United States Department of Agriculture

Agricultural Research Service

and

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Public Health Service

Food and Drug Administration

Agriculture Handbook No. 655

Insect and Mite Pests in Food

An Illustrated Key

Volume 1

003

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Plate 1. Some beetles (Coleoptera) associated with the food industry (body lengths for each species are shown in millimeters in parentheses): A, **varied carpet beetle,** *Anthrenus verbasci* (1.7-3.2) (Dermestidae); B, **carpet beetle,** *Anthrenus scrophulariae* (2-3.8) (Dermestidae); C, **warehouse beetle,** *Trogoderma variabile* (2.7-3.5) (Dermestidae); D, larger cabinet beetle,*Trogoderma inclusum* (2.5-5) (Dermestidae); E, ornate cabinet beetle, *Trogoderma ornatum* (1.6-4) (Dermestidae); F, **twobanded fungus beetle,** *Alphitophagus bifasciatus* (2.2-3) (Tenebrionidae); G, blacklegged ham beetle, *Necrobia violacea* (4-4.5) (Cleridae); H, **redshouldered ham beetle,** *Necrobia ruficollis* (4-6) (Cleridae); I, **redlegged ham beetle,** *Necrobia rufipes* (3.5-7) (Cleridae); J, **cowpea weevil,** *Callosobruchus maculatus* (3-4.5) (Bruchidae); K, Chinese pea weevil, *Callosobruchus chinensis* (2.5-3.5) (Bruchidae); L, **American spider beetle,** *Mezium americanum* (1.5-3.5) (Ptinidae); M, **spotted asparagus beetle,** *Criocerus duodecimpunctata* (6-6.5) (Chrysomelidae); N, **asparagus beetle,** *Criocerus asparagi* (5.6-6.5) (Chrysomelidae); O, **golden spider beetle,** *Niptus hololeucus* (3-4.5) (Ptinidae).

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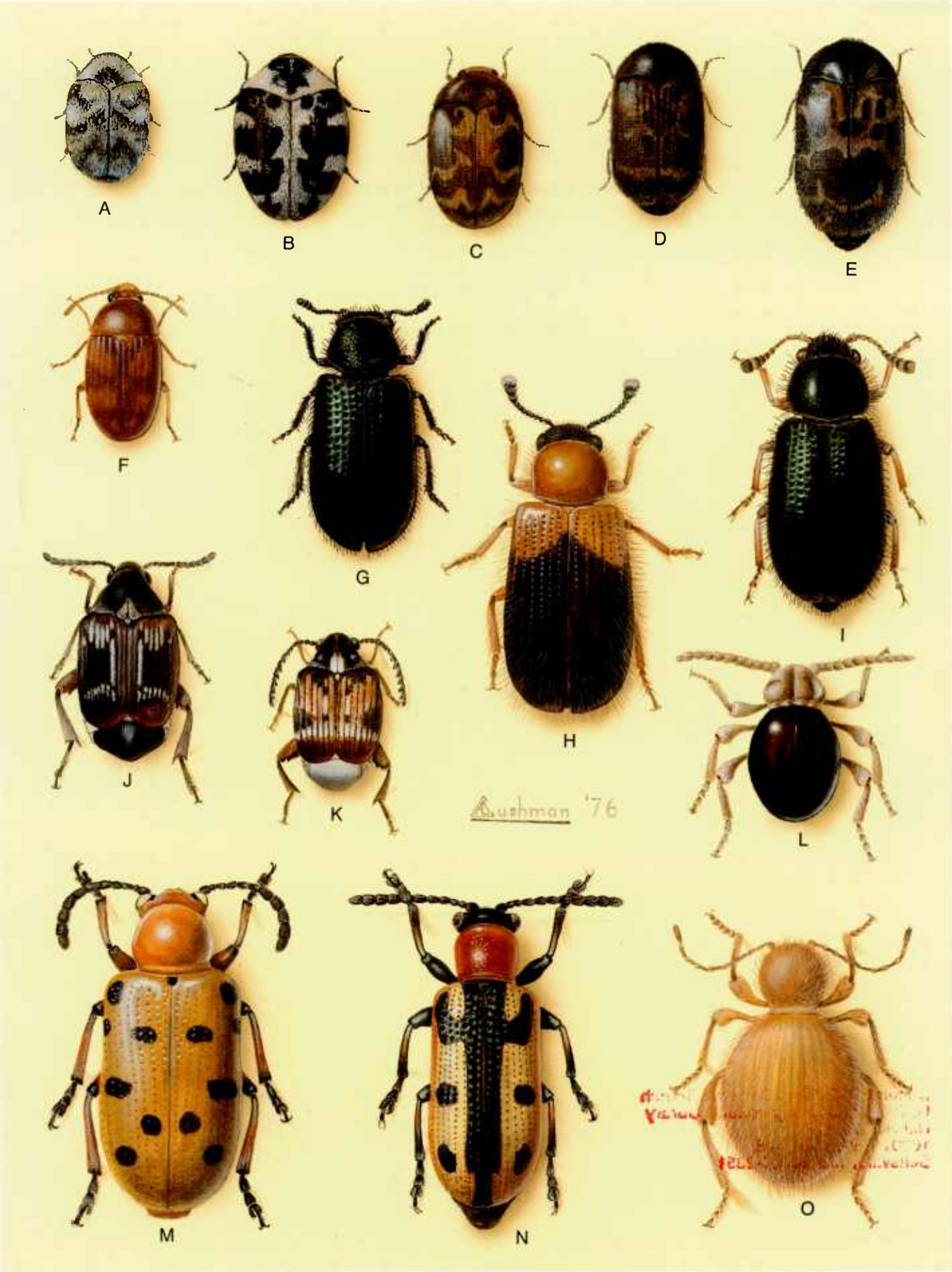
A
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This Handbook is
dedicated to
PROFESSOR MARION W. BOESEL
and to the memory of
PROFESSORS
DONALD J. BORROR
DWIGHT M. DELONG
C. CLAYTON HOFF
and
ROBERT A. HEFNER

United States Department of Agriculture

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Washington DC

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Insect and Mite Pests in Food

An Illustrated Key

J. Richard Gorham
Editor

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Abstract

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The publication, presented in two volumes, is a comprehensive treatise on the occurrence and identification of food-contaminating arthropods (insects and their relatives). It provides the user a rapid and accurate means of identifying more than 600 species of pests encountered throughout the food industry. Diagnostic keys and useful illustrations of both adult and immature stages of these pests are presented. Volume 1, arranged phylogenetically, consists of part 1 and includes keys to the major anthropod pests of stored food. Volume 2, also arranged phylogenetically, consists of parts 2 and 3. It begins with a general key to arthropod classes and insects orders. Except for chapter 7 in volume 1 and chapter 25 in volume 2, all the keys in parts 1 and 2 are illustrated by drawings associated with key couplets. The keys in part 1 are illustrated by additional drawings in part 3 (ch. 27). The two volumes complement each other and should be used simultaneously to permit the user to see at the same time both the couplet drawings (vol. 1) and the plate illustrations (vol. 2). Thus, the user can see at the same time both the specific features described in the key couplet and the general habitus of the arthropod being studied.

KEYWORDS: arthropod, stored-food pests, food pests, food insects, moths, Lepidoptera, food industry, beetles, cockroaches, weevils, ants, silverfish, psocids, thrips, aphids, parasitic wasps, springtails, scale insects

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Issued February 1991

Foreword

Responsibility for assuring safe and nutritious food supplies for the American people is shared by the Departments of Agriculture and Health and Human Services. While prevention of problems is the ideal, much past effort has been expended upon corrective constraints against foods that never should have been allowed to become defective in the first place.

In keeping with the increasing emphasis on prevention, this timely publication *Insect and Mite Pests in Food: An Illustrated Key* is a fundamental technical document to assist scientists in achieving early detection and before-the-fact prevention, as well as after-the-fact correction, of certain defects in food.

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Preface

Although most users of this handbook will be able to use it effectively without any editorial explanations, a few comments concerning the organization might be helpful to some and at least of passing interest to others. All aspects of this project have been designed with the user in mind. Our objective was to make the handbook convenient to use.

Because of the sheer volume of the material to be included in the handbook, it is being published in two volumes, each of which is intended to complement the other. Volume 1 consists of part 1 (ch. 1-17) and includes keys to major arthropod pests of stored food. The arrangement of these chapters is essentially phylogenetic, beginning with the mites and ending with the ants.

Volume 2 consists of part 2 (ch. 18-26) and part 3 (ch. 27, 28, appendix, and the index). Part 2 is also arranged phylogenetically, beginning with a general key to arthropod classes and insect orders. Except for chapters 7 and 25, all the keys in parts 1 and 2 have drawings associated with the key couplets. The keys in part 1 are further illustrated by additional drawings in part 3 (ch. 27). Since the couplet illustrations for part 1 are in volume 1 and the plate illustrations in volume 2, the identifier will need to use both volumes simultaneously. This permits the user to see at the same time both the specific features described in the key couplet and the general habitus of the arthropod under consideration.

Plate 1 is the only exception to this arrangement. Since it is the frontispiece of volume 1 and since all the taxa illustrated therein are keyed out in volume 1, the user occasionally will need to turn back to the frontispiece when keying out certain beetles in chapters 3, 5-7, 11, and 12. Chapter 14 refers to the frontispiece (plate 2) of volume 2.

With a few exceptions, the plates are arranged according to the order of appearance of each taxon in the keys of part 1. In both the couplet illustrations and in the habitus drawings of the plates, the figures are oriented so that the anterior aspect of the drawing points either up or to the left. (In a few instances, the couplet illustrations are shown head-to-head or tail-to-tail to facilitate comparison of structures.) In deference to the tradition of lepidopterists, the drawings of moth genitalia (ch. 14) are oriented so that anterior points down. The tradition of coccoidologists has also been respected in that the key to scale insects (ch. 25) uses text figures rather than couplet illustrations.

Approximately 650 taxa are keyed out in the handbook. The major cosmopolitan pests are invariably included in their respective chapters. Accidental pests are not included, as well as most field crop pests, except for those that are commonly, if inadvertently, carried into processing or storage situations. These keys, from the most general to the most specific, deal with insects and mites associated with food, not with insects and mites in general.

The geographic scope of this handbook is basically worldwide, since all the major cosmopolitan pests are included. However, with regard to those pests that are not cosmopolitan, the various specialists have selected those geographic parameters that are consistent with their own knowledge of the arthropods involved. The bionomic notes given for most species inform the reader about host materials and geographic distribution.

With the combined help of the key couplets, the couplet illustrations, the bionomic notes in the couplets, and the habitus drawings, the identifier may arrive at a confident identification. If, however, after reaching this point, the user still has some doubt about the identity of a particular specimen, he or she has two options. One is to send the specimen to a specialist to identify (see the appendix for instructions).

The second option is to consult scientific literature. To help you do this I provided a list of taxonomic aids in chapter 28 for most of the taxa included in this handbook as well for many (approximately 400) that are not. This list also serves as a taxonomic index to the handbook, with the entries, including complete scientific names and common names (if any), arranged by order and family. (Throughout the handbook, the common names approved by the Entomological Society of America are shown in boldface type.) In addition, the scientific and common names are listed alphabetically in the general index. Occasionally, the complete scientific name (genus, species, author) is used in the text. Such taxa are mentioned for illustrative purposes only, as they have no relation to stored food and therefore do not appear in chapter 28. The authors of these taxa are given for the convenience of the reader.

