Micro-Analytical Biology Workbook for Food Sanitation Control Analysts (Volume I)

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Sections in This Document

1. Introduction

Entomologists are often required to teach regulatory entomology and biology principles to individuals who have little or no background in insect taxonomy or related biological sciences. This workbook is an attempt to present a uniform concept of conducting training in this area and is to be used as a manual to teach food analysts how to identify insect and rodent contaminants of food products.

The instructor should select the insects, mammalian hairs and excreta pellets to be studied, in accordance with the time allocated for the training course, and the kinds of insect and other animal contamination usually encountered in routine analysis. The selection of appropriate material to study is also important because there is too much material in this workbook to study in the time suggested by the author. Instructions for dissecting the genitalia of adult beetles and moths are included, even though there is little reference material available. Reference materials are presently available for identification of species of *Oryzaephilus*, food infesting moths, and a few others. Identification of the genitalia will become more important in the future as additional research is done, and the resulting reference material becomes available.

This workbook is divided into two volumes. Volume I provides the fundamentals of entomology and instructions for the study of beetle adults and larvae. Volume II contains instructions for the study of the remaining insects, animal hairs, and animal excreta. Each volume is color-coded for convenience and structured to satisfy the demands of classroom type study. All green sheets are illustrations of insects, insect fragments, or mites. The student is required to complete the worksheet by referring to the proper source of information or reference to appropriately name the various structures indicated. All yellow sheets contain general information and/or methodology. The pink sheets provide specific stepwise instructions for classroom exercises to be performed by each student on individual insects, animal hairs, or animal excreta. Slide mounts should be made by the student as per instructions given in the Analyst Operations Manual, Chapter 3. The required drawings indicated can be made on separate pages and incorporated into the workbook in their appropriate places. White sheets which list individual sources of reference materials should be removed when reprints of each reference are inserted into the workbook. These reference materials will be furnished by the instructor.

The author conducts a four-week course, with an examination given after each week, which is divided as follows:

First week: The selected beetle adults are dissected and studied. A four-hour examination follows which consists of 50 slides of beetle adult fragments.

Second week: The selected beetle and moth larvae are dissected and studied. A four-hour examination follows which consists of 50 slides of beetle and moth larval fragments.

Third week: The flies, cockroaches and selected miscellaneous insects are dissected and studied. An eight-hour examination follows which consists of 100 slides of insect fragments representing all the insects studied during the first three weeks.

Fourth week: Selected mammalian hairs and animal excreta pellets are studied. A four-hour examination consisting of 20 slides of hairs plus unknown excreta pellets follows.

The slides of unknown fragments and hairs are to be prepared by the instructor. During the exams, students have access to all reference materials, including their workbook and any slides which they have prepared. A minimum passing grade should be established.

The author expresses his gratitude to his wife, Doris, for her typing and her moral support. It is hoped that students studying and using this workbook in their work will find it of practical value. If so, then the long and arduous hours of preparation by the author and his typist will have been worthwhile.

(DON J. VAIL, JR. ENTOMOLOGIST; U. S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, FOOD AND DRUG ADMINISTRATION, ATLANTA REGION OFFICE, ATLANTA, GEORGIA, 1981)

Disclaimer: This manual was originally published in 1981 and the content is being provided "as is" for training purposes only. Entomology is an evolving field of study and our current understanding, particularly taxonomy, has changed since the publication of this manual. Users of this manual are responsible for ensuring their training program aligns with current entomological science. Minor revisions were made to address clarification and readability.

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2. Fundamentals of Entomology

2.1. Insect Orders

2.1.1. Thysanura

Bristletails, Order Thysanura

1) Thysan - bristle or fringe; Ura-tail
2) Wingless insects

3) Mouth parts are of the chewing type
4) Body tapers from head to tail
5) Body covered with scales
6) The posterior end of the abdomen has 3 taillike appendages.
7) Some of the abdominal segments have style-like appendages

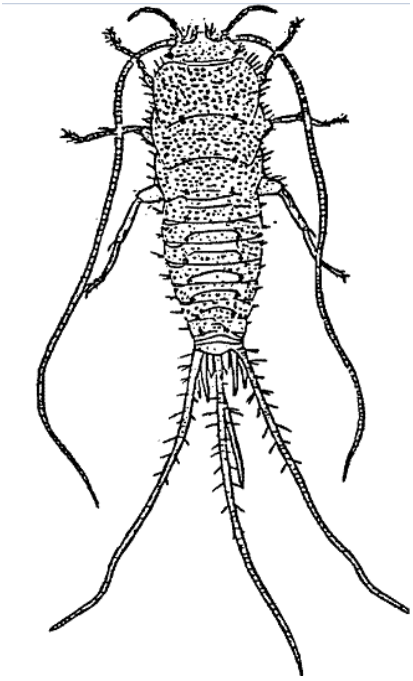

Fig. 1. The firebrat, Thermobia domestica (Packard)

From College Entomology, by E.O. Essig, the MacMillan Company, New York.

2.1.2. Collembola

Springtails, Order Collembola

Coll - glue; embola - a bolt or wedge (refers to the collophore)

1) Wingless insects
2) Chewing or piercing mouth parts
3) The forked structure on the ventral side of the fourth abdominal segment used in jumping. FURCULA.
4) Clasp-like structure on ventral side of third abdominal segment. TENACULUM.
5) Six abdominal segments

General morphology of springtails

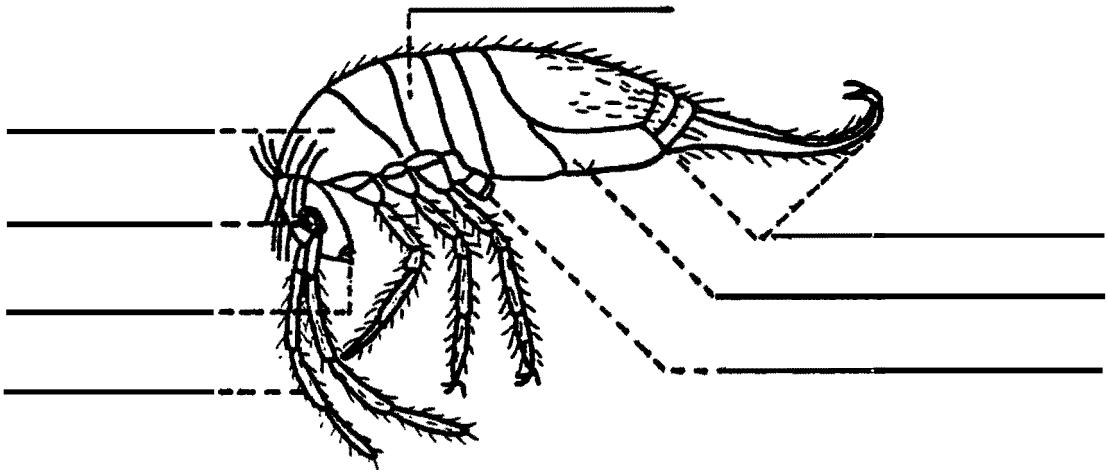

Fig. 2 Suborder Arthropleona

Fig. 2 and Fig. 3 from Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, U. S. Department of Health, Education and Welfare., Public Health Service, Center for Disease Control.

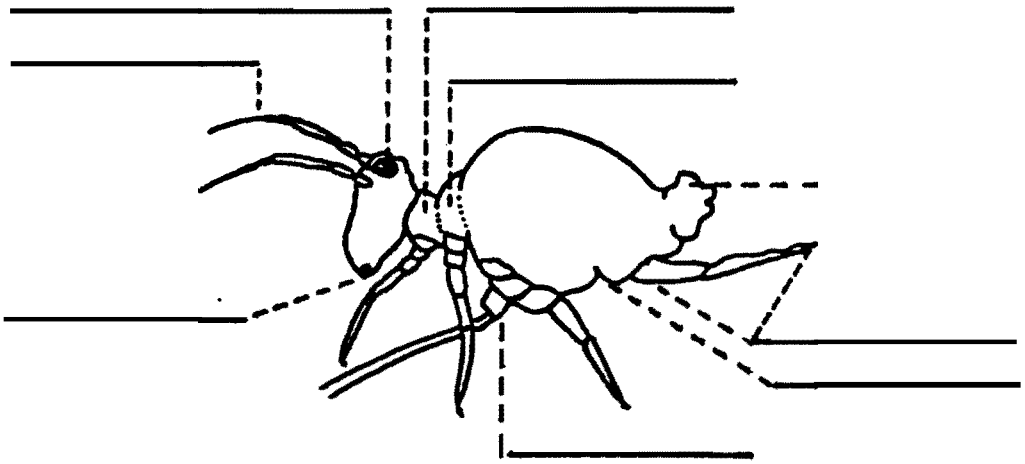

Fig. 3. Suborder Symphypleona.

2.1.3. Orthoptera

Grasshoppers, crickets, katydids, cockroaches, mantids, and walking sticks, Order Orthoptera

Ortho – straight; ptera – wings

1) These insects may be winged or wingless.
2) The winged forms usually have four wings

3) The front wings are long and narrow, many-veined, and somewhat thickened and leathery. TEGMINA.
4) The hind wings are membranous, broad and many- veined. They fold fanwise beneath the front wings when the insect is at rest.
5) Many species have long ovipositors.
6) The mouth parts are of the chewing type.

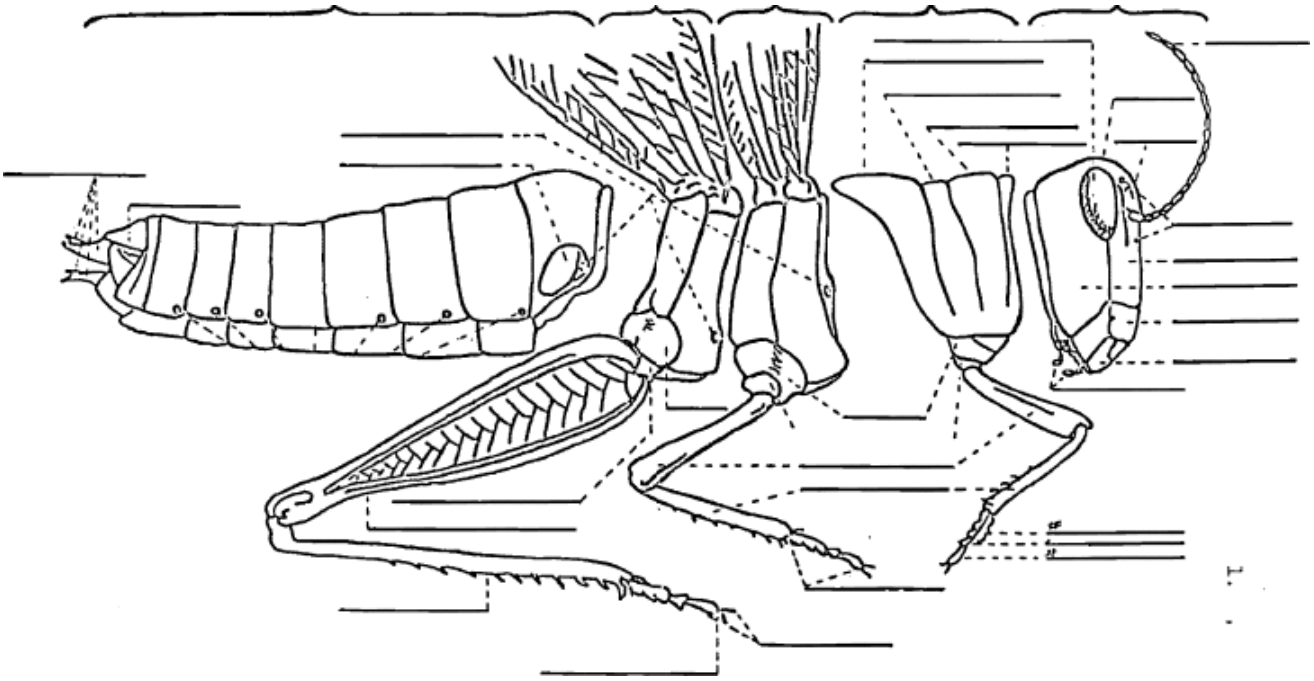

Fig. 4. Outline of body of a grasshopper as seen from the side, dissected to show the three body regions and the parts of the body commonly referred to in literature.

From Destructive and Useful Insects, by Metcalf and Flint, 4th Edition,1962. Copyright © 1967 by Mrs. Cleo F. Metcalf. Used with the permission of McGraw-Hill Book Company.

2.1.4. Isoptera

Termites, Order Isoptera

Iso- equal; ptera – wings

1) Termites are small to medium size.
2) Both winged and wingless individuals occur in the same colony.

3) The winged forms have four membranous wings with reduced venation.
4) The front and hind wings are the same size and shape.
5) The wings are held flat over the body and extend beyond the tip of the abdomen when the insect is at rest.
6) The mouth parts are of the chewing type.
7) There is no constriction between the abdomen and thorax as in ants.
8) Termites are usually light colored and soft bodied.
9) The antennae are moniliform or filiform.

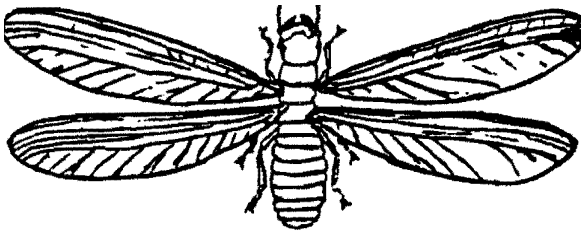

Fig. 5. A termite reproductive.

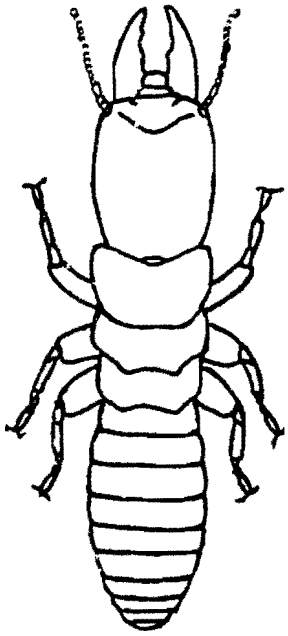

Fig. 6. A termite soldier.

Fig. 5 and Fig. 6 from Household and Stored-Food Insects of Public Health Importance and Their Control, U.S. Department of Health, Education and Welfare, Public Health Service, Center for Disease Control, Atlanta, Georgia.

2.1.5. Dermaptera

Earwigs, Order Dermaptera

Derma – skin; tera – wings (refers to the texture of the front wing)

1) Earwigs usually have 4 wings.

2) Front wings are short, leathery, and veinless.
3) Mouth parts are of the chewing type.
4) These insects are distinguished from beetles by the prominent forcepslike cerci at the tail end of the body.
5) Metamorphosis is simple.

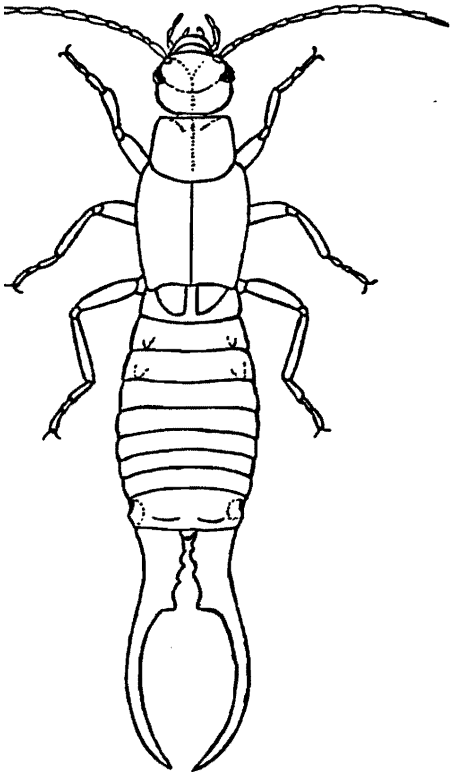

Fig. 7. European earwig. Dorsal aspect of male.

From College Entomology, by E. O. Essig, The MacMillan Company. New York.

2.1.6. Psocoptera

Psocids, Order Psocoptera

Psoco - rub small; ptera – wings (refers to the gnawing habits of these insects)

1) Small soft bodied insects. 6.0 mm. or smaller.
2) Wings may be present or absent.
3) Generally, four membranous wings. The front wings are a little larger.

