter than larva, with transverse rows of minute spines on the back. Duration about 3 weeks.

Control.—Probe or cut out grubs in fall; apply a carbolic alkaline wash in early June to trunks; apply protectors to trunk; spray with arsenical to kill adult. Woodpeckers destroy large numbers of the larvæ.

Saperda tridentata Oliv. is the well-known elm-borer. The grub girdles the tree by burrowing under the bark.

Raspberry Cane-borer (*Oberea bimaculata* Oliv.). *Adult.*—A slender black cerambycid beetle, 1/2 inch long; prothorax yellow, with two or three black spots; antennæ long, body cylindrical; June. A native American insect.

Eggs.—Large, elliptical, yellow. Egg placed in pith of tip of cane in a slit between two ring-like cuts about an inch apart. Hatches in a few days.

Larva.—A dull yellow grub with a small dark-brown head; 1 inch long; body cylindrical and segments connected. Burrows downward in the pith, often opening at surface of stem. Hibernates near base of stem as a larva.

Pupa.—Formed in burrow in spring. Perhaps this insect requires two years to complete its stages. Wilting occurs in July–August.

Control.—Cut off and destroy the wilted canes as soon as observed.

Giant Root Borer (*Prionus laticollis* Drury). *Adult.*—A large pitchy-black, long-horned beetle; thorax with three teeth on margin; wing-covers thickly punctate.

Larva.—Two to three inches long; yellowish-white; a small, horny, reddish-brown head with hard dark jaws; three years; matures in June–July, boring into roots of black berry, grape, apple, and cherry.

Locust Borer (*Cyllene robiniæ* Forst.).—Heartwood of infected trees shows longitudinal galleries often so numerous as to give honeycombed appearance to the wood.

Adult.—A black long-horned beetle, with three straight yellow bands across thorax and five broken or irregular yellow bands across wing-covers; 3/4 inch long; found on golden rod in August–October.

Eggs.—Snow-white; deposited in the fall in crevices in the bark of black locust trees; hatch in 8–10 days.

Larva.—Makes winding tunnels deep into the wood; matures in less than a year; 3/4 inch long, dull white, somewhat flattened and club-shaped. Winters as a young larva in the soft inner bark.

Pupa.—Formed in July–August and stage lasts 4 or 5 weeks.

Three-fourth inch long, stout, flattened, yellowish; dorsum of head and first six abdominal segments with chitinous points.

Control.—Badly infested branches should be cut out and burned in winter or spring. Spray infected trunks and branches with kerosene (1:2 of water) in late fall after leaves have fallen to kill the young larvæ in the bark.

FIG. 210.—The hickory borer (*Cyllene picta*) on dead or dying hickory.

Cyllene picta Drury bores in hickory and elm. Adult is velvety black with many pale yellow lines across the thorax and elytra (Fig 210).

Sugar Maple Borer (*Plagionotus speciosus* Say).—Apparently healthy trees are attacked.

Adult.—Nearly an inch long; black marked with yellow. Antennæ and eyes reddish black; legs yellow; under side of body reddish-yello variegated with brown. Thorax black with two yellow spots on each side; wing-covers black with yellow tips, a yellow spot on each shoulder, a yellow curved band, a zigzag yellow band forming the letter W, a median yellow band arching backward, and a black curved band and spot on the yellow tip. June–July.

Eggs.—Deposited in summer in slits in the bark of larger limbs.

Larvæ.—Whitish, flattened legless grubs with brownish mouth-parts, excavating shallow burrows, often several feet long, in inner bark and sapwood, and often girdling the tree. When full grown about 2 inches long.

Pupa.—Formed in the end of the burrow.

Control.—Examine trees for "sawdust" and probe the burrows to kill the grubs.

Oak Twig Pruner (*Elaphidion villosum* Fab.). *Adult.*—A slender, dark brown beetle, 5/8 inch long, sparsely covered with whitish hairs; tips of wing-covers with two teeth. July.

Eggs.—Laid on smaller twigs, between the twig and the leaf stalk.

Larva.—At first it makes burrows in the wood under the bark; later channels at centre of twig, and finally a deep circular groove which causes twig to break off. It usually changes to a pupa in the severed twig, but sometimes part of the larval and the pupal stage is passed outside of the twig.

Control.—Fallen twigs containing the grubs should be promptly gathered and burned.

Pine Wood Borers (*Monohammus* spp.).—Several species of *Monohammus* are well known as pine and spruce wood borers. They are large insects with long legs and long antennæ. The following species are common: *M. scutellatus* Say, a bronzy-black form, *M. confusor* Kby., a brown form and *M. titillator* Fab., rare in the North. Logs are preserved from their ravages by putting them in water or by covering the log piles with a thick layer of spruce or balsam boughs.

MELOIDÆ (BLISTER BEETLES)

Blister Beetles.—(Consult Bull. 43, Div. Ent. U. S. Dep. Agric., 1903; Bull. 10, Ill. Agric. Exp. Stn., 1900; 42d Rep. Ont. Ent. Soc. Blister Beetles are characterized by a long cylindrical soft body and flexible wing-covers, and by a rounded head joined to a small thorax by a slender neck. The adults are leaf-feeders, and are gregarious. As larvæ they feed on the egg-masses of grasshoppers and are, therefore, beneficial. Each female lays 500-600 eggs in a cavity in the soil in late summer and the eggs hatch in about 10 days. The larva on hatching from the eggs is long-legged, large-headed and active (the triungulin stage); and on moulting it assumes the second stage (carabidoid) with short legs and relatively smaller head. After another moult it assumes the third stage (scarabæidoid), and with the fourth moult is formed the coarctate larval stage (winter stage). In the spring another moult occurs before the pupal stage is entered. On account of their habit of traveling sometimes like army-worms blister beetles are often called "army beetles." Seven species of Blister Beetles of economic importance are found in Canada and the Northern States.

1. **Black Blister Beetle** (*Epicauta pennsylvanica* DeG.).—Uniformly black and 1/2 inch long; one of the "Aster Bugs" of the florists; serious pest of garden vegetables and flowers; occurs from June to October.

2. **Grey Blister Beetle** (*Epicauta cinerea* Forst.).—Uniformly grey; 1/2 inch long; a pest of beans, potatoes, vetch and alfalfa; occurs in July and August.

3. **Striped Blister Beetle** (*Epicauta vittata* Fab.).—One-third inch long, with four black stripes on back; the "old-fashioned potato-bug;" a general feeder; occurs from June to September; eggs laid on plants or upon the ground.

4. **Margined Blister Beetle** (*Epicauta marginata* Fab.).—Of a general black color except that the wing-covers are margined with grey; a general feeder; occurs from July to October.

5. **Ash-grey Blister Beetle** (*Macrobasis unicolor* Kby.).—Uniformly ash-grey; feeds on beets, potato and legumes; occurs in June and July.

6. **Spotted Blister Beetle** (*Epicauta maculata* Say).—With a black body which, excepting small areas on the wing-covers, is covered with grey hairs. Attacks beets, cabbage, spinach, beans and clover in the Western provinces.

7. **Western Blister Beetle** (*Cantharis nuttalli* Say).—Three-fourth to one inch long: head, thorax and body metallic golden green; wing-

covers variable in color—purple, green or coppery. Often destructive in the West to leguminous crops. June-August.

Control.—Spray with arsenical solution.

CUCUJIDÆ

Saw-toothed Grain-beetle (*Silvanus surinamensis* Linn.).—A widely distributed beetle, feeding on stored grain and their products and on starchy goods (Fig. 211).

Adult.—A minute flattened chocolate-brown beetle; margins of thorax with six tooth-like projections; 1/10 inch long; two grooves in thorax; head and thorax finely punctate; wing-covers punctured and lined. There may be four generations in a season.

Larvæ.—Flattened, with transverse, rectangular, yellowish, chitinized spots above; 6 legs; active.

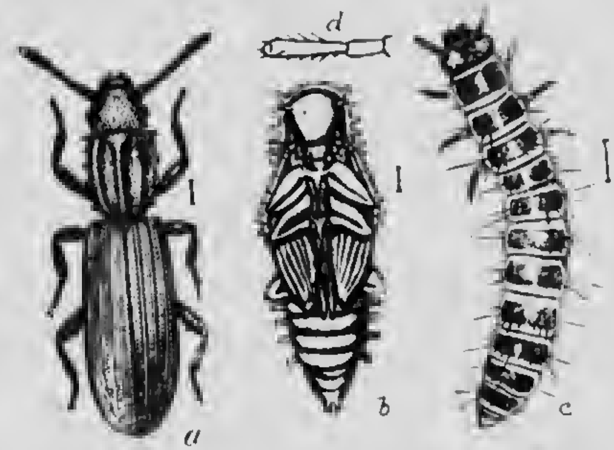


FIG. 211.—The saw-toothed grain-beetle (*Silvanus surinamensis*): *a*, adult; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of beetle. (*After Chittenden.*)

Pupa.—White, occasionally enclosed in a delicate cocoon made of particles of food.

OSTOMATIDÆ = TROGOSITIDÆ

The Cadelle (*Tenebroides mauritanica* Linn.).—Feeds on stored grain and also on other injurious grain insects.

Adult.—An elongate oblong depressed beetle, nearly black; elytra longitudinally ridged; head and thorax finely punctate; 1/3 inch long; found in granaries.

Eggs.—Small, white, much longer than broad; hatch in about 10 days.

Larva.—Fleshy, slender, 3/4 inch long, dull white with a dark brown head and prothorax; two dark horny points at posterior end.

Pupa.—White; formed in a burrow in wood.

PTINIDÆ (DEATH-WATCH AND DRUG STORE BEETLES)

Apple-twig Borer (*Amphicerus bicaudatus* Say).—(Consult Farmers' Bull. 70, U. S. Dep. Agr.) *Adult.* A cylindrical ptinid beetle, 1/3 inch long; dark brown above and black beneath; front of thorax with minute rough points; male with two little horns in front, two near the ends of wing-covers. Mature in the fall. Bores in early spring into twigs of apple, grape, pear, etc.

Eggs.—Laid in May in dead roots of smilax, or in dead shoots of grape.

Larva.—Develops during summer, transforming to pupa and beetle in fall.

Other more or less important forms belonging to this family are: the *Drug Store Beetle* (*Sitodrepa panicea* Linn.) which infests such drugs as ginger, rhubarb, licorice, peppermint and seeds; also flour, breakfast foods, chocolate, black pepper, coffee, dried beans and peas; also books and manuscripts; the *Cigarette Beetle* (*Lasioderma serricorne* Fab.) which infests tobacco in every form, pepper, ginger, rhubarb, rice, figs, yeast cakes, etc.; and *the Death Watch* (*Anobium tesselatum*) which occurs in timbers and tunneling in woodwork of houses.

LYCTIDÆ (POWDER POST BEETLES)

Several species of *Lyctus* bore into dry stored sap wood, and are known as Powder Post Beetles. The adult insects are small, slender, dark brown beetles. Eggs are laid in the wood, and the grubs tunnel in every direction through the wood. In a short time the interior of the infested material may be reduced to powder.

Control.—In house furniture remove and burn any replaceable infested parts; paint rest of infested surface with kerosene, giving several applications as long as boring dust appears.

TENEBRIONIDÆ (DARKLING BEETLES)

Yellow Meal-worm (*Tenebrio molitor* Linn.). *Adult.*—A darkling beetle, 3/4 inch long, somewhat flattened; head and thorax finely punctured; wing-covers ridged lengthwise; April–June. One generation each year; nocturnal.

Eggs.—White, bean-shaped, $\frac{1}{20}$ inch long; deposited in the meal.

Larva.—Cylindrical, waxy and slender; 1 inch long, resembling wireworms; yellowish, darker at each end. Mature in 3 months.

Pupa.—Duration about 2 weeks.

The **Dark Meal-worm** (*Tenebrio obscurus* Fab.) is dull pitchy black and has similar habits to the preceding.

Control.—Subject infested rooms to a temperature of 120°–125°F. for 6 hours; fumigate with hydrocyanic acid gas or carbon bisulphide.

Confused Flour Beetle (*Tribolium confusum* Duval). *Adult.*—A small, shining, reddish-brown beetle, $\frac{1}{8}$ inch long; flattened, oval; head and thorax finely punctate; wing-covers ridged lengthwise and sparsely punctate.

Eggs.—Minute, white, hatching in 6 days.

Larva.—Cylindrical, wiry, yellowish-white, $\frac{1}{5}$ inch long; mature in 24 days.

Pupa.—White, matures in 6 days.

CURCULIONIDÆ (WEEVILS)

Common Economic Genera:

- A. Claws simple, pygidium not exposed.
  - B. Antennæ straight, club annulated, claws toothed, gular peduncle broad.—*Ithycerus.*
  - BB. Antennæ elbowed, rostrum witb distinct scrobes, gular peduncle long, front coxæ contiguous.
    - C. Mandibles usually emarginate, 2-toothed at tip.—*Phytonomus.*
    - CC. Mandibles bi-emarginate, 3-tootbed at tip.
      - D. Lateral angles of first ventral segment uncovered.—*Lixus.*
      - DD. Lateral angles of first ventral segment not visible.—*Pissodes.*
- AA. Claws appendiculate, tootbed or cleft (except in *Tyloderma*).
  - B. Ventral sutures straight, hind angles of prothorax rectangular or rounded, prosternum short, broadly emarginate; eyes rounded, distant.—*Anthonomus.*
  - BB. Ventral sutures more or less curved.
    - C. Beak received in or upon the breast in a pectoral groove confined to prosternum; beak long; tarsi dilated; front coxæ contiguous.—*Conotrachelus.*
    - CC. Pectoral groove extending into the mesosternum, sharply limited behind; front coxæ not contiguous; metathoracic epimera distinct, mesosternum feebly emarginate.—*Tyloderma.*

CCC. Characters similar to CC, but mesosternum is deeply emarginate. Claws simple and divergent; ventral segments 2-4, equal; sutures straight.—*Cryptorhynchus.*

Poplar and Willow Borer (*Cryptorhynchus lapathi* Linn.).—(Consult Cornell Bull. 388.) An introduced beetle from Europe, infesting poplars, willows and alders from N. Dakota to Maine and Quebec.

Adult.—A sooty-brown snout-beetle, ⅓ inch long, spotted with grey; beak curved and as long as head and thorax; body thick and punctured on the surface; ends of wing-covers, sides of prothorax and two oblique bands on wing-cover light grey. After emerging the adult feeds by puncturing the bark of young tender shoots. Mating and egg-laying occur 10–14 days after emergence. July–October.

Eggs.—Cream colored, oval; laid in holes made in bark of branches 2–4 years old. Hatch in 18–25 days, in August–November.

Larva.—Burrows in the cambium until nearly full grown, then in the wood; a soft yellowish fleshy cylindrical footless grub with a pale brown head and darker mouth-parts; ½ inch long. Mature in June.

Pupa.—When ready for pupation the larva enters older wood and makes a pupal chamber (1 to several inches long) which is filled with fras. Pupa whitish-yellow, with brown spiracles; small spines scattered over dorsal surface and a pair of strong incurving brown spines at tip of abdomen. Duration 10–18 days.

Control.—Spray trees with arsenate of lead every fortnight between July 15th and September 1st; apply carbolineum to nursery stock in early spring; cut out grubs from moderately infested trees; cut down and burn badly infested trees during winter or before July 1st.

Plum Curculio (*Conotrachelus nenuphar* Herbst.).—This snout-beetle is a widely distributed native insect and is a serious pest of plums, pears, apples and peaches, cherries and apricots on account of its punctures and the dropping of infested fruit (Fig. 212).

Adult.—A stout snout-beetle, ¼ inch long, brownish, and marked with grey and black; four black-ridged tubercles on the wing-cover; hibernates and emerges just before the fruit buds open. Feeds to some extent on the buds, but mostly on the young fruit as soon as it is set. Female begins to lay eggs in the young fruit as soon as it is formed. Lives about 2 months, laying 100–300 eggs. Makes two kinds of punctures in the fruit: egg-punctures and feeding-punctures.

Eggs.—Oval, white; laid in cavities made by the snout of the beetle; protected in the hole by a crescent-shaped slit. Hatch in 4-6 days. Deposition occurs mostly in June but continues through July and August.

Larva.—Whitish footless grub, mature in about 15 days; it then bores out of the fruit and enters the ground where it forms an earthen cell and remains for 2 weeks before pupation. Infested fruit drops prematurely (except cherries).

Pupa.—White; formed in a small cell 1-2 inches below the surface, duration about 10 days; first adults emerge about 10 weeks after the apple blossoms.

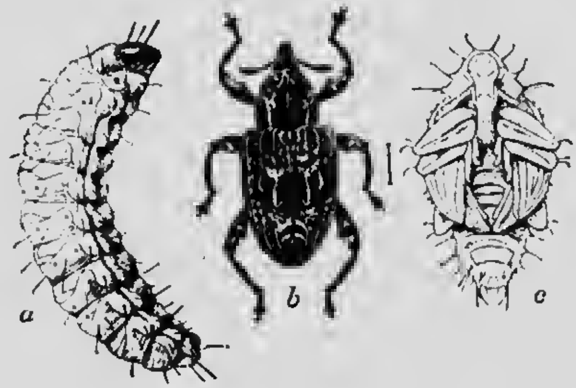


FIG. 212.—Plum curculio: *a*, larva; *b*, adult; *c*, pupa. (*Chittenden, Cir. 73, Br. of Ent., U. S. D. A.*)

Life-history.—Insect hibernates as a beetle under rubbish, etc., and emerges early to feed on buds, etc.; eggs deposited in young fruit; larvæ tunnel in the fruit for about 20 days, then enter the ground to pupate; pupa stage lasts about 10 days; adults emerge to puncture the ripening fruit, and hibernation begins about first frosts. Larvæ only in fruit that has fallen. Punctures produce gnarling of fruit. The beetles that emerge during the summer deposit no eggs.

Control.—Spray thoroughly with arsenate of lead (3 to 40 gal.) as leaf buds are opening, and again before and after the blossoming period in the case of the apple. In the case of plum and cherry the applications should be made after the blossoms fall. Practice clean cultivation and remove rubbish.

Apple Curculio (*Anthonomus quadrigibbus* Say).—(Consult Bull. 98, Ill. Agr. Expt. Stn.; Cir. 120, Bureau of Ent., U. S. Dept. Agr.)

Sometimes injurious. Adult beetle distinguished from Plum Curculio hy following characters: (1) more reddish-brown; (2) snout much longer and horne directly in front of the head; (3) wing-covers with four prominent humps; (4) abdomen more robust; (5) crescent-shaped mark absent. The life-history much the same as that of the Plum Curculio, except that the pupal stage lasts ahout a week. Beetles feed but little after they emerge in summer. Larva a hump-backed footless white grub, ½ inch long.

Control.—Spray with lead arsenate (3 lb. to 40 gal.) just after the blossoms fade, and at intervals of 10 days; gather promptly fallen fruit; jar the trees and collect beetles.

Clover Leaf Weevil (*Phytonomus punctatus* Fab.). *Adult.*—"A stout, oval, brown, finely punctured curculio," about ⅓ inch long; prothorax narrower than ahdomen; beak about 1½ times as long as the head, stout and curved.

Eggs.—Yellow, oval and pitted.

Larva.—A green, footless grub with a brown head, and a whitish stripe edged with black-red along the middle of the back, tapers to each end; lies curled in the ground. Hibernates.

Pupa.—Cocoon is oval and the pupa has "a yellowish-green head, small black eyes, and a dark green abdomen."

Life-history.—One brood a year, and winters as a partially grown larva. In spring it resumes its growth, and reaches maturity in June. Pupal stage beneath the surface does not last long, and adult beetles emerge in June and July. Eggs laid in September and October, and the grubs are partially grown when winter comes.

Control.—Plow under infested fields after second season so as to destroy early stages of insect.

The Lesser Clover Leaf Weevil (*Phytonomus nigrirostris* Fab.).—More injurious in Canada than the preceding.

Adult.—Brown on emergence, later becoming green; snout black; thorax rounded with two dorsal brown stripes; length 3 to 4 mm.

Eggs.—Ovoid, greenish, reticulate, placed beneath epidermis of leaf sheath; hatch in 7½ to 8½ days.

Larva.—Greenish straw-color; head light hrown; pale dorsal stripe. Feeding on tender leaf buds beneath sheath, or in flower heads where it destroys the florets; 17–20 days.

Pupa.—In an oval open mesh cocoon usually in flower head; about 7 days.

Life-history.—Hibernating adults come forth as soon as clover appears in spring. Egg laying commences immediately and extends over several weeks. One generation, but all stages found during the summer.

Alfalfa Leaf Weevil (*Phytonomus posticus* Gyll.).—(Consult Farmers' Bull. 741, U. S. Dep. Ag.) A European beetle, introduced about 1904 into the West, puncturing the stems and eating the leaves of alfalfa. The larvæ also feed on the tender growths, causing the tops to appear white.

Adult.—A dark brown snout-beetle, 3/16 inch long; body covered with black and grey hairs; hibernates in crowns of alfalfa or under grass, rubbish, etc.; oviposits in April and June.

Eggs.—Small, oval, shiny, yellowish; laid in punctures in stems of alfalfa; April–July; hatch in 10 days.

Larva.—A green, worm-like grub, 1/3 inch long, tapering toward both ends; head black; a light stripe down the back. May–July.

Pupa.—Cocoons globular and composed of network of white threads; spun in dead leaves or rubbish on the ground; duration 1–2 weeks.

Control.—Disk alfalfa fields in early spring and cut about middle of May when most of eggs have been laid; use a bush-drag to kill the weevil; collect the weevils; destroy weeds and rubbish; spray in April with arsenite of zinc solution (4 lb. to 100 gal.); pasture or graze infested fields after eggs are laid.

A Clover Leaf Weevil (*Tychius picirostris* Fab.) is injurious to some extent to clover heads on the island of Montreal. The adult is a black curculio 1/10 inch long, and is an introduction from Europe where it attacks the flower heads of red clover, plantain and Genista.

Strawberry Weevil (*Anthonomus signatus* Say).—(Consult Cir. 21, U. S. Dep. Ag., Div. Ent.) *Adult.* A small weevil, 1/10 inch long, from black to dull red, marked with a dark spot on each wing-cover. Snout half as long as body, slender and curved. Hibernates July–May (Figs. 213 and 214).

Eggs.—Laid in buds in spring; hatch in 6–7 days.

Larva.—Feeds on pollen and harder parts of buds. Matures in 3–4 weeks.

Pupa.—Formed in a cell in the bud; duration 5–8 days. Injury is done also when the egg is laid; then the female cuts the stem of the bud.