Many people were involved in making this handbook possible. In addition to the authors and the illustrators, others gave support to the completion of the book. For example, the book could not have been written without the administrative support of both the Food and Drug Administration and the Agricultural Research Service. In addition, many scientists, each an expert in his or her field, gave advice and suggestions to help us achieve a high level of accuracy and utility in the preparation of the keys. In short, thanks to all of you who assisted in making *Insect and Mite Pests in Food: An Illustrated Key* an informative and useful reference in its field.

J. Richard Gorham
Food and Drug Administration
Public Health Service
U.S. Department of Health and Human Services
Washington DC 20204

Introduction

This comprehensive treatise on the identification of food-contaminating arthropods (insects and their relatives) and their occurrence in food was prepared for an international audience of entomologists, food inspectors, commercial food processors, instructors in pest identification and pest management, pesticide applicators, and others involved in maintaining the purity of processed foods. We hope that this handbook will increase the efficiency of food inspection and will help guarantee the purity of foods imported into, exported from, and transported within the United States and other countries.

Precise identification of pests and suspected pests is essential in the food industry, just as it is in the production and postharvest segments of agriculture. For example, consider the most recent, expensive visit of the khapra beetle to the United States—identifications were needed of the difficult-to-identify larvae so that the extent of the infestation could be determined and control measures taken before the pest could spread throughout the country. In the food industry, particularly, rapid and accurate identification, often of only a fragment of an insect or other arthropod, must be made by persons lacking specialized training in insect/arthropod systematics. This handbook will help provide the basis for this capability, both as a reference tool and as an instructional aid.

For the first time, the combined expertise of leading specialists in the United States has been marshaled to produce a comprehensive and fully detailed manual for quick and positive identification of more than 600 species of pests encountered throughout the many facets of the food industry. No manual of this kind has ever been published before in the United States, although a few similar works have been published in England and Canada. In addition to the more numerous and better known arthropod groups such as beetles, moths, and flies, the poorly known groups such as mites, thrips, and scale insects are included. The emphases placed on diagnostic keys and useful illustrations of both adult and immature stages are special features. The two volumes, prepared largely by research entomologists of the Agricultural Research Service's Systematic Entomology Laboratory of the Biosystematics and Beneficial Insects Institute, with some sections prepared by other specialists, were designed for practical use. A prime objective was to enable frontline nonspecialists to identify authoritatively a large number of species. This will save not only their time but also the time of systematists who otherwise would be required to identify those specimens.

The practically oriented food inspector, quarantine officer, pest control operator, and others in this field should pause to consider the nature and quality of the research that makes a tool such as this available. We, current researchers and users of research, are the inheritors of more than 200 years of basic systematic work. While many difficult problems remain in the classification of pests and related species, especially at the subspecific level, much of the fundamental classification that we use today was developed over that two-century timespan. Many classifications were not developed with the present or any other practical objective in mind but are the products of basic research.

These points are particularly important when one considers that pest-identification requirements change as our food habits change; as shipping, packaging, storage, processing, and other procedures change; as new crops and foods are developed; as international pathways of commerce change; and even as the pests themselves change in their host preferences, distribution, population characteristics, and resistance to pesticides. The strengthened regulatory arms provided by scientifically based identification may become even more critical in the future as the use of certain pesticides is restricted. We can also anticipate dealing with increased numbers of diverse kinds of organisms, as well as their natural enemies, such as parasitic forms. We can feel confident that these two volumes will provide answers for many important questions for years to come. At the same time, we need to be prepared for unpredictable future needs by maintaining our systematics research and service capability.

A definitive work of this nature requires a diverse mix of knowledge and capability—practical knowledge of which species need to be identified and which need to be excluded; a solid understanding of the identity of not only those species but also of closely related or similar forms; the ability to present this broad range of specialized detail in a useful manner; and skill in scientific illustration and in organizational and editorial capability. Speaking for the authors, I would like to thank the editor, J. Richard Gorham, for his leadership of this project, and to thank the primary illustrators Candetta Feller and Arthur D. Cushman, both formerly with the Systematic Entomology Laboratory, for their outstanding contributions to this project.

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Part 1

1 MITES (ACARI)

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The key presented here to selected orders, suborders, families, genera, and species of mites associated with foods is based largely on *A Manual of Acarology* by G.W. Krantz (*20*) and on *The Mites of Stored Foods and Houses* by A.M. Hughes (*18*). (References *3, 4,* and *7* were among other important references consulted.) Several systems of subordinal nomenclature are being used by acarologists. The system used in this key, along with other systems that have been proposed, is given in table 1.1.

The central objective of the key is to help the user to identify those kinds of mites commonly associated with food. Some mites, because of their potential for occurrence in food-storage situations, are phoretic or parasitic on certain insects, birds, and mammals and are included here. Since bionomic information is sometimes a helpful adjunct in the process of making an identification, I have included as annotations to the key couplets whatever reliable information was available on foods, food habits, food associations, specific behaviors, and geographic distribution.

The characters of the adult stage form the basis for most of the key couplets. The occasional references to characters of the hypopodes (formerly, hypopi) are provided merely as supplemental information. Zakhvatkin (*28*) should be consulted for keys to hypopodes. The hypopus (deutonymph or second nymphal stage) occurs only in the Astigmata and then only occasionally. It differs widely in both morphology and behavior from earlier and later stages in the developmental cycle.

As arachnids, spiders, mites, and ticks have a kind of abdominal segmentation that is inconspicuous or apparently absent. In the subclass Araneae (spiders), the head and thorax are combined in a single unit, the cephalothorax, that is joined to the abdomen by a slender pedicel. The subclass Acari includes the ticks (fig. 1.1) and mites (fig. 1.2). The acarine body, in contrast to the rather distinct body regions of insects, is composed mainly of the idiosoma. The mouthparts are borne on the gnathosoma, an anterior region that is more or less distinct from the idiosoma. Terminology for the subdivisions of the mite body is given here.

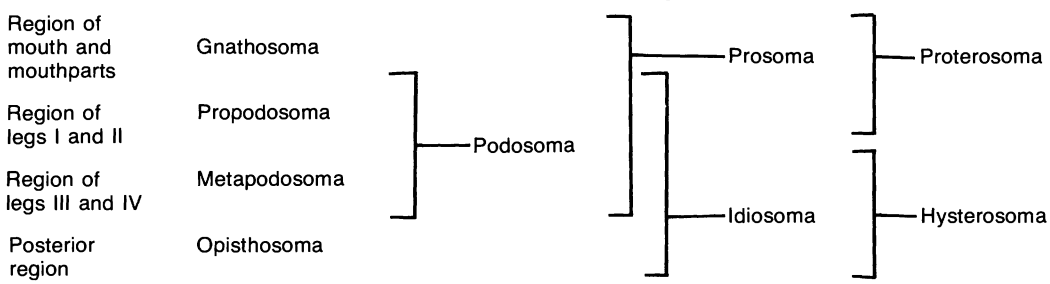


Table 1.1.
Equivalent names for some of the higher taxa, mainly suborders, of the subclass Acari

System I	System II[3]	System III[4]	System IV[5]	System V[6]
Order Parasitiformes				
Onychopalpida[1]				
Holothyroidea[2]	Tetrastigmata	Holothyrida	Holothyrina	Holothyrina[7]
Notostigmata[2]	Notostigmata	Opilioacarida	Opilioacarida	Opilioacarida[7]
Parasitiformes[2]				
Ixodides[1]	Metastigmata	Ixodida	Ixodida	Ixodida[8]
Mesostigmata[1]	Mesostigmata	Gamasida	Mesostigmata	Mesostigmata
Order Acariformes				
Trombidiformes[1,2]	Prostigmata	Actineida	Prostigmata	Prostigmata
Tetrapodili[2]				Eriophyoidea
Sarcoptiformes[1,2]				
Acaridiae	Astigmata	Acaridida	Astigmata	Astigmata
Oribatei	Cryptostigmata	Oribatida	Oribatida	Cryptostigmata

[1]These are the suborders of Baker and Wharton (*4*).
[2]Vitzthum (*27*) used 6 suborders.
[3]Evans, Sheals, and Macfarlane (*8*); Evans and Till (*9*) confer ordinal status on these suborders.
[4]van der Hammen (*14*); Krantz (*20*).
[5]Acarology Laboratory, Ohio State University (D. E. Johnston, personal communication, 1982).
[6]This subordinal system is used in this key; it was recommended, in part, by G.W. Krantz (personal communication, 1980).
[7]Since it is very unlikely that users of this key would ever encounter mites belonging to either of these rare and exotic suborders, they have been omitted from the key.
[8]Ticks, of course, do not infest food; but since they are so widely distributed, they are included here to show how they may be distinguished from mites.

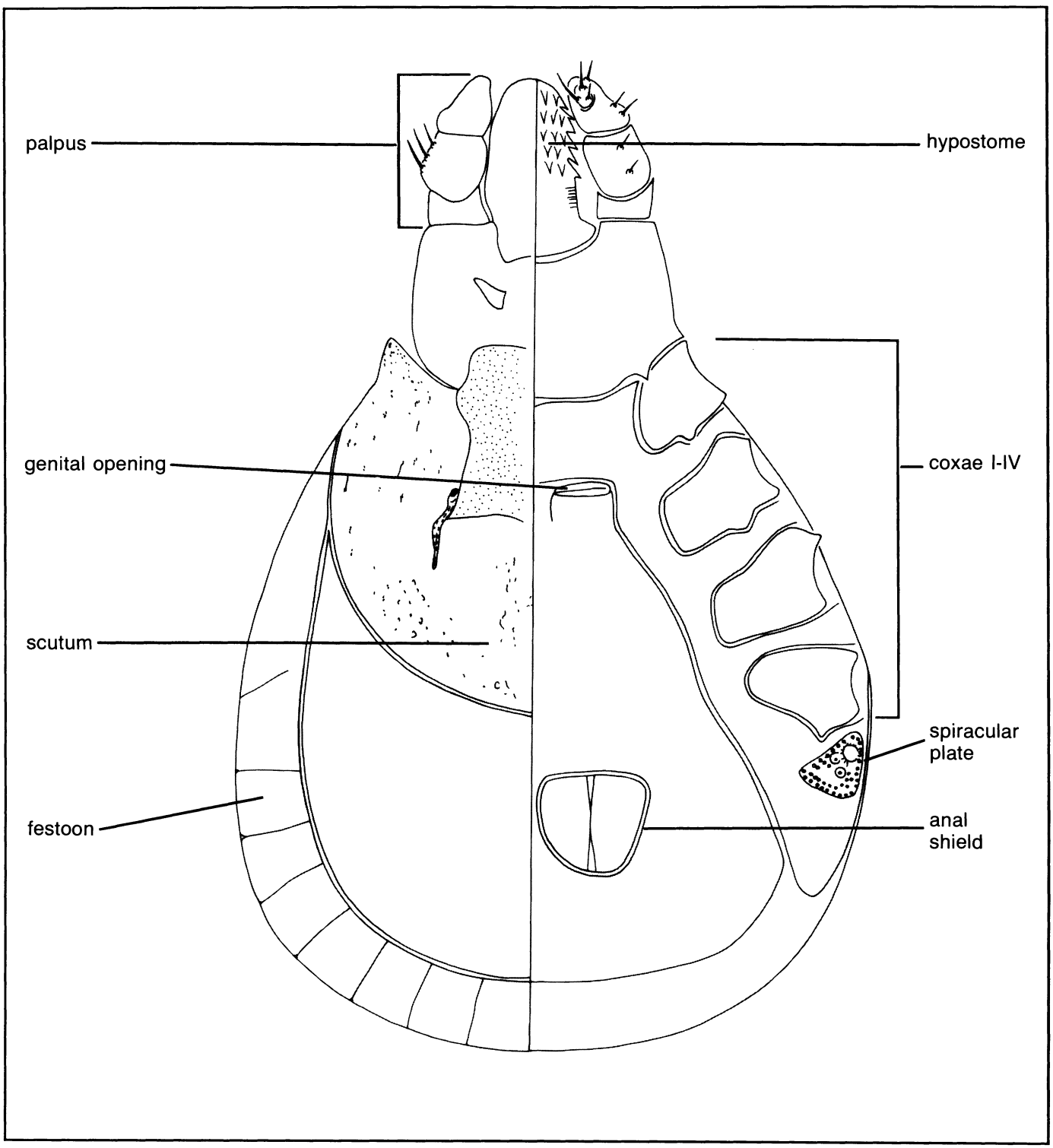


Figure 1.1. Ixodid tick (Ixodida) (diagrammatic): Left, dorsal; right, ventral. (Drawing by R.L. Smiley.)