4) The wings are held roof-like above the abdomen when the insect is at rest.
5) Antennae are fairly long.
6) The mouth parts are of the chewing type.
7) These insects have no cerci.

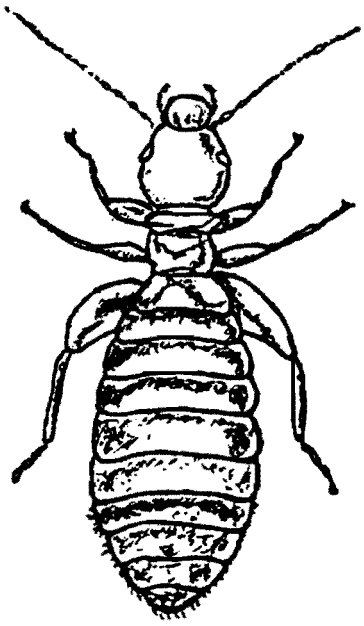

Fig. 8. Book louse.

From Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, U. S. Department of Health, Education and Welfare. Public Health Service, Center for Disease Control.

2.1.7. Thysanoptera

Thrips, Order Thysanoptera

Thysano – fringe; ptera – wings

1) Small slender-bodied insects 0.5 to 5.0 mm.
2) Wings may be present or absent.
3) Winged thrips have 4 wings.
4) The wings are long and narrow with few or no veins and are fringed with long hairs.
5) The mouth parts are of the sucking type.

6) Thrips have only 1 mandible. The right mandible is vestigial.

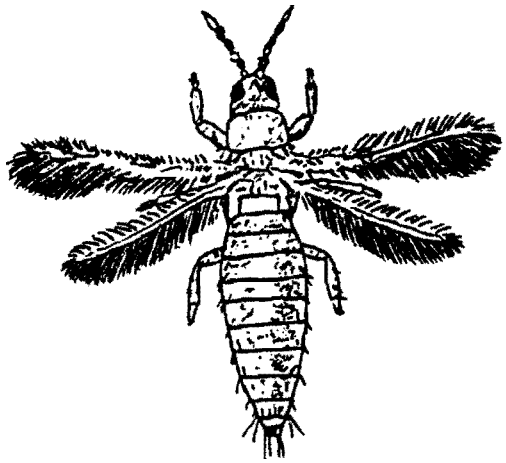

Fig. 9. Onion thrips.

From Microscopic-Analytical Methods in Food and Drug Control, Food and Drug Technical Bulletin No. 1, U.S. Department of Health, Education, and Welfare, Food and Drug Administration.

2.1.8. Hemiptera

True bugs, Order Hemiptera

Hemi – half; ptera – wings

1) The basal portion of the front wing is thickened and leathery. The apical portion is membranous.
2) The hind wing is entirely membranous and slightly shorter than the front wings.
3) When the insect is at rest the wings are held flat over the abdomen with the membranous tips of the front wings overlapping.
4) The mouth parts are of the piercing-sucking type.
5) The beak arises from the front part of the head and usually extends back along the ventral side of the body.
6) The antennae are fairly long - 4 or 5 segments.
7) The compound eyes are usually well developed.
8) Many of the members of this order are aquatic.

General morphology of a bug

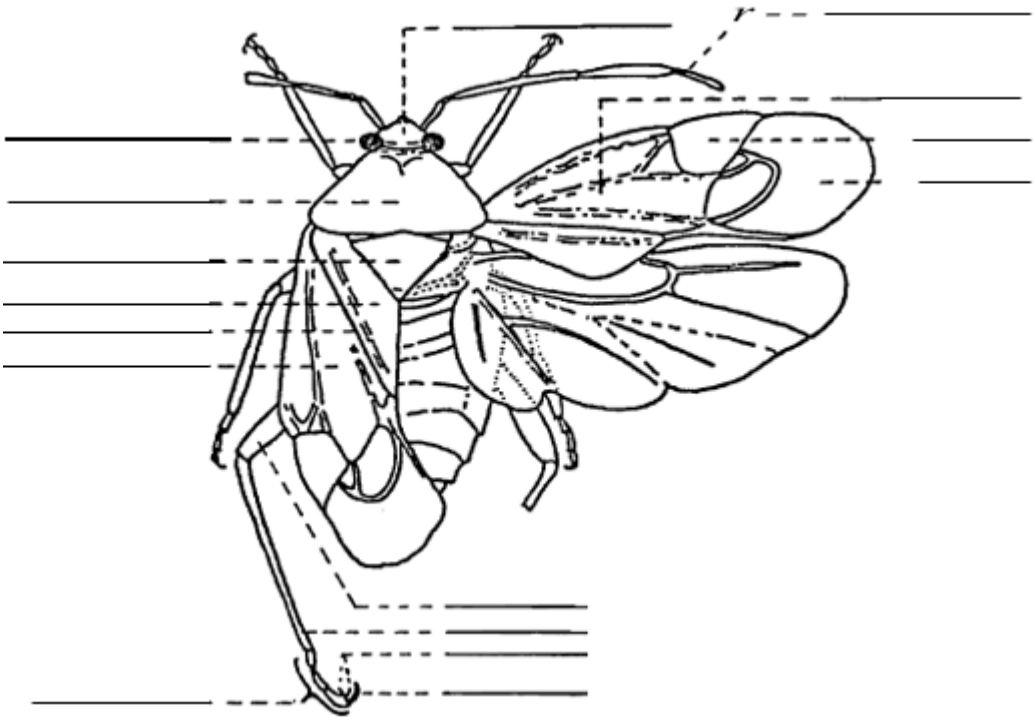

Fig. 10. Dorsal view of a bug.

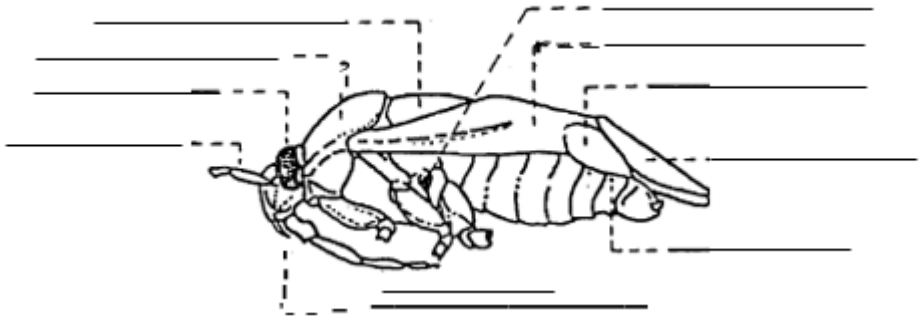

Fig. 11. Lateral view of a bug.

From an Introduction to the Study of Insects, by Barro et al. Used with the permission of the publisher.

2.1.9. Homoptera

Cicadas, hoppers, psyllids, whiteflies, aphids, and scale insects,

Order Homoptera

Homo- alike, uniform; ptera – wings (refers to the uniform texture of the front wings)

1) Individuals may be winged or wingless.
2) The winged forms have 4 wings.
3) Wings usually held roof-like over the abdomen when the insect is at rest.
4) Mouth parts are of the sucking type.
5) Beak arises from the back of the head.
6) Antennae are very short and bristle-like in most Homoptera.

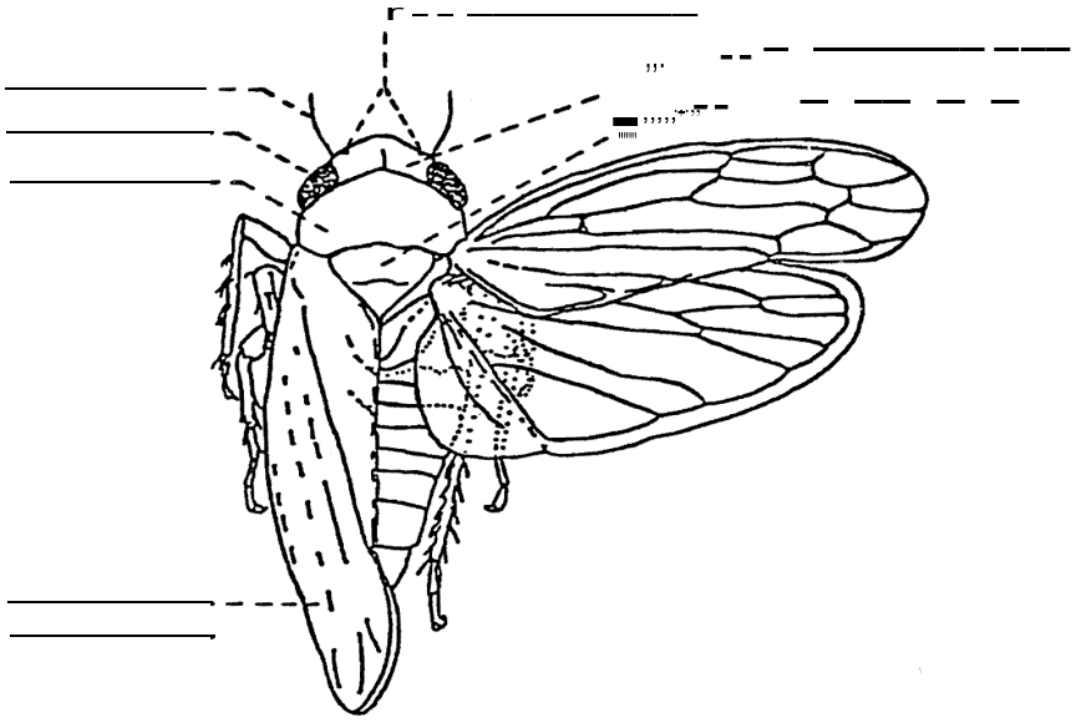

Fig. 12. Structure of a leafhopper.

From An Introduction to the Study of Insects, by Borror, et al. Used with the permission of the publisher.

2.1.10. Coleoptera

Beetles, Order Coleoptera

Coleo – sheath; ptera – wings

1) Most of the beetles have four wings.
2) The front pair of wings are thickened, leathery or hard and brittle.
3) The front wings usually meet in a straight line down the middle of the back, covering the hind wings, when the insect is at rest.
4) The hind wings are membranous and longer than the front wings.
5) The mouth parts are of the chewing type.

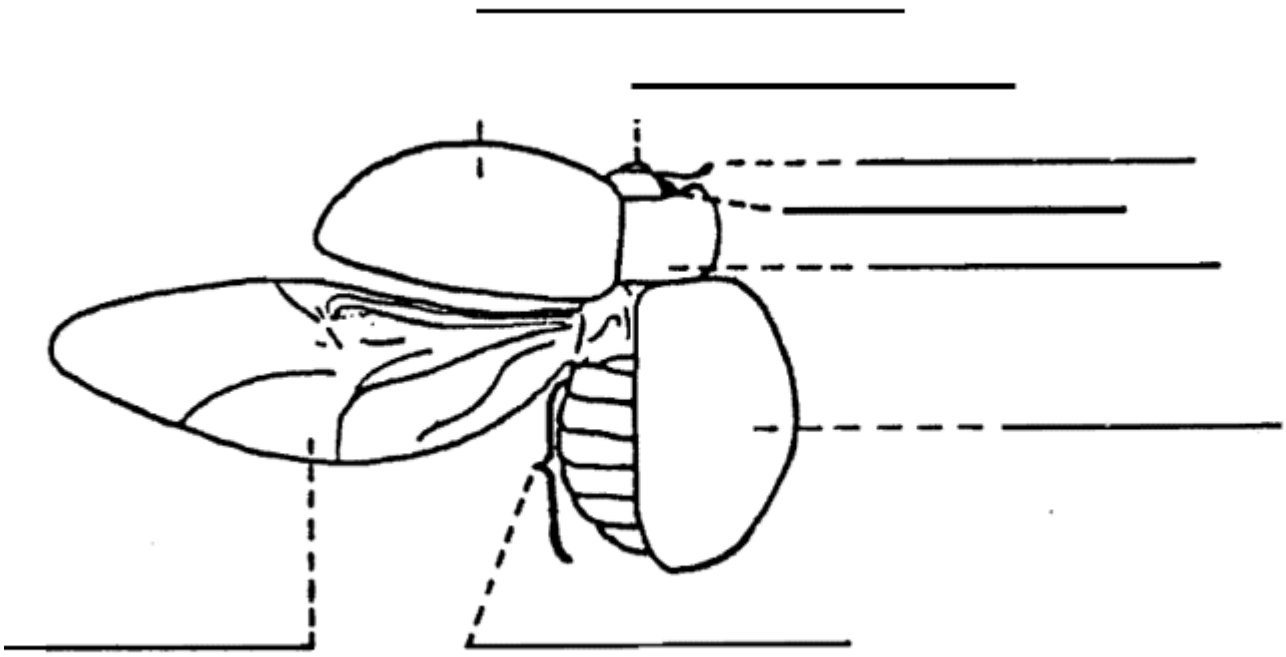

Fig. 13. Dorsal view of a ladybird beetle.

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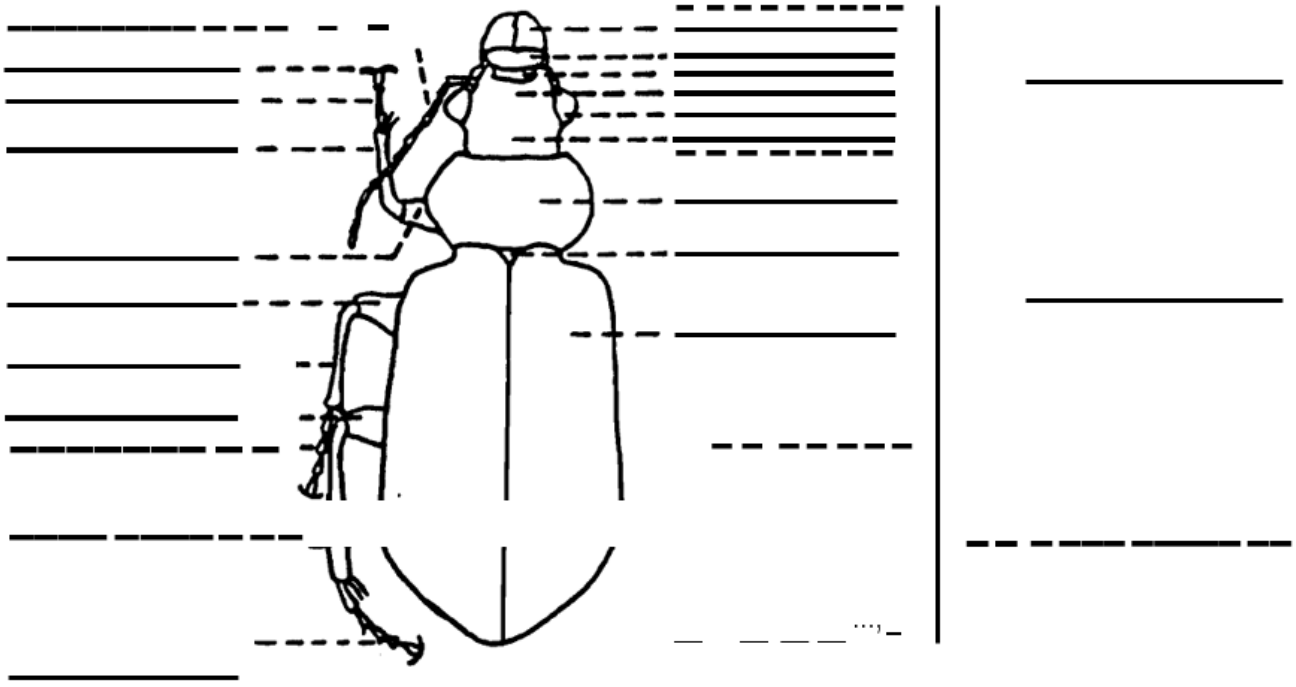

Fig. 14. Dorsal view of a beetle adult.

From Micro-Analytical Entomology for Food Sanitation Control, by O.L. Kurtz and K.L. Harris, Association of Official Agricultural Chemists, Washington, D.C. Used with the permission of the publisher.