FIG. 213.—Strawberry weevil (*Anthonomus signatus*). Enlarged. (*After Riley and Chittenden.*)

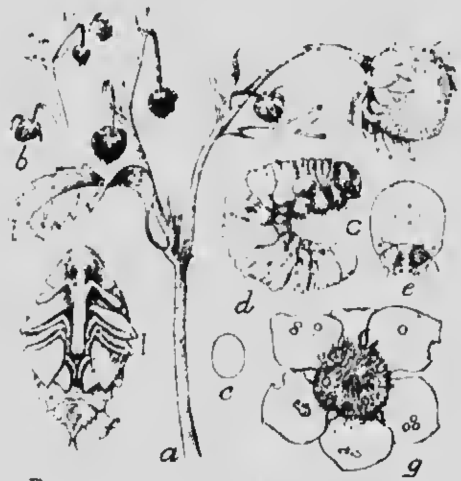


FIG. 214.—The strawberry weevil: *a*, *b*, plant showing work on bud and stem; *c*, outline of egg; *d*, larva; *e*, head of larva; *f*, pupa; *g*, bud opened to show egg and punctures. (*After Chittenden.*)

Control.—Plant mostly pistillate varieties; plant only staminate varieties as trap-crops; cover beds with muslin.

Cotton Boll-Weevil (*Anthonomus grandis* Bob.).—(Consult Bulletin 51, and Farmers' Bull. 344, Bur. Ent., U. S. Dept. of Agriculture.) A serious pest of cotton in the Southern States.

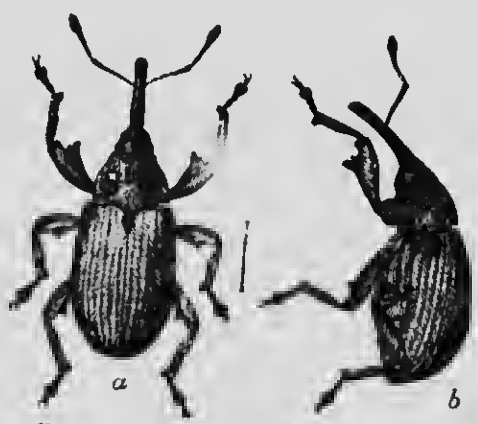


FIG. 215.—Cotton boll-weevil: *a*, beetle, from above; *b*, same, from side. About 5 times natural size. (*After W. D. Hunter, U. S. Bur. Ent.*)

Adult.—A small brownish weevil, ¼ inch long, with two teeth at tip of femora of forelegs; female lays about 140 eggs. Hibernates in sheltered situations (Fig. 215).

Eggs.—Small, oval, white; hatch in about 3 days.

Larva.—A white, footless grub with brown head; matures in 7 to 12 days (Fig. 216).

Pupa.—Soft, white; stage lasts 3–5 days. Average duration of generation about 43 days and there are probably not more than four or five generations in a season.

Life-history.—"The egg is deposited by the female weevil in a cavity formed by eating into a cotton square or boll. The egg hatches in a few days and the footless grub begins to feed, making a larger place for itself as it grows. During the course of its growth the larva sheds its skin at least three times, the third moult being at the formation of the pupa, which after a few days sheds its skin, whereupon the transformation becomes completed. These immature stages require on the average between 2 and 3 weeks. A further period of feeding equal to about one-third of the preceding developmental period is required to perfect sexual maturity so that reproduction may begin" (Hunter and Pierce).

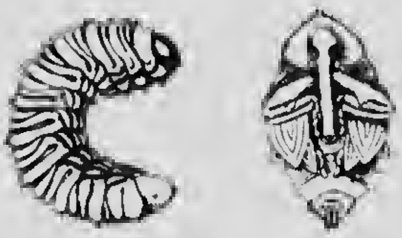


FIG. 216.—Cotton boll-weevil: larva at left, pupa at right. About 5 times natural size. (*After Hunter.*)

Strawberry Crown Borer (*Tyloderma fragariæ* Riley). *Adult.*—A small dark snout-beetle, 1/5 inch long; head and thorax black; each wing-cover with 3 black spots. Hibernates.

Eggs.—Probably laid in the crown.

Larva.—Small white grub mining out interior of the crown; 1/4 inch long; legless; head yellowish-brown. Matures in August.

Pupa.—Formed in the larval cavity. Adults emerge in late summer and fall.

Potato Stalk Borer (*Trichobaris trinotata* Say).—Burrows in the stalks of potatoes.

Adult.—A snout-beetle, 1/4 inch long, dull black to light grey; three black spots at union of prothorax and wing-covers; snout curved and as long as prothorax. Front of prothorax orange-yellow. Hibernates in burrows in the old stalk.

Eggs.—Small, oval, pearly white; laid singly in punctures in stalks.

Larva.—Yellowish-white; head light brown; legless; 3/8 inch long. Burrows in the stalks.

Pupa.—At first yellowish-white, later dull brown; 1/3 inch long, enclosed in oval greenish cocoon of fras; duration about a month.

Control.—Burn all the old stalks and rubbish as soon as crop is harvested.

The **Black-snouted Rose Beetle** (*Rhynchites bicolor* Fab.) occurs chiefly in the Transition zone and injures roses by puncturing the flower buds, and blackberries and raspberries by puncturing the fruit.

Bronze Apple-tree Weevil (*Magdalis ænescens* Leconte).—Young apple trees are sometimes severely injured in B. C. and the Pacific States.

Adult.—A slender, blackish-bronze weevil, 1/6 inch long. April–August. Feeds on the leaves.

Eggs.—Smooth, shining, yellowish-white; laid in holes in the bark.

Larva.—A plump, legless, white grub, 1/6 inch long; burrows under the bark.

Pupa.—Formed in the spring.

Grape Curculio (*Craponius inæqualis* Say).—(Consult Bull. 730, U. S. Bur. Ent.) This snout-beetle is one of the worst pests of the grape in the Upper Austral Zone, East of the Rockies, the adult feeding on the leaf in the spring and fall and the larva feeding on the pulp and seeds of the fruit.

Adult.—A short, robust, chocolate-brown, snout-beetle about 1/8 inch long. Thorax and elytra with prominent acute tubercles, and body and elytra clothed with minute whitish scales.

Eggs.—Oblong-elliptical, smooth, opaque, yellowish; deposited in cavities in the fruit during July and August. About 250 laid by each female. Hatch in 6 days.

Larva.—A legless, fusiform, curved grub; white with light brown head; 1/4 inch long; body sparsely covered with short fine hairs; mature in 10–12 days.

Pupa.—Short, stout, yellowish-white; eyes and tip of beak reddish; occupies a small spherical cocoon formed of earthen grains and lined with a delicate membrane. Duration about 18 days.

Natural Enemies.—Certain members of the following ant genera: *Solenopsis*, *Camponotus*, *Myrmica*, *Lasius*, and *Cremastogaster*. Also the parasites *Anaphoridea* and *Microbracon*.

Control.—Spray with arsenicals on the first appearance of the beetles, and again in 2 weeks.

OTIORHYNCHIDÆ (SCARRED SNOUT-BEETLES)

Strawberry Root Weevil (*Otiorhynchus ovatus* Linn.).—*Adult.* A small brownish-black snout-beetle; ¼ inch long. June and August September (Fig. 217).

Eggs.—Female lays about 50 eggs in 4 to 15 days in the soil. Hatch in 21 days. End of June to end of August.

FIG. 217.—Strawberry root weevil (*Otiorhynchus ovatus*) and its grub. (*After Treherne, Bul. 8, Div. Ent., Dept. Agric., Can.*)

Larva.—A small white grub ⅜ inch long; feeds on roots of strawberry, clover, timothy, rhubarb, rumex; lasts about 7 months. Winters partly grown.

Pupa.—Four to eight inches below surface; lasts from 21 to 24 days. May–June.

Control.—Rotation of crops as two- and three-year plantations suffer most; thorough cultivation; growing of suitable varieties; use of chickens.

The Black Vine Weevil or the Cyclamen Borer (*Otiorhynchus sulcatus* Fab.).—Occurs from the Atlantic to the Pacific in Northern U. S. and Canada, and is injurious to roots and crown of strawberry, also to *Gloxinia*, *Cyclamen*, *Primula*, Maiden-hair fern in greenhouses.

Adult.—A black beetle, ⅜ inch long, with patches of yellowish hairs on the wing-covers. Wing-covers joined together and wings absent.

It appears in April and May and attacks the foliage of various plants; nocturnal.

Larva.—Legless, white to flesh colored, usually curved; head brown, body thickest at the middle; 2/5 inch long and lives in the soil and attacks roots of *Cyclamen*, *Adiantum* and *Gloxinia*.

Feytaud, of France, reports parthenogenetic reproduction of this insect, and considers it probable that males appear sporadically. The females deposit more than 150 eggs, and reproduction is very rapid.

Control.—The adults may be caught at night by shaking them from infested plants; the grubs in the soil are not readily controlled.

Peach Leaf Weevil (*Anametis granulatus* Say).—This weevil is about 1/4 inch long, dark brown, oval, robust, densely covered with greyish scales. It sometimes damages peach, pear and apple trees by eating at night the buds and bark. Widely distributed.

CALANDRIDÆ (GRAIN WEEVILS)

Granary Weevil (*Calandra granaria* Linn.).—*Adult.* A snout-weevil, 1/8 inch long, convex, brown; thorax punctate; wing-covers

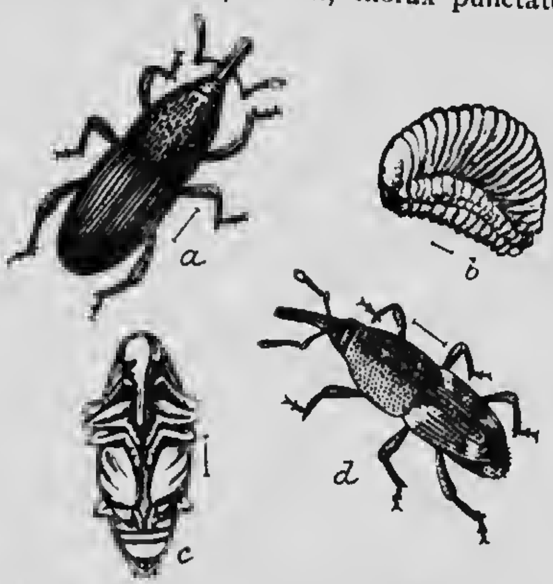


FIG. 218.—Grain and rice weevils: *a*, adult of grain beetle (*Calandra granaria*); *b*, larva; *c*, pupa; *d*, adult of rice weevil (*C. oryzæ*). (*After Chittenden.*)

ridged lengthwise. Four or five generations in a season, each requiring about 40 days (Fig. 218).

Eggs.—Minute, white, deposited in cavity of kernel.

Larva.—Small, robust, whitish, legless; one larva to a kernel of wheat, but several in corn.

Pupa.—White, clear and transparent.

Control.—Superheat for 6 hours at 120°–125°F.; fumigate with hydrocyanic acid gas or carbon bisulphide.

The **Rice Weevil** (*Calandra oryzæ*) is also of economic importance, especially in the South (Fig. 218).

FIG. 219.—The maize bill-bug (*Sphenophorus maidis*). Four times enlarged.

Corn Bill-bugs (*Sphenophorus* spp.). —*Adults.* Snout-beetles, dull black surface marked with small pits and narrow grooves; irregularly oval and rounded; 1/4–3/4 inch long; hibernate under rubbish; single brooded (Fig. 219).

Eggs.—Laid in May and June in roots and stems of grasses.

Larva.—Thick-bodied, oval, footless grub, with a hard brown head; feeding in corn stem or in root bulbs of grasses; June–August.

S. maidis.—Does injury to corn both as grub and adult. The grub burrows in lower part of stalk, and the adult occupies the burrow. Other species make holes and slits in the leaves of corn.

SCOLYTIDÆ OR IPIDÆ (BARK-BEETLES)

Three common Fruit Bark-beetles are *Eccoptogaster rugulosus*, *Phthorophloeus liminaris* and *Anisandrus pyri*, which may be distinguished by the following characters:

A. Venter of abdomen with caudal part bent abruptly upward. Antennal club flat and marked by angulated sutures.—*Eccoptogaster rugulosus* (Fruit-tree Bark-beetle).

AA. Venter of abdomen normal, regularly curved.

B. Antennal club lamellate, of three separate, laterally produced segments; head visible from above.—*Phthorophloeus liminaris* (Peach-tree Bark-beetle).

BB. Antennal club globular; truncate at tip, head deeply imbedded in prothorax whose anterior margin is nearly horizontal and invisible from above.—*Anisandrus pyri* (Shot-hole Borer). (Consult Farmers' Bull. 763.)

Fruit Tree Bark-beetle (*Eccoptogaster rugulosus* Ratz.).—Introduced from Europe; occurs in most states east of the Rockies. This small beetle, also called the Shot-hole Borer, injures fruit trees by puncturing the bark, and burrowing in the bark and wood, causing the death of twigs and leaf buds (Fig. 220).

Adult.—A small black scolytid beetle 1/10 inch long, with the tips of wing-covers and parts of the leg reddish. May–June and August.

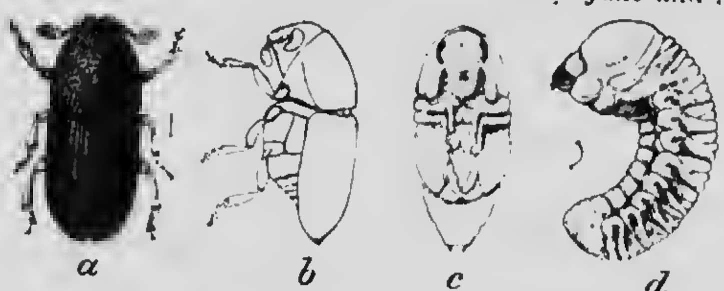


FIG. 220.—The fruit tree bark beetle (*Eccoptogaster rugulosus*): *a*, adult or beetle; *b*, same in profile; *c*, pupa; *d*, larva. All enlarged about 10 times. (*Chittenden.*)

Eggs.—Deposited in little pockets in the brood gallery or chamber between the bark and sapwood; hatch in 3 to 4 days (Fig. 221).

Larva.—Matures in 4 to 5 weeks. A minute legless grub 1/10 inch long; whitish; head small, larger in front than behind. Larval burrows 3 or 4 inches long, filled with reddish dust-like fras and at first at right angles to brood chamber.

Pupa.—Pupa formed in a slightly enlarged chamber: duration 7 to 10 days. Adults make their way out through little round holes in the bark.

Life-history.—Cycle in about 1½ months; two generations in a season in the North and more in the South. Second brood larvæ winter in the trees. Said to attack preferably unhealthy trees. Parasitized by *Chiropachys colon* Westw., a chalcid.

Control.—Remove and destroy dead or dying trees before May or June; apply a protective wash of whitewash and carbolic acid in June and August.

Peach-tree Bark-beetle (*Phthorophloeus liminaris* Harris). (Consult Farmers' Bull. 763, U. S. Dept. Ag.) This native borer cuts its tunnels between the bark and the wood of peach and cherry. Two broods a year. Common in wild cherry in some localities.

Adult.—Brownish-black, 1/10 inch long; head large and visible from above; antennal club lamellate, of three separate laterally produced segments. Breeds in weak and dying limbs, but in fall bores

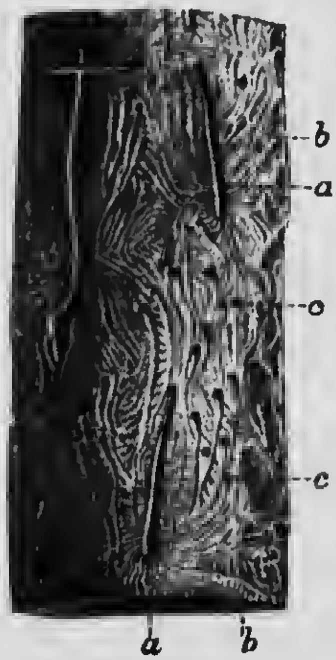


FIG. 221.—Galleries of the fruit tree bark beetle on twig under bark: *a*, *a*, main galleries; *b*, *b*, side or larval galleries; *c*, *c*, pupal cells. Natural size. (*Ratzeburg*.)

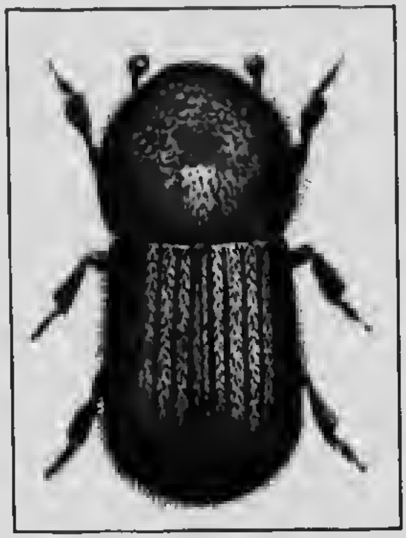


FIG. 222.—Shot-hole borer (*Anisandrus pyri*). (*After Swaine. Bul.* 14, *En., Bur Can.*)

holes in healthy limbs from which much sap exudes following season. Hibernates.

Eggs.—Small, white; 80 to 160; laid in niches along sides of egg-tunnel or brood chamber in spring. Hatch in 17–20 days.

Larvæ.—White; head yelowish, mouth-parts dark; mature in 25–30 days. Form galleries off the egg-tunnel.

Pupæ.—Formed in enlarged end of larval galleries; adults appear through holes cut in the bark above the pupal cells; duration 4–6 days.

Shot-hole Borer (*Anisandrus pyri* Peck).—This borer cuts round, black tunnels deep into the wood; in small branches or stems one division of the tunnels partially circles the wood (Fig. 222).

Adult.—Cylindrical, black, 1/8 inch long; antennal club globular and truncate at tip; pronotum strongly bent downward in front so as to be nearly vertical. Male wingless, smaller than female, and with a curious, humped back. June.

Eggs.—Laid free in galleries in June.

FIG. 223.—Clover root borer (*Hylastinus obscurus*). Natural size at right. (*After Webster U. S. Bur. Ent.*)

FIG. 224.—Larva or grub of the clover root borer. Enlarged. (*After Webster.*)

Larvæ.—Feed on fungus growing on walls of tunnel; mature late in season.

Pupæ.—Formed in tunnels and adults emerge through entrance hole cut by mother beetle.

Clover Root Borer (*Hylastinus obscurus* Marsh).

Adult. A small dark brown cylindrical hairy scolytidid beetle, 1/10 inch long; wing-covers coarsely punctate (Fig. 223).

Eggs.—Minute, white, elliptical and shining.

Larva.—A white stout footless grub with yellow head and brown mouth-parts; 1/8 inch long (Fig. 224).

Pupa.—White, with a pair of spines at top of head, and another at tip of abdomen (Fig. 225).

FIG. 225.—Pupa of the clover root borer. Enlarged. (*After Webster.*)

Life-history.—There is but one brood each year. The adult winters in the clover roots, and lays her eggs during May and June in the crown or on the sides of the root. The larvæ tunnel the root, and mature in July; the pupæ transform to adults before October 1st.

Control.—Plow up infested clover fields after the hay is taken off; break up clover sod after taking one crop.

Forest Bark-beetles (*Dentroctonus* spp. chiefly).—(Consult bulletins by Hopkins and Swaine.) Reference can be made here to only a few of the economic wood-boring beetles that do an immense amount of injury to the forests of the United States and Canada:

1. *Dendroctonus borealis* Hopk., Attacks spruce of the western forests in Alberta and British Columbia.
2. *D. brevicomis* Lec., Western yellow pine.
3. *D. engelmanni* Hopk., Engelmann's spruce of the west.
4. *D. monticolæ* Hopk., Western pines (Figs. 226 and 227).
5. *D. murrayanæ* Hopk., The lodge-pole pine of the West; not injurious.
6. *D. obesus* Lec., The Sitka spruce.

Fig. 226.—The western pine borer (*Dendroctonus monticolæ*. (*After Swaine, Bul.* 14. *Ent. Bur. Can.*)

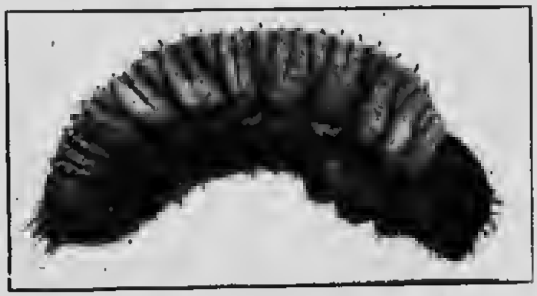


Fig. 227.—Larva of *Dendroctonus monticolæ* (*After Swaine, Bul.* 14. *Ent. Bur. Can.*)

7. *D. piceaperda* Hopk., Eastern spruces.
8. *D. pseudotsugæ* Hopk., The Douglas fir and western larch.
9. *D. simplex* Lec., Larch (Eastern).
10. *D. valens* Lec., Pinus and Picea.
11. *Dryocœtes confusus* Sw., Alpine fir of British Columbia and Alberta.
12. *Polygraphus rufipennis* Ky., Spruces throughout Canada.
13. *Pityokteines sparsus* Lec., Balsam fir in the east.

The bark-beetles are small (1–9 mm. long), brownish or black, and usually cylindrical beetles. One group, the Ambrosia bark-beetles make their tunnels in the wood whose walls are stained black by the growth of the fungus Ambrosia which nourish them. The other group—the true bark-beetles—make their tunnels in the bark or between the bark and the wood.

The systems of tunnels show much variation in shape but are often distinctive of the individual species. They may be simple longitudinal, simple transverse, irregular elongate, irregular short, forked, radiate, cave, pith or ambrosia. In some forms the egg-tunnels originate from a small cavity, the nuptial chamber, at the base of the entrance hole. The eggs are laid in niches along the sides of the egg-tunnels, and the larvæ make slender mines leading away from the egg-tunnels. At the ends of these mines are the enlarged pupal cells. The adult beetles, in emergence, bore round holes through the bark.

With most of the destructive bark-beetles, there is but one brood, or a partial second one, each season. They pass the winter as adults and larvæ in the dying trees entered by the parent adults early in the same season.

While most of the bark-beetles breed in dying and dead trees, some species attack sound trees. The latter are, therefore, called "primary" and the former "secondary" enemies. Some species, however, fall into both classes as they are known to attack both sound and dead and dying trees.

Natural Control.—Several natural factors operate in checking the development of bark-beetles. These are (*a*) weather conditions, such as cold and wet seasons; (*b*) certain hymenopterous and mite parasites; (*c*) certain predaceous beetles; (*d*) wood-peckers; and (*e*) certain parasitic fungi.