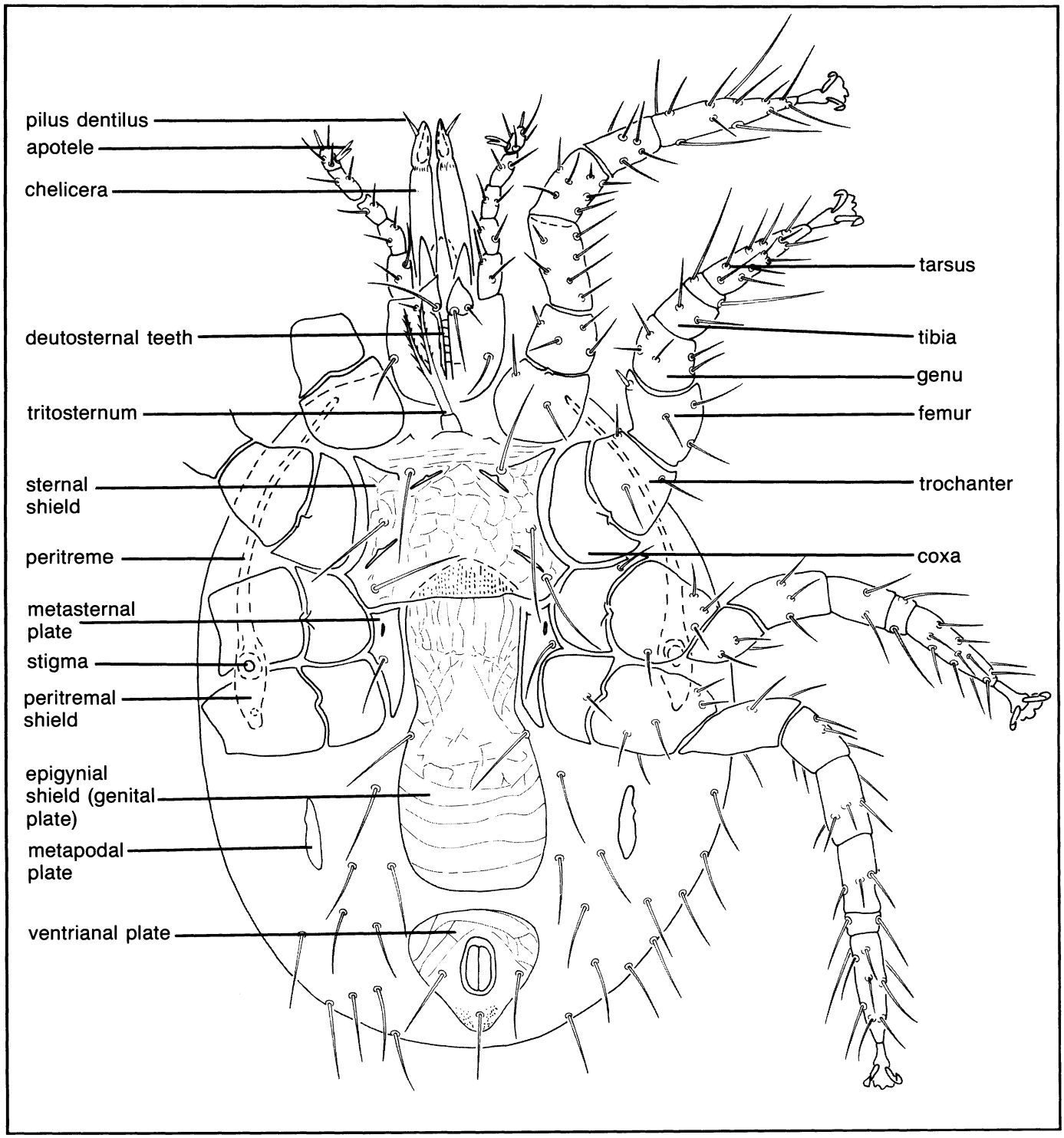


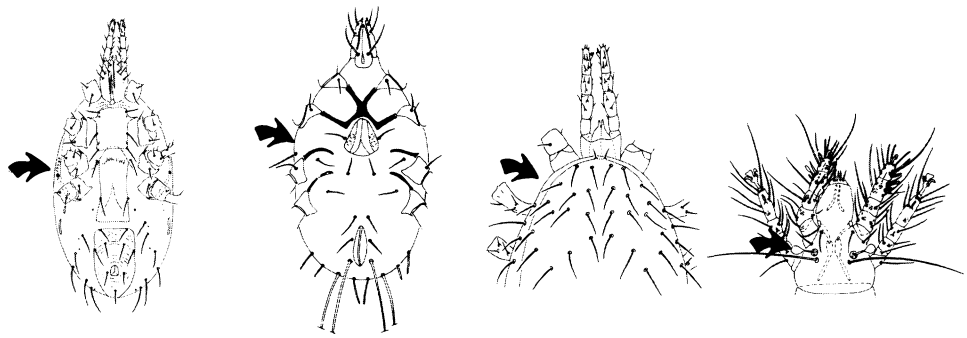
Figure 1.2. Mesostigmatid mite, *Androlaelaps casalis* (Laelapidae, Mesostigmata), ventral view of female (see pl. 3, 11, and 45 for other structural details). (Drawing by R.L. Smiley.)

KEY

Drawings by R.L. Smiley and C. Feller unless otherwise noted.

1 With 1 to 4 pairs of lateroventral hysterosomal stigmata (1A); sensillum (propodosomal trichobothrium) absent (1B). Order Parasitiformes---------- 2

Without hysterosomal stigmata (1C) (except for certain Cryptostigmata that may have inconspicuous stigmata); sensillum present (1D) or absent. Order Acariformes - 17

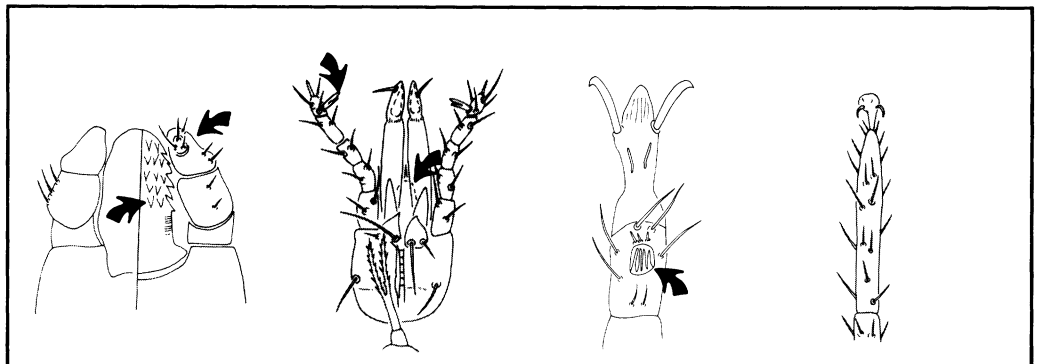


1A *Blattisocius keegani* 1C *Carpoglyphus lactis* 1B *Blattisocius keegani* 1D *Pyemotes tritici*

Order Parasitiformes

2 Large leathery Acari (usually more than 1 mm long), with sclerotized plates or shields (see scutum, fig. 1.1); palpus without tined apotele (2A); hypostome with retrorse teeth (2A); spiracular (stigmal) plate (surrounds stigma) oval, rounded, comma-shaped, or subtriangular (fig. 1.1) and located between coxae III and IV or behind coxa IV; Haller's organ (on dorsum of tarsus) present (2B); external parasites ----------**ticks,** Suborder Ixodida

Small nonleathery Acari (usually less than 1 mm long), with or without sclerotized plates or shields; palpus with tined apotele (2C); hypostome without retrorse teeth (2C); stigma located between coxae II and III or between III and IV, and sometimes surrounded by an elongate peritremal shield (fig. 1.2); Haller's organ absent (2D); parasitic or free living. Suborder Mesostigmata (mesostigmatid mites) ---------- 3



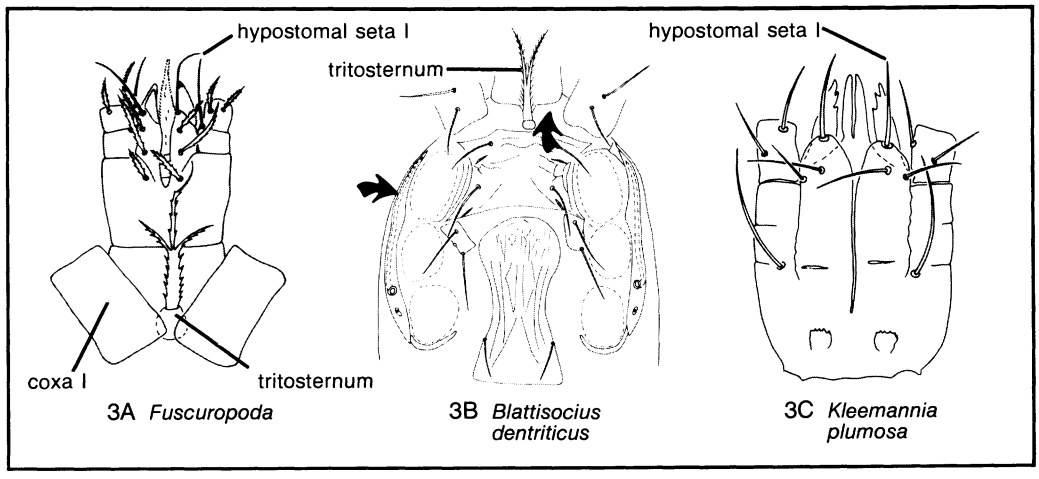
2A ixodid tick 2C *Androlaelaps casalis* 2B ixodid tick 2D *Blattisocius keegani*

Suborder Mesostigmata

3 Coxa I partially contiguous with and partially covering base of tritosternum (3A); hypostomal setae I-III arranged in a row (3A); peritreme elongate and often strongly convoluted (pl. 3B); coxae III and IV with foveae pedales (leg grooves) (pl. 3B). Uropodidae (uropodid or tortoise mites) ---------- 4

The uropodids of interest here are found in damp, moldy grain in ships and warehouses; they are probably mycophagous.