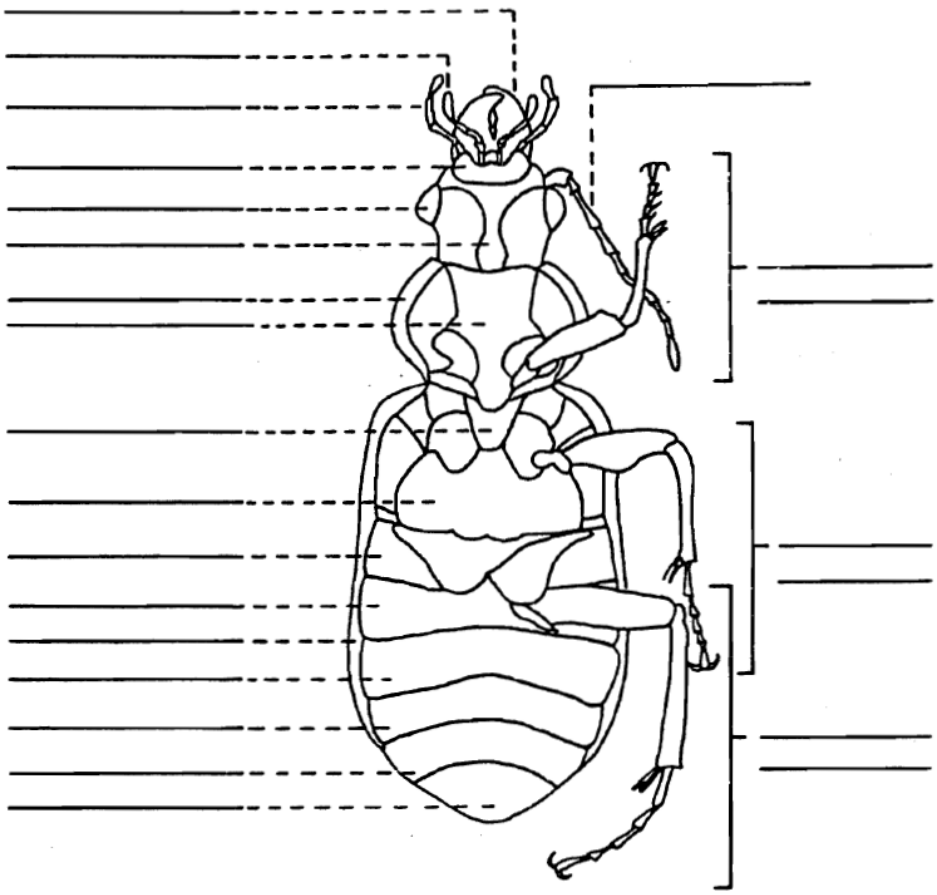

Fig. 15. Ventral view of a beetle adult.

From Micro-Analytical Entomology for Food Sanitation Control, by O.L. Kurtz and K.L. Harris, Association of Official Agricultural Chemists, Washington, D.C. Used with the permission of the publisher.

2.1.11. Lepidoptera

Butterflies and moths, Order Lepidoptera

Lepido – scale; ptera – wings

1) The bodies and wings of these insects are covered with scales.
2) The mouth parts are usually fitted for sucking.
3) These insects have relatively large compound eyes.
4) The butterflies have knobbed antennae, lack a frenulum and are generally small-bodied and day-flying.

5) The moths have feathery antennae of various sorts (usually not knobbed), a frenulum, and are generally large-bodied and night-flying insects.
6) Skippers differ from other butterflies in that the tips of the antennae are usually recurved or hooked.

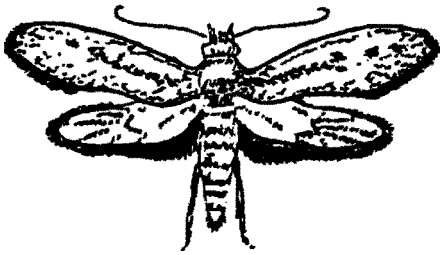

Fig. 16. Angoumois grain moth.

From Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control.

2.1.12. Diptera

True flies, Order Diptera

Di - two; ptera- wings

1) These insects possess only one pair of wings, the front wings.
2) The hind wings are reduced to small, knobbed structures called halteres. These are balancing organs.
3) The mouth parts are of the sucking type. Variations may be piercing, sponging, or lapping and in some mouth parts are nonfunctional.
4) Some of the flies are wingless.

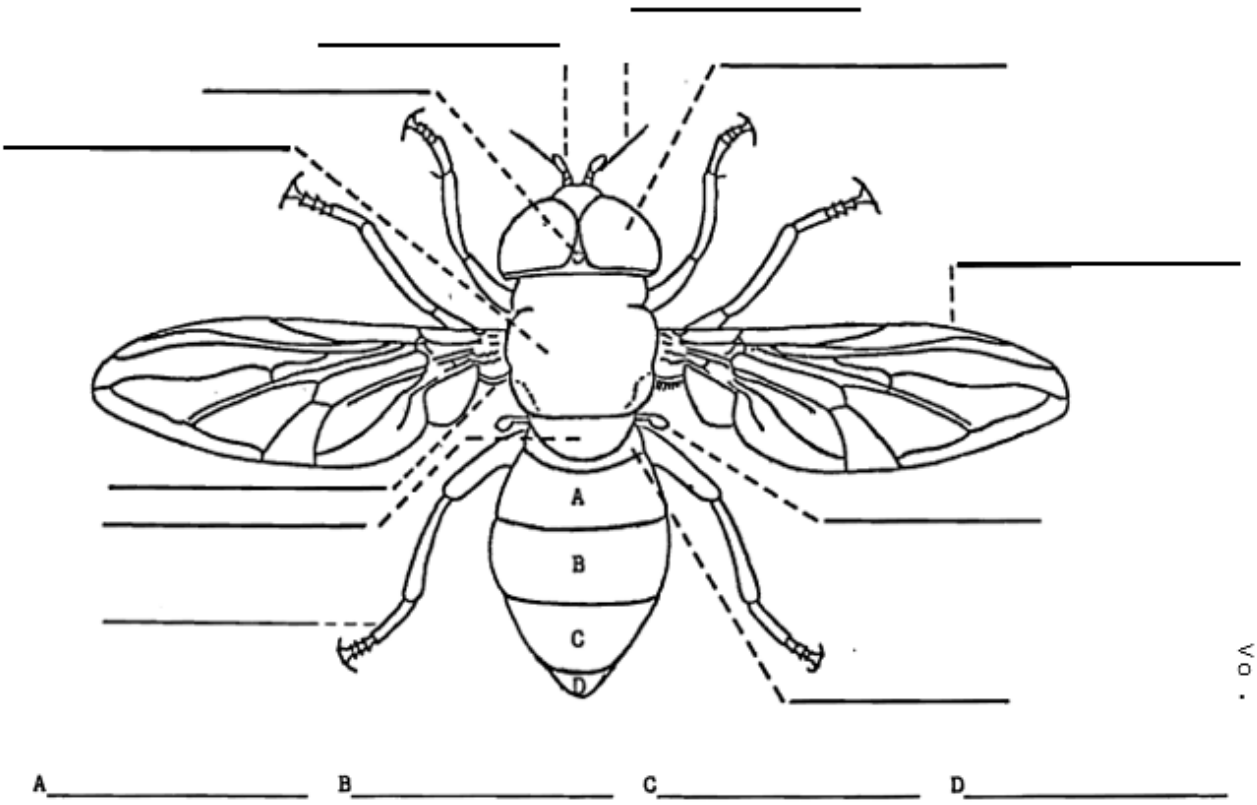

Fig. 17. Dorsal view of a male syrphid fly.

From Destructive and Useful Insects, by Metcalf and Flint, 4th Edition. Used with the permission of R.L. Metcalf.

2.1.13. Siphonaptera

Fleas, Order Siphonaptera

Siphon - a tube; aptera – wingless

1) Fleas are small wingless insects.
2) Fleas are strongly flattened laterally.
3) Fleas have numerous backward-projecting spines and bristles.
4) The antennae are short and lie in grooves in the head.
5) The mouth parts are of the sucking type.
6) The eyes may be present or absent.

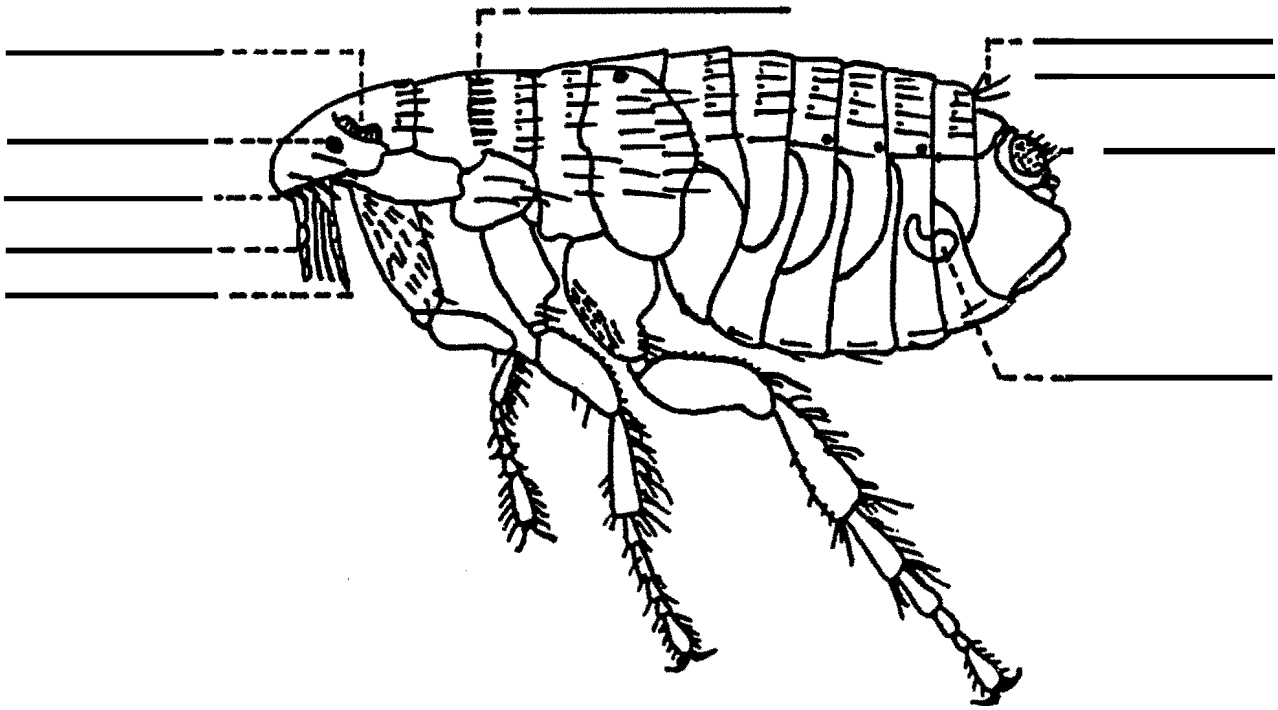

Fig. 18. Lateral view of a flea.

From Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control.

2.1.14. Hymenoptera

Sawflies, ichneumons, chalcids, ants, wasps and bees, Order Hymenoptera

Hymeno - god of marriage; ptera- wings (refers to the union of front and hind wings by means of hamuli)

1) These insects have 4 wings, if wings are present.
2) The hind wings are smaller than the front wings.
3) The hind wings have a row of tiny hooks on their anterior margin (hamuli). These hooks attach the hind wing to the front wing when the insect is in flight.
4) Mouth parts are mandibulate. In the higher forms, such as bees, the labium and maxillae form a tongue-like structure through which liquid food is taken.
5) The ovipositor is modified into a stinger in the higher forms in this order. Only the females can sting.

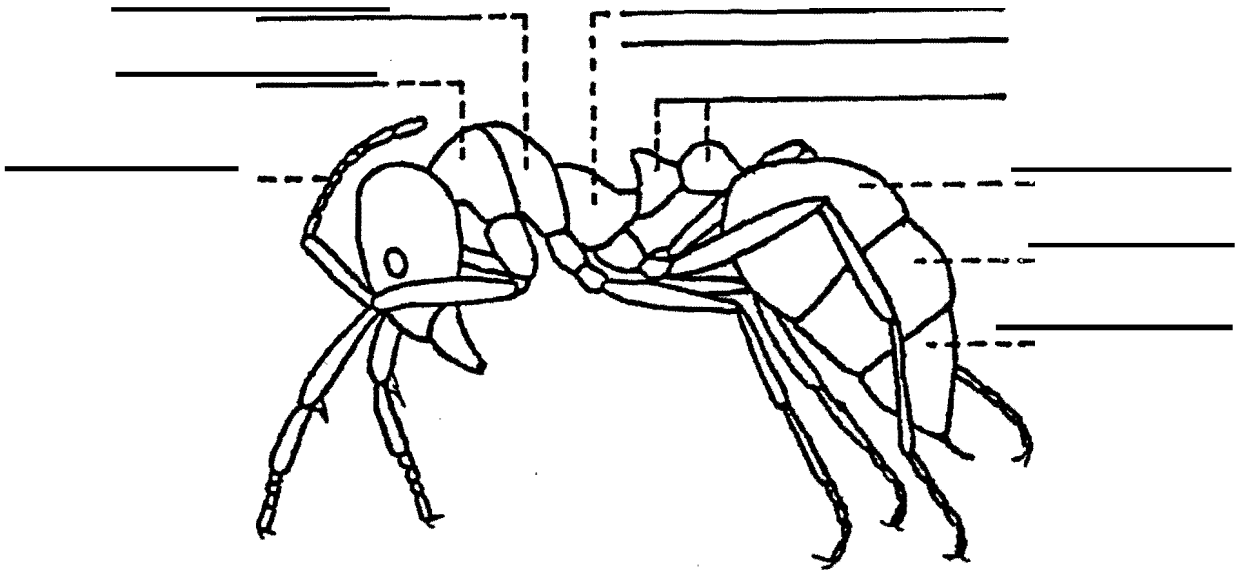

Fig. 19. Diagram of a fire ant.

From Pictorial Keys to Arthropods, Reptiles, Birds and Mammals of Public Health Significance, U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control.

2.2. Metamorphosis

Metamorphosis - A change in form during development

2.2.1. No metamorphosis

1) Thysanura (silverfish) and Collembola are primitive insects and develop without metamorphosis.
2) These insects hatch from the egg and look like the adult. They do not change appreciably during growth.

2.2.2. Simple metamorphosis

1) The young are called nymphs.
2) The wings develop externally.
3) Compound eyes are present in the nymph if they are present in the adult.

2.2.3. Complete metamorphosis

1) The young are called larvae.
2) The larvae do not have compound eyes.

3) The larvae usually have chewing mouth parts, even in orders where the adults have sucking mouth parts.
4) The wings develop internally.
5) Insects in this group have a resting pupa stage.

2.3. Morphology of Insects

1) Exoskeleton (body wall) serves as the outer covering of the body and a supporting structure.
2) Muscles are attached to the body wall.
3) Body wall has three principal layers.
    1. An outer cuticula, which contains pigment and other substances including a characteristic chemical compound called chitin.
    2. A cellular layer, the hypodermis, which lies beneath and secretes the cuticula.
    3. A thin noncellular layer beneath the hypodermis, called the basement membrane.

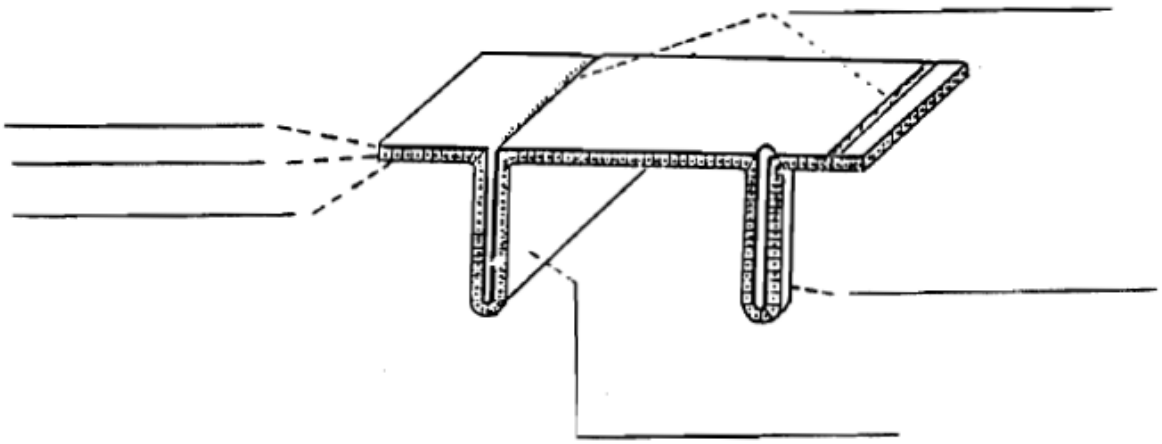

Fig. 20. Diagram of external and internal features of body wall.