Control Measures.—Epidemic and sporadic outbreaks often occur in spite of the operation of the natural control factors mentioned above, especially in districts swept by fires, or subjected to careless lumbering operations where much "slash" is left. If, however, the slash is burned in winter or the trees injured by fire are cut during the first winter after the fire, and got into water or sawn before spring opens, most of the beetles will be destroyed, if the slabs are burned.

The cutting and barking of infested trees, with the burning of the bark during winter or early spring, may be adopted as a control measure. Sometimes cutting and charring the bark will be found sufficient to destroy the beetles.

HYMENOPTERA (ANTS, BEES, WASPS, ET AL.)

Principal Groups and Families

A. Trochanter with two segments; female with ovipositor.
  B. Abdomen sessile or joined broadly to thorax.

C. Tibia of forelegs with two apical spurs; female with saw-like ovipositor.—*Tenthredinidæ* (Saw-flies) (Fig. 228), p. 345.

CC. Tibia of forelegs with one apical spur; female with ovipositor fitted for boring.—*Siricidæ* (Horntails), p. 350.

BB. Abdomen joined to thorax by slender petiole or stalk.

C. Fore wings with few or no cross veins, hence with no closed cells.

D. Ovipositor issuing before the apex of the abdomen; anten-

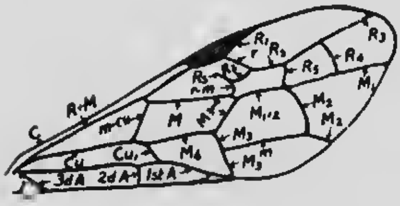


FIG. 228.—Venation of a tenthredinid (*Janus*). (*After Comstock.*)

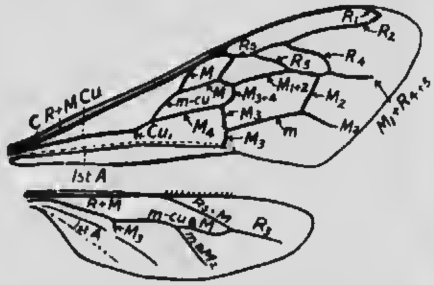


FIG. 229.—Venation of the honeybee. (*After Comstock.*)

næ elbowed and with one or more ring-like segments next to last.—*Chalcididæ* (Chalcis Flies), p. 353.

DD. Ovipositor issuing from the apex of the abdomen; antennæ straight, or if elbowed without ring-like segments.—*Proctotrypidæ*, p. 351.

CC. Fore wings with one or more closed cells.

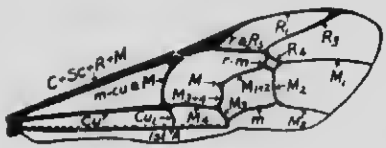


FIG. 230.—Venation of an ichneumonid. (*After Comstock.*)

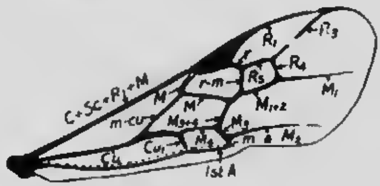


FIG. 231.—Venation of a braconid. (*After Comstock.*)

D. Fore wings without a stigma; antennæ with not more tha 16 segments and straight.—*Cynipidæ* (Gall Flies), p. 351

DD. Fore wings with a stigma; antennæ with more than segments and straight.

E. Fore wing with vein between Media 1 and 1st Media wanting.—*Braconidæ* (Braconid Flies) (Fig. 231), 352.

EE. Fore wing with vein between Media 1 and 1st Media present.—*Ichneumonidæ* (Ichneumon Flies (Fig. 2 p. 352.

AA. Trochanter simple; female usually with a sting.

B. Fore wings without closed submarginal cells.
  C. Abdomen and antennæ long; body smooth and black.—*Pelecinidæ*, p. 352.
  CC. Abdomen and antennæ short; body colored and often sculptured.—*Chrysididæ* (Cuckoo Flies).
BB. Fore wings with one or more closed submarginal cells.
  C. Abdominal stalk normal.
    D. First segment of the tarsus of the hind leg more or less compressed, at least on inner side, and often thickly hirsute.—Group *Apoidea* (Bees) (Fig. 229), p. 356.
    DD. First segment of the tarsus of the hind leg more or less cylindrical, neither markedly broadened nor hairy.
      E. Fore wings folded once lengthwise; antennæ usually clearly bent at an angle; pronotum extending back so as to touch or reach above the tegulæ.—Group *Vespoidea* (Wasps), p. 356.
      EE. Fore wings not folded lengthwise; hind angles of pronotum remote from and below the tegulæ. Abdomen appended or pedunculate, oval or broadest anteriorly, gradually tapering posteriorly.—Group *Sphecoidea* (Digger and Mud Wasps), p. 356.
  CC. Abdominal stalk formed of one or two knots or scale-like rings; antennæ flagellum-like.—Group *Formicoidea* (Ants), p. 359.

The classification given above is deemed sufficient for the purposes of this book, but recent monographs show a breaking up of many of the old families into new ones, with new groupings. (See *Hymenoptera of Connecticut*, Bull. 22, State Geol. and Nat. Hist. Survey, 1916.)

TENTHREDINIDÆ (SAW-FLIES)

Currant Stem Girdler (*Janus integer* Norton).—*Adult.* A slender black saw-fly with yellowish legs; male smaller than female, with abdomen brownish-yellow. Abdomen in female is half reddish-orange and half black. May. Stem girdled by female.

Eggs.—Deposited in pith of cane; elongate-oval, yellowish-white, 1/25 inch long. Laid in May and June; hatch in about 11 days.

Larva.—One-half inch long, straw color; head darker yellow; thoracic segments broadest; tip of abdomen with a horny brown bifid spine. Tunnels in the pith. Winters in a silken cocoon

Pupa.—Formed in April; white. Wilting of cane occurs in May.

Control.—Cut off and burn infested canes 8 or 10 inches below the girdled part, in June or fall.

Imported Currant Worm (*Pteronus ribesii* Scop.).—*Adults.* Four-winged saw-flies, 1/3 inch long; female with light yellow abdomen marked with black; male smaller and darker; May and July.

Eggs.—Laid in rows on leaves along the mid-ribs; hatch in 4 to 10 days.

Larva.—At first the caterpillar is whitish and with white head; after first moult the body is green with black spots on side of body. When full grown, 3/4 inch long, they lose their black spots and descend to ground to pupate. Two or three weeks.

Pupa.—Formed in an oval brownish silken cocoon on the surface of the ground. Pupa of second brood winters over.

Life-history.—Two broods a year; adults emerge in spring and again in July. Broods overlap.

Control.—Dust or spray with hellebore or with an arsenical poison

Larch Saw-fly (*Lygæonematus erichsonii* Hartig.).—(Consult Bull. 10, Div. Ent. Dep. Ag. Can.) A serious pest of larch introduced from Europe.

Adult.—A large thick black saw-fly, with second, fifth and part of sixth abdominal segments bright red. April–May.

Eggs.—Laid in slits in terminal shoots June–July; white, cylindrical, tapering at each end; 1/20 inch long; hatching in 8–10 days.

Larvæ.—Feeding on leaves in June–July; mature in 20 days when they descend to ground and spin cocoons; hibernate. Full grown larvæ with jet-black head and glaucous green body About each segment, except second, double parallel rows of minute dark dots; five moults.

Pupæ.—In dark brown, oval, elongated cocoons, 2/5 inch long beneath the surface.

Parasites.—*Pteromalus nematicidus* Pack., a chalcid, and *Mesolei tenthredinidis*, an ichneumonid.

Birch Saw-fly (*Hylotoma pectoralis* Leach).—Defoliates birch in Quebec and Prince Edward Island, while *Fir Saw-fly* (*Lophyrus abietis* Harr.) and *Abbott's Pine Saw-fly* (*L. abbotii* Leach) do damage to firs and pines respectively.

Raspberry Web Worm (*Pamphilius fletcheri* MacG.)—Injurious in New Brunswick.

Adult.—Three-eight inch long; head and thorax black with white markings. Abdomen of male black with a broad median transverse yellowish band; abdomen of female with front third black and remainder reddish-yellow. Middle of June.

Larva.—Smooth, bright green, $\frac{1}{2}$ inch long, feeding within a tent formed by webbing together the terminal leaves. Hibernates.

Dock False Worm (*Ametastegia glabrata* Fallen = *Taxonus nigrisoma* Norton).—(Consult Bull. 265, Bur. Ent. U. S. Dep. Ag., 1916.) The green worm-like larva of this saw-fly often burrows into apples to hibernate. Its natural food plants are dock and related plants. Four broods a year.

Elm Saw-fly (*Cimbex americana* Leach).—Feeds on leaves of elm, willow, poplar, maple and basswood.

Adult.—A saw-fly with head and thorax black; body steel-blue with three or four oval yellowish spots on each side; wings smoky brown; legs bluish-black; tarsi yellowish; antennæ short and knobbed. May.

Eggs.—Elongate or oval, flattened, clear; laid in the leaf.

Larva.—Three-fourths inch long; yellowish-white, coiled, with a black stripe along the middle of back; 8 pairs of prolegs; legs greenish-white. Matures in July–August, and forms a tough, coarse silken cocoon at base of tree where it hibernates.

Pupa.—Formed in spring in cocoon.

Parasite.—*Opheltes glaucopterus* Holmgr., an ichneumon.

Raspberry Saw-fly (*Monophadnus rubi* Harris).—(Consult Bull. 150, N. Y. Agr. Expt. Station, Geneva.) *Adult.* A saw-fly, $\frac{1}{4}$ inch long; female with body black, with segments of abdomen from 2 to 6 yellowish-white, and under side rusty brown; male black with shoulders yellowish-white; May.

Eggs. Pear-shaped, yellowish white, $\frac{1}{20}$ inch long; inserted under upper cuticle of leaf; hatch in 7 to 10 days.

Larva.—At first pale yellowish-green covered with whitish spiny tubercles, mature larva $\frac{3}{4}$ inch long, green, covered with barbed spiny tubercles, brown on back and white on sides, feed for 10 days, then enter soil and form small, brown, oval cocoons. Hibernate in cocoons.

Pupa.—Formed in May, and lasting a few days.

Strawberry Saw-fly (*Harpiphorus maculatus* Norton).—(Consult Bull. 54, Mo. Agr. Expt. Station.) *Adult.* A black saw-fly with a row of light spots on sides of abdomen, [illegible] inch long; May.

Eggs.—Inserted beneath epidermis of leaf, hatch in 2 weeks.

Larva.—Slug-like, $\frac{1}{2}$ inch long, yellowish with a pale stripe along the back; coiled when at rest; 8 pairs of prolegs; full grown in a month; entering soil and forming a cocoon. Hibernates.

Pupa.—Formed in May.

Rose Saw-fly Slug (*Endelomyia rosæ* Harr.).—This insect is often injurious to the leaves of roses. The slug-like larvæ eat the upper surface of the leaves. The pupæ are found in the ground. There are two broods each year; June and August.

Cherry Saw-fly Leaf Miner (*Profenusa collaris* MacG.).—(Consult Bull. 411, N. Y. Ag. Exp. St.) This insect has been injurious to cherries in New York State for several years. It produces blister-like areas on leaves. The adult is a small saw-fly 1/7 inch long, appearing in May, and the larva passes part of its existence in the leaf as a miner and in the ground in an earthen cell. Pupation occurs in late April or early May.

Plum Web-spinning Saw-fly (*Neurotoma inconspicua* Norton). Forms ugly nests in the leaves of plum and cherry.

Adult.—A saw-fly, 1/2 inch long; wings hyaline with a faint fuscous band behind stigma; body, coxæ and tarsi black, legs reddish. May June as leaves expand.

Eggs.—Smooth, elongate, yellow; deposited in two or three rows along mid-rib of under surface of leaf. Hatch in about 8 days.

Larva.—Three-fourth inch long, grey above and yellow or pinkish below; head yellow; thoracic shield and anal segment black; full grown in a month; feeds on leaves under webs. Passes the winter in an earthen cell 6 inches below the surface of the ground.

Pupa.—In early spring pupa forms near the surface.

Pear Slug (*Eriocampoides limacina* Retzius, *Caliroa cerasi* Linn.).—(Consult Circ. 26, Div. Ent., U. S. Dept. of Agriculture.) The slug-like larvæ of this European insect are often found feeding on the surfaces of the leaves of pear, plum and cherry.

Adult.—A glossy black saw-fly, 1/5 inch long; wings with a smoky band across the middle. May and June, and August. Two generations in the North but one along the Lower St. Lawrence.

Eggs.—Deposited beneath the upper surface of leaf in a cut made by ovipositor; hatch in 2 weeks.

Larva.—At first white with yellowish-brown head; later, darker with brownish-black head: body covered with slime like a slug; anterior portion of body enlarged; 7 pairs of prolegs. Full grown in about

25 days; ½ inch long with orange-yellow dry body and light colored head; enters the ground for a week where it forms a cell.

Pupa.—Formed in a cell in the ground, 1–2 inches below surface; duration 1 week. Pupæ of last brood hibernate, but some larvæ do not pupate until spring.

Parasite.—Pentarthron minutum.

Control.—Readily controlled by arsenicals or tobacco-soap solutions, or by dry hellebore or air-slaked lime.

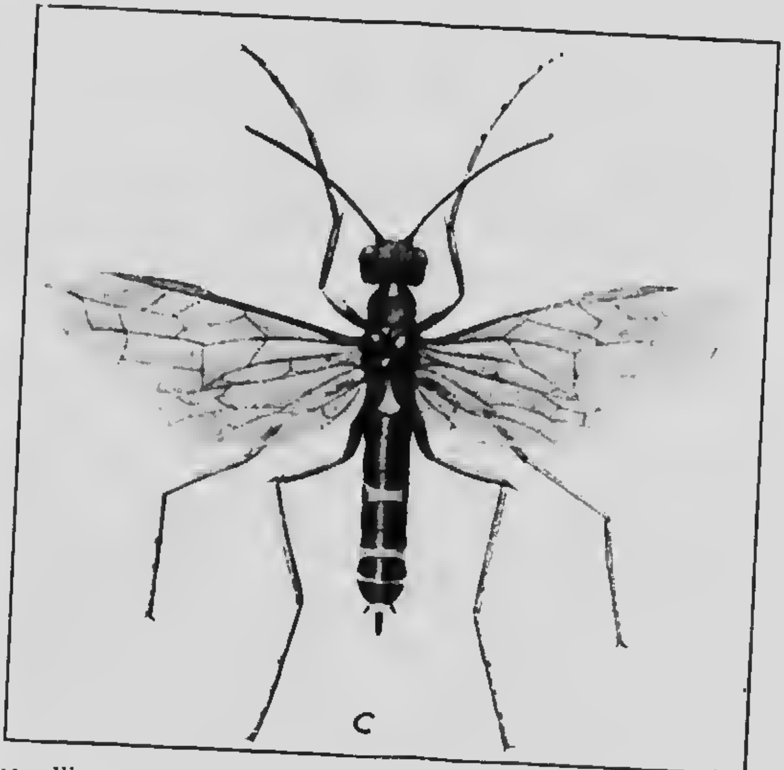


FIG. 232.—Western wheat-stem saw-fly (*Cephus occidentalis*): *c*, adult. (*After Criddle, Ent. Bul. 11, Dept. Agric. Ottawa.*)

Rose-slugs.—Three species infest the rose, the American Rose-slug (*Endelomyia æthiops* Fab.), the Bristly Rose-worm (*Cladius pectinicornis* Fourcr) and the Curled Rose-worm (*Emphytus cinctipes* Nort.). They vary from ⅓–⅔ inch in length.

Western Wheat-stem Saw-fly (*Cephus occidentalis* R. and M.).—(Consult Ent. Bull. 11, Dep. Agric., Ottawa.) A native of N. America, probably with species of *Agropyron* as its host plants. A serious pest in the West on wheat and rye (Figs. 232 and 233).

Adult.—A shiny black 4-winged fly, 1/3 inch long; abdomen with three prominent yellow rings; legs yellow. Female with a short stout horn-like ovipositor. It rests head downward on the stems of grasses, with its wings very close together over the body. June 10–July 10.

Eggs.—Minute, white, cylindrical.

Larva.—Dull yellowish-white, 1/3–1/2 inch long; first two segments swollen; end of abdomen with a short blunt projection. Always occurs within the stem. Bores downward in the stem, reaching base

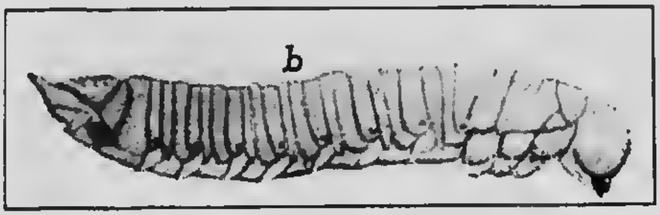


FIG. 233.—Full grown larva of the western wheat-stem saw-fly (*Cephus occidentalis*) (*After Criddle, Bul. 11, Ent. Br. Can.*)

about August 1st and cutting the stems through level with ground; remains all winter in stub until following May.

Pupa.—Formed in May in stub inhabited by larva.

Control.—1. Plough infested stubble 5 inches deep in fall, with attention at least to worst infested fields.

2. All infested grasses, such as western rye grass, timothy and the prairie grasses next to growing crops should be cut between July 10th and August 1st.

SIRICIDÆ (HORN-TAILS)

Pigeon Tremex (*Tremex columba* Linn.).—Injures elm and maple.

Adult.—Female a large 4-winged fly, 2 inches long, with a prominent yellow horn at end of abdomen; head and thorax reddish-black, abdomen cylindrical, dark brown, with seven yellowish band-like markings; male smaller, without horn. June–August (Fig. 234).

Eggs.—Oblong oval, jointed at ends, 1/20 inch long.

Larva.—Large, soft, yellowish, cylindrical, with six true legs and a horny point at end of abdomen; boring into wood. Parasitized by

Thalessa lunator, a slender, brown and yellow, wasp-like Ichneumon with a long delicate ovipositor.

Pupa.—Formed in burrow within a cocoon made of silk and chips.

CYNIPIDÆ (GALL-FLIES)

The injury done by Cynipids to economic plants is not serious, being confined mainly to oaks and roses. (Consult Felt's Key to American Insect Galls).

Eggs are laid in the leaves, stems and roots, and soon gall-like enlargements are formed as a result of the stimulus of the larvæ. The galls are closed and are very varied in shape.

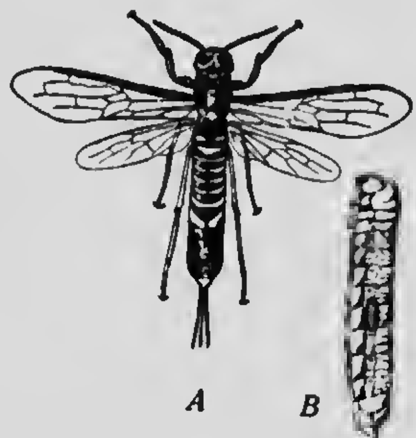


FIG. 234.—Pigeon tremex (*Tremex columba*): *A*, adult; *B*, larva (with parasitic larva of *Thalessa* attached). Natural size. (*After Riley.*)

The **Mossy Rose-gall** on Sweetbrier, produced by *Rhodites rosæ* Linn., is many-celled and consists of a number of hard kernels embracing the stem, covered with reddish-green mossy filaments.

The **Pithy Blackberry-gall,** produced by *Diastrophus turgidus* on blackberry canes consists of an elongated, many-celled, ridged, woody, reddish-brown gall.

Pithy Blackberry-gall Fly (*Diastrophus turgidus* Bass.). *Adult* Black, 1/12 inch long; feet and antennæ red; four wings, transparent and almost without veins. Early summer.

Larva.—White, 1/10 inch long, mouth-parts and spiracles reddish; hibernates in cells of gall.

Pupa.—Formed in spring.

Control.—Cut out and burn infested canes during the winter.

Several species infest oaks, viz., *Amphibolips* spp., *Holcaspis* spp., *Andricus* spp., and *Cynips* spp., each producing its characteristic gall.

PROCTOTRYPIDÆ (PROCTOTRYPIDS)

The members of this family, or rather the group *Proctotrypoidea*, are the smallest of insect parasites. They are usually black and without metallic lustre. Sometimes they occur as secondary parasites on primary parasites. The larvæ live within other insects, often within insect eggs and sometimes within larvæ or pupæ. The larvæ of *Polygnotus* develop within the digestive tract of gall midges, and *Trichacis* in the nervous system of the same midge. *Telenomus* is a common form infesting the eggs of many butterflies and moths. *Anopedius* is parasitic on the clover seed midge and the wheat midge, and *Platygaster* on the Hessian-fly. The eggs of Proctotrypids are ovate, with a peduncle at the end."

The neuration of the wings shows great diversity. As a rule the hind wings are veinless. In some sub-families the veining of the fore wings resembles that of the Braconids and the Chrysidids and Scoliids, and in others the Chalcids. (Consult Ashmead's Monograph of the N. A. Proctotrypidæ and Brues' *Serphoidea* in *Hymenoptera of Connecticut.*)

Family Pelecinidæ

Pelecinus obturator Drury is a long black hymenopter (female 2–2½ inches long), parasitic on white grubs (*Lachnosterna*). It is sometimes grouped with the Proctrypids under the *Serphoidea.*

Ichneumonidæ (Ichneumon Flies)

These insects form an important group of parasites upon injurious forms. The females lay their eggs either within or upon the host larva, and the maggots feed within the host until maturity, feeding upon its blood by osmosis through the skin; in some cases, by attacking muscle tissues and the fat body, and getting air, probably by attachment to the tracheæ. Cocoons are often spun on the back of the host, from which emerge the adults. Some common genera are *Ophion* (light brown with compressed abdomen), parasitic on *Polyphemus* larva, *Thalessa* (with a long flexible ovipositor) on Pigeon Tremex, *Pimpla conquisitor* on the pupæ of tent-caterpillars, the cotton-worm and the Brown-tail, *P. inquisitor* on tussock caterpillars (see Howard's *Insect Book*), and *Trogus* parasitic on chrysalids of *Papilio.*

Braconidæ (Braconid Flies) (Figs. 235 and 236)

Braconids are, as a rule, smaller than the Ichneumons, but like the latter are valuable parasites. *Aphidius* and *Lysiphlebus* parasitize plant-lice, *Apanteles* tomato worms, cabbage worms and others, *Microgaster* Grape Sphinx caterpillars; *Meteorus* Fall Web-worms. Braconid flies are wasp-like, brownish or yellowish-black, and about $\frac{1}{8}$ inch long.