Coxa I not contiguous with and not overlapping tritosternal base (3B); hypostomal setae I-III not arranged in a row (3C); peritreme elongate but not convoluted (3B); coxae III and IV without foveae pedales (3B) ---------- 5



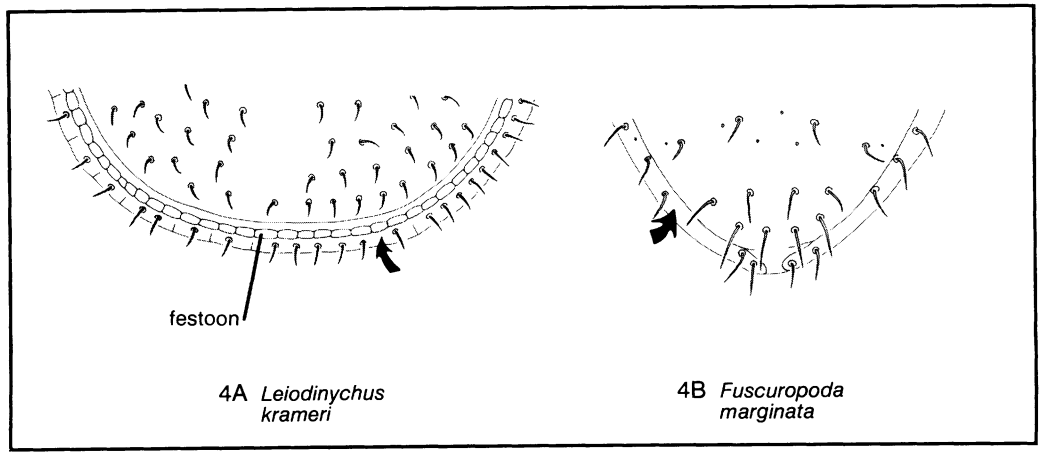
3A *Fuscuropoda* 3B *Blattisocius dentriticus* 3C *Kleemannia plumosa*

4 Idiosoma broadly rounded at posterior margin (pl. 3A); dorsal shield bordered, at least posteriorly, with a single row of platelets (festoons) (4A)----------*Leiodinychus krameri*

Distribution: cosmopolitan.

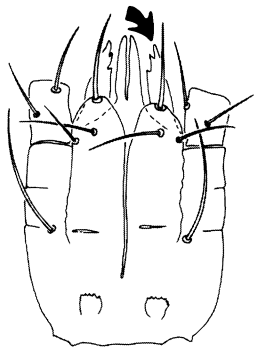
Idiosoma tapered at posterior margin (pl. 3C); dorsal shield not bordered by a row of platelets (4B)----------*Fuscuropoda marginata*

Distribution: Europe, United States.

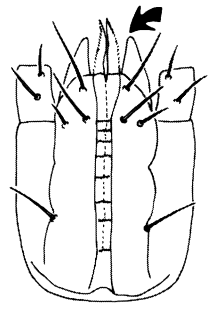


4A *Leiodinychus krameri* 4B *Fuscuropoda marginata*

5 Corniculus forked distally (5A). Ameroseiidae (ameroseiid mites) ---------- 6
Corniculus not forked (5B)---------- 7



5A *Kleemannia plumosa*



5B *Lasioseius*

6 Dorsal setae narrow and pectinate, without thickened midrib (6A); pl. 4A
----------*Kleemannia plumigera*

Distribution: England, Germany, Ireland, Netherlands.
Food habits: mycophagous.

Dorsal setae broad and serrate, each with a thickened midrib (6B); pl. 4B&C
----------*Kleemannia plumosa*

Distribution: Australia, Canada, England, Germany, Iceland, Ireland, Israel, Netherlands, United States.
Food habits: mycophagous.

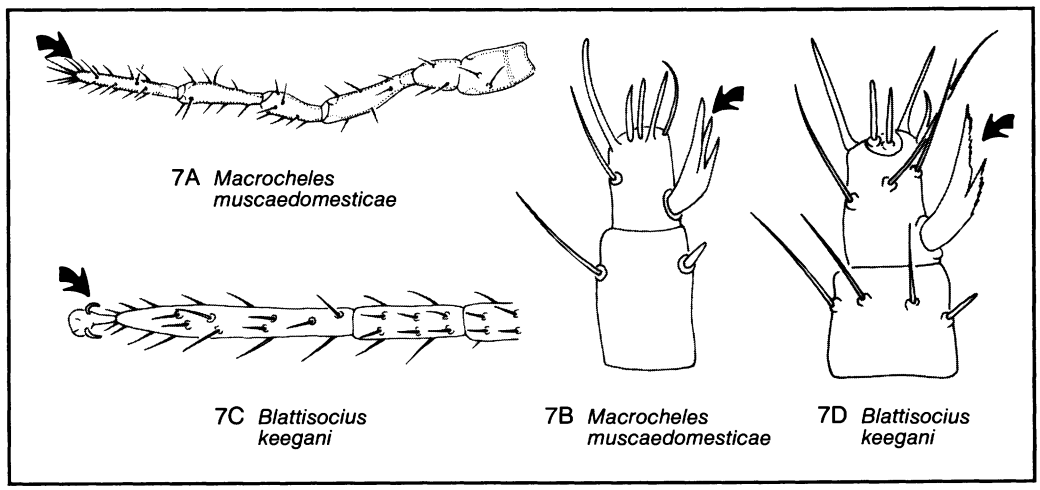
6A *Kleemannia plumigera*

6B *Kleemannia plumosa*

7 Tarsus I without claws (7A); apotele of palpal tarsus 3-tined (7B); pl. 5. Macrochelidae (macrochelid mites)---------- house fly mite, *Macrocheles muscaedomesticae*

Distribution: cosmopolitan. Foods: eggs of house flies (*Musca domestica*) and related muscids. Habits: phoretic on muscid flies.

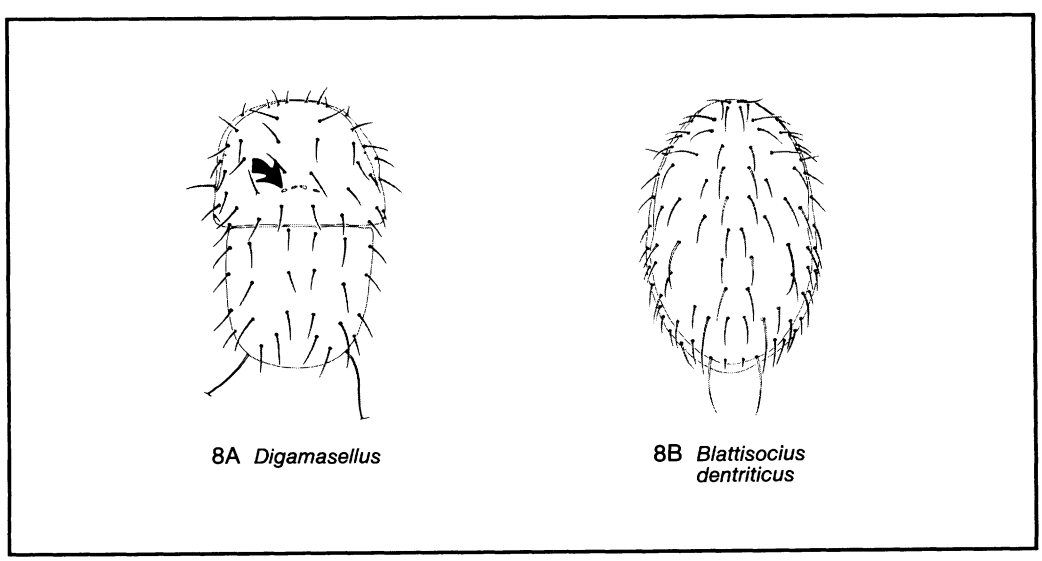
Tarsus I with claws (7C); apotele of palpal tarsus 2-tined (7D)---------- 8



8 Dorsal propodosoma with scleronoduli (8A); dorsum covered with subequal propodosomal (podonotal) and hysterosomal (opisthonotal) shields (8A). Digamasellidae (digamasellid mites) ----------*Digamasellus*

Distribution: probably cosmopolitan. Food habits: probably predaceous on small arthropods.

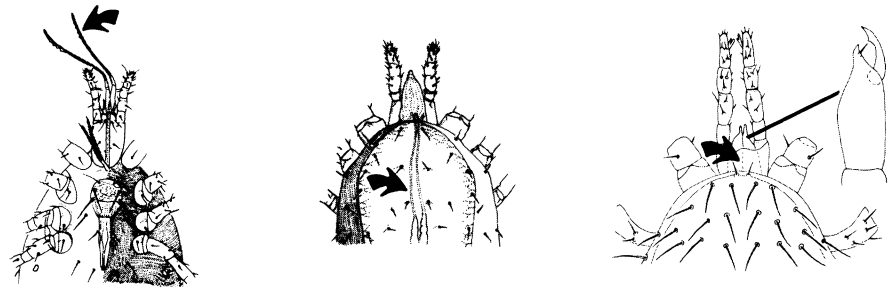
Dorsal propodosoma without scleronoduli (8B); dorsal shield usually undivided (8B) and often reduced (see 11B); if dorsal shield is divided, then anterior (podonotal) shield is much larger than posterior (opisthonotal) shield (see 11A)---------- 9



9 Chelicera slender (9A), whiplike or needlelike, originating from and retractable into propodosoma (9B) ---------- 10

9A&B adapted from *3*.

Chelicera stout, originating from and retractable into gnathosoma (9C) ---------- 13



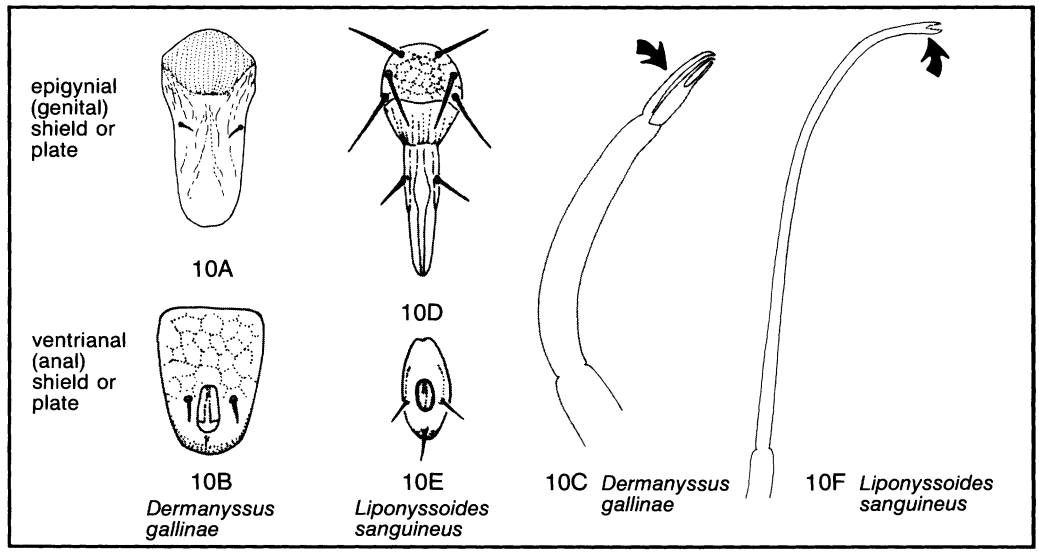
9A *Liponyssoides sanguineus* 9B *Dermanyssus gallinae* 9C *Blattisocius dentriticus*

10 Epigynial shield rounded posteriorly (10A); anal shield subrectangular (10B); chelicera scissorlike (10C), chela movable ----------**dermanyssid mites,** Dermanyssidae

The **chicken mite,** *Dermanyssus gallinae* (pl. 6), a cosmopolitan species, is representative of this family. Chicken mites live in the nests of their hosts—chickens, pigeons, starlings, and sparrows. The mites sometimes leave the nests and invade buildings through windows and other exterior openings.
10A&B adapted from *3*.