From An Introduction to the Study of Insects, by Borror, et al. Used with the permission of the publisher.

4) Spines are outgrowths of the cuticula that are not separated from it by a joint.

Spines are produced by undifferentiated hypodermal cells and are usually if not always of multicellular origin.

5) Setae are commonly called the hairs of insects. A seta is an appendage of the body wall and is the product of a single hypodermal cell. Setae are hollow.

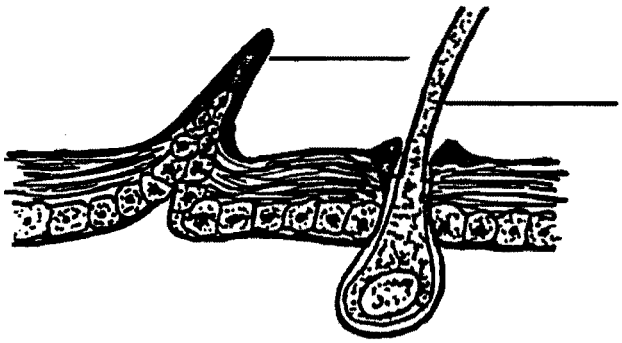

Fig. 21. A section of body wall.

From An Introduction to Entomology, by Comstock. Used with the permission of the publisher.

It is recommended that the student reviews Harris,1950, Reference 13.

2.4. Terminology of Orientation

I. Body Regions

A. Head

1. Bears the eyes, antennae, and mouth parts.

B. Thorax

1. First segment of thorax, next to the head, is the prothorax and bears the first pair of legs.
2. The next segment is the mesothorax and bears the second pair of legs and the first pair of wings in adults.
3. The third segment is the metathorax and bears the third pair of legs and the second pair of wings in adults with two pairs of wings.

C. Abdomen

1. It does not bear appendages of locomotion.
2. It bears appendages such as cerci, genitalia, or ovipositor.
3. It is eleven segmented, but these may be reduced in number.

II. Aspects of Body or Surfaces

A. Dorsum: The back of an insect, the upper side. Dorsal surface.

B. Venter: The underside of the body opposite the dorsum. Ventral surface.

C. Latus: The surfaces connecting the dorsum and venter on each side. Lateral surface or pleura. The left surface is the sinistral surface, and the right surface is the dextral surface.

D. Cephalon: The head end of the body. Cephalic end.

E. Cauda: Tail end of the body or hind portion of any region away from the cephalon. Caudal end.

F. Meson: This term is applied to the imaginary plane by which bilaterally symmetrical animals are divided into two similar right and left halves. Mesal line.

III. Cardinal Directions

A. Cephalad: Toward the head.

B. Caudad: Toward the tail end.

C. Laterad: To the right or left away from the meson, or sinistrad to the left and dextrad to the right.

D. Mesad: Toward the meson.

E. Dorsad: Toward the dorsum.

F. Ventrad: Toward the venter.

G. Oblique directions: Compound terms such as meso-caudad or dextro-cephalad.

H. Proximal & Distal: These terms are applied only to the appendages of the body.

Proximal indicates nearness to the end of the portion that is attached to the body.

Distal indicates nearness to the free or unattached end of an appendage.

The term apical is frequently used to denote the terminating segment or point of an appendage. It can be used interchangeably with distal.

There are six principal directions to which the position and direction of the parts of a bilaterally symmetrical animal like an insect, are commonly referred. These are as follows:

The cephalic direction or headward. This is the direction indicated by a line drawn from the center of the animal to the head.

The caudal direction or tailward. This is the opposite of the cephalic direction.

Two lateral directions or toward the right and toward the left.

The ventral direction or bellyward. This is the direction indicated by a line drawn from the center of the body to the ventral surface and forming a right angle with each of the preceding directions.

The dorsal direction or backward. This is the opposite of the ventral direction.

The adverbial forms of the adjectives cephalic, caudal, lateral, ventral, and dorsal are cephalad, caudad, laterad, ventrad, and dorsad. Thus, a part which extends in a cephalic direction may be said to extend cephalad.

Understand that cephalad does not necessarily mean toward the head, but headward; that is, toward a point which is in a direction indicated by a line drawn from the center of the animal to the head, but at an infinite distance in that direction. In other words: Draw a line from the distal end of an extended wing of an insect to the head. Even though this line would extend directly towards the head, this would not be cephalad, but more nearly mesad. A line extending cephalad from any part of the body is parallel to the cephalo-caudal axis of the body.

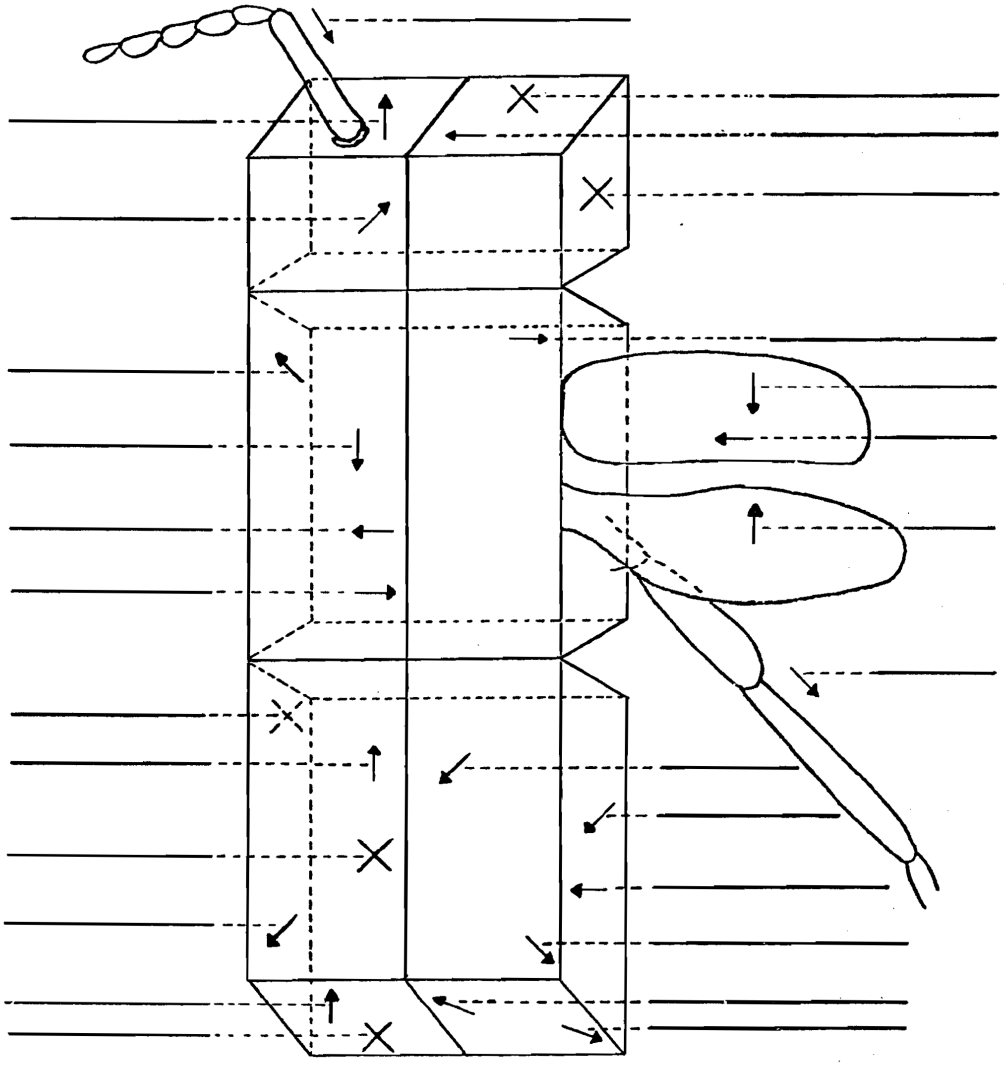

Fig. 22. Schematic drawing of an insect illustrating the terminology of body aspects and directions.

2.5. Identifications of Head Components

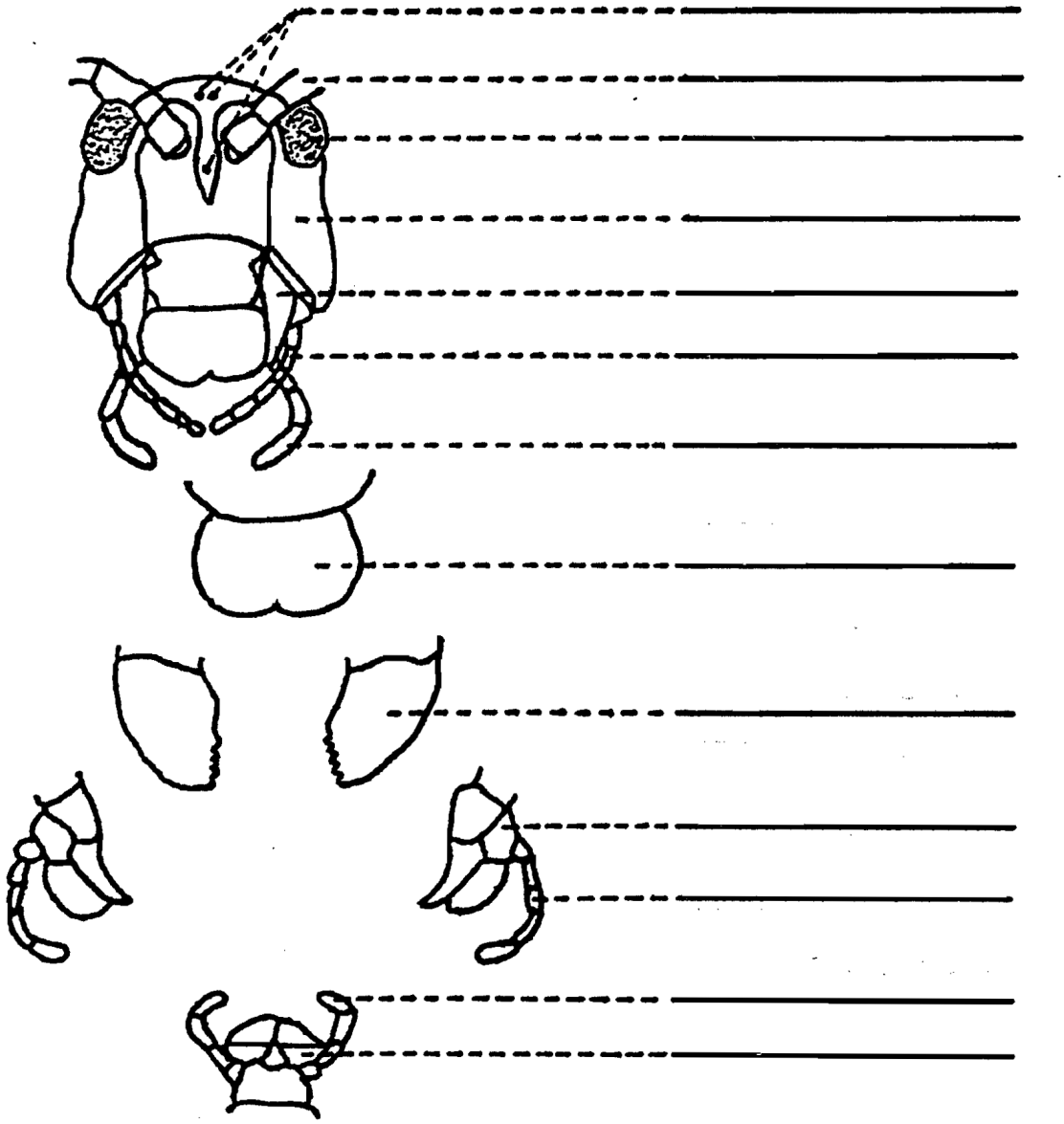

Fig. 23. Front of an adult insect head and appendages.

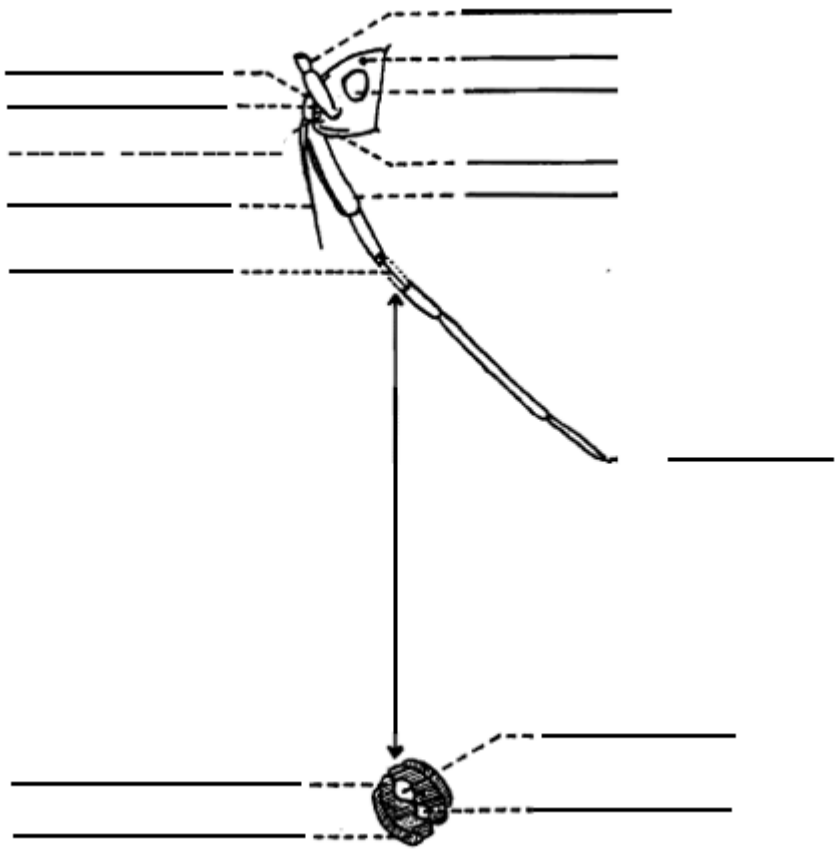

Fig. 24. Mouth parts of the large milkweed bug.

From An Introduction to the Study of Insects, by Borror, et al. Used with the permission of the publisher.

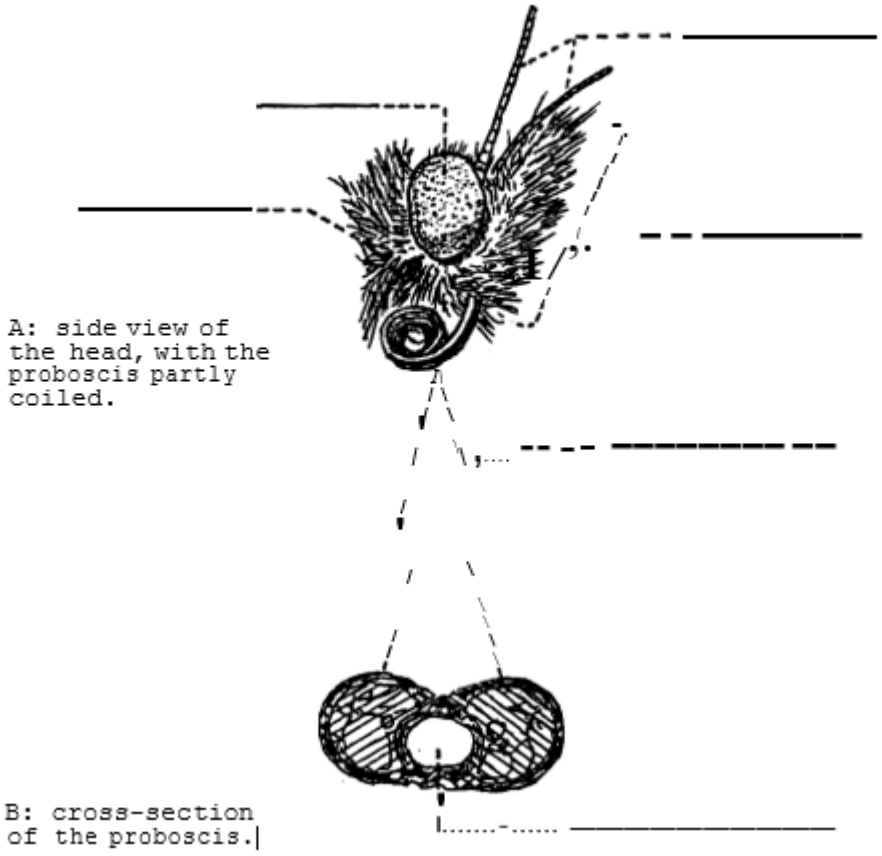

Fig. 25. Siphoning type of mouth parts as found in a moth or butterfly.