FIG. 235.—A tomato worm (*Phlegethontius sexta*), bearing cocoons of the parasitic *Apanteles congregatus*. Natural size. (*After Folsom.*)

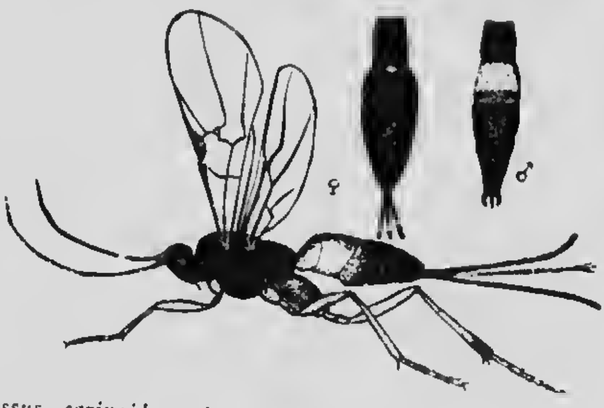


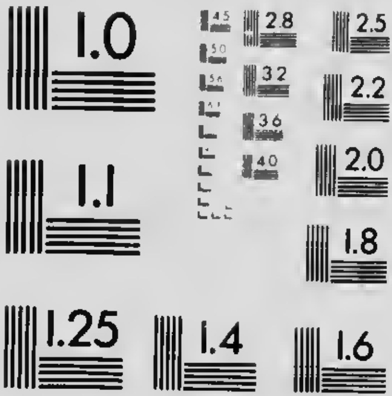
FIG. 236.—*Bassus earinoides.* A braconid parasite of the budmoth. Much enlarged.

CHALCIDIDÆ (CHALCID FLIES) (Fig. 237)

The great majority of Chalcis-flies are beneficial as parasites on injurious insects. They are minute metallic insects with stout heads

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



and bodies. They are recognized by the branched single vein of the fore wings. Their larvæ attack many species of caterpillars. Among the more common forms are *Pteromalus puparum* on the pupæ of the White Cabbage Butterfly; *Aphelinus* on scale insects; *Monodontomerus æreus* on the Brown-tail and Gypsy Moths; *Trichogramma* on many caterpillars, and *Cœlopistha nematicida* on the Larch Saw-fly. *Tetrastichus, Dibrachys, Coccophagus, Scutellista, Prospaltella, Eupelmus* and *Aphycus* are other valuable economic forms.

The four following species are injurious:

Wheat Joint Worm (*Isosoma tritici* F tch.).—(Consult Farmers' Bull. 132 and 1006, U. S. Dept. of Agric.) *Adult.* A minute black 4-winged ant-like fly; 1/5 inch long. May. Injurious in the East on account of the larva living in the stems of wheat, sucking the juices and causing a swelling in the stem. Infested plants contain one or more hard woody cells in the stem just above the second or third joint from the ground, in which live the larvæ or grubs. On nearing maturity the stems fall or break at the places of injury.

Eggs.—Small, white, round-oval. Inserted in daytime, singly at a place, in the stem by the sharp ovipositor, but of en as many as 15 into one stem. Each female may lay as many as 70 or mo e eggs. Hatch in about 14 days.

Larva.—A yellowish-white maggot, 1/5 inch long, tips of jaws brown, 3 to 4 moults; full grown in 3 weeks; hibernates in wheat straw; forms cell in stem. Most of the larvæ change to pupæ late in Autumn.

Pupa.—Yellow to black; 1/5 inch long.

Parasites.—*Ditriponotus aureoviridis, Homoporus chalcidephagus. Eurytoma bolteri parva, Eupelmus epicasta* Walk., all chalcids.

Control.—Rotation of crops; burning and deep plowing under of stubble when practicable, or harvesting of stubble in spring, collecting with horse-rake and burning; preparation of good seed-bed.

Wheat Straw Worm (*Isosoma grande* Riley).—A pest west of the Mississippi; adults emerge in April–May from stubble and lay eggs. and the larvæ eat the forming heads of wheat. Adults appear again in June and lay eggs above the upper joints. Larvæ pupate by October and winter is passed in the stubble.

Species of Isosoma (Females) (after Howard)

A. Mesonotum smooth, polished, shining.—*grande.*

AA. Mesonotum rugulose; abdomen longer than thorax.

B. Pronotal spot minute.—*hordei.*
BB. Pronotal spot large, distinct.
C. Second abdominal segment longer than fourth and fifth together.—*secale.*
CC. Second abdominal segment shorter than fourth and fifth together.—*tritici.*

Apple Seed Chalcid (*Syntomaspis druparum* Boh.).—An introduced insect from Europe. Well distributed in the Northern States. Causes deformities and corky discolored streaks in the fruit when repeated puncturing occurs.

Adult.—A wasp-like chalcid, bright green with bronzy reflections; legs brownish-yellow; wings clear hyaline. Female 1/6 inch long, with long slender ovipositor; male smaller than female. June–July.

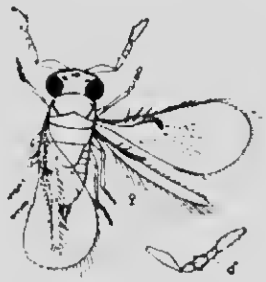


FIG. 237.—*Pentarthron minutum*, a chalcid parasite of the budmoth.

Eggs.—Elongate-oval, one end prolonged into a slender twisted pedicle, yellowish-white. Laid in the seed and hatch in 6 to 8 days.

Larva.—Spindle-shaped and curved; 1/5 inch long; five instars. Feeds on the soft kernel until September, then hibernates in the hollow seed until spring.

Pupa.—Dark greenish when mature; duration about 4 weeks.

Control.—Collect and destroy apples lying under the trees.

Clover Seed Chalcid (*Bruchophagus funebris* Howard). *Adult.*—A minute black four-winged fly, 1/12 inch long.

Egg.—Elliptical with a slender tube, whitish and smooth.

Larva.—A white stout footless maggot, 1/15–1/12 inch long.

Pupa.—Dark and less than 1/12 inch long.

Life-history.—This insect usually winters over in the seed as a well-developed larva; the pupal stage is rather short, and the adult lays her eggs in May and June. The first of the adults of this brood appear in July and August, but some do not come out till the following spring. There is much overlapping of stages and the number of broods is difficult to determine. Folsom traced as many as three generations per year, with a possibility of four.

Group Vespoidea (Wasps)

The true wasps are divided into the Solitary Wasps (*Eumenidæ*) and the Social Wasps (*Vespidæ*). The former have similar habits to the Digger Wasps (see below), forming burrows in the earth, in wood or on twigs of shrubs. In the latter class two genera are common, *Polistes* with a spindle-shaped abdomen, and black ringed with yellow, and *Vespa*, the common hornet or yellow-jacket. The paper nests attached to buildings, trees or in the earth are constructed from bits of wood made into a pulp, and are provisioned with spiders or insects. The nest of *Polistes* consists of a single comb, attached by a short stem, but that of *Vespa* consists of several layers of combs with a papery covering.

The White-faced Hornet is well known as the maker and owner of the large paper nest. It provides its young with noxious larvæ, and undoubtedly does much to control insect life. Occasionally, however, it may injure grapes or peaches by eating holes in them. The life-history is quite similar to that of the Bumble Bee—males, females and workers (undeveloped females) making up the colony. Only the females survive the autumn and hibernate.

Group Sphecoidea (Digger Wasps)

The Digger Wasps contain a large number of families. (See Comstock's *Manual of Insects* and *Hymenoptera of Connecticut.*) They are solitary and store their nests with paralyzed insects or spiders. The nests vary in structure; some are made of mud attached to ceilings of buildings, some made in the pith of elder, sumach, etc., and others in sandy banks. The more common genera are *Tiphia*, *Pelopæus*, *Sphecius*, *Stigmus* and *Trypoxylon.*

Group Apoidea (Bees)

The bees are grouped into two families, the *Andrenidæ* (Short-tongued bees) and the *Apidæ* (Long-tongued bees). In provisioning their nests with honey or pollen, or both, which they collect from flowers, bees are of great economic importance in the cross-fertilization of many flowers. (See Part I.)

Most of the *Andrenidæ* are miners and make their nests in the ground. They are solitary, each female making her own nest, but frequently the nests are close together. Some of the more common genera are *Andrena, Halictus* and *Prosopis.*

To the *Apidæ* belong the Leaf-cutter bees (*Megachile*), Carpenter bees (*Ceratina* and *Xylocopa*), Guest-bees (*Psithyrus*), Bumble Bees (*Bombus*) and Honey Bees (*Apis*). The Leaf-cutter bees (*Megachile*) make tubular cells out of nearly semi-circular pieces of leaves cut from rose bushes and various plants. These cells are placed in burrows made either in the ground or in soft wood.

The Mason Bees (*Osmia*) construct nests of clay and sand in stone walls, old fence posts and trunks of trees. The cells are composed of sand, earth or clay mixed with pebbles or bits of wood, all glued firmly together. (See *Manuals* of Comstock and Kellogg, and Sladen's "Humble bee" for details regarding the habits of bees.)

Social Habits of Bees.—Bees show a gradation from solitary forms like *Ceratina, Prosopis, Andrena* and *Halictus* to colonial forms like the bumble bee and honey bee. This gradation may be represented as follows:

A. Solitary bees.
- B. Queen dies after egg-laying and providing food for larvæ.
  - C. Nests quite apart.—*Prosopis, Ceratina.*
  - CC. Nests in colonies, but females work independently.—*Andrena, Anthrophora, Osmia.*
  - CCC. Females hibernate in companies.—*X[illegible]pa.*
  - CCCC. Two or more females use a common h[illegible]e or refuge.—*Halictus, Panurgus.*
- BB. Queen survives to see the brood and watch over the nest.—Species of *Halictus.*

AA. Social Bees.
- B. Fertilized female hibernates alone.—*Bumble Bees.*
- [illegible] Permanent societies with perfect combs.—*Honey Bees.*

Bu[illegible]e Bees (*Bombus* spp.).—From an economic standpoint Bumble Bees are of importance as agents in pollination of red and other clovers. The over-wintering queen starts her nest in the spring usually in a deserted mouse's nest. She places in it some pellets of pollen and nectar and on them in a wax cell lays her first eggs. Next she constructs a "honey-pot" for holding the honey collected at the entrance to the nest. The larvæ feed on the pollen, and when full grown—about 11 days after the eggs are laid—form silken cocoons in which they spend their pupal period of about 11 days. The first brood are small workers who relieve the queen of further work except that of egg-laying. Later broods are large workers and the last brood consists of males and females. In the autumn all succumb except the young queens.

The males and females of *Bombus* are reared after the workers near the close of the summer, and mating occurs then. The number of workers is relatively small, 300 in some of the underground-dwelling species to 60 in some of the surface-dwelling species.

The more common species are *B. borealis*, *B. terricola*, *B. ternarius*, *B. pennsylvanicus*, *B. vagans*, and *B. fervidus*.

Honey Bee (*Apis mellifera* Linn.).—There are three kinds of individuals—*queen*, *drones* and *neutral workers*. The queen is the mother of the colony and lays the eggs; the drones are males and relatively few. A colony at the beginning of the season contains 30,000 to 40,000 workers.

Honey.—Obtained from nectaries of flowers by workers and carried in the *honey sac* in the abdomen. Nectar is stored in cells and the surplus water is evaporated by currents of air to 10 to 12 per cent. Finished product is stored in wax cells about the brood chambers.

Wax.—Made from honey and sugar. Gorged workers hang in dense masses and plates of wax appear beneath the abdomen in about 24 hours. The wax is then transferred to the mouth and there masticated with a fluid excreted by the cephalic glands. Twenty pounds of honey are required to make 1 pound of wax.

Propolis.—Obtained from buds and used to strengthen the cells.

Brood.—Egg hatches in 3 days. The grubs are nursed by workers on fluids from the mouth; later they are fed on pollen, honey and water; after 5 days the grub spins its cocoon, and 13 days later the winged bee emerges.

Duration of Stages.—

	Egg	Larva	Pupa	Total
Queen	3 days	5½ days	7 days	15½ days
Drone	3 days	6 days	15 days	24 days
Worker	3 days	5 days	13 days	21 days

The queen grub is fed on *royal jelly*—the nutritious fluid excreted by the nurses.

Swarming.—As the queen lays about 1000 eggs per day a time arrives when a prosperous colony tends to be overcrowded. The workers then rear new queens and the old queen collects several thousand workers about her and emerges to found a new colony. This phenomenon is known as *swarming.* Frequently a hive may swarm twice or thrice during a favorable season. The expert apiarist may save much worry and trouble by inducing swarming artificially.

Fertilization.—The queen is fertilized by a drone during the nuptial flight, when her spermathecæ are filled with spermatozoa. She usually mates but once, and the sperms are sufficiently numerous to fertilize the thousands of eggs which produce workers. The queen may also lay some, relatively few, unfertilized eggs which produce drones.

CHARACTERISTICS OF THE MORE IMPORTANT RACES OF HONEY BEES—(*Dr. E F. Phillips*)

Race	Color of abdomen	Disposition	Quality as a producer	Cappings of comb honey	Remarks
German	Black	Cross	Poor	White	First race introduced into America.
Italian	Yellow stripes	Gentle	Best	Fairly white	Most popular race.
Carniolan	Grey	Gentle	Good	White	Some advocates in the United States.
Caucasian	Yellow grey	Gentlest known	Good	White	Recently introduced. Good for amateurs.
Banat	Black	Gentle	Good	White	Recent.
Cyprian	Yellow	Vicious	Good	Watery	Now practically abandoned in United States.

GROUP FORMICOIDEA (ANTS)

FAMILY FORMICIDÆ

(Consult Howard's *Insects*, Wheeler's *Ants* and *Formicoidea* in *Hymenoptera of Connecticut*)

Three classes of individuals occur in an ant colony—males, females, and wingless workers, the last being undeveloped females.

The males and females mate in the air, after which the males die and the females tear off their wings. They then build small cells and commence egg-laying. These eggs and their larvæ are first tended by the queen but later by the workers. The larvæ are white and legless, and at maturity spin egg-shaped cocoons. How queens are developed is not known, but they and the workers may live for many years. The food of ants is quite varied, but is usually of animal origin, especially nectar and dead insects. On the whole ants are beneficial.

As to general habits ants may be classified into:

1. *Hunting ants* which prey upon insects, other ants, etc.

2. *Slave-making* ants which capture other species and make slaves of them.

3. *Honey ants* which collect honey and store it in certain members of the colony—mostly western forms.

4. *Leaf-cutting ants* which bite off bits of leaves, take them to their nests, and grow fungi upon them—mostly tropical forms.

5. *Harvesting ants* which collect and store seeds for food supply in underground granaries—mostly southern forms.

The colonies or nests occur either in the ground or in decaying wood, and consist of irregular cavities that intercommunicate. Often above the nests are dome-shaped hills in which the eggs are hatched, and the legless larvæ and pupæ nurtured.

Ants belonging to the sub-family *Camponotinæ* are stingless, and here belong the genera *Lasius*, *Camponotus* and *Formica*. Those belonging to the sub-family *Myrmicinæ* are stinging ants, including the genera *Solenopsis*, *Tetramorium*, *Monomorium*, *Cremastogaster*, and *Myrmica*.

House and lawn ants may be classified, according to *origin*, into:

1. Tropical old-world ants, represented by the *little red ant* or *Pharaoh's ant* (*Monomorium pharaonis* Linn.), the *crazy ant* (*Prenolepis longicornis* Latr.), a related species *Prenolepis vividula* Nyl. and *Plagiolepis longipes* Jerden.

2. Introduced tropical new-world ants, represented by the *Argentine ant* (*Iridomyrmex humilis* Mayr.), and *Prenolepis fulva var. pubens* Fovel.

3. Native Temperate N. A. ants, represented by the *thief ant* (*Solenopsis molesta* Say), the *carpenter ant* (*Componotus herculaneus var. pennsylvanicus* DeG.), the *little black ant* (*Monomorium minimum* Bckley), the *American lawn* or *corn ant* (*Lasius niger var. americanus*

Emery), and the *European meadow ant* or *pavement ant* (*Tetramorium cæspitum* Linn.). The three last mentioned species are also frequenters of gardens and lawns (Fig. 238).

House Ants (*Monomorium pharaonis* Linn.).—(Consult Circ. 34, Farmers' Bull. 740, U. S. Dep. Ag.; Wheeler's *Ants.*) These are the little red ants that have their nests in the wall, or beneath the flooring,

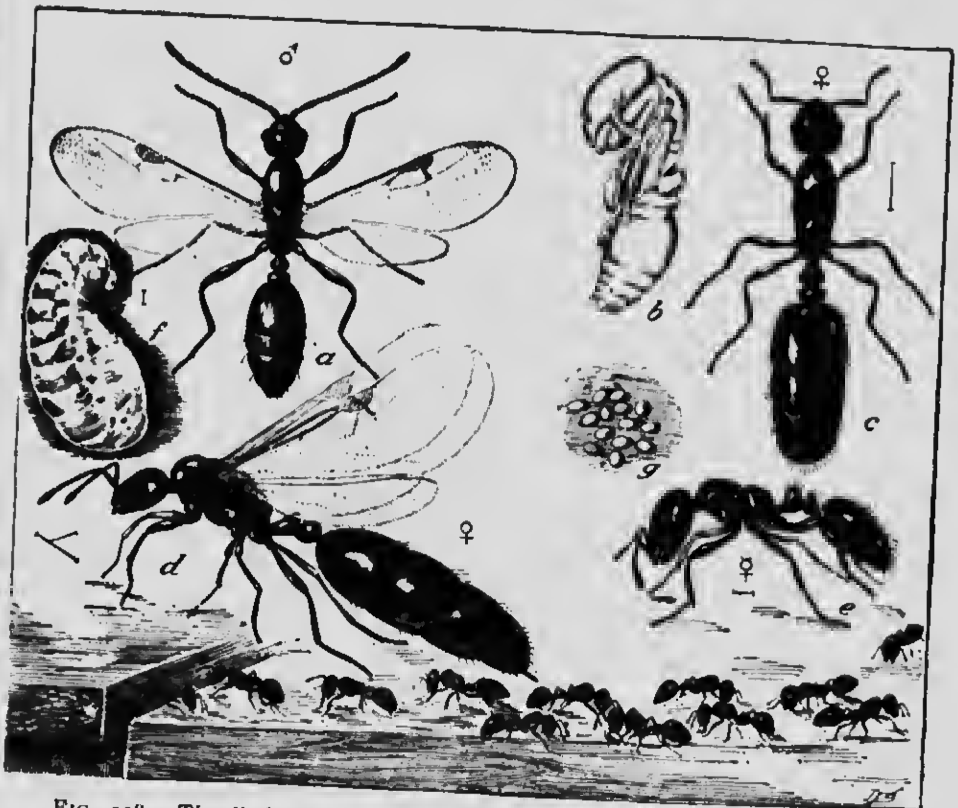


FIG. 238.—The little black ant (*Monomorium minimum*): *a*, male; *b*, pupa; *c*, female; *d*, same with wings; *e*, worker; *f*, larva; *g*, eggs; group of workers in line of march below. All enlarged, the lettered illustrations all drawn to the same scale. (*After Marlatt, U. S. Dept. Agric.*)

and are nuisances about houses. The black ant (*M. minutum*) and the pavement ant (*Tetramorium cæspitum*) are also occasionally found in houses (Fig. 239).

Adults.—Worker neuters, winged males and females, and wingless females constitute an ant colony.

Eggs.—Laid in immense numbers by the solitary queen mother, minute, oval, whitish; cared for by the workers.

Larvæ.—Fed by workers.

Pupæ.—White, cared for by workers; egg-like but much larger than the true eggs.

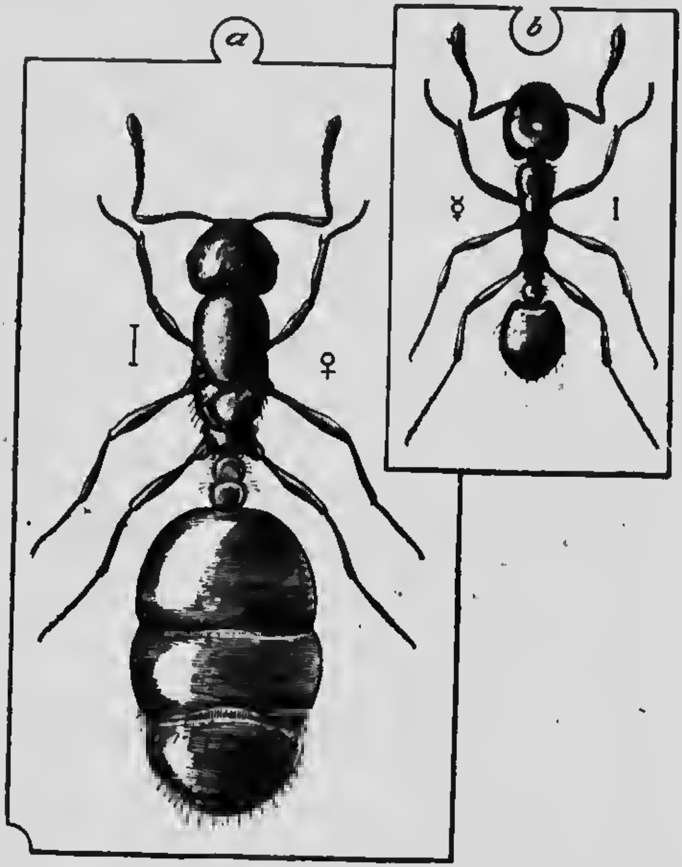


FIG. 239.—The little red, or Pharaoh's ant (***Monomorium pharaonis***): *a*, queen or female; *b*, worker. Both drawings enlarged to the same scale. (*After Marlatt.*)

Control.—Destroy nests with hot water or carbon bisulphide; dust with sodium fluoride; trap ants in sponges soaked in sweetened water or in a syrup poisoned with arsenate of soda. Formula: sugar, 1 lb.; arsenate of soda, 125 grains; water, 1 qt.; boiled and strained.

Lawn or Corn Ant (*Lasius niger var. americanus* Em.).—This ant, which is very abundant in the corn-growing districts of the Central

States, is closely associated with the corn-root louse or aphid (*Aphis maidiradicis* Forbes). Forbes has shown very interestingly how the ants carry the eggs of this aphis into the underground galleries of their nests on the approach of winter, tend them carefully, and in the spring carry the young aphids to suitable weeds, transferring them later to the corn plants.

In the control of this aphid, therefore, the best method is to plow and harrow in the autumn infested fields so as to break up the ants' nests, to destroy the weeds that may serve as temporary food-plants, and to practise crop rotation.