Epigynial shield pointed posteriorly (10D); anal shield oval in shape (10E); chelicera not scissorlike (10F), chela fixed. Macronyssidae (**macronyssid mites**)---------- 11

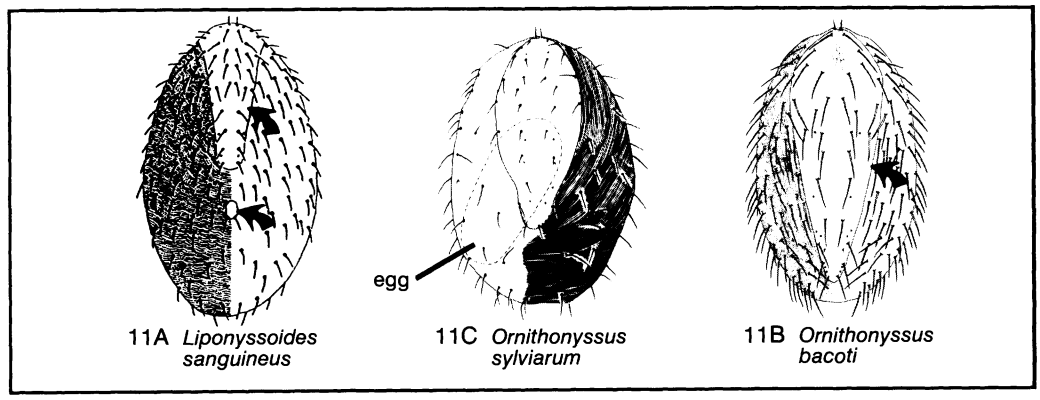
Macronyssid mites parasitize numerous kinds of birds and mammals, including domestic rats and mice.
10D&E adapted from *3*.



11 Dorsum with 2 shields (11A); pl. 7---------- **house mouse mite,** *Liponyssoides sanguineus*

Distribution: Egypt, United States (New York); probably cosmopolitan.
11A adapted from 3.

Dorsum with 1 shield (11B, 11C). Genus *Ornithonyssus*---------- 12



12 Dorsal shield pointed posteriorly; setae on dorsal shield equal in length to setae on unshielded dorsum (see 11B); pl. 8----------**tropical rat mite,** *Ornithonyssus bacoti*

Distribution: cosmopolitan.

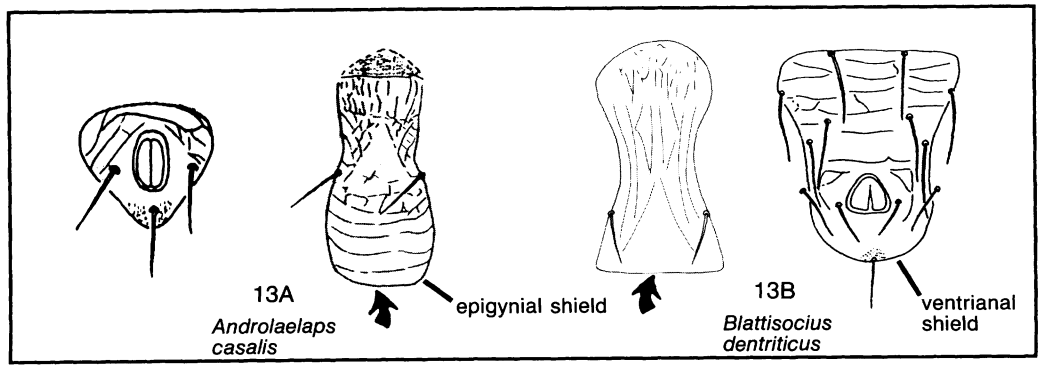
Dorsal shield rounded posteriorly; dorsal shield setae often much shorter than setae on unshielded dorsum (see 11C)----------**northern fowl mite,** *Ornithonyssus sylviarum*

Distribution: Australia, Europe, Japan, Korea, New Zealand, North America, South Africa, Russia; temperate regions of the world.

13 Epigynial shield rounded posteriorly and at least twice as long as ventrianal shield (13A); fig. 1.2. Laelapidae (laelapid mites)----------*Androlaelaps casalis*

Distribution: cosmopilitan. Food habits: in stored-food situations, feeds on other arthropods.

Epigynial shield truncate posteriorly and about equal in length to ventrianal shield (13B). Ascidae (ascid mites)---------- 14

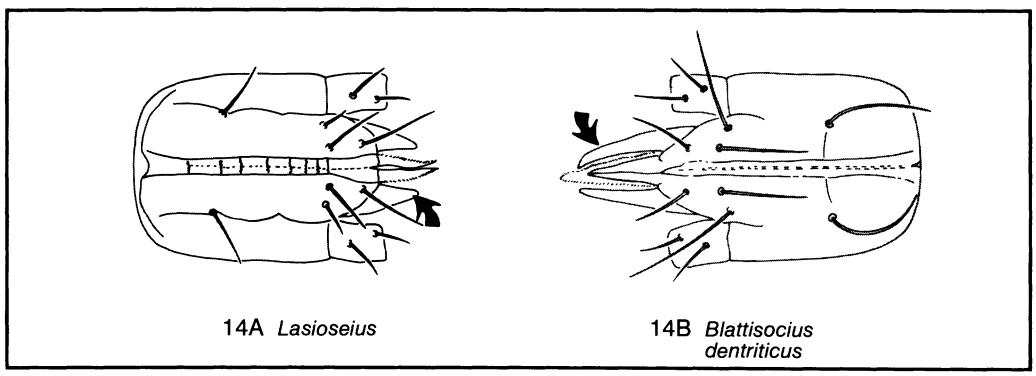


14 Corniculi relatively short, more or less parallel, and well separated distally (14A) ----------*Lasioseius*

Distribution: Europe, United States. Food habits: probably mycophagous or predaceous.

Corniculi long, slender, convergent, and close together distally (14B). Genus *Blattisocius* ---------- 15

The 3 species mentioned here are virtually cosmopolitan. They prey on insects and on other mites associated with stored foods.



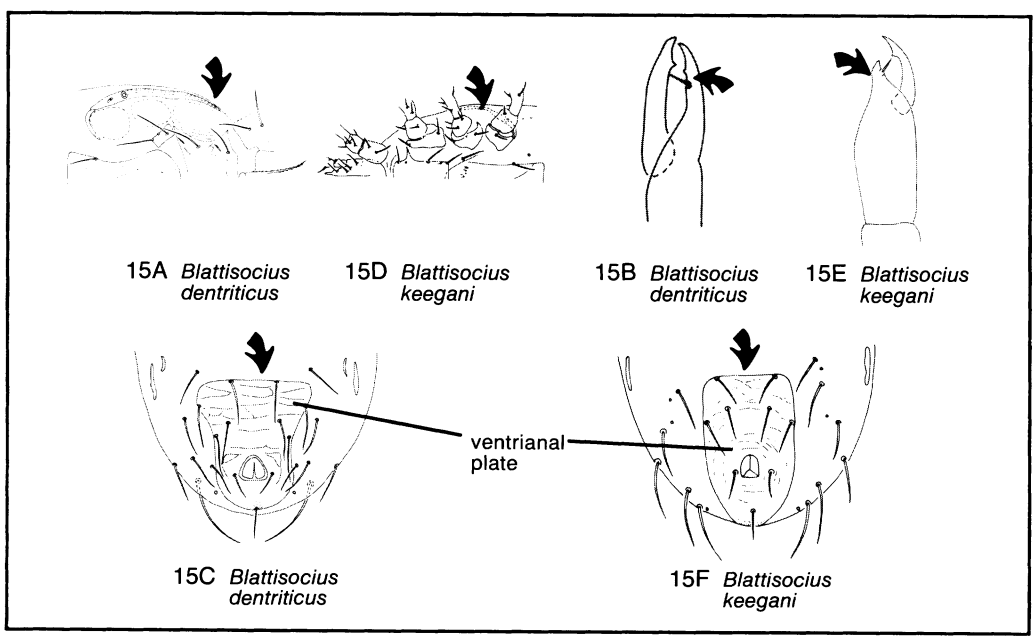
14A *Lasioseius*

14B *Blattisocius dentriticus*

15 Peritreme long, extending forward to coxa II (15A); cheliceral fixed digit with 1 tooth (15B); fixed and movable digits subequal in length (15B); ventrianal plate with 11 setae (15C); pl. 9A----------*Blattisocius dentriticus*

See also couplet illustration 8B.

Peritreme short, extending to coxa III (15D); cheliceral fixed digit toothless (15E); fixed digit much shorter than movable digit (15E); ventrianal plate with 9 setae (15F) 16



15A *Blattisocius dentriticus*

15D *Blattisocius keegani*

15B *Blattisocius dentriticus*

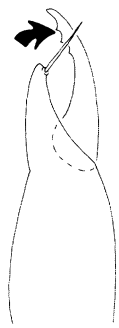
15E *Blattisocius keegani*

15C *Blattisocius dentriticus*

15F *Blattisocius keegani*

16 Cheliceral movable digit with 3 teeth (16A); pl. 9B ---------- *Blattisocius tarsalis*

Cheliceral movable digit with 1 tooth (16B); pl. 10 ---------- *Blattisocius keegani*