From Destructive and Useful Insects, by Metcalf and Flint, 4th Edition. 1962. Copyright (c) 1967 by Mrs. Cleo F. Metcalf. Used with the permission of McGraw-Hill Book Company.

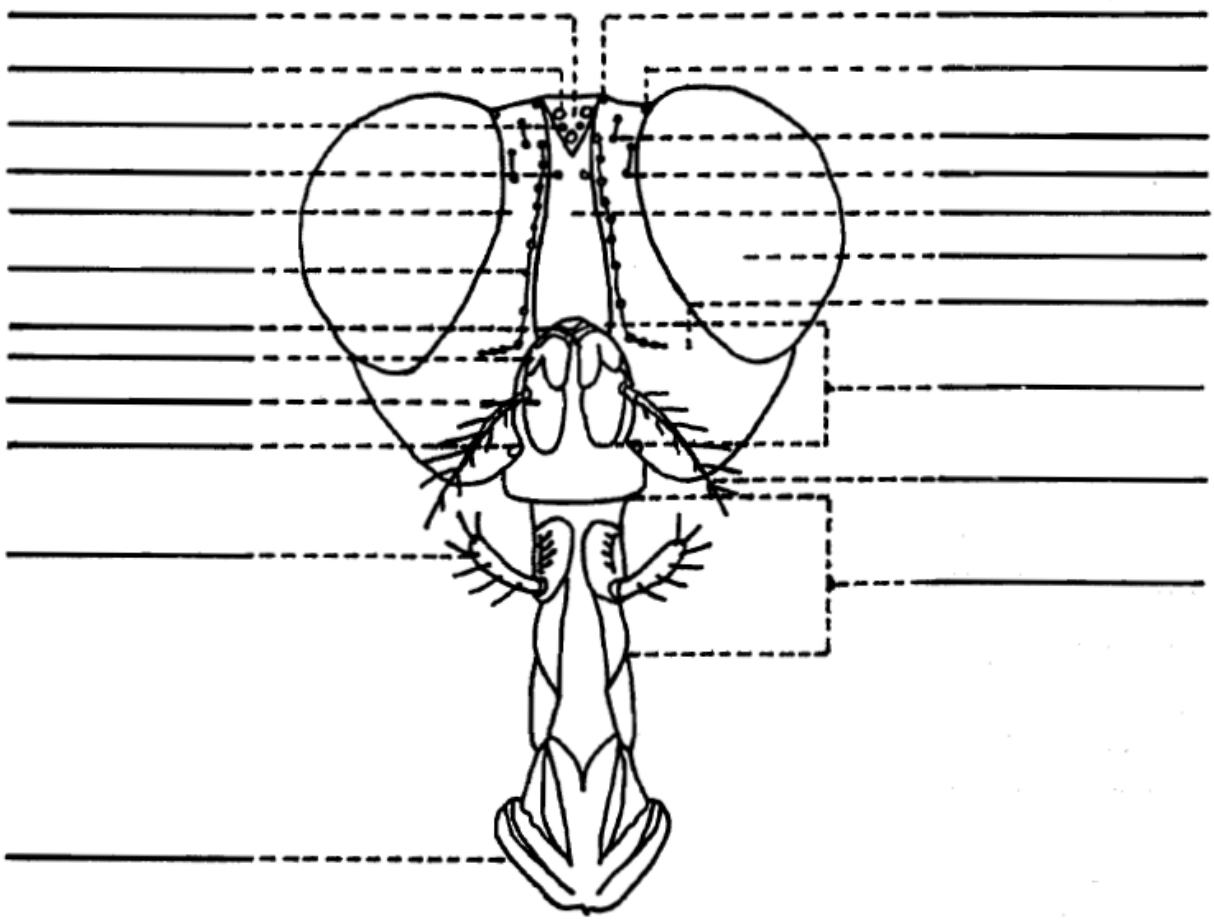

Fig. 26. Frontal view of muscoid fly head.

From and used with the permission of Journal of the Association of Official Agricultural Chemists. Ref. 2.

It is recommended that the student reviews Van Dame, Reed, Ikar,1958, Reference 30.

2.6. Leg Structure

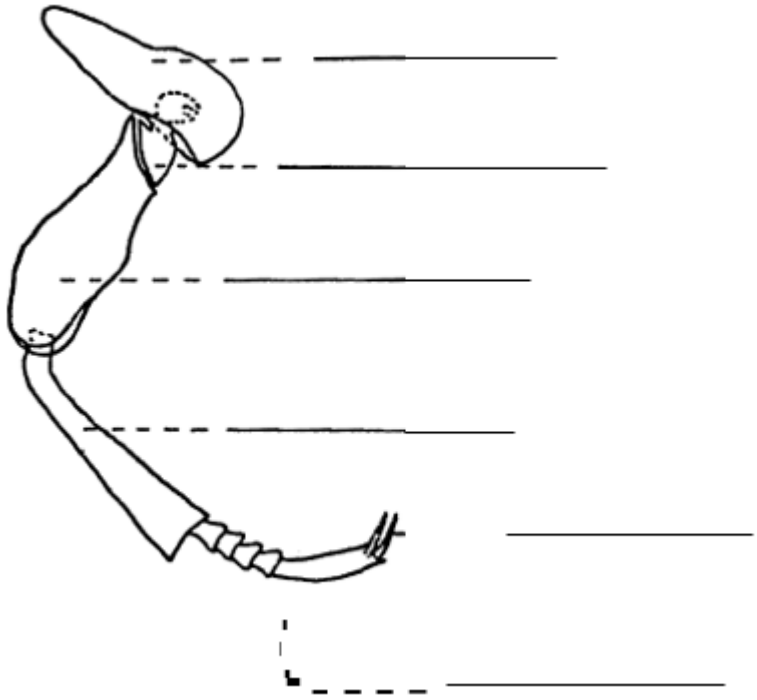

Fig. 27. General insect leg morphology.

From and used with the permission of the Journal of the Association of Official Agricultural Chemists. Ref. 27.

It is recommended that the student reviews Thrasher, Kurtz, 1957, Reference 27.

2.7. Antennae

General insect antennae morphology.

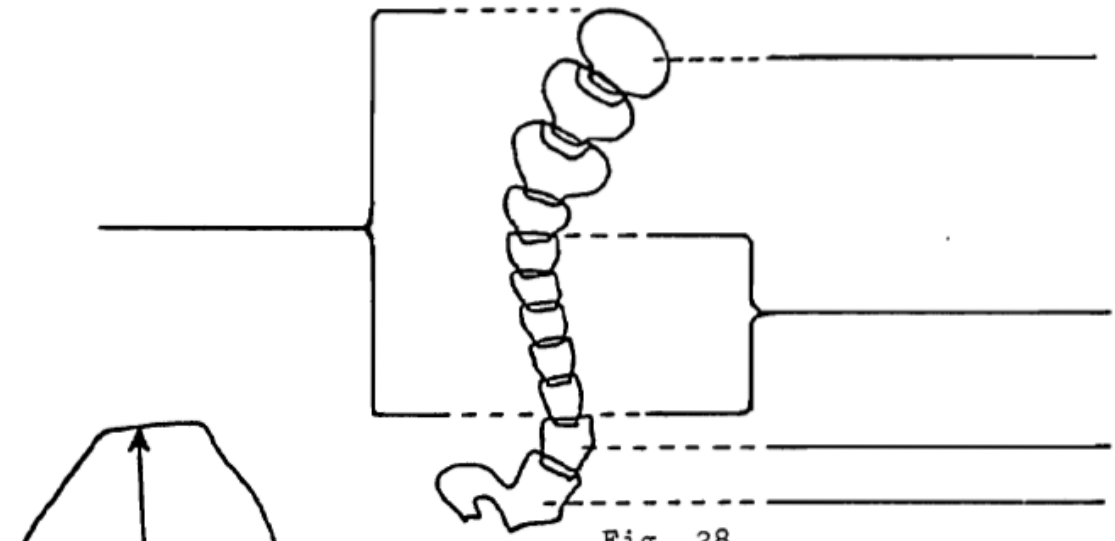

Fig. 28.

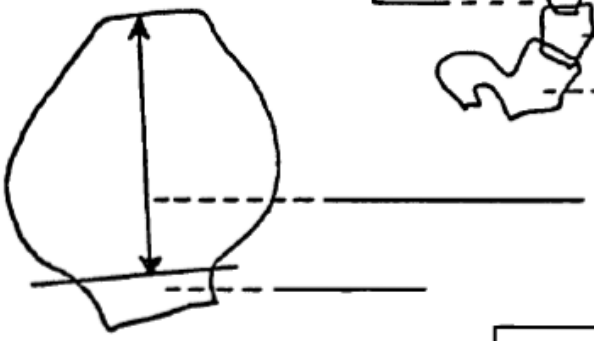

Fig. 29.

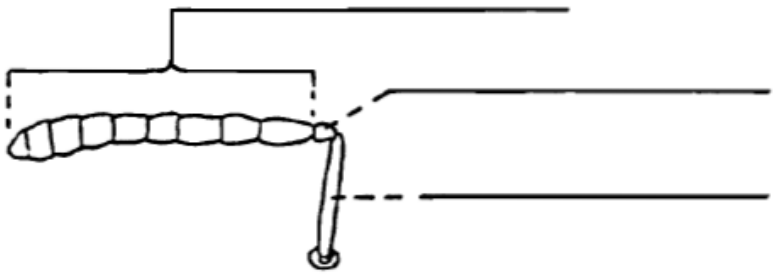

Fig. 30.

Fig. 31.

Fig. 32.

Figs. 28 and 29 from and with the permission of Journal of the Association of Official Agricultural Chemists. Ref. 17. Figs. 30, 31 and 32 from An Introduction to the Study of Insects, by Borror and DeLong.

Beetle adult antennae

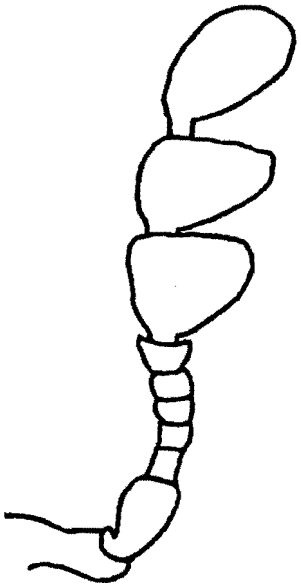

Fig. 33

1) _____

2) _____

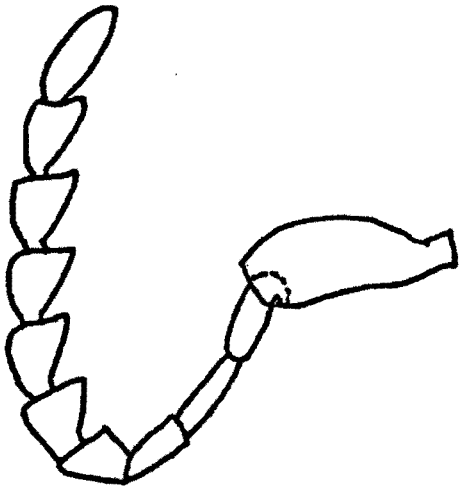

Fig. 34

1) _____

2) _____

Fig. 35

1) _____

2) _____

Fig. 36

1) _____

2) _____

Fig. 37

1) _____

2) _____

1) Identify the insect.

2) Identify the antennal form.

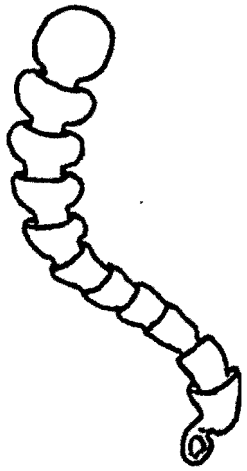

Fig. 38

1) _____

2) _____

Fig. 39

1) _____

2) _____

Fig. 40

1) _____

2) _____

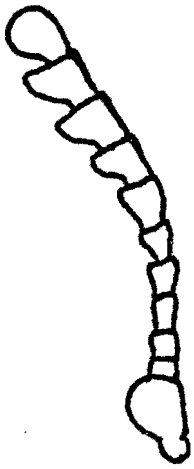

Fig. 41

1) _____

2) _____

From Micro-Analytical Entomology for Food Sanitation Control, by O.L. Kurtz and K.L. Harris, Association of Official Agricultural Chemists, Washington, D.C. Used with the permission of the publisher.

It is recommended that the student reviews Jackson, Ratay, Wozinicki, 1956, Reference 17.

2.8. Beetle Mandibles

General mandible morphology

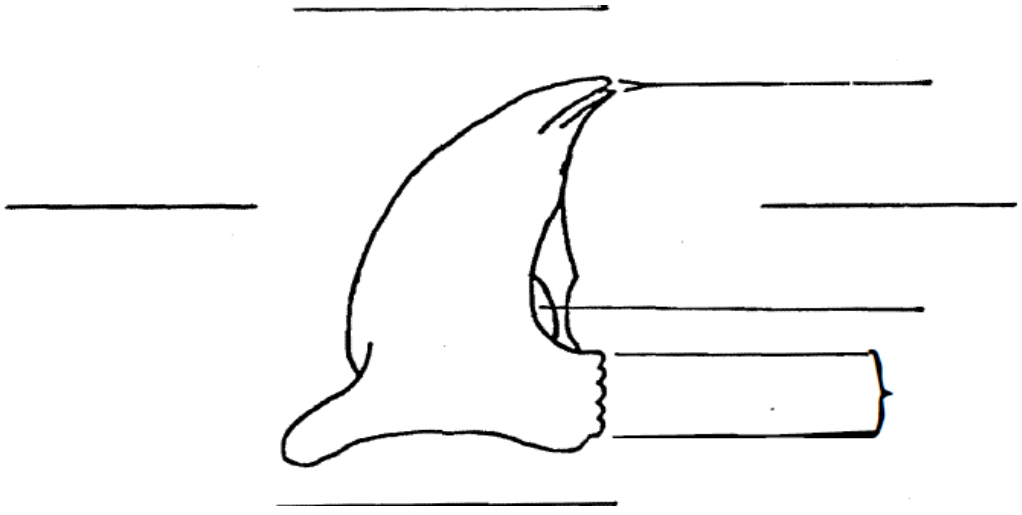

Fig. 42

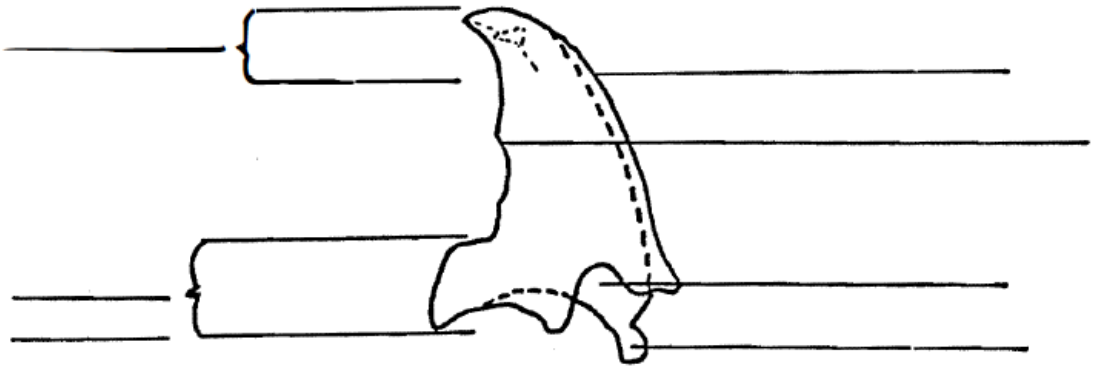

Fig. 43

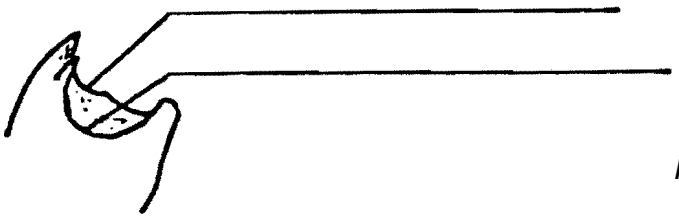

Fig. 44

Fig. 42 from Micro-Analytical Entomology for Food Sanitation Control. Used with the permission of AOAC, Ref. 23. Figs. 43 and 44 from and with the permission of Journal of the Association of Official Agricultural Chemists. Ref. 18.