NEAR RELATIVES OF INSECTS INJURIOUS TO PLANTS AND ANIMALS

Crustaceans, Arachnidans and Myriapods belong also to the great Branch of Animals called the *Arthropoda*, hence are here termed "near relatives" of insects.

CLASS CRUSTACEA

Sow Bugs, Pill Bugs or Wood Lice.—Sow bugs cause considerable injury both indoors and outdoors to young growing flower and vegetable crops. They occur in dark moist conditions, near dwellings such as cellars, outhouses; about walls, cisterns, water barrels; under boards, stones and rubbish; in greenhouses and rockeries. They usually feed at night. They are sometimes injurious in mushroom beds and to the roots of strawberries.

FIG. 240.—*Porcellio lævis*, a common sow bug. (*After Essig.*)

The eggs are laid in early summer. The incubation period varies with the different species—in *Armadillium vulgare* Latr. about 70 days. The young are carried in a pouch formed of modified plates on the abdomen of the female. Other species are *Porcellio lævis* Latr., *A. quadrifrons*, and *Oniscus asellus* Linn. They have seven pairs of legs, and antennæ which are 7-jointed (Fig. 240).

Control.—Cleanliness about outhouses, potting houses, etc.; the use of baits of sliced potatoes covered with a thin coating of Paris green, or Paris green, sugar and flour (1:2:2), or of bran-Paris-green-molasses-orange juice; sprinkling or spraying with kerosene emulsion;

sprinkling Paris green on the floor of greenhouses and covering it with damp boards; trapping by means of inverted flower pots containing damp hay or moss; flushing crevices, edges of greenhouse beds, benches and ground beneath with hot water or steam; fumigation with NaCN or KCN (¼–½ oz. of cyanide to every 100 cubic feet of space).

Class Arachnida

ORDER ACARINA (MITES AND TICKS)

Abdomen unsegmented, sometimes with annulations; without a deep constriction between cephalothorax and abdomen; legs usually well developed; body more or less depressed.

Chief Families and Genera

Eriophyidæ = Elongated annulated forms. *Eriophyes*—on plants.
Argasidæ = *Argus, Ornithodoros*—on birds and mammals.
Ixodidæ = *Ixodes, Dermacentor, Rhipicentor, Margaropus, Boophilus, Amblyomma*—on mammals.
Dermanyssidæ = *Liponyssus, Dermanyssus*—chiefly on birds.
Gamasidæ = *Lælaps*—on Arthropods and mammals.
Tarsonemidæ = *Pediculoides, Tarsonemus*—on man and grain and other plants.
Tyroglyphidæ = *Tyroglyphus, Rhizoglyphus*—on dried fruits and bulbs, and man
Sarcoptidæ = *Psoroptes, Sarcoptes, Chorioptes*—producing itch on mammals and birds.
Tetranychidæ = *Tetranychus, Bryobia*—on plants.
Trombidiidæ = *Trombidium.* Harvest mites.

(Consult *Handbook of Medical Entomology*, by Riley and Johannsen, pp. 259–273).

Family Dermanyssidæ (Poultry Mites)

(Consult Bulls. 553 and 801, Bur. Ent., U. S. Dep. Agric.)

A most common form is the **Chicken Mite** (*Dermanyssus gallinæ* DeG.), a flattened, elliptical mite, with 8 legs, $\frac{1}{40}$ inch long, distinctly reddish after feeding.

The eggs are oval, smooth and pearly white, and laid in cracks and crevices of the wood or straw of the nests and roosts. They hatch in 48 hours at summer temperature and young mites become mature in less than 10 days. They are most active at night. The young larva on hatching is white and has 3 pairs of legs. In about 24 hours it moults and this nymph (first stage) with 4 legs moults in about 24 hours forming the second stage nymph which moults into the adult.

Control.—(*a*) Cleanliness and sunlight, as mites thrive best in damp, dirty houses; (*b*) remove droppings and all ol nesting material; (*c*) clean and scrub or wash with water all the perches, roosts, nests, floor and walls; (*d*) spray or paint these with a 5 per cent. cresol, crude petroleum, or with 3 parts kerosene and 1 part crude carbolic acid, or with kerosene emulsion. Two or three applications are necessary at intervals of a few days.

When houses are whitewashed 4 oz. crude carbolic acid should be added to each gallon of whitewash. It is often advantageous to scatter a mixture of three part of dry slaked lime and one part sulphur with the doors and windows closed.

Family Argasidæ

Spinose Ear Tick (*Ornithodoros megnini.*).—Found attached to the ears of domestic animals and jack rabbits. Occurs in the southwestern U. S. as far north as Nevada and Oregon and is often troublesome. Treated by an injection of a mixture of two parts pine tar and one part cotton-seed oil into the ears. (Consult Farmers Bulletin 980, U. S. Dept. Ag.)

Family Sarcoptidæ (Scab and Itch Mites)

The **Poultry Itch Mite** (*Sarcoptes mutans* Robin) produces "scaly-leg" of fowls, turkeys, etc. It may also attack the comb and beak. The disease is contagious. The mites bore under the scales of the foot and leg and burrow deeper and deeper into the tissue, setting up an irritation, frequently a lameness, and sometimes causing the loss of some of the toes.

Control.—(1) Oil of carraway (1 part to 5 parts white vaseline) rubbed into leg and foot every few days; (2) bathing in warm soapy water and applying sulphur ointment or naphthaline mixed with 9 parts lard, or 5 per cent. creolin or zenoleum, or vaseline and zinc ointment.

Itch Mite of Man (*Sarcoptes scabiei* Latr.).—This pest burrows under the skin where eggs are laid. In about a week the eggs hatch and the young mites become mature in about 4 weeks. The lesions and blisters formed are very irritating, and the disease may spread rapidly.

Sheep Scab Mite (*Psoroptes communis var. ovis* Furst).—This mite burrows under the skin of sheep forming large areas of crust called scabs. From these areas, commonly confined to the neck, back and rump, the wool falls away. The disease is contagious. Each female lays 15–24 eggs which hatch in 2–3 days; the young mites mature in 15 days. (See Farmers' Bull. 713, U. S. Dept. Agr.)

Family Ixodidæ (Ticks)

Cattle Tick (*Margaropus annulatus* Say).—In the Southern States this tick causes large losses as the agent responsible for the Texas

Fig. 241.—Rocky mountain spotted fever tick (*Dermacentor venustus*): 1, unengorged female; 2, unengorged male. (*Year Book, U. S. Dept. Agric.*)

Cattle Fever. It is a dark 8-legged creature. The engorged female drops from cattle to the ground and lays its eggs. The young ticks (seed ticks) on hatching crawl up nearby herbage and drop on the backs of cattle as they brush by. Attached to the skin they feed until they become mature.

Rocky Mountain Spotted Fever Tick (*Dermacentor venustus* Banks) —This tick, with others, is able to transmit the so-called "Spotted Fever" of man in the Rocky Mountain states. It is possible that the ground squirrel of the region serves as a reservoir of the virus. The disease is probably transferred through the salivary secretion of the tick. Dr. Hadwen reports cases of "tick paralysis" of man and sheep in British Columbia due to the bites of this species (Fig. 241).

D. variabilis Say is a widespread form occurring on dogs, cattle horses and man, but apparently is of little economic importance.

Family Tetranychidæ (Red Spiders)

"Red Spider" (*Tetranychus bimaculatus* Harvey).—(Consult Bull. 416, U. S. Dep. Agr., 1917; Bull. 79, Mass. Ag. Exp. St.) A common pest on roses, violets, carnations in greenhouses; cucumbers in the vegetable garden; and on many outdoor perennials; and a serious pest in Western Colorado on fruit trees, in Central California on hops, and in the Southern States on cotton.

Adult.—Color of female variable—rusty green, amber, yellowish, but more often brick red, with pigment blotches on the sides; legs pale amber; palpi pale salmon; body oval, pear-shaped, 1/50 inch long; color of male rusty salmon, body 1/70 inch long.

Eggs.—Spherical; clear becoming opaque; 50–100 eggs laid by each female over a period of 7–12 days. Incubation period varies with the temperature—3–17 days. Laid singly on the under side of the leaves.

Larval stage.—Six-legged, round and colorless; duration 2–17 days.

First Nymphal Stage.—Eight-legged, oval, darker in color; duration 2–4 days.

Second Nymphal Stage.—Females only have this stage; elongate; duration 1½–13 days.

Feeding is done by means of sharp, slender, lance-like mouth-parts thrust into the leaf, producing spotting. The fine webs spun on the under surface of the leaf are probably protective. Reproduction is both sexual and parthenogenetic.

Control.—Spray with water; with lime-sulphur, nicotine sulphate and miscible oil, *linseed oil emulsion* or fish oil soap, potassium sulphide, kerosene emulsion; dust with finely resublimed sulphur; clean culture or eradication of weeds which harbor mites during winter.

Clover Mite (*Bryobia pratensis* Garman).—This is a small red mite about 3/100 inch long which injures the leaves of clover, apple and other orchard and forest trees by puncturing the tissues, causing them to become yellowish and sickly. The winter is passed in the egg stage, and the small round red eggs can be readily recognized in the crotches of fruit trees. There are several generations in a season. In autumn it sometimes invades houses.

Family Eriophyidæ (Blister Mites)

(Consult Bull. 283, N. Y. Ag. Exp. St.)

Pear-leaf Blister Mites (*Eriophyes pyri* Pgst.).—This introduced mite is responsible for the reddish or yellowish blisters on the leaves

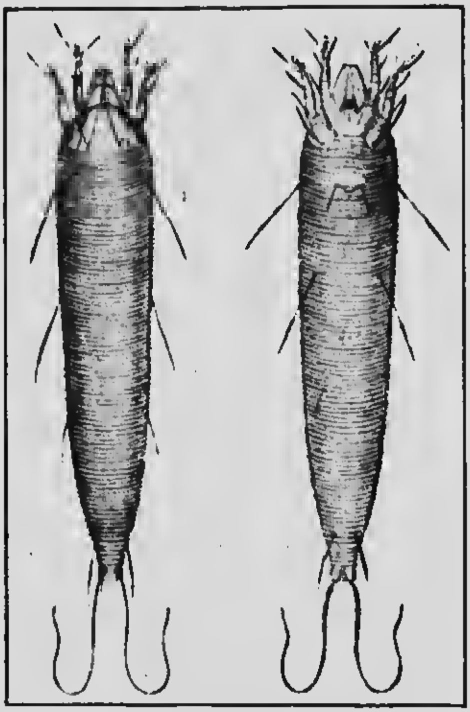


Fig. 242.—Pear-leaf blister mite (*Eriophyes pyri*). (*After Nalepa and Parrott*)

of pear and apple. These blisters turn brown later in the season, and badly infested leaves drop. Nursery stock is often badly injured.

The mites live in colonies beneath the epidermis, forming blister-like galls. Within these galls the minute oval white translucent eggs are laid and hatched, and the young mites grow to maturity. They then leave by a minute opening on the lower surface and go to new leaves where new blisters are started. The winter is passed as eggs beneath the bud scales. The adult mite is white, elongate, 4-legged, 1/125 inch long (Fig. 242).

Control.—Spray with lime sulphur, wash before leaf buds open.

In addition, the following Eriophyids occur in orchards: *Epitrimerus pyri* Nal. and *Phyllocoptes schlechtendali* Nal. on apple and pear, *Eriophyes phlœocoptes* Nal. on plum, and *Phyllocoptes cornutus* Banks on peach.

Family Tarsonemidæ

Cyclamen Mite (*Tarsonemus pallidus*).—This mite is reported from many scattered sections as destructive to cyclamens. It destroys the flowers and flower buds, and all stages may be found there. Attacked flowers become distorted, streaked and flaccid and die prematurely. In many cases they die before opening. Infested leaves curl.

The adult mite is pale brown, 1/125 inch long; the eggs are oval and translucent.

Control.—Spray plants with nicotin and soap solution when the younge plants are transferred from flats to pots, and every 10 days thereafter.

Fig. 243.—A common milliped. (*After Folsom.*)

Class Diplopoda

Millipeds.—Millipeds are often termed "thousand-legs," "galley-worms," or "false wireworms." They sometimes occur in rich garden soils containing much refuse organic matter, and do considerable injury. They attack plants grown from seed, and also gnaw holes in potatoes, strawberries and bulbs (Fig. 243).

The eggs are laid in holes in the soil in the spring, and it requires about 2 years for the young forms to reach maturity. They are night-feeders. The most common injurious forms belong to the Families *Julidæ* and *Polydesmidæ*. *Julus canadensis* is dark brown or black above with sides spotted with yellow, and is from 1 to 2 inches long. *Julus virgatus* injures lettuce and *J. cæruleocinctus* the fruit and roots of strawberries. The young millipeds have only three pairs of legs. *Spirobolus* is from 3 to 5 inches long. *Polydesmus canadensis* is a deep brown flattened form.

Oxidus gracilis is a common pest of greenhouses, sometimes occurring in millions in an abundant supply of decaying vegetable matter. It attacks sprouting seeds, and burrows into the decaying spots of roots. In color it is chestnut-brown marked in parts with lemon yellow. Gossard says that the whitish eggs are laid in April and May in the soil in masses of from 100 to 300 or more and hatch in about 20 days. So far as known there is but one generation a year.

Control.—(1) Trap with slices of beet or potato; (2) mix thoroughly with the soil tobacco dust, gas lime (3 tons to acre in fall), or soot; (3) give the soil a thorough drenching with kerosene emulsion or two or three light dressings of nitrate of soda (100 lb. to acre).

BRANCH MOLLUSCA

Class Gastropoda

Garden Slugs (*Limax* spp.).—Garden slugs are mollusks and not arthropods, but may be treated here. They are frequently injurious in moist situations to garden and greenhouse produce. They dislike sand, sawdust and ashes as these dry up the secretion of mucus. They spend the winter in the ground encased in their own slime. Some species, however, winter in greenhouses and remain active throughout the year. They are active at night, and feed upon green succulent leaves, mushrooms and ripe fruit.

There are three common injurious species: *L. maximus*, *L. agrestis* and *L. flavus*. Slugs differ from snails in the apparent absence of a shell, hut in reality the shell is reduced to a thin horny plate embedded in the mantle.

The eggs are large, round, transparent, yellowish, occurring in gelatinous clusters under boards or refuse. They hatch in spring and the slugs become half grown by fall. The adults may live several years. Blackbirds, toads, moles, centipeds, and poultry destroy slugs and snails.

Control.—(*a*) Trapping by placing out shingles or boards is quite effective. Examine the traps every morning and crush the slugs collected under them. (*b*) Liming the soil is also useful. (*c*) If slugs have collected on the plants dust them with a mixture of lime 5 parts and fresh hellebore 1 part. Providing the hellebore is fresh this is very effective and does not injure the plants. (*d*) Use the bran-arsenic-treacle mash as for cutworms. (*e*) Broadcast salt at night in misty weather. (*f*) Use poultry. (See Farmer's Bull. 959, U. S. Dept. Ag.)

Nematodes or Eelworms

Common Eelworm (*Heterodera radicicola* Greef).—Eelworms, although not closely related structurally to insects may be considered here in connection with them. They are common pests of roots and underground parts of plants, producing root-knots, galls or rough warty surfaces. Tomatoes indoors and potatoes outdoors are often injured, especially when grown on sandy soil. The males are microscopic in size and resemble miniature eels, hence the name eelworms. The females are glistening pearly white and pear-shaped or rounded, about half the size of a pin head.

Life-history.—The eggs are oval-shaped and are produced by the females in great numbers in the knots or galls. They hatch in a short time and the young eelworms seek new quarters and feed upon the roots of plants producing the characteristic deformities. They may pass the winter in their host; or it may be on other plants. The young forms may even encyst themselves in the soil.

The following plants are liable to be severely injured by Nematode attacks (Gilbert, Farmers' Bulletin 625): Soy bean, beet, carrot, celery, cow pea, crimson clover, cucumber, lettuce, peach, potato, squash, tobacco, tomato, watermelon; less severely: alfalfa, asparagus, Lima bean, cabbage, sweet clover, cotton, onion, garden pea, radish, spinach, strawberry, vetch. The following plants are largely immune: barley, corn, grasses, oats, rye, wheat, and cow peas (some varieties).

Control.—Infested soil in greenhouses may be sterilized by steam, carbolic acid (1:20) or formalin; mix the soil intimately with gas-lime; rotation of crops; summer fallow; plant clean nursery stock.

PART IV

THE CONTROL OF INJURIOUS INSECTS

The effective control of injurious insects demands a knowledge of the habits of the insects themselves so that they may be attacked at the most vulnerable point. As insects differ greatly in their habits and life-history, methods of control must also differ greatly, not only with regard to individual insects but also with regard to the crops that are attacked. For example, it is obvious that insects that live mostly in the ground and injure roots must be controlled in a different way from insects that feed on foliage. Moreover, insects that attack the cereal crops of the farm cannot profitably be treated in the same way as insects that attack the fruit and leaves of garden or orchard crops.

It has been said that the aim of the economic entomologist should be the control of injurious insects *at a profit.* It may not be possible to achieve this aim in all cases, for insects must be controlled sometimes for esthetic reasons, not entirely for the losses they cause. Moreover, recent investigations go to show that many so-called minor insects if left untreated simply because it does not pay to treat them, may turn out to be harmful in some indirect way.

The term "at a profit" used above is rather indefinite. It is sometimes impossible to say whether the control of injurious insects is profitable or not for there are many factors to be considered. A control, seemingly unprofitable from the money standpoint for a particular year, may be profitable from the standpoint of the health of the trees and of future production of fruit. Moreover, orchardists recognize the cumulative effect of continuous spraying.

Factors of Insect Control

The factors operating in the control of noxious insects may be grouped as follows:

1. *Climatic.*—The range and number of insects are strongly influenced by temperature, rainfall, winds, etc. (see Part I).

2. *Food Supply.*—An important regulator of insect life (see Part I).
3. *Parasites.*—Protozoa, bacteria, fungi and insects.
4. *Predatory Animals.*—Birds, insects, snakes, toads, annelids, etc.
5. *Cultural or Preventive Methods* (see below).
6. *Artificial or Remedial Methods* (see below).

The first four factors are, however, almost wholly beyond man's control.

Methods of Control

The main practical methods of control of injurious insects may, therefore, be grouped into two general classes: (*a*) *Cultural* or *Preventive Methods*—those practices of culture or of handling the crop that prevent, or interfere with, the development of injurious insects; and (*b*) *Artificial* or *Remedial Methods*—those which deal with injurious insects when they appear by the use of poisonous or contact substances, or other artificial means.

A. CULTURAL OR PREVENTIVE METHODS

For most farm crops Cultural Methods are the only practicable methods. They are essentially Preventives. The most important cultural methods are the following:

1. *Rotation of Crops.*—The growing of crops year after year on the same land permits many insects which feed on the roots to develop and multiply. On the other hand, a good crop rotation makes it impossible, or very difficult, for an insect to pass through its life stages without being seriously disturbed and its food supply destroyed.

(*a*) Some rotations are preferable to others when wireworms and white grubs are abundant. For example, where corn is the chief crop a rotation of clover, corn, oats is better than forage grasses, corn, oats. Professor Forbes, of Illinois, advises plowing the grass in early fall, and sowing clover either with barley, wheat, or rye. The clover is allowed to stand 2 years and is followed by corn or roots. As certain crops such as clover, barley, wheat and rye are not so liable to attack as corn, potatoes, mangels and oats they are better adapted to follow sod.

(*b*) Moreover, if sod infested with white grubs is broken up early, sown to turnips or rape, and pastured with hogs in late summer and autumn most of the white grubs will be destroyed by the hogs. As the grubs burrow deeply at the approach of cold weather it is not advisable to pasture hogs late in the season. Clover is seldom attacked by white grubs, hence is useful as a "starvation" crop before planting to corn, potatoes or mangels.

(*c*) Where the clover root borer is injurious in second year clover fields, the sod should be plowed up after the first season.

2. *Good Cultivation.*—This involves careful treatment of the soil, the crop, and its products. It means careful attention to the waste products and the waste places which are breeding places for many injurious insects. It means the adoption of deep, late fall plowing under certain conditions, which practice is one of the best methods of dealing with wireworms, white grubs, cutworms and grasshoppers. It means high fertility of soil, and good drainage of the land so that vigorous healthy plants, capable of resisting the drains of insect attacks, are grown instead of poorly nourished plants which are more likely to succumb.

Timely plowing, planting, and harvesting are often effective against some of the worst insects of the farm. For example, two or three fall plowings destroy large numbers of maturing wireworms and white grubs; early plowing of grass in August destroys the eggs and larvæ of cutworms and grasshoppers. Late sowing of fall wheat prevents Hessian-fly injury; and early cutting of the first crop of clover destroys the first brood of the clover seed midge and thus saves the clover seed of the later crop.

The destruction of rubbish, screenings, stubble, dead stalks and weeds deprives many hibernating insects of resting or breeding places. Such insects are Hessian-fly "flaxseed," chinch bug, clover hay worm, tarnished plant bug, squash bug, stalk borers, etc.

Cutworms endeavor to lay their eggs in August and September on weeds and grasses. Consequently if the land is kept free from weeds and the grass is fed or mown few cutworms will appear the following spring.

The application of fertilizers, such as nitrate of potash, barnyard manure, wood-ashes, and tobacco dust, is often advantageous in forcing the growth of plants that are attacked, and in repelling insects.

3. *Co-operative Measures.*—Co-operation among the farmers of a district is required for the successful control of certain insects such

as the Hessian-fly, the pea-weevil, the codling moth, the San José scale, the plum curculio, the apple maggot, grasshoppers and many others (Fig. 244).

4. *Natural Enemies of Insects.*—(*a*) Farmers and fruit-growers can do much to encourage the presence of insectivorous birds among the crops. These birds are most important in keeping injurious insects under control.

FIG. 244.—The San José scale. (*After Alwood.*)

(*b*) Frequently, too, hogs and poultry can be utilized to advantage in destroying white grubs, cutworms, grasshoppers, asparagus beetles, etc., in infested fields.

(*c*) Lady-bird beetles, ground beetles, and other predaceous insects should be protected as far as possible (see Section relating to the Utilization of Parasites, p. 401).

5. *Restriction and Exclusion of Foreign Insects.*—It has been frequently pointed out in the preceding pages that many of the mo

destructive insects are imported forms. Until recent years no effort had been made to exclude foreign insects, but now a rigid inspection of plants which may harbor dangerous pests occurs at the ports of entry. In some cases plants are subjected to fumigation with hydrocyanic acid gas.