16A *Blattisocius tarsalis*

16B *Blattisocius keegani*

Order Acariformes

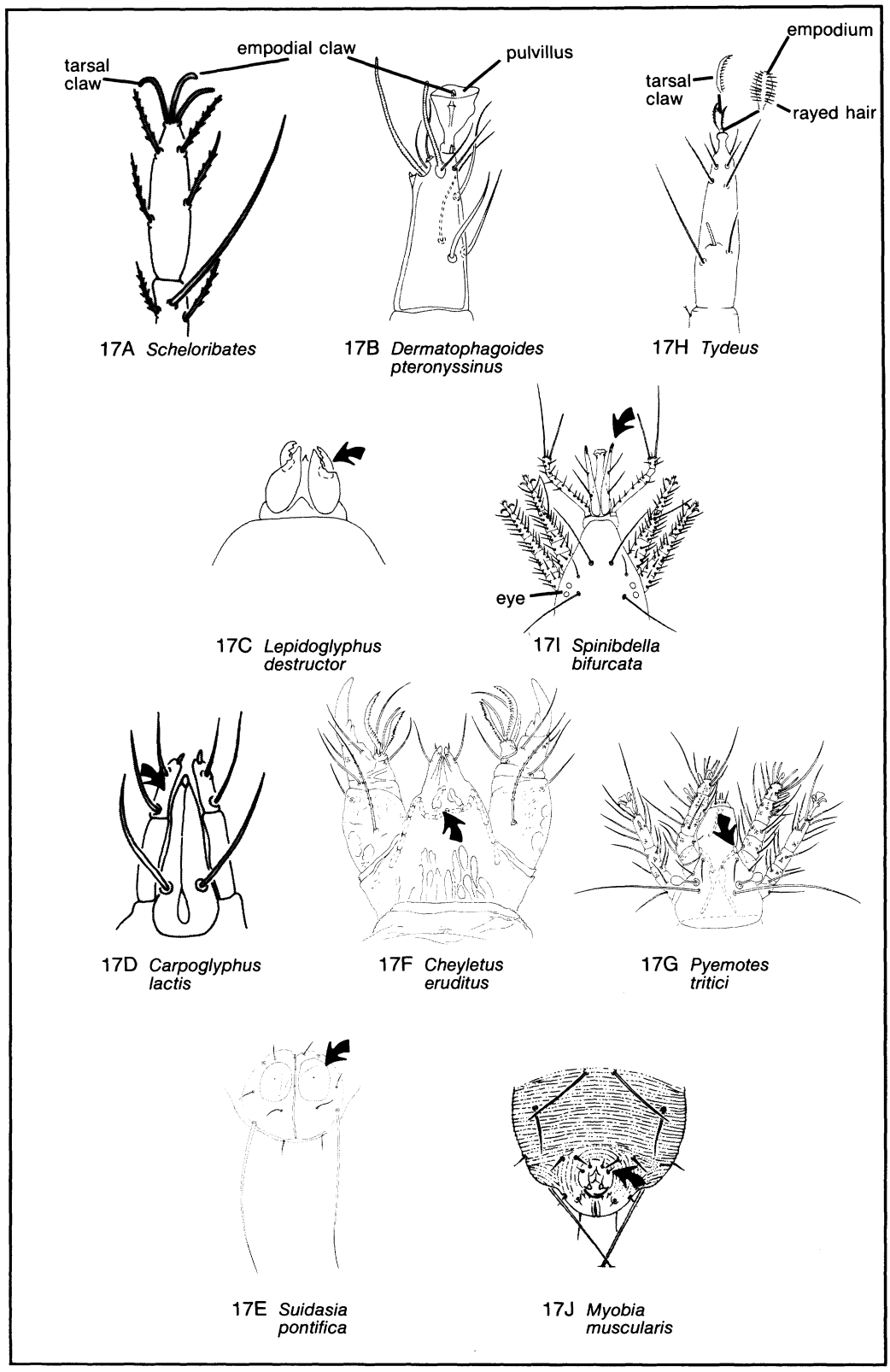
17 Stigmata absent (as in all Astigmata) or present (as in some Cryptostigmata), but if present, never opening between bases of chelicerae or on shoulders of anterior propodosoma ---------- 18

Since stigmata are always difficult to see in the Cryptostigmata (hence the name of this suborder) and are sometimes difficult to see in the Prostigmata, some additional characters are given here to help the reader sort out the Astigmata, Cryptostigmata, and Prostigmata. Astigs and cryptostigs are characterized by the following: Adults always with 4 pairs of legs; tarsal claw present (17A), without tenent hairs; empodium usually present, often clawlike (17A) (claw may be very small, as in 17B) and sometimes surrounded by a suckerlike pulvillus (17B); empodium never with tenent hairs (17A, 17B); chelicera seldom hooklike or styletiform, usually strong, chelate, and dentate (17C); palpus sometimes with retrorse teeth but never with a thumb-claw complex or strong claw (17D); ventral metapodosoma (opisthogaster) sometimes with claspers or anal plate suckers (17E); hypopodes sometimes present (pl. 17A&C, 18B, 19B, 20A, 23, 25).

Stigmata present and opening either between bases of chelicerae (17F) or on shoulders of propodosoma (17G). Suborder Prostigmata (prostigmatid mites)---- 47

Adults with 2 to 4 pairs of legs; tarsal claw, if present, sometimes with tenent or rayed hairs (17H); empodium, if present, usually clawlike or padlike (17H), usually with tenent or rayed hairs (17H), and not surrounded by a suckerlike pulvillus (if any structure resembling a suckerlike puvillus is present, then a clawlike empodium is absent); chelicera usually hooklike or styletiform (17I), rarely strong, chelate, and dentate; palpus without retrorse teeth, but sometimes with a strong claw (17F) or thumb-claw complex; ventral metapodosoma without claspers or anal plate suckers (17J); hypopodes absent.

17J adapted from *3*.



17A *Scheloribates*

17B *Dermatophagoides pteronyssinus*

17H *Tydeus*

17C *Lepidoglyphus destructor*

17I *Spinibdella bifurcata*

17D *Carpoglyphus lactis*

17F *Cheyletus eruditus*

17G *Pyemotes tritici*

17E *Suidasia pontifica*

17J *Myobia muscularis*

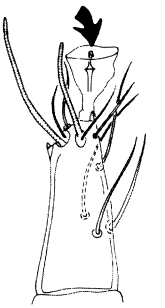
18 Integument usually strongly sclerotized; empodium, if present, clawlike, not borne on pretarsus (18A); sensory setae (sensilla or prodorsal trichobothria) present on propodosoma (18B); genital opening longitudinal (18C) (not shaped like an inverted U, Y, or V) and usually flanked by 3 pairs of genital discs; genital (18C) and anal (18D) openings similar in shape and covered by trapdoorlike valves; pl. 11A ---------- beetle mites, oribatid mites, Suborder Cryptostigmata

Sexes usually homomorphic. Oribatid mites are widely distributed in soils around the world. Only a few species have been found (and then only infrequently) in food-storage facilities or in stored or processed foods, notably mushrooms or foods that were moldy or out-of-condition. Among these are *Aphelacarus acarinus, Phauloppia lucorum, Scheloribates laevigatus,* and *Trichoribates novus.*

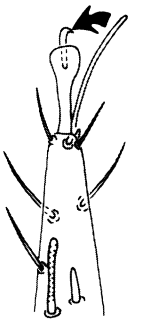
Integument weakly sclerotized, if at all; empodium clawlike (18E, 18F), often borne on pretarsus; sensory setae absent from propodosoma (18G); genital opening transverse or shaped like an inverted U, V (18H), or Y (18I), and usually flanked by 2 pairs of genital discs; genital (18H, 18I) and anal (18J, 18K) openings not similar in shape. Suborder Astigmata (astigmatid mites) ---------- 19

Sexes homomorphic or heteromorphic.

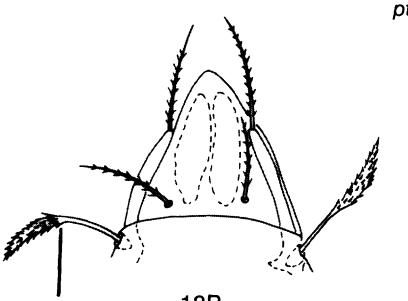
18A



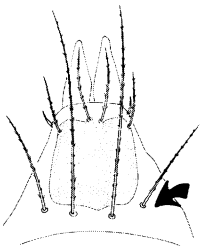
18E *Dermatophagoides pteronyssinus*



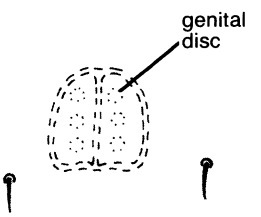
18F *Gohieria fusca*



18B

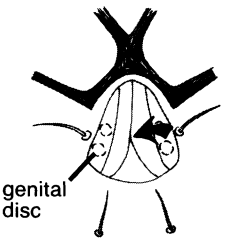


18G *Tyrophagus putrescentiae*

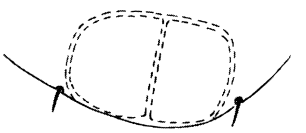


18C

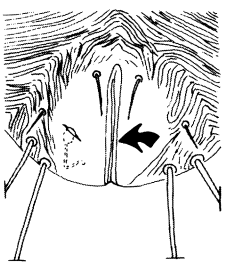
18H



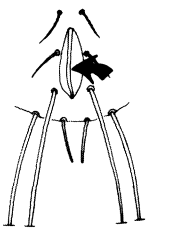
18I



18D *Scheloribates* (A-D)



18J *Dermatophagoides farinae* (H&J)



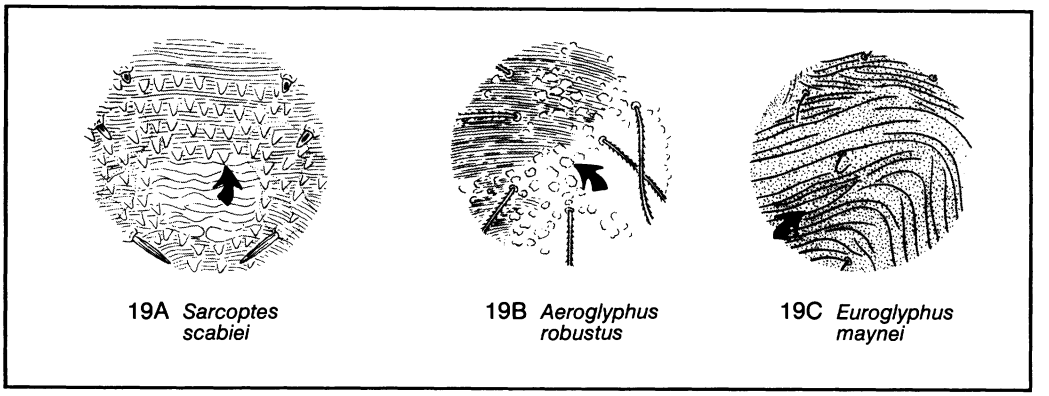
18K *Carpoglyphus lactis* (I&K)

Suborder Astigmata

19 Integumental striae of dorsal hysterosoma broken by spinelike projections (19A); pl. 11B. Sarcoptidae (sarcoptid mites)---------- **itch mite,** *Sarcoptes scabiei*

Distribution: cosmopolitan. Food habits: skin parasite of mammals.
19A adapted from *3*, 19B from *2*, and 19C from *10*.

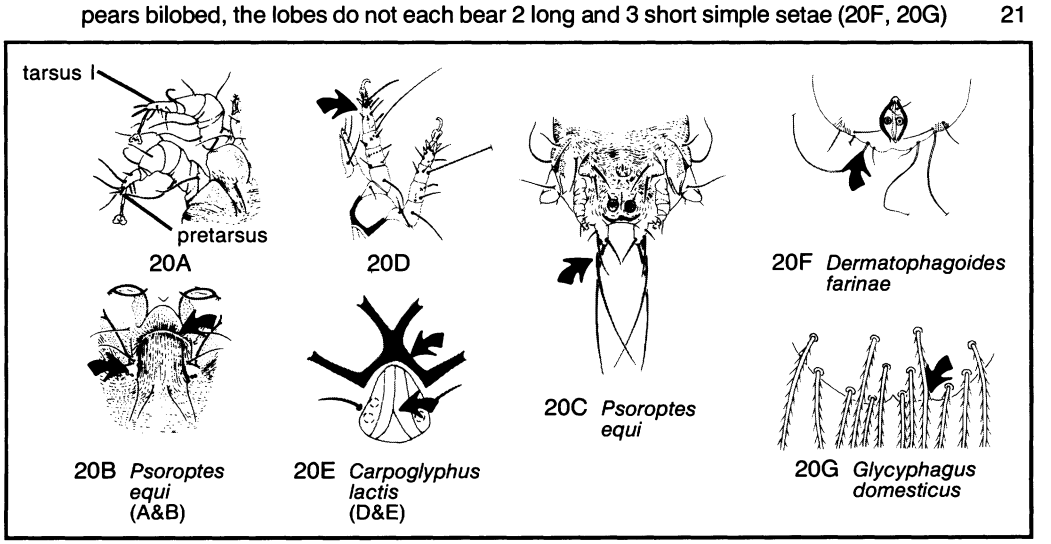
Integumental striae not broken by spinelike projections—surface may be warty (19B), smooth, or granular (19C) ---------- 20