It is recommended that the student reviews Jackson, Ratay, Woznicki,1958, Reference 18 and Kurtz, Carson, Van Dame, 1955, Reference 22.

2.9. Elytral Patterns

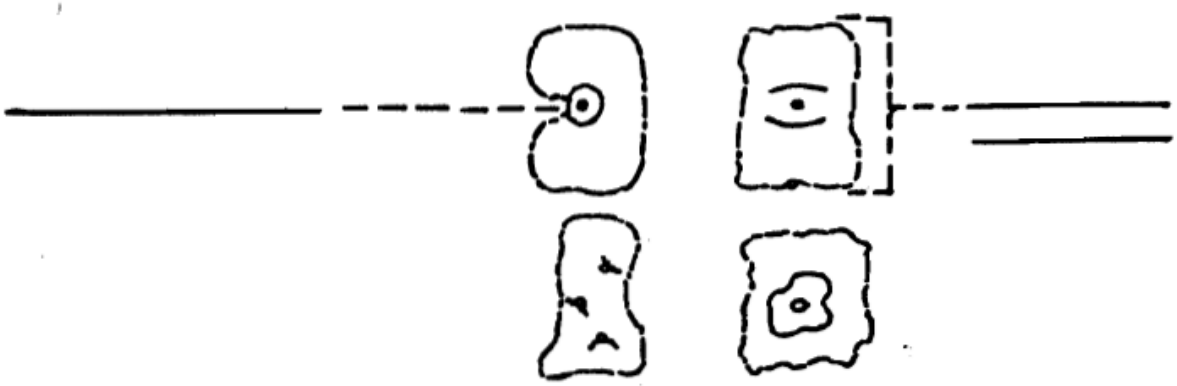

Fig. 45 Square to rectangular units

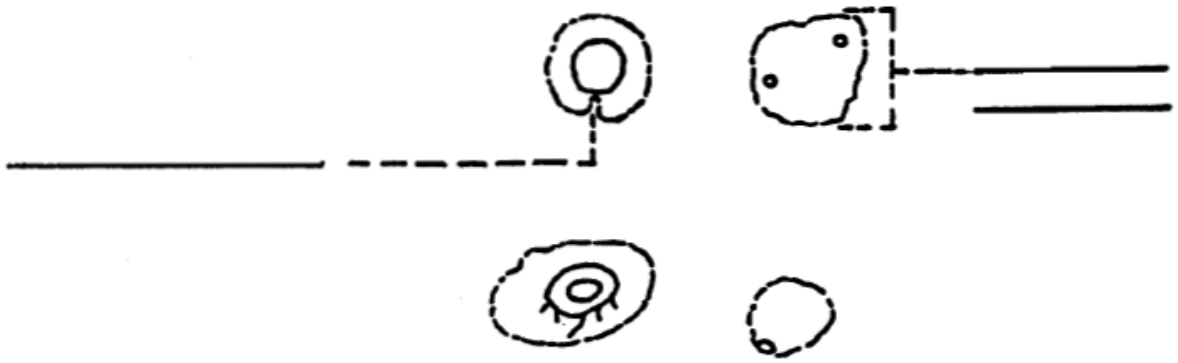

Fig. 46. Rounded units

Figs. 45 and 46 from and with the permission of Journal of the Association of Official Agricultural Chemists. Ref. 15.

It is recommended that the student reviews Heuermann, Kurtz,1955, Reference 15.

3. Beetle Adults

3.1. Dark and yellow mealworm, *Tenebrio* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the scape of an antenna. Make slide. Draw.
6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Dissect the mesonotum. Make slide. Draw.

10) Dissect the mesosternum. Make slide. Draw.

11) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23, 27.

3.2. Rice and granary weevil, *Sitophilus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
3) Dissect the apical segment of an antenna. Make slide. Draw.
4) Dissect the scape of an antenna. Make slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
7) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments. Draw the kinds of setae found on the femur.
8) Dissect the first and third tarsal segments Make a slide of each. Draw.
9) Remove the prothorax. Make slide. Draw.
10) Dissect the mesonotum. Make slide. Draw.
11) Dissect the mesosternum. Make slide. Draw.

Ref. 17, 18, 23, 27

3.2.1. Rice weevil, *Sitophilus oryzae* (Linnaeus)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Include in the drawing the kinds of setae found on the elytra. Compare the size and shape of the punctures with those of *Sitophilus granarius*.

   Note: The rice weevil has two reddish-gold spots on each elytron.

2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw.

   Note: The segments of the antenna are slimmer than those of *Sitophilus granarius.*

3) Make a slide of a fragment from the dorsal surface of the prothorax. Observe the punctations under high magnification. Draw. Compare the rounded punctations with those of *Sitophilus granarius*.

4) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 2.

3.2.2. Granary weevil, *Sitophilus granarius* (Linnaeus)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface, pattern. Include in the drawing the kinds of setae found on the elytra. Compare the size and shape of the punctures with those of *Sitophilus oryzae*.

   Note: The granary weevil has no membranous hind wings.

2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw.

   Note: The segments of the antenna are bulkier than those of *Sitophilus oryzae.*

3) Make a slide of a fragment from the dorsal surface of the prothorax. Observe the punctations under high magnification. Draw. Compare the elongate-oval punctations with those of *Sitophilus oryzae*.

4) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.3. Lesser grain borer, *Rhyzopertha dominica* (Fabricius)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.

3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

4) Dissect the apical and subapical segments of an antenna. Make a slide of each. Draw.
5) Dissect the scape of an antenna. Make slide. Draw.
6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
9) Dissect a fragment of the dorso-anterior edge of the prothorax. Make slide. Draw. Indicate the tubercles and the fine teeth.
10) Dissect a fragment of the dorsal surface of the prothorax. Make slide. Draw. Indicate the ridges of tubercles.
11) Dissect the mesonotum. Make slide. Draw.
12) Dissect the mesosternum. Make slide. Draw.
13) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23, 27.

3.4. Flour beetle, *Tribolium* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
3) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Illustrate the characteristics which adequately describe *Tribolium* spp. adult mandibles.
4) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
5) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

6) Remove the prothorax. Make a slide. Draw.

7) Dissect the mesonotum Make slide. Draw.

8) Dissect the mesosternum. Make slide. Draw.

Ref. 17, 18, 23, 27.

3.4.1. Confused flour beetle, *Tribolium confusum* Jacquelin deVal

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with *Tribolium castaneum.*

2) Dissect the apical segment from one antenna and the apical end (6 segments) of another antenna. Make a slide of each. Draw. Compare with other species of *Tribolium*.

3) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

   Note: The gena projects prominently outward in front of the eyes.

4) Make a slide of a head capsule (without antennae or mandibles) with the ventral surface up. Draw.

   Note: Compare the distance between the two ventral lobes of the eyes with the transverse diameter of each ventral lobe of the eye.

5) Dissect the lateral surface of the head. (This fragment includes the surface well above the eye, the eye, and the surface below the eye.) Make slide. Draw.

   Note: There is a carina above the eye.

6) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 23.

3.4.2. Red flour beetle, *Tribolium castaneum* (Herbst)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with *Tribolium confusum*.

2) Dissect the apical segment from one antenna and the apical end (6 segments) of another antenna. Make a slide of each. Draw. Compare with other species of *Tribolium*.

3) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

   Note: The gena does not project prominently outward in front of the eyes.

4) Make a slide of a head capsule (without antennae or mandibles) with the ventral surface up. Draw.

   Note: Compare the distance between the two ventral lobes of the eyes with the transverse diameter of each ventral lobe of the eye.

5) Dissect the lateral surface of the head. (This fragment includes the surface well above the eye, the eye, and the surface below the eye.) Make slide. Draw.

   Note: There is no carina above the eye. It is not as implied under *Tribolium madens*, Ref. 23, page 181, paragraph 1.

6) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 23.

3.4.3. Flour beetle, *Tribolium destructor* Uyttenboogaart

This beetle has no common name.

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with other species of *Tribolium*.

2) Dissect the apical segment from one antenna and the apical end (6 segments) of another antenna. Make a slide of each. Draw. Compare with other species of *Tribolium*.

3) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

   Note: The gena projects slightly in front of the eyes.

4) Make a slide of a head capsule (without antennae or mandibles) with the ventral surface up. Draw.

   Note: Compare the distance between the two ventral lobes of the eyes with the transverse diameter of each ventral lobe of the eye.

5) Dissect the lateral surface of the head. (This fragment includes the surface well above the eye, the eye, and the surface below the eye.) Make slide. Draw.

Note: The eyes are narrowly margined above.

6) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 23.

3.4.4. Black flour beetle, *Tribolium audax* Halstead

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with other species of *Tribolium*.
2) Dissect the apical segment from one antenna and the apical end (6 segments) of another antenna. Make a slide of each. Draw. Compare with other species of *Tribolium*.
3) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

   Note: The gena scarcely projects in front of the eyes.
4) Make a slide of a head capsule (without antennae or mandibles) with the ventral surface up. Draw.

   Note: Compare the distance between the two ventral lobes of the eyes with the transverse diameter of each ventral lobe of the eye.
5) Dissect the lateral surface of the head. (This fragment includes the surface well above the eye, the eye, and the surface below the eye.) Make slide. Draw.

   Note: There is no carina above the eye.
6) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

See Tribolium madens in Ref. 23.

3.5. Broadhorned and slender-horned flour beetle, *Gnatocerus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
3) Dissect a mandible from a male and a female-beetle. Make a slide of each. Draw. Describe the differences between a male and a female

beetle mandible. Compare this female beetle mandible with the female beetle mandibles of species of *Tribolium*.

4) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

5) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

6) Dissect the mesonotum. Make slide. Draw.

7) Dissect the mesosternum. Make slide. Draw.

Ref. 17, 23, 27.

3.5.1. Broadhorned flour beetle, *Gnatocerus cornutus* (Fabricius)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with *Gnatocerus maxillosus.*

2) Dissect the apical segment from one antenna and the apical end (7 segments) from another antenna. Make a slide of each. Draw. Compare with *Gnatocerus maxillosus*.

3) Dissect the right and left mandibles from the head of a male beetle. Make a slide of each. Draw. Compare with *Gnatocerus maxillosus*.

4) Dissect the right and left mandibles from the head of a female beetle. Make a slide of each. Draw. Indicate any differences between the mandibles. Compare with *Gnatocerus maxillosus*.

5) Make a slide of a male head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

6) Make a slide of a female head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

7) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 18, 23.

3.5.2. Slender-horned flour beetle, *Gnatocerus maxillosus* (Fabricius)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern. Compare with *Gnatocerus cornutus*.
2) Dissect the apical segment from one antenna and the apical end (7 segments) from another antenna. Make a slide of each. Draw. Compare with *Gnatocerus cornutus*.
3) Dissect the right and left mandibles from the head of a male beetle. Make a slide of each. Draw. Compare with *Gnatocerus cornutus*.
4) Dissect the right and left mandibles from the head of a female beetle. Make a slide of each. Draw. Indicate any differences between the mandibles. Compare with *Gnatocerus cornutus*.
5) Make a slide of a male head capsule (without antennae or mandibles) with the dorsal surface up. Draw.
6) Make a slide of a female head capsule (without antennae or mandibles) with the dorsal surface up. Draw.
7) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.6. Smalleyed and depressed flour beetle, *Palorus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make a slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Compare with species of *Gnatocerus* and *Tribolium*.
6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
7) Dissect the coxa, trochanter. femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any

differences between the prothoracic. Mesothoracic, and metathoracic leg segments.

8) Remove the prothorax. Make slide. Draw.

9) Dissect the mesonotum. Make slide. Draw.

10) Dissect the mesosternum. Make slide. Draw.

11) Remove the abdomen from the beetle. Make a slide with the ventral surface of the abdomen up. Draw. Observe the laterally rounded prominent processes on the two sternites shortest in width.

Ref. 23.

3.6.1. Smalleyed flour beetle, *Palorus ratzeburgi* (Wissmann)

1) Make a slide of a head capsule (without antennae or mandibles). Draw.

   Note: The eyes are small and round. The front portion of the eye is not concealed.

2) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.6.2. Depressed flour beetle, *Palorus subdepressus* (Wollaston)

1) Make a slide of a head capsule (without antennae or mandibles). Draw.

   Note: The eyes are large, and the vertical diameter is slightly, but distinctly, larger than horizontal. The front portion of the eye is concealed.

2) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

See Palorus ratzeburgi in Ref. 23.

3.7. Longheaded flour beetle, *Latheticus oryzae* Waterhouse

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.

3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antenna and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.
7) Remove the prothoracic, mesothoracic. and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter. Femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
9) Dissect the mesonotum. Make slide. Draw.
10) Dissect the mesosternum. Make slide. Draw.
11) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.8. Cadelle, *Tenebroides mauritanicus* (Linnaeus)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make slide. Draw. Indicate the type of antennae and the number of segments. Note the shape of the apical segment.
4) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences 'between the mandibles.
5) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of each intact leg. Draw.
6) Dissect the mesonotum. Make slide. Draw.
7) Dissect the mesosternum. Make slide. Draw.
8) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23.

3.9. Sawtoothed and merchant grain beetle, *Oryzaephilus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the scape of an antenna. Make slide. Draw.
6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Observe the dark circular spot present between the ventral articulation and the mola at the base of the mandible.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

    NOTE:

    1. The metathoracic femur of the male has a spur on the inside margin. Make a slide of a male and a female metathoracic femur. Draw.
    2. The metathoracic trochanter of the male has a finger-like projection. Make a slide of a male and a female metathoracic trochanter. Draw.

9) Remove the prothorax. Make slide. Draw.
10) Dissect the mesonotum. Make slide. Draw.
11) Dissect the mesosternum. Make slide. Draw.

Ref. 15, 17, 18, 23, 27.

3.9.1. Sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus)

1) Remove the head from the beetle. Make slide. Draw. Measure the length of the eye and the length of the temple. Compare with *Oryzaephilus mercator*.
2) Dissect the eighth and ninth abdominal sternites from a male beetle. Clear the abdominal sternites in lactophenol solution (1+1). Make slide. Draw. Indicate the number, size, and location of the setae on the eighth sternite. Compare with *Oryzaephilus mercator*.
3) Dissect the genitalia from a female beetle. Clear the genitalia in lactophenol solution (1+1). Make slide. Draw. Compare with *Oryzaephilus mercator*.

Ref. 25, 26.

It is recommended that the student reviews Slow,1958, Reference 26 and Olsen, 1977, Reference 25.

3.9.2. Merchant grain beetle, *Oryzaephilus mercator* (Fauvel)

1) Remove the head from the beetle. Make slide. Draw. Measure the length of the eye and the length of the temple. Compare with *Oryzaephilus surinamensis*.
2) Dissect the eighth and ninth abdominal sternites from a male beetle. Clear the abdominal sternites in lactophenol solution (1+1). Make slide. Draw. Indicate the number, size, and location of the setae on the eighth sternite. Compare with *Oryzaephilus surinamensis*.
3) Dissect the genitalia from a female beetle. Clear the genitalia in lactophenol solution (1+1). Make slide. Draw. Compare with *Oryzaephilus surinamensis*.

Ref. 25, 26.

3.10. Square-necked grain beetle, *Cathartus guadricollis* (Guérin-Méneville)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface patter.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the scape of an antenna. Make slide. Draw.
6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
9) Remove the prothorax. Make slide. Draw.
10) Dissect the mesonotum. Make slide. Draw.
11) Dissect the mesosternum. Make slide. Draw.
12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23, 27.

3.11. Foreign grain beetle, *Ahasverus advena* (Waltl)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the scape of an antenna. Make slide. Draw.
6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Remove the prothorax. Make slide. Draw.

10) Dissect the mesonotum. Make slide. Draw.

11) Dissect the mesosternum. Make slide. Draw.

12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

See Cathartus advena in Ref. 23.

Ref. 15, 17, 18, 23, 27.