That such restriction and exclusion are very important is evident in view of recent experiences with the brown-tail moth, the white Ermine moth, the Mediterranean fruit-fly, and others. On the other hand it is advisable to import foreign species that prey upon other foreign insects already here as was done in the case of the gypsy moth and the cottony cushion scale.

B. ARTIFICIAL OR REMEDIAL METHODS

Artificial methods may be conveniently classified as follows:

1. The application of poisons against biting insects.
2. The application of contact substances against sucking insects.
3. The use of poisonous gases.
4. The application of repellent substances.
5. The use of protectors.
6. The use of traps and trap crops.
7. The use of ditches.
8. The use of hopperdozers, etc.
9. Collecting, digging out, jarring, etc.
10. High and low temperatures.

1. The Application of Poisons for Biting Insects

(Consult Farmers' Bull. 908, U. S. Dep. Ag.)

The three essentials of a good insecticide are:

(*a*) *Effectiveness* against insects.

(*b*) *Cheapness*, both with regard to material and application.

(*c*) *Harmlessness* with regard to insect hosts.

With regard to *Effectiveness*, an insecticide must be applied:

(*a*) In the proper manner.

(*b*) At the proper time.

When the application of the insecticide is ma[illegible]e form of a spray some form of pump is necessary. In smal[illegible] and gardens cheap hand-pumps are usually sufficient; but for orchards pressure-pumps, operated either by hand or by power, are essential. With orchards over 5 or 10 acres or with high trees power-pumps or sprays, capable of giving a high pressure of 150 to 200 lbs. are now generally used. An important feature of all spray pumps is the *agitator* for keeping the chemicals in the tank well stirred. Moreover, it is very essential that the spraying be done *thoroughly* and at the proper time.

Thoroughness of spraying, while largely a matter of personal attention is secured with greater convenience with a pump of *high pressure* and with suitable *nozzles*, *extension rods* and *hose*, so that every part of the plant, the tips of the twigs as well as the larger branches, is drenched.

The *proper time* of application is determined by the habits of the insect, and herein lies the value of a knowledge of the life-history of the insect.

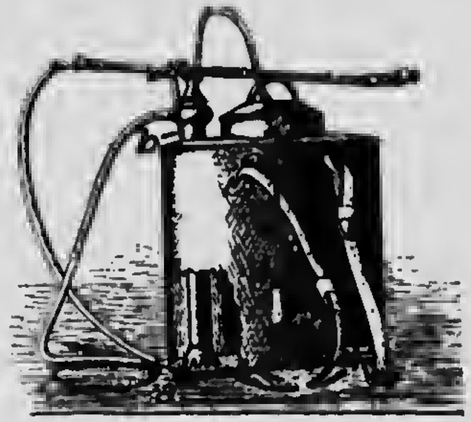


FIG. 245.—Knapsack sprayer.

FIG. 246.—Bucket force pump.

SPRAYING EQUIPMENT

Outfits for spraying may be classified as follows:

1. *Atomizer sprayer*, useful for treating individual plants.

2. *Bucket with force pump*, convenient for small areas (Fig. 246

3. *Knapsack or compressed air sprayer*, operated either by hand or by compressed air, useful in greenhouses, stables, poultry houses, etc. (Fig. 245).

4. *Hand-cart sprayer*, a small barrel mounted on a hand cart and operated by a hand-pump. Useful in gardens.

5. *Barrel sprayer*, with force pump operated by hand. Useful in small orchards and gardens.

6. *Tank sprayer*, with pressure pump operated either by hand, compressed air, traction gearing, gasoline motor, or liquid carbon dioxide.

FIG. 247.—An up-to-date spraying outfit in an apple orchard, using the "spra-gun." (*Courtesy of the Friend Manufacturing Co.*)

In orchard spraying every outfit should be provided with a *spray-tower* so that the tips of the branches may be treated properly (Figs. 247 and 248).

Other accessories are *strong hose*, able to withstand a pressure of about 300 lbs. per square inch, half-inch hose being commonly used; and *extension rods* with *drip guards* and *cut-offs*.

The *essentials* of a good nozzle are:

1. *Simple in construction, adjustable, light* and *free from projecting parts.*
2. *Not liable to dribble* on account of wearing of packing or springs.
3. *Easy to clean.*
4. *Not liable to clog.*
5. *Giving a uniform spray* when pressure is constant.

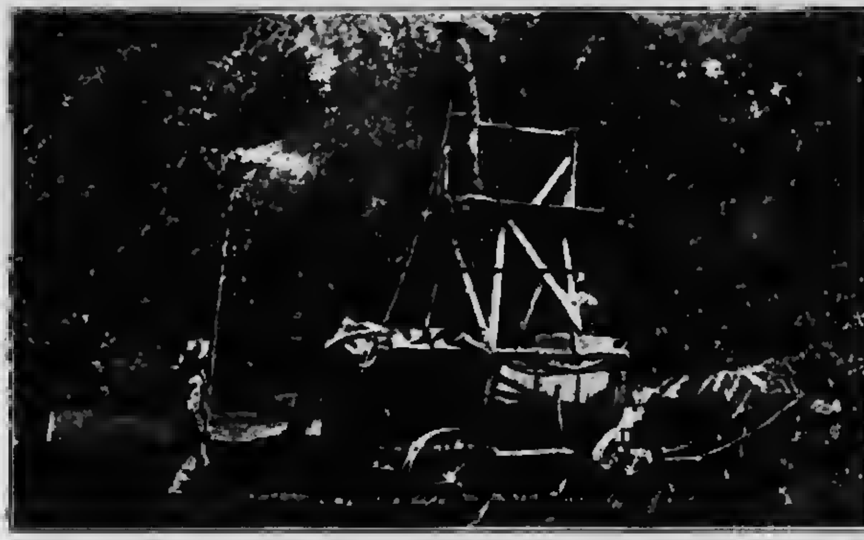


FIG. 248.—Spraying large orchard and shade trees by means of a tank platform an two lines of hose.

NOZZLES

Three types of nozzles are used in spraying operations—the *Bordeaux, Vermorel* and *Disk.*

The Bordeaux nozzle has its opening adjustable by means of a stop-cock so that various forms of sprays can be employed. The spray is made by a straight stream hitting a lip and breaking up into a fan-shaped spray. It is well adapted for vineyard work where Bordeaux and arsenicals are used. When clogged it can be readily cleaned by reversing the stop-cock. "Perfecto," "Niagara," "Seneca" are trade names.

The Vermorel nozzle has a central opening in front of a chamber, into which the liquid enters at a tangent. It gives a fine cone-shaped spray but is very liable to clog. A needle operated by a spring can be used to clean the clogged nozzle. It is unsuited to large orchards or with large outfits. "Buena," "Cyclone," "Eureka," "Dewey," "Spramotor," "Vapor Mist" are trade names.

The Disk nozzle, known under several trade names, has been evolved from the Vermorel for modern power outfits. It is larger and has a disk plate at the orifice which may be changed when desired. The chamber is broad and flat and the liquid enters it by two spiral grooves. As a result a strong rotary motion is given to the liquid which breaks up into a fine spray as it leaves the large opening. It is the most satisfactory nozzle at the present time. Trade names are "Friend," "Cyclone," "Jumbo," "Atomic," "Mistry," "Power," "Simplex," "Tiger," "Whirlpool."

The "Nusystem" or "Spra-gun" Nozzle is an improved form of the Disk. It has a large chamber, entered by several spiral grooves, at one end of a *heavy* brass rod, and an adjuster at the other end. Near this end is an opening for attachment to the hose (Fig. 247).

COST OF SPRAYING

The cost of spraying depends on: (1) the materials used, (2) the location and size of the trees, (3) the outfit and (4) the rate of pay for labor.

Many carefully kept records are now available for comparison, but the following cases will suffice here:

Case 1.—Cost of spraying 500 20-year-old apple trees in Okanagan Valley, B. C., averaged 8 cents per tree.

Case 2.—In Dr. Hedrick's experimental 10-acre orchard, Geneva, N. Y., about 30 years old, the cost of spraying averaged per year for 10 years 41.8 cents per tree for 2–3 sprayings.

Case 3.—Five-year average cost of spraying eight orchards in Indiana, the trees being from 18 to 23 years of age, a first dormant spray with lime-sulphur, and four other summer sprays mostly with lime-sulphur and arsenate of lead; 41 cents per tree, $16.89 per acre, and 17.98 gal. per tree (Bull. 194, Purdue Univ. Agr. Exp. Stn., 1916).

Case 4.—Cost of spraying in New Hampshire (labor and material, arsenate of lead and Bordeaux) 11⅓ cents per tree per application.

Case 5.—In 1916 the average cost of spraying eleven widely separated orchards in Massachusetts was 52 cents per tree, and the average profit was $4.50. These results are interesting as they were obtained from farmers under ordinary farm conditions.

DUST SPRAYING

During the last 6 or 7 years there has been a revival of dust spraying, especially in New York State. Professors Reddick and

FIG. 249.—A dust sprayer in operation in an orchard. (*Courtesy of the Niaga Sprayer Co.*)

Crosby of Cornell University carried out a series of experiments fro 1911 to 1917 with dust sprays against insects and fungous diseases the orchard. Different mixtures were used:

1. Sulphur, 80 per cent.; arsenate of lead, 20 per cent.

2. Sulphur, 40 per cent.; arsenate of lead, 10 per cent.; finely grou gypsum, 50 per cent.

3. Sulphur, 40 per cent.; arsenate of lead, 10 per cent.; hydrated lime, 50 per cent.

In every case the sulphur was finely ground so that it could pass through a 200-mesh screen. The results were very staisfactory, comparing very favorably with those obtained from the liquid spray. The cost of the materials in dust spraying, however, was high, but the cost of lahor was lower than in liquid spraying. The only objection, at present, to the complete substitution of the dust method for spraying is that there is no known dust preparation that will kill scale insects, or that is effective against aphis, pear psylla or red bugs.

The d t method makes it possible to protect the orchard at critical times, as a large orchard can be treated in about one-fifth of the time required by liquid spraying (Fig. 249).

POISONS FOR BITING INSECTS

(Consult Farmers' Bull. 908, U. S. Dep. Ag.)

The most important poisons used for the destruction of biting insects are (*a*) Paris green; (*b*) arsenite of lime; (*c*) arsenate of lead; (*d*) arsenate of lime; (*e*) hellebore; (*f*) sodium fluoride. When leaves or other portions of plants, dusted or sprayed with suitable quantities of these substances, are eaten by insects the latter are poisoned. As a rule, better results are secured by spraying the plants than by dusting them; sometimes, however, it is impracticable to spray and resort must be had to dusting.

(*a*) *Paris Green.*[1]—Pure Paris green, $3Cu(AsO_2)_2.Cu(C_2H_3O_2)_2$, composed of 58.65 per cent. arsenious oxide, 31.29 per cent. copper oxide, and 10.06 per cent. a c acid, is soluble in ammonia but only slightly soluble in water. In commercial forms there is usually a small amount of free arsenious acid, so that it is necessary to add lime to prevent injury from the burning of the foliage. The amount of lime used should be at least equal to that of the Paris green, but when it is added to Bordeaux mixture the excess of lime renders the addition of lime unnecessary. One pound of Paris green is sufficient for an acre of potatoes. Paris green particles are heavy and sink readily in

[1] Paris Green first came into use as an insecticide about 1870 in the early effort to control the Colorado potato beetle, and lead arsenate was first used in Massachusetts about 1892 as a safe chemical against the gypsy and brown tail caterpillars.

water. The finer the particles the longer they remain in suspension, consequently it should first of all be made into a thin paste in a small amount of water, and after it is in the barrel it should be kept in suspension by a mixer. *It cannot be used with lime-sulphur solution.*

The usual formula employed is: Paris green, 1 lb.; best stone lime, 1 to 4 lb.; water, 160 gal. imperial or 200 gal. U. S. measure. The Paris green is made into a paste with water and stirred into the lime-and-water mixture. When used as a dry application for the potato beetle, 1 lb. of Paris green is thoroughly mixed with 20 lb. cheap flour, air-slaked lime or finely sifted land plaster.

(*b*) *Arsenite of Lime.*—White arsenic (As_2O_3), combined with washing soda or sal soda (Na_2CO_3) and quick lime (CaO), is frequently used on account of its cheapness. The combination is made as follows:

Dissolve 1 lb. white arsenic and 1 lb. sal soda in 1 gal. of water by boiling in an iron vessel for 20 minutes. Add this while hot to slake the lime; then add 2 gal. of water. Use 2 qt. of this to 40 gal. of water. $As_2O_3 + Na_2CO_3 + Ca(OH)_2 = Ca(AsO_2)_2 + CO_2 + 2NaOH$; or rather $As_2O_3 + Na_2CO_3 = 2NaAsO_2 + CO_2$; $2NaAsO_2 + Ca(OH)_2 = Ca(AsO_2)_2 + 2NaOH$.

(*c*) *Arsenate of Lead.*—This insecticide is preferred by many fruit growers to Paris green since it adheres better to foliage, is less likely to do injury, and no lime is required in standard preparations.

The commercial form consists of a mixture of the neutral triplumbic arsenate [$Pb_3(AsO_4)_2$] and the acid plumbic hydrogen arsenate ($PbHAsO_4$). The neutral product may be prepared by dissolving acetate of lead (11 oz.) and arsenate of soda (4 oz.) in 120 gal. water. The reaction is as follows:

$$3Pb(C_2H_3O_2)_2 + 2Na_3AsO_4 = Pb_3(AsO_4)_2 + 6NaC_2H_3O_2.$$

When lead nitrate is used instead of lead acetate more of the acid arsenate is formed.

For fruit trees 2 lb. of arsenate of lead (paste) to the barrel (40 gal.) of water is the usual strength. For the Potato Beetle 4 lb (paste) or 2 lb. (powder) to the barrel should be used. Acid brands are apt to burn the leaves.

Commercial arsenate of lead is put up in the *paste*, the usual form, and the *powder* form of which but half the amount is required. The former contains about 15 per cent. As_2O_5; the latter has about 33 per cent. As_2O_5, but does not remain well in suspension. The powder form is used in dust spraying.

Sometimes a gallon of molasses is added to 40 gal. of the solution with good effect against fruit-flies, rose-chafers and grape root-worm beetles. Arsenate of lead can be used safely with the lime-sulphur mixture for summer sprays.

(*d*) *Arsenate of Lime.*—Recently arsenate of lime or calcium arsenate has given good results against certain chewing insects. It may be prepared according to the following formula:

Stone lime (90 per cent. CaO), 55 lb.; sodium arsenate (dry powdered), 65 per cent. As_2O_5, 100 lb.; water, 26 gal.

$$2Na_3AsO_4 + 3Ca(OH)_2 = Ca_3(AsO_4)_2 + 6NaOH.$$

The lime is slaked in a small amount of water; while slaking is taking place the sodium arsenate, dissolved in hot water, is poured in; sufficient water is added to prevent burning. The calcium arsenate formed in this way contains about 18 per cent. As_2O_5.

The killing action is about equal to that of lead arsenate, perhaps a little slower, when used at the rate of 2 lb. to each 50 gal. of water. It can be used with lime-sulphur as a combined insecticide and fungicide. It can be prepared more cheaply than lead arsenate.[1]

Arsenate of lime, when used alone as a spray, is liable to burn the leaves, but when used in combination sprays with Bordeaux mixture, lime sulphur, and sodium sulphide ("Soluble sulphur," "Sulphocide") it is as safe as any other arsenical and probably the cheapest of all insecticides.

(*e*) *Hellebore.*—This substance is sometimes used as a substitute for arsenicals on fruit which is nearly ripe. It may be applied dry or liquid; dry with five parts of flour or air-slaked lime, liquid at the rate of 1 oz. of hellebore to 2 gal. of water.

Although an internal poison to insects it is harmless to man in the quantities named. It is too expensive for use on large areas.

(*f*) *Sodium Fluoride.*—Acts both as a poison and a contact substance. Applied as a fine powder or dust pure or mixed with flour or lime. Effective against ants, cockroaches, etc.

[1] Some chemists maintain that arsenate of lead, when added to Bordeaux, is converted into arsenate of lime; hence it is more economical to add arsenate of lime in the first place.

2. The Application of Contact Substances Against Sucking Insects

(Consult Farmers' Bull. 908, U. S. Dep. Ag.)

The main substances used as Contact Insecticides against sucking insects are: (*a*) Lime-sulphur wash; (*b*) whale-oil soap; (*c*) kerosene emulsion; (*d*) tobacco decoction; (*e*) miscible oils; (*f*) pyrethrum; (*g*) lime dust; (*h*) commercial sodium fluoride; (*i*) carbolic acid emulsion, (*j*) other substances.

(*a*) *Lime-sulphur Wash.*—This wash first came into use in the control of the San José scale on dormant wood where its beneficial effects were evident also against other insects and against certain fungous diseases. It cannot be used on potato leaves.

It is prepared in two forms—home-made lime-sulphur wash and commercial lime-sulphur wash, diluted for use on dormant wood and on summer foliage as required.

I. *Home-made Preparation* (Boiled).—Lime (best), 20 lb.; sulphur (flowers), 15 lb.; water, 40 gal. (imperial).[1]

II. *Concentrated Formula* (Stock Wash).—Lime, 50 lb.; sulphur 100 lb.; water, 40 gal. (imperial) or 50 gal. U. S. measure.

Heat water (20 gal.) to near boiling and add the fresh lime. While slaking is in progress add with frequent stirrings the sulphur which has been made into a paste. Add water to make up to 40 gal. and boil for an hour replacing the water lost by boiling. Strain through a 20-mesh screen, and place in storage barrels. By means of a lime-sulphur hydrometer the amount of dilution can be determined for each spraying. "For use before buds burst" dilute to sp. gr. 1.03; "before blossoms burst" 1.009; and "just after blossoms fall," 1.008. To get the amount of dilution divide the reading after the decimal point of the stock solution by the reading after the decimal point of the solution desired. For example, if the hydrometer reading of the stock solution is 1.3 and that of solution to use "before buds burst" is 1.03, the amount of dilution is 30 divided by 3 = 10. That is 1 gal. of stock solution makes 10 gal. of spray (Fig. 250).

Some recent experiments go to show that the lime-sulphur applica-

[1] The capacity of a barrel is expressed in all cases in imperial gallons (40); sometimes the equivalent in U. S. measure (50) is also given.

tion 10 days or 2 weeks after the blossoms fall should be diluted to a sp. gr. of 1.005 on account of the tenderness of the apple pedicels.

The amount of spray liquid varies with the size of the tree. A thrifty 9- or 10-year-old tree on the average requires 1¼ gal. for the dormant spray and 1 gal. for each of the later sprays. A 30-year-old tree requires 5 gal. for the dormant spray and 4 gal. for each of the later sprays.

In boiling lime and sulphur together according to the formulæ given above, two sulphides of calcium (CaS_4 and CaS_5) and the thiosulphate of calcium (CaS_2O_3) are formed. These are soluble in water. If too much lime is used a sediment will form. Only the best stone lime should be employed, and the boiling should not be too prolonged as insoluble compounds are formed.

$$3Ca(OH)_2 + 11S = CaS_4 + CaS_5 + CaS_2O_3 + 3H_2O.$$

When the hydrometer has the Baumé graduation marks ranging from 0 to 36° the mixture for the San José scale (dormant stage) should test between 4.5° and 5° Baumé, and for the summer spraying about 1° Baumé (Fig. 250).

The following table of dilutions of lime-sulphur has been calculated for both hydrometer graduations:

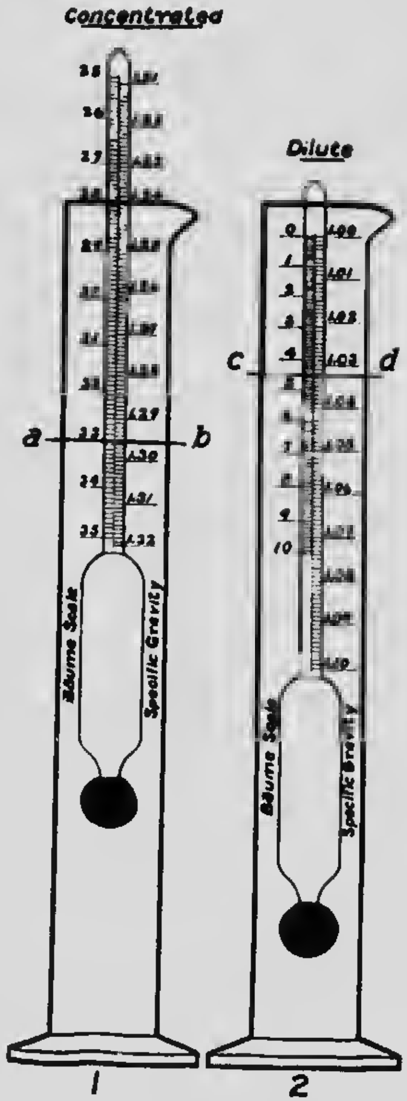


FIG. 250.—Diagram of hydrometer in use. 1, For concentrated solutions and graduated from 1.21 to 1.32 specific gravity, with surface of liquid indicated at *a–b*: 2, for diluted solution and graduated from 1.00 to 1.10 specific gravity, with surface of liquid indicated at *c–d*. (*After Corby.*)

Specific gravity	Degrees Baumé	To make a dormant spray testing 5° Baumé or 1.03 sp. gr. For 1 gal. of lime-sulphur use gal. water	For 1 gal. of lime-sulphur use following gallons of water, to make a summer spray testing 1.009 sp. gr.	1.008 sp. gr.	1.007 sp. gr.	1.006 sp. gr.	1.005 sp. gr.
1.318	35	9½	34	39	44	52	62
1.306	34	9	33	37	43	50	60
1.295	33	8¾	32	36	41	48	58
1.283	32	8½	30	34½	39	46	55½
1.272	31	8	29	33	38	44	53½
1.261	30	7¾	28	31½	36	42½	51
1.250	29	7¼	27	30	35	40½	49
1.239	28	7	26	29	33	39	47
1.229	27	6½	24	27½	32	37	45
1.218	26	6¼	23	26	30	35	43
1.208	25	6	22	25	29	33½	40
1.198	24	5½	21	24	27	32	39
1.188	23	5¼	20	22½	26	30	37
1.179	22	5	19	21	25	29	35
1.169	21	4½	18	20	23	27	33
1.160	20	4¼	17	19	22	26	31
1.151	19	4	16	18	21	24	29
1.142	18	3¾	15	17	19	22½	27
1.133	17	3½	14	15½	18	21	26
1.124	16	3	13	14½	17	20	24
1.115	15	2¾	12	13	15	18	22

III. *Commercial Wash.*—Commercial washes are now sold which are quite reliable. Directions are given as to dilution. Usually they test about 1.290 sp. gr. or 33° Baumé.