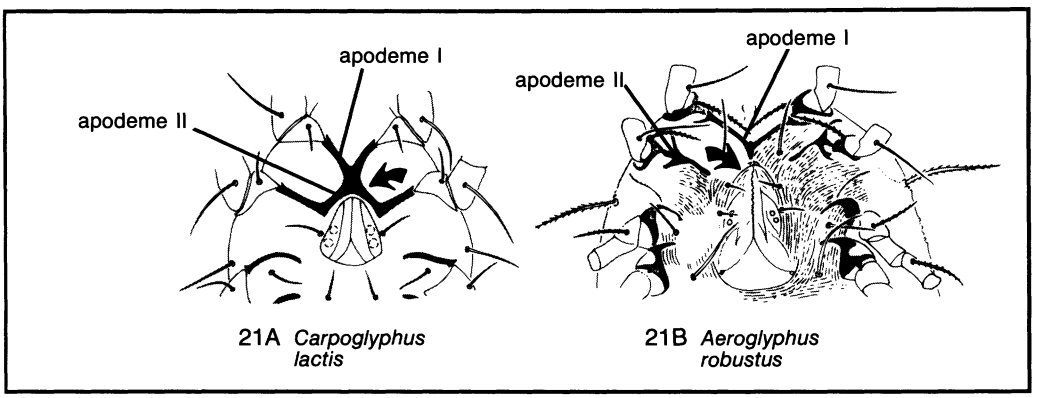
20 Legs I and II clawlike (i.e., the whole leg functions as a claw) and terminating in long pretarsi (20A); tarsi I and II heavily sclerotized (20A); genital opening of female shaped like an inverted U (20B) and flanked by sclerotized genital apodemes; opisthosoma of male bilobed, each lobe bearing 2 long simple setae and 3 short simple setae (20C); pl. 12. Psoroptidae (**scab mites**)
---------- **scab mite,** *Psoroptes equi*

Distribution: cosmopolitan. Food habits: skin parasites of mammals.
20A-C adapted from *3*.

Legs I and II neither clawlike nor terminating in long pretarsi; tarsi I and II lightly sclerotized (20D); genital opening of female not shaped like an inverted U (20E); sclerotized genital apodemes present (20E) or absent; if posterior end of male appears bilobed, the lobes do not each bear 2 long and 3 short simple setae (20F, 20G) 21



21 Apodemes I and II fused with sternum and surrounding anterior end of genital plate (21A) ---------- 22
Apodeme II not fused with sternum and not adjoining anterior end of genital plate (21B) 23



21A *Carpoglyphus lactis*

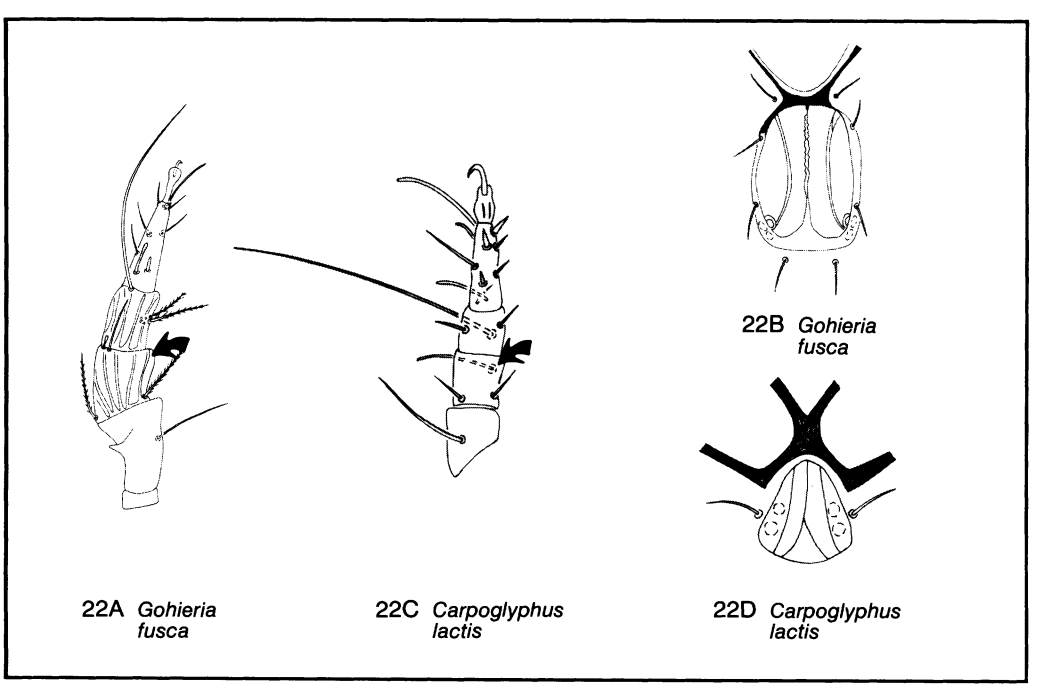
21B *Aeroglyphus robustus*

22 Genua and tibiae I to IV with sclerotized ridges (22A); epigynial shield subrectangular (22B); pl. 13A. Glycyphagidae (**glycyphagid mites**) (in part)
---------- **brown flour mite,** *Gohieria fusca*

Distribution: cosmopolitan. Food associations: often in flour and in many other kinds of stored food.

Genua and tibiae I to IV without sclerotized ridges (22C); epigynial shield subtriangular (22D); pl. 13B. Carpoglyphidae (**driedfruit mites**)
---------- **driedfruit mite,** *Carpoglyphus lactis*

Distribution: Argentina, Europe, North America; probably cosmopolitan. Food associations: foods containing sugar.



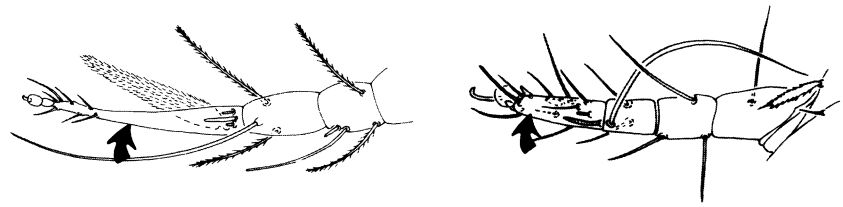
22A *Gohieria fusca*

22B *Gohieria fusca*

22C *Carpoglyphus lactis*

22D *Carpoglyphus lactis*

23 Tarsi I to IV slender, and more than twice as long as adjacent tibiae (23A). Glycyphagidae (**glycyphagid mites**) (in part) ---------- 24
Tarsi I to IV stout, and usually not more than twice as long as adjacent tibiae (23B) ------- 26



23A *Lepidoglyphus destructor* 23B *Suidasia nesbitti*

24 Dorsal idiosoma with conspicuous wartlike tubercles (24A); cuticle at least partially striate (24A); pl. 14 ---------- **warty grain mite,** *Aeroglyphus robustus*

Distribution: North America. Food: stored grains, grain products, and dried fish products. 24A adapted from 2.

Dorsal idiosoma without wartlike tubercles (24B) (but small triangular spicules may be present); cuticle without striations (24B) ---------- 25

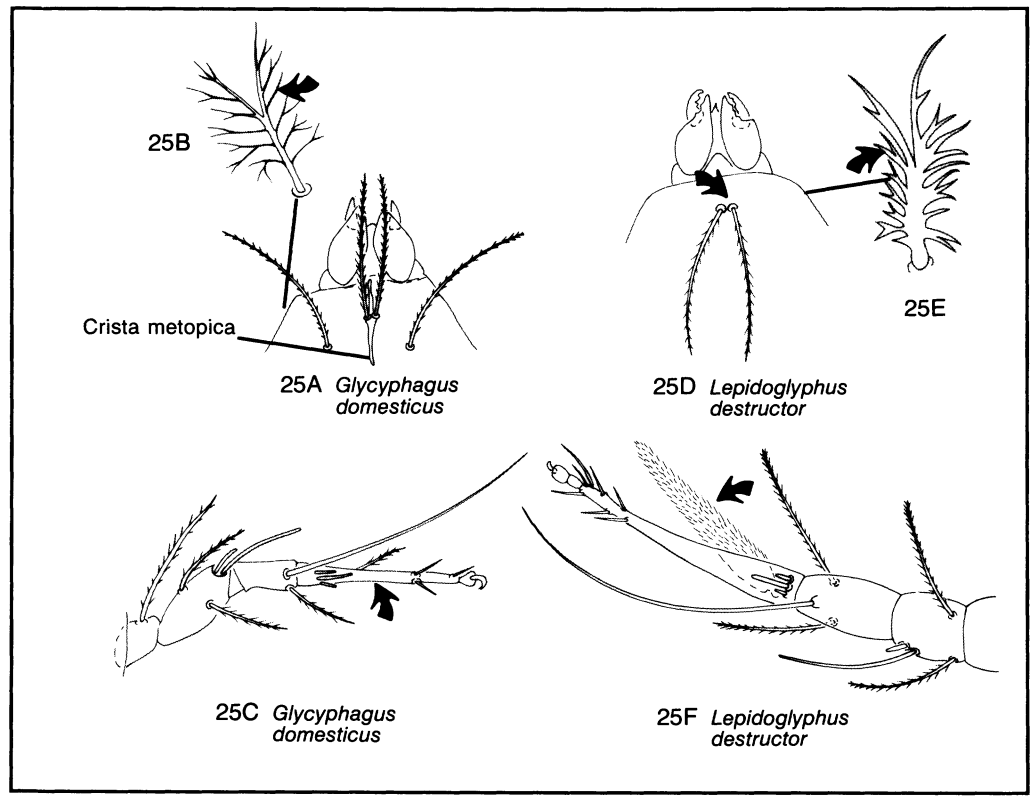
24A *Aeroglyphus robustus* 24B *Glycyphagus domesticus*

25 Crista metopica (prodorsal sclerite) present (25A); supracoxal seta with slender branches (25B); leg I without tarsal scale (25C) ---------- *Glycyphagus*

The **house mite,** *Glycyphagus domesticus* (pl. 15), is representative of this genus. *G. domesticus* is widely distributed around the world and is associated with numerous kinds of stored foods and with fungi.

Crista metopica absent (25D); supracoxal seta with stout branches (25E); leg I with tarsal scale (25F) ---------- *Lepidoglyphus*

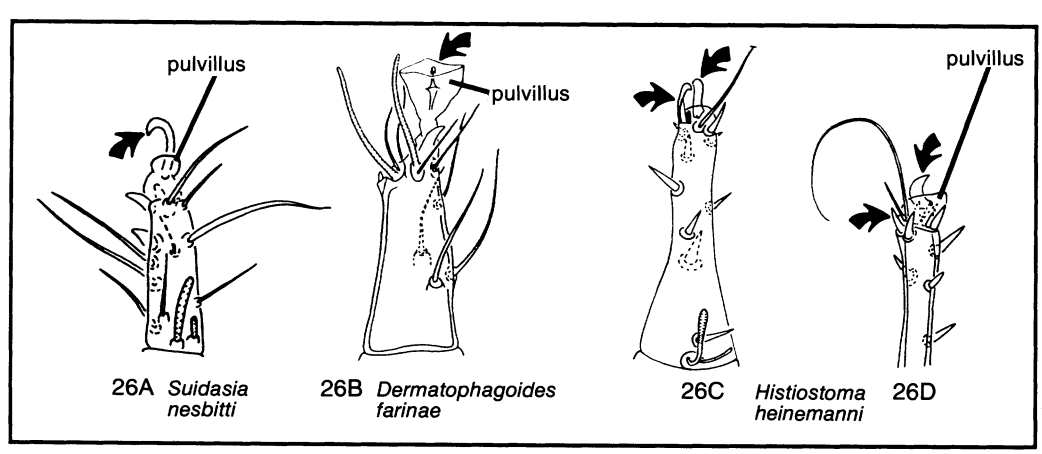
Lepidoglyphus destructor, one of the more common mites associated with stored food, is representative of this genus. This species is cosmopolitan in distribution. It has been found on many kinds of stored foods and on fungi.