3.12. Grain beetle, *Ahasverus rectus* LeConte

This beetle has no common name.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.

3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

4) Dissect the apical segment of an antenna. Make slide. Draw.

5) Dissect the scape of an antenna. Make slide. Draw.

6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.

7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Remove the prothorax. Make slide. Draw.

10) Dissect the mesonotum. Make slide. Draw.

11) Dissect the mesosternum. Make slide. Draw.

12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Compare with *Ahasverus advena*, Ref. 23.

There is no known reference for *Ahasverus rectus*.

3.13. Flat grain beetle, *Cryptolestes pusillus* (Schönherr)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from a male and a female beetle. Make a slide of one antenna from each. Draw. Indicate the type of antennae and the number of segments of each.
4) Dissect the apical and the subapical segments of a male and a female antenna. Make a slide of each. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
7) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
8) Remove the prothorax. Make slide. Draw.
9) Dissect the mesonotum. Make slide. Draw.
10) Dissect the mesosternum. Make slide. Draw.
11) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution {1+1). Make a slide of each. Draw.

Some publications use Genus Laemophloeus. Ref. 15, 17, 18, 23, 27.

3.14. Cigarette beetle, *Lasioderma serricorne* (Fabricius)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical and 2 or 3 subapical segments of an antenna. Make a slide of each. Draw.

5) Dissect the scape of an antenna. Make slide. Draw.

6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Compare with *Stegobium paniceum*.

7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Remove the prothorax. Make slide. Draw.

10) Dissect the mesonotum. Make slide. Draw.

11) Dissect the mesosternum. Make slide. Draw.

12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23, 27.

3.15. Drugstore beetle, *Stegobium paniceum* (Linnaeus)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.

3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

4) Dissect the apical and the 2 subapical segments of an antenna. Make a slide of each. Draw.

5) Dissect the scape of an antenna. Make slide. Draw.

6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Compare with *Lasioderma serricorne*.

7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any

differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Remove the prothorax. Make slide. Draw.

10) Dissect the mesonotum. Make slide. Draw.

11) Dissect the mesosternum. Make slide. Draw.

12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 17, 18, 23, 27.

3.16. Dermestid, Family *Dermestidae*

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

3) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles. Observe the setae which arise along the lateral margin of the mandible, which is typical of many dermestid mandibles.

4) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

5) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

   NOTE: Observe the deeply grooved longitudinal margin of the femur.

6) Remove the prothorax. Make slide. Draw.

7) Dissect the mesonotum. Make slide. Draw.

8) Dissect the mesosternum. Make slide. Draw.

9) Draw the kinds of setae found on this beetle.

   NOTE: Some species of *Dermestidae* have scales on the body. Scales are specialized setae.

See black carpet and buffalo carpet beetles in Ref. 23. Ref. 17, 18, 23, 27.

3.16.1. Black carpet beetle, *Attagenus megatoma* (Fabricius)

1) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
2) Remove the antennae from a male and a female beetle head. Make a slide of one antenna from each. Draw. Describe any differences between the male and female antennae.
3) Draw the kinds of setae found on this beetle.
4) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

See Attagenus piceus in Ref. 23. Ref. 15, 23.

3.16.2. Carpet beetle, *Anthrenus scrophulariae* (Linnaeus)

1) Remove the elytra from the beetle. Make a slide of an elytron. Draw. Include the elytral color pattern in the drawing.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from a male and a female beetle head. Make a slide of one antenna from each. Draw. Describe any differences between the male and female antennae.
4) Draw the kinds of setae found on this beetle.

   NOTE: Scales are specialized setae.
5) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Common name is Buffalo carpet beetle in Ref. 23. Ref. 15, 23.

3.16.3. Larger cabinet beetle, *Trogoderma inclusum* LeConte

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw. Include the elytral color pattern in the drawing.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from a male and a female beetle head. Make a slide of one antenna from each. Draw. Describe any differences between the male and female antennae.
4) Draw the kinds of setae found on this beetle.

5) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 15, 23.

3.17. Driedfruit and corn sap beetle, *Carpophilus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the scape of an antenna. Make slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
7) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
8) Remove the prothorax. Make slide. Draw.
9) Dissect the mesonotum. Make slide. Draw.
10) Dissect the mesosternum. Make slide. Draw.

See dried fruit beetle in Ref. 15, 17, 18, 23, 27.

3.17.1. Dried fruit beetle, *Carpophilus hemipterus* (Linnaeus)

1) Remove the antennae from the beetle head. Make a slide of one antenna. Draw.

   NOTE: The second antennal segment is approximately the same length as the third. (Antennal segments are numbered as illustrated in Fig. 28.) Compare with *Carpophilus dimidiatus*.

2) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.17.2. Corn sap beetle, *Carpophilus dimidiatus* (Fabricius)

1) Remove the antennae from the beetle head. Make a slide of one antenna. Draw.

   NOTE: The second antennal segment is much shorter than the third. (Antennal segments are numbered as illustrated in Fig. 28.) Compare with *Carpophilus hemipterus*.

2) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.18. Spider beetle, *Ptinus* spp.

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
7) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
8) Remove the prothorax. Make slide. Draw.
9) Dissect the mesonotum. Make slide. Draw.
10) Dissect the mesosternum. Make slide. Draw.
11) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.19. Hairy fungus beetle, *Typhaea stercorea* (Linnaeus)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.
4) Dissect the apical segment of an antenna. Make slide. Draw.
5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.
6) Make a slide of a head capsule (without antennae or mandibles) with the dorsal surface up. Draw.

   NOTE: The head is sharply indented behind the eye preventing a fully rounded eye.
7) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.
8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.
9) Remove the prothorax. Make slide. Draw.
10) Dissect the mesonotum. Make slide. Draw.
11) Dissect the mesosternum. Make slide. Draw.
12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.20. Coffee bean weevil, *Araecerus fasciculatus* (De Geer)

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.
2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.
3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments. Compare these antennae with the antennae from *Stegobium paniceum.*

4) Dissect the apical and the 2 subapical segments of an antenna. Make a slide of each. Draw.

5) Dissect the scape and the second antennal segment of an antenna. Make slide. Draw.

6) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.

7) Remove the prothoracic, mesothoracic,and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

8) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

9) Remove the prothorax. Make slide. Draw.

10) Dissect the mesonotum. Make slide. Draw.

11) Dissect the mesosternum. Make slide. Draw.

12) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

3.21. Lesser mealworm, *Alphitobius diaperinus* Panzer

1) Remove the elytra from the beetle. Make a slide of one elytron. Draw.

2) Make a slide of an elytral fragment. Observe the surface pattern under high magnification. Draw the surface pattern.

3) Remove the antennae from the beetle head. Make a slide of one antenna. Draw. Indicate the type of antennae and the number of segments.

4) Dissect the apical and the toothed subapical segments of an antenna. Make a slide of each. Draw.

5) Dissect the right and left mandibles. Make a slide of each. Draw. Indicate any differences between the mandibles.

6) Remove the prothoracic, mesothoracic, and metathoracic legs from the beetle. Make a slide of one intact leg. Draw.

7) Dissect the coxa, trochanter, femur, tibia, and tarsus from each of the three legs. Make a slide of each leg segment. Draw. Indicate any differences between the prothoracic, mesothoracic, and metathoracic leg segments.

8) Remove the prothorax. Make slide. Draw.

9) Dissect the mesonotum. Make slide. Draw.

10) Dissect the mesosternum. Make slide. Draw.

11) Dissect the genitalia from a male and a female beetle. Clear the genitalia in lactophenol solution (1+1). Make a slide of each. Draw.

Ref. 23.

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4. Beetle Larvae

4.1. Morphology of Beetle larval head

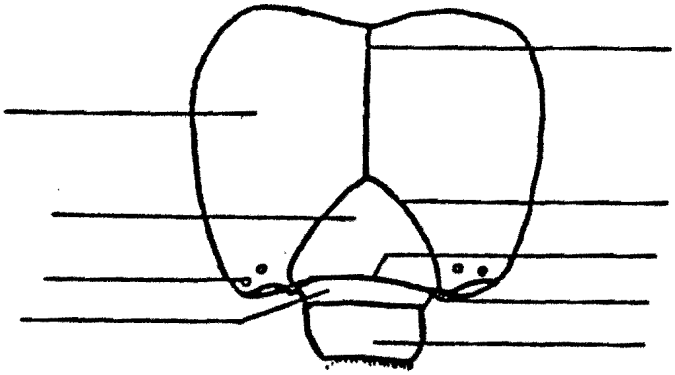

Fig. 47. Beetle larval head, anterior (dorsal) view.

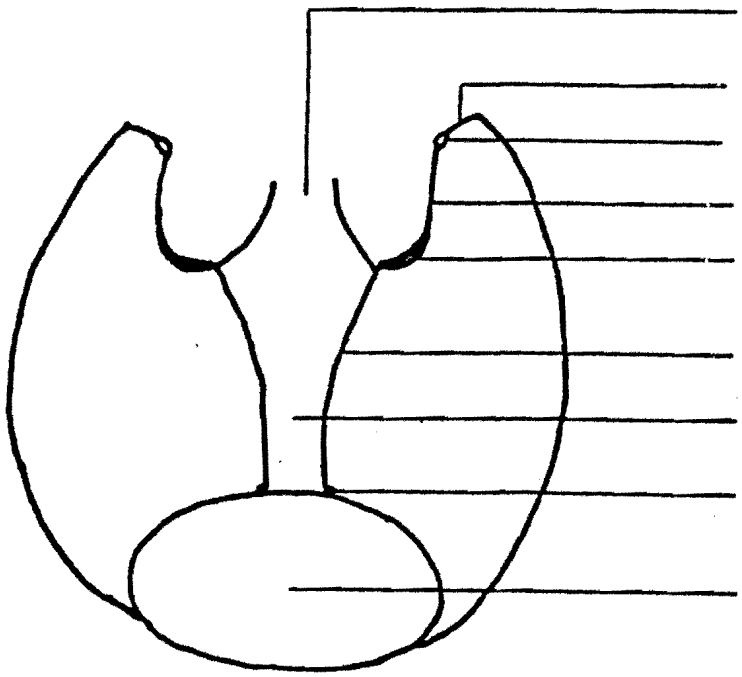

Fig. 48. Beetle larval head, ventral (posterior) view.

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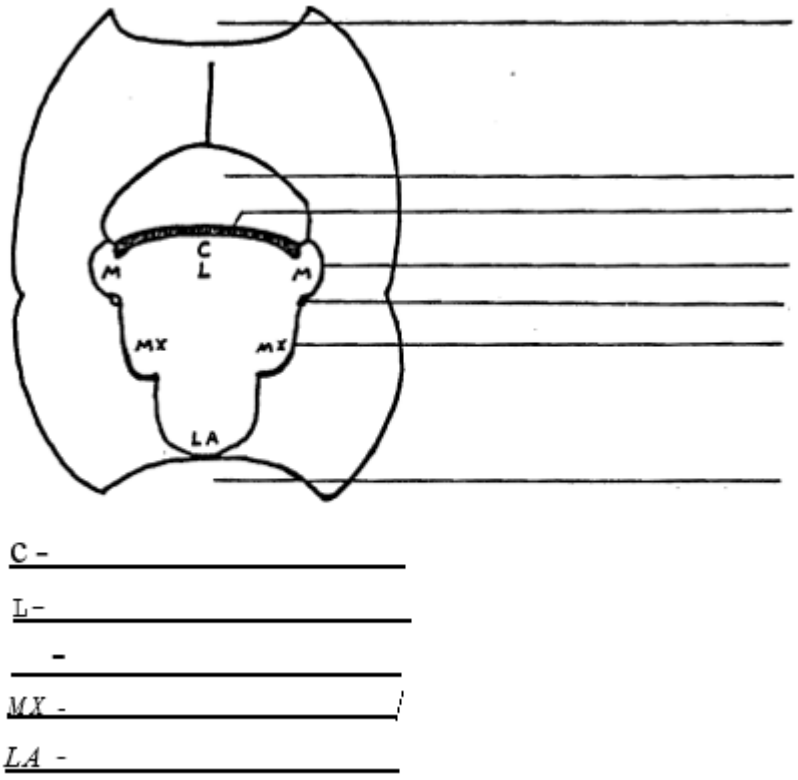

Fig. 49. Beetle larval head, anterior (dorsal) posterior (ventral) view.

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4.2. Dark and yellow mealworm larvae, *Tenebrio spp.*

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Epicranial and epistomal sutures are present. See Key, Ref. 11. page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate the dorsal and ventral articulations. Indicate any differences between the mandibles.

3) Dissect the dorsal surface from the head of a second larva. Make slide. Draw. Indicate the frontal sutures, the epistomal suture, the clypeus, the labrum, and the antenna. Compare with species of *Tribolium*.

4) Dissect the maxilla from the ventral surface of the head. Make slide. Draw.

5) Dissect the labium from the ventral surface of the head. Make slide. Draw. Indicate the labial palps.
6) Dissect the labial sclerome from the larval head. Make slide. Draw.
7) Dissect a gena fragment. Make slide. Draw. Compare with species of *Tribolium*.
8) Dissect the anal cerci from the larva. Make slide. Draw. Describe the shape. Compare with species of *Tribolium*.

Ref. 11, 18, 23.

4.3. Rice and granary weevil larvae, *Sitophilus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Head is free of long hairs. Epicranial sutures are present. See Key, Ref. 11, page 142.
2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the frons from a larval head. Make slide. Draw. Describe the shape of the epistomal suture. Compare with species of *Tribolium*.
4) Dissect the frons from the head of another larva. Break the epistomal suture in half. Make a slide of one half. Draw.
5) Dissect the labrum. Make slide. Draw. Indicate the pair of labral rods.
6) Dissect a gena fragment. Make slide. Draw. Compare with species of *Tribolium*.

Ref. 11, 18, 21, 23.

4.4. Lesser grain borer larva, *Rhyzopertha dominica* (Fabricius)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule.

   NOTE: The epicranial sutures (frontal and coronal) are absent. See Key, Ref. 11, page 142.
2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the molar lobe from another mandible. Make a slide of the molar lobe. Draw. Make a slide of the mandible without the molar lobe. Draw.

4) Dissect the composite structure from the anterior cranial margin of the head. See Ref. 21, page 997. Fig. 5. This fragment includes the epistoma, the pleurostomal margin, the ventral mandibular articulation, and the hypostomal margin. Make slide. Draw. Label the structures mentioned. Indicate the dorsal mandibular articulation and the antennal base.
5) Dissect the frons from the head of another larva. Break the epistomal suture in half. Make a slide of one half. Draw.
6) Dissect the ventral mandibular articulation from the composite structure. Make slide. Draw.
7) Dissect the epipharyngeal (labral) sclerome. Make slide. Draw.

Ref. 11, 18, 21, 23.

4.5. Flour beetle larvae, *Tribolium* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule, with the dorsal surface up. Draw.

   NOTE: Epicranial and epistomal sutures are present. Frontal sutures do not reach posterior margin. See Key, Ref. 11, page 142.
2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the frons. Make slide. Draw. Describe the shape of the epistomal suture.
4) Dissect a gena fragment. Make slide. Draw. Describe the shape.
5) Dissect the anal cerci. Make slide. Draw.

   NOTE: Concavity of anal cerci is more or less V shaped. See Key, Ref. 11, page 142.

See confused and rust-red flour beetles in Ref. 11, 18, 21, 23.

4.5.1. Confused flour beetle larva, *Tribolium confusum* Jacquelin du Val

1) Observe the dorsal surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the dorsal surface of one abdominal segment.

   OR

Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface at high magnification (100X or higher) with transmitted light. Draw the setal map of the dorsal surface of one abdominal segment.

2) Observe the ventral surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the ventral surface of one abdominal segment.

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the ventral surface up. Observe the ventral surface at high magnification (100X or higher) with transmitted light. Draw the setal map of the ventral surface of one abdominal segment.

3) Compare both the dorsal and ventral abdominal setal maps of *Tribolium confusum* with those of *Tribolium castaneum*, *Tribolium destructor*, and *Tribolium audax*.

Ref. 12, 16, 23.

4.5.2. Red flour beetle larva, *Tribolium castaneum* (Herbst)

1) Observe the dorsal surface of an intact mature larva at low magnification (l0X to 60X) with reflected light. Draw the setal map of the dorsal surface of one abdominal segment

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface at high magnification (l00X or higher) with transmitted light. Draw the setal map of the dorsal surface of one abdominal segment.