Lime-sulphur when used at summer strength acts also as a stomach poison, but more slowly than arsenate of lead. Flour-paste as a "sticker" is often added, especially in summer sprays (8 lb. flour boiled into a thin paste in 8 gal. of water, mixed with 160 gal. of lime-sulphur).

It is to be noted that Lead Arsenate, not Paris green, is to be used with the Lime-sulphur Wash. When Paris green, a copper-aceto compound, is added to lime-sulphur the copper is attacked and free soluble arsenic is liberated in quantity sufficient to kill foliage.

IV. *Lime-sulphur* (Self-boiled).—Prepared by slaking 8 lb. best stone lime in a small quantity of cold water; while slaking 8 lb. of finely powdered sulphur are added with constant stirring, also sufficient water to prevent burning. Then add water to make 40 gal. This liquid is a mixture of lime and sulphur, for little combination takes place, and is a good fungicide against brown rot of stone fruits. It is not used to any great extent by fruit growers.

Sulphur and Lime.—Flowers of sulphur and hydrated lime in equal parts, when blown upon citrous trees, keep in control red spiders and mites.

Recent experiments in Nova Scotia show that arsenate of lime is preferable to arsenate of lead as a poison with lime-sulphur solutions. When standard arsenate of lead is added to lime-sulphur a double decomposition occurs with the formation of lead sulphide and a crude arsenate of lime, 5 per cent. of which is soluble.

When the soluble sodium sulphides, such as "soluble sulphur," "sulfocide," "spra sulphide," etc., are used in combination with arsenicals of copper, lead and zinc soluble arsenical salts of sodium are formed which are unsafe as apple sprays. However, when used with arsenate of lime and water-slaked lime (3 lb. soluble sulphur, $1\frac{1}{4}$ lb. arsenate of lime and 5 to 10 lb. water-slaked lime) no injury results to apple foliage.

In Nova Scotia it has been found that when the common poisons are added to Bordeaux mixture their killing power is usually decreased by about 50 per cent. Sodium arsenate, however, retains its power after its addition to Bordeaux if prepared as follows:

Dissolve 1 lb. sodium arsenate in water and with this solution slake 5 lb. of fresh stone lime and make up to 20 gal. Dissolve 4 lb. bluestone in another 20 gal. of water and pour the two together.

Sodium sulphide, on the other hand, increases the killing value of poisons.

With the advent of high power sprayers complaints have come in regarding injury to and drop of the leaves and fruit of trees sprayed with the summer strength of lime-sulphur, especially with the later sprayings. This result is due to the destructive action of the lime-sulphur on the contents of the leaf-cells. Experiments showed that when the upper surface of the leaves only was sprayed no drop of leaf or fruit ensued, but when the spray was applied to the under surface much drop followed. This result does not follow the application of sodium sulphide or Bordeaux.

The "spray gun" may be safely used, however, at a high pressure by the long distance method of spraying in which only the upper side of the leaves becomes wet.

Bordeaux frequently causes "russetting" of the fruit, and for this reason fruit growers began the use of the summer strength of lime-sulphur. The latter, however, causes a drop of the fruit, and the soluble sulphur-slaked lime-arsenate of lime combination is recommended as being free from injurious effects.

A modification of the 4:40:40 Bordeaux formula is now recommended in Nova Scotia for the later sprayings in apple orchards: 2 lb. bluestone, finely pulverized; 10 lb. lime; 40 gal. water.

Many evidences point to the conclusion that in mixtures of Bordeaux and arsenious compounds the lack of injury to foliage is due to the formation of a copper-arsenide compound rather than to the supposed neutralizing action of the lime.

Soluble Sulphur.—A patent preparation containing about 60 per cent. soluble sulphur and 40 per cent. inert matter. It is used as a substitute for lime and sulphur. Its value has not yet been definitely determined on account of conflicting reports by growers. It has the merit of being easily handled.

(*b*) *Whale-oil Soap.*—Potash whale-oil soap of a good grade, when dissolved in warm water at the rate of 2 lb. to a gallon of water, makes an excellent spray for early spring treatment of orchards—just before the buds swell. It is also valuable as a summer treatment against aphids and pear psylla, but it should be diluted: 1 lb. of soap dissolved in 4–6 gal. of warm water. The soap has an invigorating effect on the tree, but the cost prohibits its use in orchards on a large scale.

Against scale insects on palms, rubber plants, cycads, and oleanders in conservatories whale-oil soap is used at the rate of 1 lb. to each gallon of water; on ferns however, fir-tree oil or lemon oil (1–15 or 20 water) is used as these plants are readily injured by whale-oil soap.

Soap Solution.—This solution is made by dissolving 1 lb. of hard soap in 5 gal. of water. It is effective in controlling plant-lice and other sucking insects on house and garden plants.

The addition of soap solution, 3–5 lb. in 80 gal. of tobacco extract solution, is recommended for plant-lice.

Sulphur-soap Mixture (for Red Spider).—Prepared by dissolving 1 lb. laundry soap in 8 gal. water and adding ½ lb. flowers of sulphur. The under side of the leaves should be sprayed.

(*c*) ***Kerosene Emulsion.***—A soap emulsion of kerosene has for many years been used against aphids and other sucking insects. It is prepared by dissolving ½ lb. of soap in 1 gal. of warm water, and adding 2 gal. of kerosene to the hot soap solution. The whole is then agitated until a creamy emulsion is formed. This stock solution when properly made keeps indefinitely. When required for use the stock solution is diluted with 10 times its volume of water.

(*d*) *Tobacco Decoction.*—A strong decoction of tobacco stems or leaves is an excellent remedy against aphids, either in the field or in the greenhouse. The decoction is an extract and is made by steeping refuse tobacco in warm water for several hours until a deep brown liquid is obtained. Two pounds of tobacco are treated in 2 gal. of water and afterward made up to 5 gal. It is a safe remedy.

Several tobacco preparations are now on the market, the most valuable for orchard spraying being "Black Leaf 40." This concentrated extract contains 40 per cent. nicotine sulphate and is usually diluted with water, 1 part to 1000, when used against plant-lice and other sucking insects. It can be safely used with lime-sulphur, arsenate of lead or soap solutions.

"Nico-fume" contains 40 per cent. nicotine sulphate and is much used in greenhouses by vaporizing it at the rate of ½ oz. to 2000 cu. ft.

Tobacco papers are also used in greenhouses. Dense fumes are given off when they are ignited.

(*e*) *Miscible Oils.*—Certain proprietary mixtures containing mineral oils in combination with a small quantity of vegetable oil and some alkali to make them miscible with water are valuable in the control of scale insects. Reliable market preparations are more satisfactory than those made at home and less likely to be injurious to the trees. There is always a certain amount of risk in using these oils, but the danger is lessened if they are used on dormant trees in fine weather. The more reliable brands are "Scalecide," "Target Brand," "Orchard Brand" and "Kil-O-Scale."

(*f*) ***Pyrethrum.***—Pyrethrum, known also as Buhach, Persian and Dalmatian insect powders, and by other trade names, is used frequently on aphids, slugs, and some household pests, where operations are confined to a small area.

It may be used either as a spray or in the dry form. As a spray it should first of all be made into a paste in a small quantity of water and afterward diluted to the proper strength, viz.: 1 oz. to 3 gal. of water. When used dry, 1 part of powder is thoroughly mixed with 4 parts of flour, and kept in a tight can for a day. The mixture is dusted on either by a bellows or through a coarse bag, on account of the fact that the essential ingredient is a volatile oil.

Pyrethrum loses its strength on exposure to the air; the can must, therefore, be kept tightly closed.

(g) *Lime.*—Air-slaked lime is effective against slugs and other soft-bodied larvæ. It should be applied as a very fine dust.

Some investigators report beneficial effects from the application of thick lime-wash about onion plants as soon as they are up as a protection against the onion maggot.

Professor Parrott of the Geneva Agricultural Experiment Station finds that lime with nicotine is much more effective against aphis, leaf-hopper and pear psylla than nicotine alone, or soap, or oil emulsion.

(h) *Commercial Sodium Fluoride.*—This substance, both a poison and a contact insecticide, is effective against cockroaches, chicken lice and other insects when applied, pure or mixed with flour or plaster, as a fine dust by means of a dust blower.

(i) *Carbolic Acid Emulsion.*—For the control of root-feeding larvæ such as onion maggots and radish maggots, an emulsion of carbolic acid has given good results. It is prepared by dissolving 1 lb. of hard soap in 1 gal. of hot water and adding 1 pt. of crude carbolic acid. The mixture is agitated until a thick, emulsion is produced. This is the stock solution, and is diluted with 20-30 parts of water for use. A tablespoonful is poured about the base of the plant to prevent egg-laying, and at the same time to kill the newly hatched larvæ.

(j) Scale insects on ferns are treated effectively by the use of 1 part fir-tree or lemon oil to 15 or 20 parts of water.

(k) *Cattle Dips.*—The most widely used methods of controlling cattle-scab diseases are:

1. *Dipping* the animals in lime-sulphur or nicotine solutions twice, 10 to 14 days apart. Dipping plants are arranged so

that the cattle enter one end of a vat filled with warm dip through which they swim, and leave the vat at the opposite end. The lime-sulphur dip is made by mixing 12 lb. unslaked lime and 24 lb. flowers of sulphur in 100 gal. of water. Nicotine dips should contain about 5/100 of 1 per cent. of nicotine, and should be used warm, not above 100°F.

2. *Spraying* the animals. This method is neither so economical nor so effective as dipping, but is recommended where but a few animals are to be treated.

Cattle lice can be controlled by the following means:

1 *Hand applications* with a brush or cloth at intervals of about 3 weeks, of (*a*) cottonseed oil and kerosene (equal parts); (*b*) kerosene and lard (½ pt. to 1 lb.); (*c*) crude petroleum; (*d*) any of the dip solutions.

2. *Spraying* with any of the dip solutions.

3. *Dipping* in (*a*), an arsenical solution, prepared as follows:

4 lb. caustic soda (85 per cent. pure).
8 lb. white arsenic (99 per cent. pure) in fine powder.
8 lb. sal soda crystals.
1 gal. pine tar.
500 gal. water (temp. 65°–90°F.).

(*b*) Coal-tar creosote, sold under many trade names and to be used according to instructions.

(*c*) Nicotine solution, sold under many trade names and to be used according to instructions.

(Consult Farmers' Bull. 909 and 1017, U. S. Dep. Agric.)

3. The Use of Poisonous Gases

The more important poisonous gases used to control insects are: (*a*) carbon bisulphide; (*b*) hydrocyanic acid gas; (*c*) sulphur dioxide; (*d*) tobacco; (*e*) formalin; (*f*) carbon tetrachloride.

(*a*) *Carbon Bisulphide.*—This is an ill-smelling liquid which is readily volatile. The gas is much heavier than air, and if placed in shallow pans above or on top of grain or other vegetable foods the fumes sink, and being poisonous will kill the insects. It is specially valuable for the fumigation of peas infested with weevils, or grain infested with weevils and other insects. It is also used for the destruction of household pests such as clothes moths, etc.

Two pounds of the liquid is sufficient for 100 bu. of peas or grain, or 1000 cu. ft. of space. It is inflammable.

(*b*) *Hydrocyanic Acid Gas.*—This gas is liberated when diluted sulphuric acid is added to potassium or sodium cyanide. It is a deadly poisonous gas, and great care should be taken in its use as an insecticide.

It came into use in California for the fumigation of citrus and olive trees. Later it was introduced into eastern nurseries for the treatment of San José scale on dormant nursery stock, and for the control of flour mill pests, and, in some cases, greenhouse and household pests.

The formula for nursery stock and household fumigation is: Cyanide of potash or soda, 1 oz.; sulphuric acid (sp. gr., 1.83), 1 fl. oz.; water, 3 fl. oz. per 100 cu. ft. space. For greenhouse fumigation at night the formula is: Cyanide of potash or soda, 1/2 oz.; sulphuric acid, 1 fl. oz.; water, 3 fl. oz. per 1000 cu. ft. space.

This gas is lighter than air and diffuses very rapidly.

(*c*) *Sulphur Fumes.*—The destructive action of sulphur is largely due to the readiness with which it oxidizes to sulphur dioxide, a gas fatal to many forms of insect life. Mites are controlled in greenhouses by the dusting of fine sulphur on the surfaces of the leaves.

When sulphur is burned on a hot plate over a low flame sulphur dioxide is rapidly formed, recognized by its suffocating odor. This is, perhaps, the simplest method of dealing with ordinary household pests such as bed bugs, fleas, and other forms.

Combined with a soap, sulphur is used as a wash for mange which is caused by a mite.

(*d*) *Tobacco.*—Tobacco fumes are destructive to aphids on greenhouse and household plants. They are liberated by the application of heat to certain Nicotine Extracts, Nicotine Paper, or finely divided tobacco powders. These "fumigating" powders and extracts may now be had in the market and are convenient methods of dealing with house plants.

(*e*) *Formalin.*—As a rule, formalin (40 per cent. formaldehyde) is not effective as an insecticide, although an excellent germicide. As a fly-poison, however, it is strongly recommended when used as follows: Mix 1 tablespoonful formalin with 1/2 cup sweet milk or 1/2 cup water, and expose in a shallow plate with a slice of bread in it.

(*f*) *Carbon Tetrachloride.*—This liquid although not so active as carbon bisulphide is not explosive. It may be used for fumigating bins infested with insects, when applied at the rate of 2 lb. for every 100 cu. ft. of space or 100 bu. of grain.

4. The Application of Repellent Substances

Several substances are known to act as "repellents" to insects, and may sometimes be used to advantage in preventing insect attack. Among such substances are: (*a*) Bordeaux mixture; (*b*) tobacco dust; (*c*) carbolic acid emulsion; (*d*) kerosene; (*e*) turpentine; (*f*), coal tar; (*g*) naphthaline; (*h*) zenoleum and creolin compounds; (*i*) tanglefoot; (*j*) carbolineum emulsion; (*k*) soap-carbolic-Paris green wash.

(*a*) *Bordeaux Mixture.*—This fungicidal mixture keeps away flea-beetles from potato leaves and striped cucumber beetles from pumpkins and squashes when applied as a fine spray. It is prepared as follows: Copper sulphate (bluestone), 4 lb.; quicklime, 4 lb.; water, 40 gal.

$$CuSO_4.\ 5H_2O + Ca(OH)_2 = Cu(OH)_2 + CaSO_4 + 5H_2O.$$

$$2[Cu(OH)_2,\ CuSO_4] + CO_2 = 2CuSO_4 + Cu(OH)_2 + CuCO_3 + H_2O.$$

In mixing solutions of these two substances care must be taken that they come together in a large quantity of water, and that enough lime is present to act on all the bluestone.

(*b*) *Tobacco Dust.*—In the case of certain garden crops fine sprinkling of the ground when moist with refuse tobacco dust not only fertilizes the soil but also repels the striped cucumber beetle and the melon aphis.

(*c*) *Carbolic Acid Emulsion.*—Carbolic acid is a repellent, as well as an irritant and stomach poison, and in various forms is used for the control of insects. Reference has already been made to its use as a contact insecticide. As a repellent it is added to a solution of washing soda or lye as a protective wash against borers in orchards and shade trees; as an emulsion with soap against root-maggots of cabbage and onion; and often also used in poultry house against biting lice and mites.

(*d*) *Kerosene*, (*e*) *Turpentine* and (*f*) *Coal tar* are sometimes mixed with saw-dust, sand, or other materials; when placed around plants or seeds they are said to have a repellent action toward insects.

(g) *Naphthaline.*—This substance is the basis of camphor balls, and is commonly used as a preservative of household goods and wearing apparel against the attacks of clothes moths and other insects.

(h) *Zenoleum and Creolin Compounds.*—Some excellent compounds of creolin and related substances are prepared as repellents against flies that bother cattle, and against biting lice and mites of poultry. The cow horn-fly may be controlled by the use of such substances.

(i) *Tanglefoot.*—A sticky substance; is used as fly-paper and as sticky bands for trees to prevent caterpillars such as those of Gypsy moth and Tussock moth from ascending.

(j) *Carbolineum Emulsion.*—Used against bark beetles, shot-hole borers and poplar borers. Four pounds naphtha soap are dissolved in 4 gal. of hot water, the carbolineum added, and the whole agitated to form an emulsion. For use 3 gal. of hot water are added and emulsion is sprayed on the trees while warm.

(k) *Wash for Tree Trunks.*—To protect trees against borers the following wash is of value: Dissolve 1 lb. of hard soap or 2 qt. of soft soap in a pail of water, then add 1/2 pt. of crude carbolic acid, and 2 oz. of Paris green; thicken with lime.

5. The Use of Protectors

Various forms of protectors are used to ward off insect attacks. The application is confined mainly to the street, orchard and garden. The following methods are those most commonly in use: (a) metal or sticky bands; (b) cheese-cloth or muslin screens; (c) wire-netting; (d) tarred felt paper.

(a) *Metal or Sticky Bands.*—To protect trees from the attacks of climbing caterpillars such as the tussock and canker worms, special bands are placed about the trunk a few feet above the ground. The caterpillars are prevented from passing up, and they often collect in large numbers under the flaps or rim of the band where they are readily destroyed. The gypsy, the tent-caterpillars, climbing cutworms and walnut caterpillars are also kept in check by this method.

(b) *Cheese-cloth or Muslin Screens.*—Such devices are often effective against cucumber beetles, flea-beetles and the radish root-maggot. As these insects are most injurious while the plants are just coming above the ground, the frames holding the screens should be placed in position soon after the plants are set out or the seeds planted. They can be readily removed for a short time whenever weeding, cultivation and watering are necessary.

(*c*) *Wire-netting.*—Wire-netting is often placed about trees to protect them from the Peach-borer, and the Round-headed apple tree Borer.

FIG. 251.—Tool and device for cutting disks. (*After Britton.*)

(*d*) *Single-ply Tar Felt Paper Disks.*—Used to protect cabbage and cauliflower plants against the cabbage-root maggot (Figs. 251 253).

6. THE USE OF TRAPS, TRAP CROPS, ETC.

The following forms of traps are sometimes used to advantage: (*a*) boards or chips; (*b*) special crops; (*c*) poison baits.

(*a*) *Boards or Chips.*—Squash bugs, cutworms and other insects may be readily trapped in large numbers by placing small bits of board or chips or bunches of grass among the rows of plants where these insects hide.

(*b*) *Special Crops.*—Such crops have been found advantageous in the control of Hessian fly, army worms, squash bugs, cucumber beetles, and asparagus beetles. In the case of the Hessian fly narrow strips are planted early so that the flies may deposit their eggs on the wheat before the regular planting of the field. These trap strips are then destroyed. With the army worm, a similar narrow strip on the border of the field may be poisoned with an arsenical spray. With cucumber beetles and asparagus beetles, a few plants may be set apart to trap the early beetles nd then destroyed.

(*c*) *Poison Baits.*—Such are very effective against grasshoppers, cutworms and other insects. The Criddle Mixture, made by mixing thoroughly 1 lb. of Paris green or white arsenic, 1 lb. of salt (dissolved in water), and 15 gal., hy measure, of fresh horse droppings, with sufficient water to make the

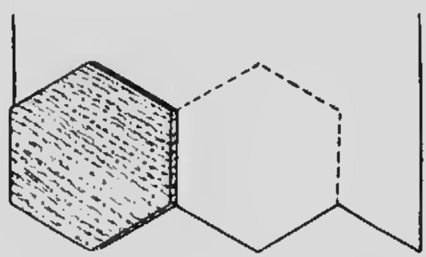


FIG. 252.—Wood form for cutting hexagonal disks for the cabbage-root maggot. (*After Britton.*)

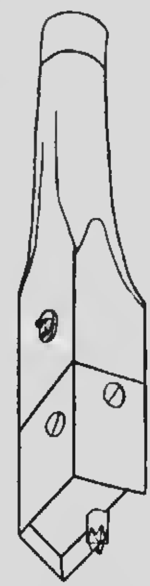


FIG. 253.—Tool for cutting cards of tarred building paper. (*After Slingerland.*)

whole mass moist but not soggy, is used in the West against grasshoppers. When the mixture is scattered about grass lands and the edges of grain fields in hot, sunny weather the grasshoppers are readily poisoned.

Another bait, first used in Kansas against grasshoppers, is now usually employed against cutworms, army worms and grasshoppers. The formula is: 1 lb. Paris green, 20 lb. wheat bran, 2 qt. of cheap molasses, the juice and pulp of 3 oranges or lemons, and 2 to 2½ gal. water. The hait, sown broadcast in early morning, will show results in a few days.

Professor Sanders of Pennsylvania recommends the following poison bait spray against the adults of the *onion maggot:* 5 grams of sodium arsenite dissolved in a gallon of hoiling water into which is thoroughly mixed a pint of molasses. This hait is applied as a coarse spray of large drops once a week across the onion field throughout the summer.

For cockroaches and ants in kitchens and pantries powdered borax mixed with sweetened chocolate, scattered in the evening about the haunts of the insects, and powdered sodium fluoride, pure or mixed with flour or plaster, applied by means of a dust blower are effective.

Sponges filled with sugared water attract ants that infest houses, and large numbers can be readily destroyed.

7. Ditches, Furrows and Trenches

When fields are threatened with the army worm or grasshoppers, a ditch or deep furrow made in front of the advancing army has had excellent results. The insects falling into the ditch may be destroyed in large numbers.

8. The Use of Hopperdozers, Etc.

In the grasshopper-infested regions of the West hopperdozers or hopper-catchers are used to great advantage. Various devices are in use, but they all agree in principle. They are essentially machines for gathering up the grasshoppers as they are drawn across an infested field. Attached to each machine is a contrivance for destroying the insects when collected by means of coal-oil, or tanglefoot, or pitch tar.

Best results are secured by using the dozers when the hoppers are small. If infested fields are gone over frequently the damage will be reduced to a minimum.

9. Collecting, Digging-out, Jarring, Etc.

Under this head are collected a number of mechanical methods which the careful farmer and fruit grower employ to good advantage. Sometimes much damage can be averted by the timely picking of the eggs, larvæ, or adults of insects such as the tobacco and tomato worms (*Sphingidæ*), corn ear worm, potato beetle, celery caterpillar, white grubs, cabbage butterflies, asparagus beetles, etc.

Again, it is often wise to cut out, burn, or otherwise destroy certain insects whenever they appear. For example, web-worms, tent-caterpillars, stalk-borers, etc., may be effectively dealt with at certain stages in this way.

Sometimes, too, under certain conditions, insects can be controlled by jarring and beating the infested plants. When poisons are objectionable, this method of dealing with potato beetles, currant worms, plum curculio, etc., is recommended.

10. High and Low Temperatures

In flour or meal mills it has been practicable to raise the temperature to 120° or 125° for 6 to 8 hours, when it is found that all the insects—eggs, larvæ and adults—are killed. On the other hand insects are not able to develop at cold-storage temperatures, hence products kept in cold storage are kept free from injury.

THE ACTION OF INSECTICIDES

(Consult Tech. Bulls. 11 and 21, Mich. Agric. Coll.)

Until recently the mode of action of insecticides was not well understood. It was commonly stated that contact substances kill insects by stopping the breathing pores or plugging the tracheæ, producing death by suffocation. Recent investigations, however, go to show that insects are not readily suffocated. The death-producing action of chemicals is mainly due to their absorption into their tissues. The volatile portions of kerosene, carbon bisulphide, gasoline, creolin, pyrethrum, etc., are effective long before the liquids have time to penetrate the chitin or the spiracles into the tissues.

With the penetration of the volatile substances the nervous system is seriously affected, and results resembling narcosis are produced, where there is a disturbance of the respiratory activity. Insect tissues soon become saturated when exposed to the vapors of the substances mentioned, and death ensues through the inability of the tissues to absorb oxygen in the presence of these vapors.

In the case of lime-sulphur, its effectiveness is due to its reducing power, and with scale insects to its softening action on the wax about the margin of the scales and to its effect on the waxen covering making it less permeable to oxygen.

Alkaline washes, corrosive sublimate solution and other liquids, which are able to dissolve or precipitate certain constituents of the tissues, pass through the chitin slowly.

Moreover, gasoline, carbon bisulphide, hydrocyanic acid gas, sodium fluoride, etc. act strongly on the oxidases and other enzymes in the tissues of insects causing serious disturbances.

Fat or fat-like membranes absorb the vapors of gasoline and chloroform, but in doing so become less permeable to oxygen; and waxen membranes when wet with lime-sulphur also become less permeable to oxygen.

Non-volatile finely powdered solids, such as borax, hellebore, sodium fluoride, etc., in addition to being stomach poisons, are effective also as contact insecticides because they adhere to exudations on the body wall, and later become dissolved and absorbed through the integument into the tissues.

The Utilization of Parasitic Insects

The economic use of parasitic insects shows three phases: (1) the utilization of the native parasites of the district; (2) the transportation of the parasites from one district to another; and (3) the importation of parasites from one country to another.

1. In the great majority of cases of insect outbreak the native parasites are able to control it in time. In fact injurious forms are mainly held in check by their parasites. Occasionally, however, through the operation of some obscure factor, the multiplication of parasites is prevented; then the injurious forms are permitted to reproduce with much less check and much loss occurs before parasites are able to "catch-up" again.

2. Some successes have been reported where parasites were transported from one locality to another. LeBaron of Illinois in 1872 introduced *Aphelinus mali*, a parasite of the Oyster Shell Scale. Webster in 1907 transported *Polygnotus hiemalis* from Marion, Pa., to a field of wheat infested with Hessian fly at Sharpsburg, Md., and

observed that later in the season nearly every "flaxseed" was parasitized. W. D. Hunter introduced parasites of the Cotton Boll-weevil from Waco to Dallas and from Texas to Louisiana with considerable success (Fig. 254).

3. Several conspicuous successes have attended the importation of parasites from foreign countries. Perhaps the introduction of the lady-bird, *Novius cardinalis*, from Australia to California in 1888 for the purpose of controlling the Cottony Cushion or Fluted Scale of the Orange (*Icerya purchasi*) is one of the most interesting cases. This scale was brought to California about 1868, probably on *Acacia*

Fig. 254.—*Polygnotus hiemalis*, a parasite of the Hessian fly: adult. Greatly enlarged. (*From Webster, U. S. Bur. Ent.*)

latifolia. It began to multiply rapidly in the orange and lemon groves in spite of every measure that was tried against it. Dr. Riley, U. S. entomologist, and his staff made the scale a subject of special study for 4 or 5 years and he became convinced that it was a native of Australia. Accordingly, two entomologists, Koebele and Webster, were sent to that country to collect possible parasites, and to send them to California. *Novius cardinalis* was found at Adelaide and small shipments of it were sent. The lady-birds began to feed on the *Icerya scale insect* as soon as they were liberated, and to breed rapidly —the result being that within a year the orange growers confessed that their groves had been saved. Later, *Novius cardinalis* was sent to New Zealand, Portugal, Cape Colony, Florida, Hawaiian Islands, Italy, Syria and Egypt, and equally good results were secured. Dr. Howard gives the following reasons for this success: (1) *Novius* produces in one year double the number of generations that *Icerya* does; (2) *Novius* feeds preferably on eggs of *Icerya;* (3) the absence of parasites of *Novius;* and (4) *Novius* is an active insect, while *Icerya* is fixed to the plant.

Another interesting example of successful parasitism through importation in 1901 is that of *Scutellista cyanea*, a chalcid insect from South Africa to control the Black Scale of the Olive (*Lecanium oleæ*) of California.

The West Indian Peach Scale (*Diaspis pentagona*) occurs in the Southern States but is not very injurious on account of the presence of a parasite, *Prospaltella berlesei.* Specimens of the parasite were sent to Italy where mulberry plantations were seriously injured, with the result that it is now well established and holding the scale in check.

The recent attempt to control the Gypsy and Brown-tail Moths in New England has been of great value to entomologists in demonstrating the many complicated factors that exist when foreign parasites are introduced. From 1905 to 1913 more than thirty species of parasites were imported from Europe and Japan and a number of the most important ones have been acclimatized and are rapidly spreading.

The present improvement in Massachusetts "is due to at least four main causes: (1) The perfection and standardization of the methods for artificial repression; (2) the death of a large proportion of the more susceptible trees or their removal from the infested woodlands; (3) the importation of parasitic and predatory insect enemies; (4) the development of the 'wilt' disease" (Fiske).

The problem of the control of insects such as the Gypsy Moth and the Brown-tail Moth by parasites is a more difficult one than appears on the surface. From extensive studies of the life-history of the Gypsy Moth it has been determined that the probable potential rate of increase is 250-fold annually. On account, however, of the heavy death-rate from various causes the actual rate of increase is only 6- to 10-fold.

The problem was then to secure sufficient parasites to keep the insect in control. In other words, if the increase annually be 6-fold, five out of every six insects, either egg, caterpillar, or pupa, or 83.3 per cent. would require to be parasitized. If the increase be 10-fold, nine out of every ten, or 90 per cent. must be parasitized. To rely entirely upon egg parasites, such as *Anastatus* or *Schedius*, to destroy such a large percentage of the eggs was out of the question, for these parasitized only the upper layer of eggs in each mass. It became necessary, therefore, to call in the aid of the parasites affecting the caterpillar and the pupa. Consequently efforts have been made to secure a sequence of parasites from foreign countries so that every stage of the moth is subjected to attack, and which would bring up the death-rate to 85 or 90 per cent. (See Bull. 91, U. S. Bureau of Ent.)

FIG. 255.—*Apanteles lacteicolor:* adult female and cocoon. Much enlarged. (*After Howard and Fiske.*)

The task of importing the foreign parasites of the Gypsy and the Brown-tail Moths to the United States has been a most arduous and difficult one. In the first place it has involved much labor in getting competent collectors in Europe to gather sufficient parasitized material, for the plan of the utilization of foreign parasites on a large scale in the control of injurious forms is recent in conception, and was put into operation for the first time by the U. S. Bureau of Entomology in the fight against the Gypsy and the Brown-tail Moths. In the second place, many difficulties in transportation have had to be overcome. In the third place, the work of sorting out the various parasites and herding them in sufficiently large numbers in the laboratories for

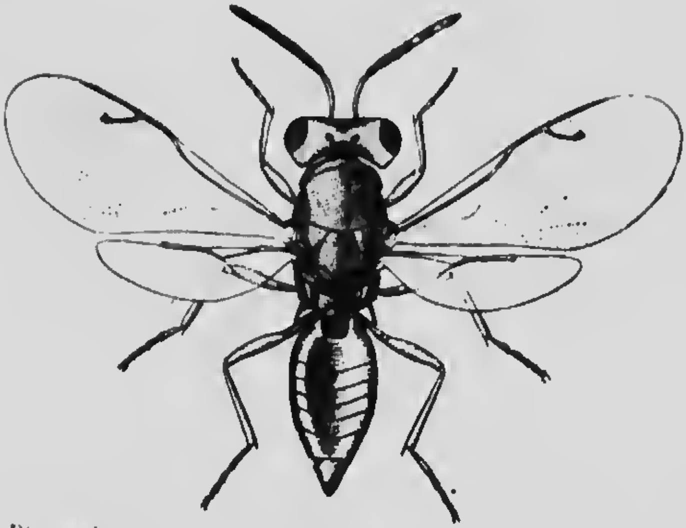


FIG. 256.—*Pteromalus egregius:* adult female. Greatly enlarged. (*After Howard and Fiske.*)

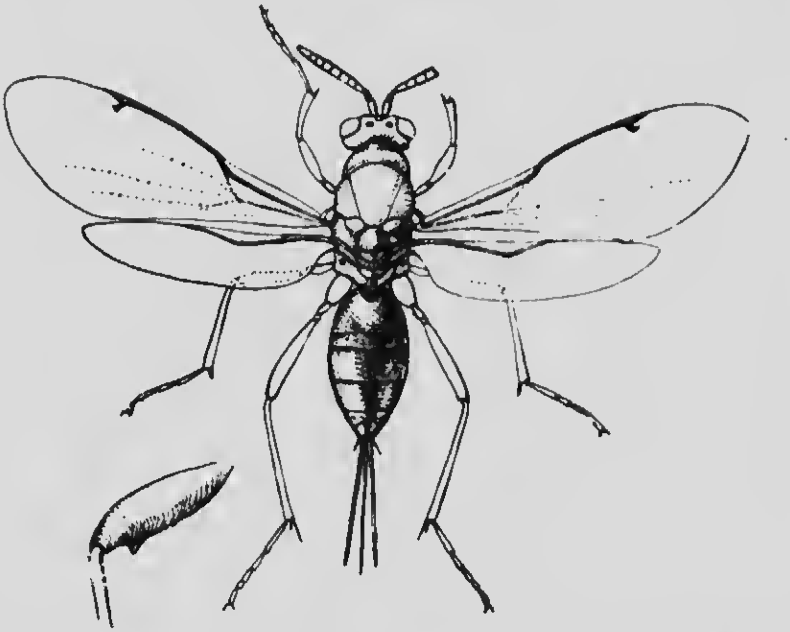


FIG. 257.—*Monodontomerus æreus:* adult female. Greatly enlarged. (*After Howard and Fiske.*)

colonization purposes in the field has been much greater than was anticipated at the outset. In the fourth place, the habits of many of the parasites were not well known and had to be determined for American conditions. As a result, many of the parasites reported favorably in Europe were found to be secondary parasites, or unsuited for the task in hand (Figs. 255–257).

The parasites of the Gypsy and Brown-tail Moths may be grouped as follows:

(I = Imported, N = Native, C = Chalcid, T = Tachinid, Ic = Ichneumon, Ca = Carabid.)

Host	Egg parasites	Larval parasites	Pupal parasites
Gypsy Moth.	Anastatus bifasciatus (C.I.) Schedius kuvanæ (C.I.)	Compsilura concinnata (T.I.) Blepharipa scutellata (T.I.) Calosoma sycophanta (Ca.I.)	Monodontomerus æreus (C.I.)
Brown-tail Moth.	Trichogramma pretiosa (C.N.)	Pteromalus egregius (C.I.) Apanteles lacteicolor (B.I.) Meteorus versicolor (B.I.) Zygobothria nidicola (T.I.) Pales favida (T.I.) Dexodes nigripes (T.I.) Calosoma sycophanta (Ca.I.)	Monodontomerus æreus (C.I.) Pimpla conquisitor (Ic.N.) Chalcis compsiluræ (C.N.)

From Melrose Highlands, Mass., where the parasite laboratory is located, not only have the parasites and the predaceous *Calosoma sycophanta* been distributed throughout the infested areas of New England but also into New Brunswick and other eastern provinces lying in the probable zone of infestation.

Hewitt introduced into Canada in 1910 the European ichneumonid, *Mesoleius tenthredinidis* Morley, to combat the larch saw-fly. The results have been fairly satisfactory. In 1908 the egg parasite, *Tetrastichus xanthomelænæ*, of the elm leaf beetle was introduced into New England from France. The results are not conclusive although the parasite has multiplied and spread slightly.

Other examples of the introduction of parasites to combat injurious insects might be cited of which many have been unsuccessful. The valuable experience gained in the Gypsy and Brown-tail experiments will no doubt be utilized in future work of this nature and more successes will probably be recorded.

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GLOSSARY (*After Smith*)

Acalyptrata. / **Acalypteræ.** Those muscoid flies in which alulæ are absent or elementary.

Accessory Glands. Any glands opening into the ducts of the reproductive system (Fig. 32).

Androconia. Specialized, usually small scales of peculiar form, found localized on some male butterflies.

Aculeata. Hymenoptera; the stingers, including bees and wasps.

Agamic. Reproducing without union with a male.

Alate. Winged.

Alternation of Generations. Periodic productions of parthenogenetic females in a species that occurs in both sexes. These females produce both sexes. Examples occur in Cynipidæ and in some Homoptera.

Alulæ. A pair of membranous scales above the halteres, behind the root of the wing, one above or before the other; the anterior attached to the wing and moving with it, the posterior fastened to the thorax and stationary. Occurs in Diptera. Synonyms calyptra; squama; squamula; lobulus; axillary lobe; aileron; scale; tegulæ. In Coleoptera a membranous appendage of the elytra which prevents dislocation.

Alulet. The lobe at basal portion of wing in Diptera (posterior lobe). Sometimes used for alula.

Amnion. The inner of the two membranes enclosing the embryo (Fig. 36).

Anal Angle. That angle on the secondaries nearest the end of the abdomen when the wings are expanded. The angle between the inner and outer margin of any wing.

Anal Area. In Orthoptera and Neuroptera the hinder or anal portion of a wing within the anal vein.

Anal Plate. In caterpillars the shield-like covering of the dorsum of the last segment (Fig. 18).

Apterous. Without wings.

Arista. A specialized bristle or process on the antennæ of certain Diptera (Fig. 180).

Arthropoda. Jointed animals having jointed appendages.

Brachycerous. Having short three-jointed antennæ, Diptera (Fig. 144).

Cæcum. A blind sac or tube supplied to appendages, opening into the alimentary canal at the junction of the mid and hind gut (Fig. 29).

Calypter. In Diptera, the alula when it covers the haltere.

Cœcum. See Cæcum.

Capitate. Terminating in a little head or knob (Fig. 88).

Carabidoid. Resembling a Carabid (Fig. 40).

Cauda. The tail; any process resembling a tail (Fig. 87).

Caudal Setæ. Thread-like processes at the end of the abdomen.

Chætotaxy. The science dealing with the arrangement and nomenclature of the bristles on the body of insects.

Chitin. The material of which the hard parts of the insect body are formed.

Chrysalis—id. The intermediate stage between larvæ and adult in the butterflies (Fig. 39).

Cilia. Fringes.

Clavate. Club-shaped; thickening gradually toward end (Fig. 87).

Clavus. The club of an antenna; clava and clavola; in *Heteroptera* the oblong sclerite at the base of the inferior margin of the hemelytra; the knob at the end of the stigmal or radial veins in certain *Hymenoptera.*

Clypeus. The anterior median portion of the head to which the lahrum is usually attached (Fig. 4).

Coarctate. Contracted; compact. Applied to a pupa in which all the appendages are concealed in a bardened covering which is usually the last larval skin (Fig. 39).

Corium. The elongate middle section of the hemelytra which extends from base to membrane below the embolium (Fig. 101).

Cornicles. Glandular tubes on the abdomen of plant-lice which secrete a yellowish waxy liquid (Fig. 88).

Costa. An elevated ridge that is rounded at its crest; the thickened anterior margin of a wing.

Coxa. The basal segment of the leg (Fig. 19).

Coxal Cavity. The opening or space in which the coxa articulates. In the *Coleoptera* the coxal cavity is said to be *closed* when the epimeron extends bebind the coxa to the sternum. It is described as *open* when the epimeron does not reach the sternum (Fig. 185).

Crenate. Scalloped.

Cuneus. *Heteroptera;* the small triangular area at the end of the embolium of hemelytra; *Odonata*, the small triangle of the vertex between the compound eyes (Fig. 101).

Dorsum. The upper surface.

Ecdysis. Moulting or casting of the skin.

Ecology. The science of the relation of organisms to each other and to their surroundings.

Elytra. The anterior leathery or chitinous wings of beetles (Fig. 181).

Embolium. The narrow sclerite extending along the anterior margin of the hemelytra, from base to cuneus or membrane, in *Heteroptera* (Fig. 101).

Empodium. The small process between the pulvilli in Diptera. The bifid pseudotarsi between the claws in Coleoptera (p. 14).

Entomophagous. Insect-feeding.

Episternum. The anterior and larger lateral thoracic sclerite between the sternum and notum (Fig. 18).

Eruciform. Caterpillar-like in appearance (Fig. 38).

Evaginate. Extruded by eversion; turned inside out when extruded.

Exserted. Protruded.

Foveola—æ. A pit-like shallow depression.

Frenulum. The spine, simple in males, compound in females, arising from the base of secondaries in many *Lepidoptera*, whose function it is to unite the wings in flight (Fig. 120).

Front. Anterior portion of the head between the base of antennæ and below the ocelli (Fig. 2).

Frontal Lunule. *Diptera;* an oval or crescentic space above the base of antennæ in *Cyclorrhapha*, bounded by the frontal suture.

Gena. Cheek; that portion of the head below the eyes on each side extending to the gular suture (Fig. 2).

Genitalia. External organs of reproduction and their appendages (p. 23).

Halteres. The poisers or balancers; capitate movable filaments in *Diptera*, situated one on each side of the thorax and representing rudimentary hind wings (p. 15).

Hermaphrodite. A bisexual individual.

Heterogamy. Alternation of generations, two sexual or a sexual and a parthenogenetic.

Hibernaculum. A tent or sheath in which a larva hibernates.

Histogenesis. The formation and development of tissue.

Histolysis. The degeneration and dissolution of organic tissue.

Hyper-metamorphosis. The case in which an insect passes through more than the normal stages of development (Fig. 40).

Hyperparasite. A parasite that is parasitic upon another parasite.

Imago. The adult or sexually mature insect.

Instar. The period or stage between moults in a larva (Fig. 38).

Integument. The outer covering to the insect body.

Labium. The lower lip (Fig. 7).

Labrum. The upper lip (Fig. 4).

Lacinia. The inner lobe of the first maxilla, articulated to the stipes, bearing brushes of hairs or spines (Fig. 6).

Lamellate. Divided laterally into distinct leaf-like plates (Fig. 183).

Larva. The second stage in the development of the insect, follows immediately after the egg stage.

Macrochætæ. The long bristles occurring singly on the body of *Diptera*.

Maggot. The footless larva of *Diptera* (Fig. 38).

Mandibulate. With jaws or mandibles.

Maxilla—æ. Jaws; one on each side of the mouth immediately beneath the mandibles (Fig. 6).

Mentum. A labial sclerite bearing the movable parts (Fig. 7).

Mesenteron. The middle portion of the primitive intestinal canal; the mid-gut (Figs. 1, 36).

Mesonotum. The primitively upper surface of the middle thoracic ring (Fig. 18).

Metabolism. Transformation, changes of food into tissue and of tissue into waste products.

Metanotum. The primitively upper surface of the third or posterior thoracic ring (Fig. 18).

Metathorax. The third thoracic ring or segment (Fig. 18).

Microchætæ. Small bristles, as opposed to macrochætæ, in *Diptera.*

Moniliform. Beaded like a necklace (Fig. 183).

Nectaries. A term which was applied to the cornicles of the Aphids under the mistaken notion that these structures secreted the honey dew (Fig. 88).

Nymph. The larval stage of insects with incomplete metamorphosis (Fig. 88).

Obtect. Wrapped in a hard covering (Fig. 39).

Ocellus. A simple eye.

Oogenesis. The process of egg-formation.

Ova. Eggs.

Ovipositor. The structure by means of which the eggs are placed (Fig. 23).

Pædogenesis. Reproduction in the larval or the pupal stage.

Parthenogenesis. Reproduction by direct growth of germs from egg-cells without fertilization by the male.

Pleura. Plural of pleuron or pleurum; the lateral sclerites between the dorsal and sternal portion of the thorax; in general, the sides of the body between the dorsum and sternum.

Polyembryony. Production of more than one embryo from one egg.

Pulvillus—i. Soft, pad-like structures between tarsal claws; the cushions of short stiff hair or other clothing on the under side of tarsal joints; rarely flesby lobes (p. 14).

Pupa. The intermediate stage between larva and adult (Fig. 39).

Puparium. The thickened larval skin within which the pupa is sometimes formed (Fig. 39).

Pygidium. The last dorsal segment left exposed by the elytra. In *Diaspinæ* (Coccidæ) the compound terminal segment (Fig. 127).

Reticulate. Like net-work.

Roatrum. A snout-like prolongation of tbe bead.

Sclerite. Any piece of the body-wall bounded by sutures (p. 2).

Scrobes. Grooves formed for the reception or concealment of the appendages. In *Rhyncophora* grooves at the sides of the rostrum to receive the scape of antennæ.

Sensoria.	The circular openings covered by membrane on the antennæ or legs of plant-lice.
Spermatogenesis.	Development of the spermatozoa.
Spinneret.	Any organ consisting of an internal tube, terminating in a pore, spine or process, producing a silky or waxy fibre.
Spiracle.	A breathing pore opening to the trachea (Fig. 28).
Sternite.	The ventral piece in a ring or segment (Fig. 17).
Suctorial.	Adapted for sucking.
Sulcus.	A furrow or groove; a groove-like excavation.
Suture.	A seam or compressed line indicating the division of distinct parts of body-wall; the line of junction of elytra in *Coleoptera.*
Tergal.	Belonging to the primitively upper surface.
Thorax.	The second or middle portion of the insect body, bearing the true legs and wings; made up of three sections, the pro-meso- and meta-thorax (p. 14).
Trachea—æ.	The breathing tubes of insects (p. 23).
Transition Zone.	The transcontinental belt in which the austral and boreal elements overlap; it is divided into a humid or Alleghanian area, a western arid area, and a Pacific coast humid area.
Truncate.	Cut off squarely at tip.
Venation.	The system of chitinous framework supporting the wings.
Viscera.	The internal organs of the body.
Vittate.	Striped.
Viviparous.	Bearing living young.

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