2) Observe the ventral surface of an intact mature larva at low magnification (l0X to 60X) with reflected light. Draw the setal map of the ventral surface of one abdominal segment.

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the ventral surface up. Observe the ventral surface at high magnification (100X or higher) with transmitted light. Draw the setal map of the ventral surface of one abdominal segment.

3) Compare both the dorsal and ventral abdominal setal maps of *Tribolium castaneum* with those of *Tribolium confusum*, *Tribolium destructor*, and *Tribolium audax*.

Ref. 12, 16.

4.5.3. Flour beetle larva, *Tribolium destructor* Uyttenboogaart

This beetle has no common name.

1) Observe the dorsal surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the dorsal surface of one abdominal segment.

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface at high magnification (l00X or higher) with transmitted light. Draw the setal map of the dorsal surface of one abdominal segment.

2) Observe the ventral surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the ventral surface of one abdominal segment.

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the ventral surface up. Observe the ventral surface at high magnification (l00X or higher) with transmitted light. Draw the setal map of the ventral surface of one abdominal segment.

3) Compare both the dorsal and ventral abdominal setal maps of *Tribolium destructor* with those of *Tribolium confusum*, *Tribolium castaneum*, and *Tribolium audax*.

Ref. 12, 16.

4.5.4. Black flour beetle larva, *Tribolium audax* Halstead

1) Observe the dorsal surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the dorsal surface of one abdominal segment.

   OR

Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface at high magnification (l00X or higher) with transmitted light. Draw the setal map of the dorsal surface of one abdominal segment.

2) Observe the ventral surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the ventral surface of one abdominal segment.

   OR

   Dissect the abdomen from a mature larva and remove the anal cerci. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the ventral surface up. Observe the ventral surface at high magnification (l00X or higher) with transmitted light. Draw the setal map of the ventral surface of one abdominal segment.

3) Compare both the dorsal and ventral abdominal setal maps of *Tribolium audax* with those of *Tribolium confusum*, *Tribolium castaneum*, and *Tribolium destructor*.

Ref. 12.

It is recommended that the student reviews Ho,1967, Reference 16 and Galacci, 1974, Reference 12.

4.6. Broadhorned and slender-horned flour beetle larvae, *Gnatocerus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The frontal sutures fork near the epistomal margin. See Key, Ref. 11, page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the labial sclerome from the larval head. Make slide. Draw.

4) Dissect a gena fragment. Make slide. Draw.

5) Dissect the anal cerci from the larva. Make slide. Draw.

See Broadhorned flour beetle in Ref. 11, 18, 21, 23.

4.7. Smalleyed and depressed flour beetle larvae, *Palorus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The frontal sutures do not fork. See Key, Ref. 11, page 142.

2) Make a slide of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the labial sclerome from a larval head. Make slide. Draw.

4) Dissect a gena fragment. Make slide. Draw.

5) Dissect the anal cerci from a larva. Make slide. Draw.

See Palorus ratzeburgi in Ref. 23. Ref. 11, 23.

4.8. Longheaded flour beetle larva, *Latheticus oryzae* Waterhouse

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The head capsule is lightly sclerotized. Very faint lines indicate the frontal sutures.

2) Make a slide of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect a gena fragment. Make slide. Draw.

4) Dissect the anal cerci from the larva. Make slide. Draw.

Ref. 23.

4.9. Cadelle larva, *Tenebroides mauritanicus* (Linnaeus)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The head is nearly black. The frontal sutures reach the posterior margin of the head. See Key, Ref. 11, page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the frons from the head of a larva. Make slide. Draw. Indicate the epistoma.

4) Dissect the maxilla-labial complex from the ventral surface of the larval head. Make slide. Draw.

5) Dissect a gena fragment. Make slide. Draw.

6) Dissect the dorsal surface of the thorax from the larva. Make slide. Draw. Indicate the pair of dark spots on the dorsal surface of each thoracic segment.

7) Dissect the anal cerci from the larva. Make slide. Draw.

   NOTE: The concavity of the anal cerci is U shaped. Prongs of the anal cerci are parallel. See Key, Ref. 11, page 142.

Ref. 11, 18, 21, 23.

4.10. Sawtoothed and merchant grain beetle larvae, *Oryzaephilus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Antennae are almost as long as the head. Epistomal suture is absent. Clypeus is broadly expanded. See Key, Ref. 11, page 142.

2) Dissect the frontal-clypeal-labral complex from the head of a second larva. Make slide. Draw. Indicate the dorsal mandibular articulations.

3) Dissect the hypopharyngeal sclerome. Make slide. Draw.

4) Dissect a gena fragment. Make slide. Draw. Indicate the hypostomal margin.

See Sawtoothed grain beetle in Ref. 11, 18, 21, 23.

4.10.1. Sawtoothed grain beetle larva, *Oryzaephilus surinamensis* (Linnaeus)

1) Dissect the right and left mandibles from the head. Make a slide of each. Draw.

2) Observe the dorsal surface of an intact mature larva at low magnification (l0X to 60X) with reflected light. Draw the setal map of the abdominal tergites, segments 2 through 7.

   OR

   Dissect the abdomen from a mature larva. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface of the abdomen at high magnification (100X or higher) with transmitted light. Draw the setal map of the abdominal tergites, segments 2 through 7.

3) Compare the mandibles and the abdominal setal maps of *Oryzaephilus surinamensis* with those of *Oryzaephilus mercator*, *Cathartus guadricollis*, and *Ahasverus advena*.

Ref. 6, 23, 28.

4.10.2. Merchant Grain beetle larva, *Oryzaephilus mercator* (Fauvel)

1) Dissect the right and left mandibles from the head. Make a slide of each. Draw.
2) Observe the dorsal surface of an intact mature larva at low magnification (l0X to 60X) with reflected light. Draw the setal map of the abdominal tergites, segments 2 through 7.

   OR

   Dissect the abdomen from a mature larva. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface of the abdomen at high magnification (l00X or higher) with transmitted light. Draw the setal map of the abdominal tergites, segments 2 through 7.
3) Compare the mandibles and the abdominal setal maps of *Oryzaephilus mercator* with those of *Oryzaephilus surinamensis*, *Cathartus guadricollis*, and *Ahasverus advena*.

Ref. 6, 28.

4.11. Square-necked grain beetle larva, *Cathartus quadricollis* (Guérin-Méneville)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.
2) Dissect the frontal-clypeal-labral complex from the head of a larva. Make slide. Draw. Indicate the dorsal mandibular articulations.
3) Dissect the hypopharyngeal sclerome. Make slide. Draw.
4) Dissect a gena fragment. Make slide. Draw. Indicate the hypostomal margin.

Compare with Sawtoothed grain beetle in Ref. 23. No references for #1 through #4 above.

5) Dissect the right and left mandibles from the head. Make a slide of each. Draw.

6) Observe the dorsal surface of an intact mature larva at low magnification (10X to 60X) with reflected light.

   NOTE: Spots are conspicuous on dorsa of abdominal segments. See Key, Ref.11, page 142.

   Draw the setal map of the abdominal tergites, segments 2 through 7.

   OR

   Dissect the abdomen from a mature larva. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface of the abdomen at high magnification (l00X or higher) with transmitted light. Draw the setal map of the abdominal tergites, segments 2 through 7.

7) Compare the mandibles and the abdominal setal maps of *Cathartus quadricollis* with those of *Oryzaephilus surinamensis*, *Oryzaephilus mercator*, and *Ahasverus advena*.

For #5 and #6 above only, Ref. 6, 11, 28.

4.12. Foreign grain beetle larva, *Ahasverus advena* (Waltl)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.
2) Dissect the frontal-clypeal-labral complex from the head of a larva. Make slide. Draw. Indicate the dorsal mandibular articulations.
3) Dissect the hypopharyngeal sclerome. Make slide. Draw.
4) Dissect a gena fragment. Make slide. Draw. Indicate the hypostomal margin.

Compare with Sawtoothed grain beetle in Ref. 23. No references for #1 through #4 above.

5) Dissect the right and left mandibles from the head. Make a slide of each. Draw.
6) Observe the dorsal surface of an intact mature larva at low magnification (10X to 60X) with reflected light. Draw the setal map of the abdominal tergites, segments 2 through 7.

   OR

   Dissect the abdomen from a mature larva. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface of the abdomen at high magnification (l00X or higher) with transmitted light. Draw the setal map of the abdominal tergites, segments 2 through 7.

7) Compare the mandibles and the abdominal setal maps of *Ahasverus advena* with those of *Oryzaephilus surinamensis*, *Oryzaephilus mercator*, and *Cathartus guadricollis*.

For #5 and #6 above only, Ref. 6, 28.

4.13. Grain beetle larva, *Ahasverus rectus* LeConte

This beetle has no common name.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.
2) Dissect the frontal-clypeal-labral complex from the head of a larva. Make slide. Draw. Indicate the dorsal mandibular articulations.
3) Dissect the hypopharyngeal sclerome. Make slide. Draw.
4) Dissect a gena fragment. Make slide. Draw. Indicate the hypostomal margin.

Compare with Sawtoothed grain beetle in Ref. 23. No references for #1 through #4 above.

5) Dissect the right and left mandibles from the head. Make a slide of each. Draw.
6) Observe the dorsal surface of an intact mature larva at low magnification (l0X to 60X) with reflected light. Draw the setal map of the abdominal tergites, segments 2 through 7.

   OR

   Dissect the abdomen from a mature larva. Clear the abdomen in lactophenol solution (1+1). Make a slide of the abdomen with the dorsal surface up. Observe the dorsal surface of the abdomen at high magnification (l00X or higher) with transmitted light. Draw the setal map of the abdominal tergites, segments 2 through 7.
7) Compare the mandibles and the abdominal setal maps of *Ahasverus rectus* with those of *Oryzaephilus surinamensis*, *Oryzaephilus mercator*, *Cathartus guadricollis*, and *Ahasverus advena*.

For #5 above only, Ref. 28.

It is recommended that the student reviews Cutler,1971, Reference 6 and Vail, 1980, Reference 28.

4.14. Flat grain beetle larva, *Cryptolestes pusillus* (Schönherr)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

NOTE: The head is flattened. The epicranial sutures are inconspicuous. The epistomal suture is absent. See Key, Ref. 11, page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the dorsal head surface from a larval head. Make slide. Draw. Indicate the frons fragments.

4) Dissect a frons fragment from a larval head. Make slide. Draw.

5) Dissect the ventral head surface from a larval head. Make slide. Draw. Indicate the gena fragments (hypostomal rods).

6) Dissect a gena fragment from a larval head. Make slide. Draw.

7) Dissect the anal cerci from the larva. Make slide. Draw.

NOTE: The concavity of the anal cerci is more or less V shaped. See Key, Ref. 11, page 142.

Some publications use Genus Loemophloeus. Ref. 11, 18, 21, 23.

4.15. Cigarette beetle larva, *Lasioderma serricorne* (Fabricius)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

NOTE: The dorsal part of the head is not uniformly colored. The epicranial sutures are distinct. See Key, Ref. 11, page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles. Compare with *Stegobium paniceum.*

3) Dissect the frons. Make slide. Draw. Describe the shape of the epistomal suture.

4) Dissect a gena fragment. Make slide. Draw. Describe the shape.

Ref. 11, 18, 21, 23.

4.16. Drugstore beetle larva, *Stegobium paniceum* (Linnaeus)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

NOTE: The dorsal part of the head is uniformly colored. The epicranial sutures are absent. See Key, Ref. 11, page 142.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles. Compare with *Lasioderma serricorne.*
3) Dissect the frons. Make slide. Draw. Describe the shape of the epistomal suture.
4) Dissect a gena fragment. Make slide. Draw. Describe the shape.

Ref. 11, 18, 21, 23.

4.17. Dermestid larvae, Family *Dermestidae*

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.
2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the frons. Make slide. Draw. Describe the shape of the epistoma.
4) Dissect a gena fragment. Make slide. Draw. Describe the shape.
5) Dissect the dorsal surface of the abdominal segments which bear tubercles if they are present. Make slide. Draw.
6) Make slides of any specialized setae. Draw.

See black carpet and buffalo carpet beetles in Ref. 23. Ref. 18, 21, 23.

4.17.1. Black carpet beetle larva, *Attagenus megatoma* (Fabricius)

1) Dissect cuticle from the dorsal surface of the abdomen of a larva. Make slide. Draw. Describe the type of setae found on the abdomen.
2) Dissect the caudal end of the larva. Make slide. Draw. Describe the setae found on the end of the larva.

See Attagenus piceus in Ref. 23. Ref. 18, 21, 23.

4.17.2. Carpet beetle larva, *Anthrenus scrophulariae* (Linnaeus)

1) Dissect cuticle from the dorsal surface of the abdomen of a larva. Make slide. Draw.

NOTE: Hastisetae arise from the membranous area on the caudolateral edge of abdominal segments. See Key, Ref. 11, page 142, *Anthrenus* sp.

2) Make a slide of the Hastisetae found on the abdomen. Draw.

See buffalo carpet beetle in Ref. 11, 18, 21, 23.

4.17.3. Larger cabinet beetle larva, *Trogoderma inclusum* LeConte

1) Dissect cuticle from the dorsal surface of the abdomen of a larva. Make slide. Draw.

   NOTE: Hastisetae arise from the sclerotized dorsal surface of abdominal segments. See Key, Ref. 11, page 142 *Trogoderma* sp.

2) Make a slide of the Hastisetae found on the abdomen. Draw.

Ref. 11, 23.

4.18. Driedfruit and corn sap beetle larvae, *Carpophilus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Epistomal suture is absent.

2) Dissect the maxilla-labial complex from the ventral surface of the larval head. Make slide. Draw.

3) Dissect a gena fragment from the head. Make slide. Draw.

Ref. 21, 23.

4.18.1. Driedfruit beetle larva*, Carpophilus hemipterus* (Linnaeus)

1) Dissect the right and left mandibles from the larval head. Make a slide of each. Draw. Observe the strongly sclerotized 5 apical teeth on the mesal margin of the prostheca.

2) Dissect the anal cerci from the larva. Make slide. Draw.

   NOTE: The anal cerci (urogomphi) is broad and truncate. The prongs of the anal cerci are evenly narrowed to the apex.

See Carpophilus dimidiatus, technical description in Ref. 23. Ref. 18, 21, 23.

4.18.2. Corn sap beetle larva, *Carpophilus dimidiatus* (Fabricius)

1) Dissect the right and left mandibles from the larval head. Make a slide of each. Draw. Observe the feebly sclerotized teeth on the mesal margin of the prostheca.
2) Dissect the anal cerci from the larva. Make slide. Draw.

   NOTE: The inner margin of the anal cerci (urogomphi) is a narrow round emargination. The prongs are abruptly constricted near the apex.

Ref. 23.

4.19. Spider beetle larvae, *Ptinus* spp.

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Epistomal suture is present
2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the labrum from a larval head. Make slide. Draw.
4) Dissect a gena fragment. Make slide. Draw.

Ref. 23.

4.20. Hairy fungus beetle larva, *Typhaea stercorea* (Linnaeus)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The frontal sutures join near the posterior margin of the head. There are several distinct ocelli.
2) Make a slide of the right and left mandibles. Draw each. Indicate any differences between the mandibles.
3) Dissect the labial sclerome from a larval head. Make slide. Draw.
4) Dissect the labrum from the head. Make slide. Draw.
5) Dissect the anal cerci from the larva. Make slide. Draw.

Ref. 23.

4.21. Coffee bean weevil larva, *Araecerus fasciculatus* (De Geer)

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: The epistomal suture is a weakly sclerotized band.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the hypopharyngeal sclerome. Make slide. Draw.

4) Dissect a gena fragment. Make slide. Draw.

Ref. 23.

4.22. Lesser mealworm larva, *Alphitobius diaperinus* Panzer

1) Remove the head from a larva. Dissect the mandibles from the head. Make a slide of the resulting head capsule. Draw.

   NOTE: Epistomal suture is present.

2) Make slides of the right and left mandibles. Draw each. Indicate any differences between the mandibles.

3) Dissect the labial sclerome from a larval head. Make slide. Draw.

4) Dissect a gena fragment. Make slide. Draw.

5) Dissect the anal cerci from the larva. Make slide. Draw.

Ref. 23.

It is recommended that the student reviews Kurtz,1956, Reference 21.

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