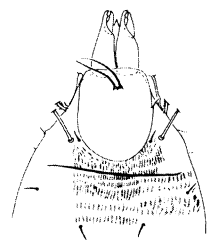
26 Tarsal tip bearing a large and conspicuous clawlike empodium associated with a pulvillus of variable size (26A); metapodosomal venter without prominent, strongly-sclerotized, ringlike structures ---------- 27

Tarsal tip bearing a minute claw surrounded by a conspicuous discoid or bell-shaped pulvillus (26B), and metapodosomal venter without prominent, ringlike structures (as in 42D); or tip of tarsus I bearing a large, clawlike empodium (26C, 26D), and metapodosomal venter with prominent, strongly-sclerotized, ringlike structures (see 42B) ---------- 42

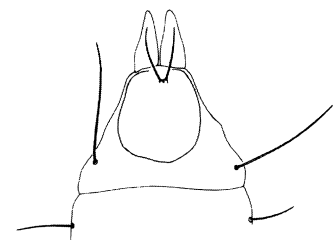
26C&D adapted from *15*.



27 Dorsal idiosoma patterned (27A). Acaridae (**acarid mites**) (in part) ---------- 28
Dorsal idiosoma unpatterned (27B) ---------- 29



27A *Suidasia nesbitti*



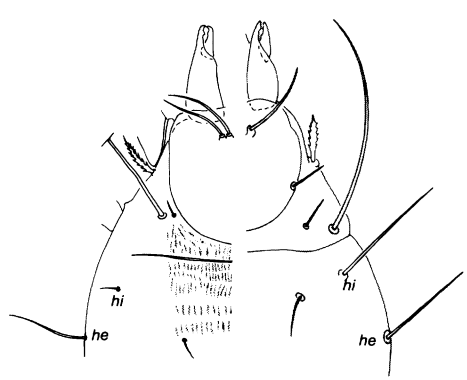
27B *Thyreophagus entomophagus*

28 Female with *hi* (apical dorsolateral seta of hysterosoma) shorter than *he* (humeral seta) (28A) and with anal region subcircular (28B); male without anal suckers (28C); pl. 16 ---------- **scaly grain mite,** *Suidasia nesbitti*

Distribution: Africa, Europe, North America. Foods: wheat bran, rice.

Female with *hi* as long as or longer than *he* (28D) and with anal region circular (28E); male with anal suckers (28F) ---------- *Suidasia pontifica*

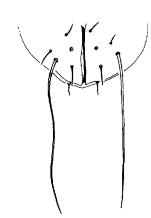
Distribution: Africa, Europe, Puerto Rico, Sumatra. Foods: copra, cowpeas, peanuts, rice bran. Synonym: *Suidasia medanensis* Oudemans.



28A *Suidasia nesbitti* 28D *Suidasia pontifica*

28B

28E



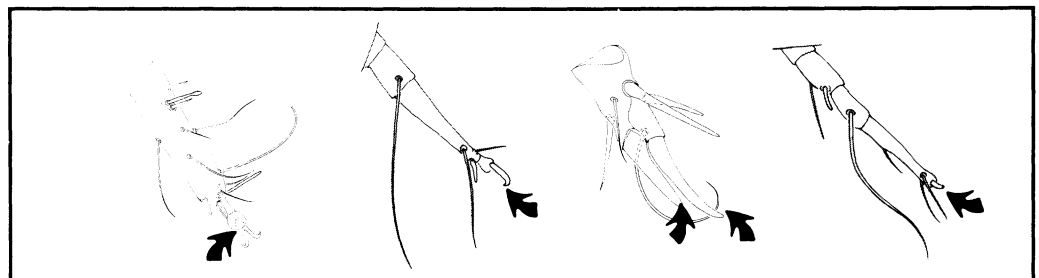
28C *Suidasia nesbitti* (B&C)

28F *Suidasia pontifica* (E&F)

29 Tarsal claws I to IV of female bifurcate (29A); tip of tarsus III of male with 2 large spines (29B). Lardoglyphidae (lardoglyphid mites). Genus *Lardoglyphus*---------- 30

Tarsal claws I and II of male bifurcate. See Olsen (*H001* in chapter 28) on *L. angelinae* for a key to separate this species from *L. konoi* and *L. zacheri*. References: *23, 28*.

Tarsal claws of female simple (29C); tip of tarsus III of male with a simple claw (29D). Acaridae (**acarid mites**) (in part)---------- 31



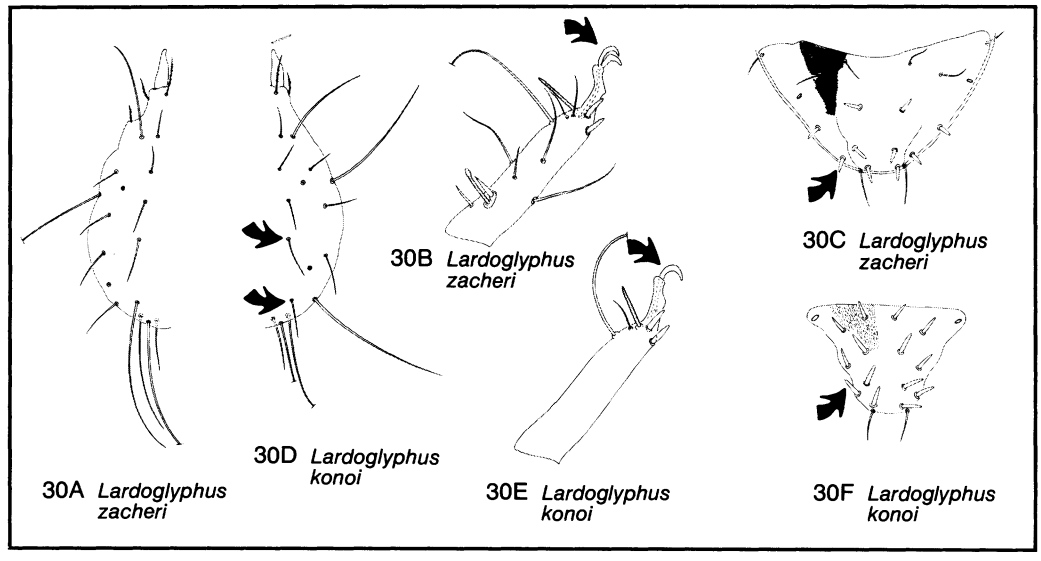
29A *Lardoglyphus zacheri* 29C *Acarus siro* 29B *Lardoglyphus zacheri* 29D *Acarus farris*

30 Seta d_4 more than 3 times as long as d_3 (30A); tarsi I (30B) and II male with bifurcate claws; hysterosomal shield of hypopus with 10 spines (30C); pl. 17A&B ----------*Lardoglyphus zacheri*

Distribution: Australia, Europe, Mexico, South America, United States. Food associations: slaughterhouse by-products and wastes; moldy cheese.

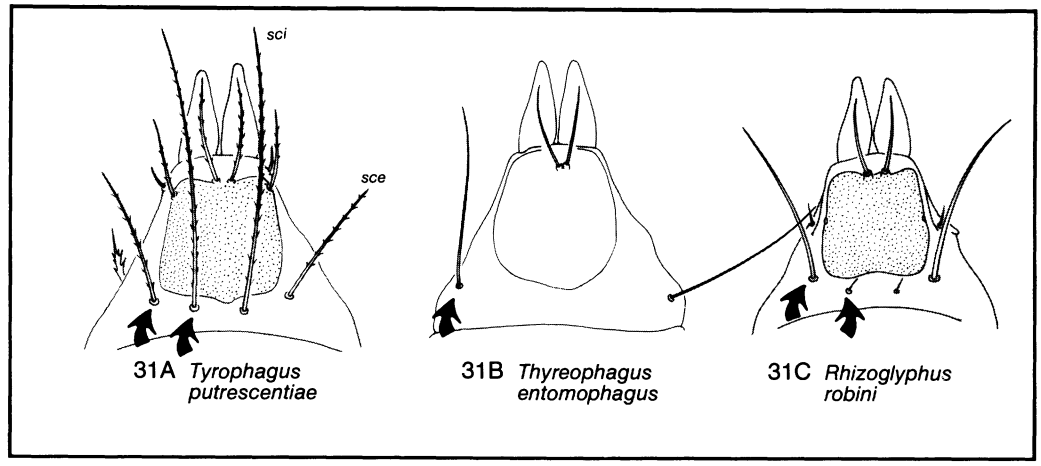
Seta d_4 subequal in length to d_3 (30D); tarsi I (30E) and II of male with simple claws; hysterosomal shield of hypopus with 14 spines (30F); pl. 17C-------- *Lardoglyphus konoi*

Distribution: Europe, India, Japan, Kenya, United States. Foods: dried and salted fish, dried meat.



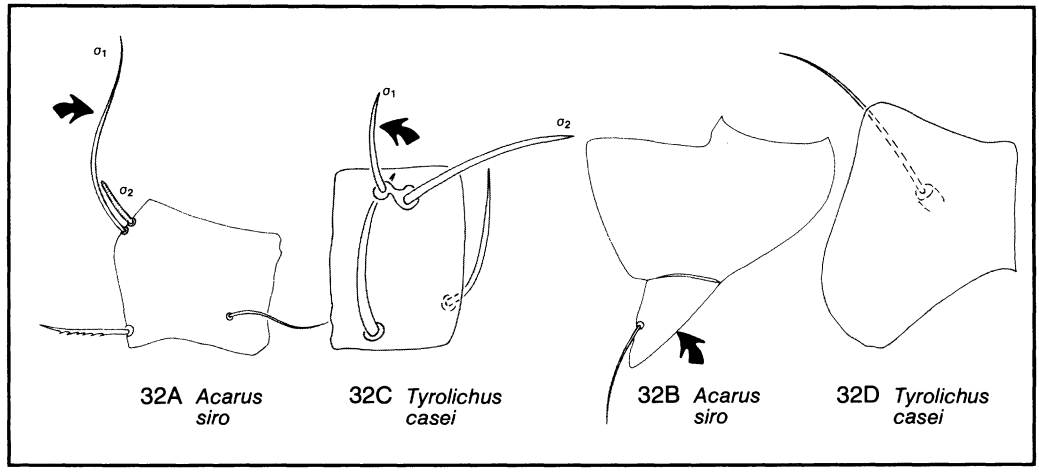
30A *Lardoglyphus zacheri* 30D *Lardoglyphus konoi* 30B *Lardoglyphus zacheri* 30E *Lardoglyphus konoi* 30C *Lardoglyphus zacheri* 30F *Lardoglyphus konoi*

31 Inner proximal seta (*sci*) approximately as long as or longer than outer proximal seta (*sce*) (31A)---------- 32
Inner proximal seta absent (31B) or much shorter than outer seta (31C) ---------- 37



32 Solenidion σ_1 on genu I more than 3 times longer than σ_2 (32A); femur I of male enlarged, with a ventral conical process (32B). Genus *Acarus*---------- 33
Solenidion σ_1 on genu I less than 3 times longer than σ_2 (32C); femur I of male not enlarged and not bearing a ventral conical process (32D) ---------- 35

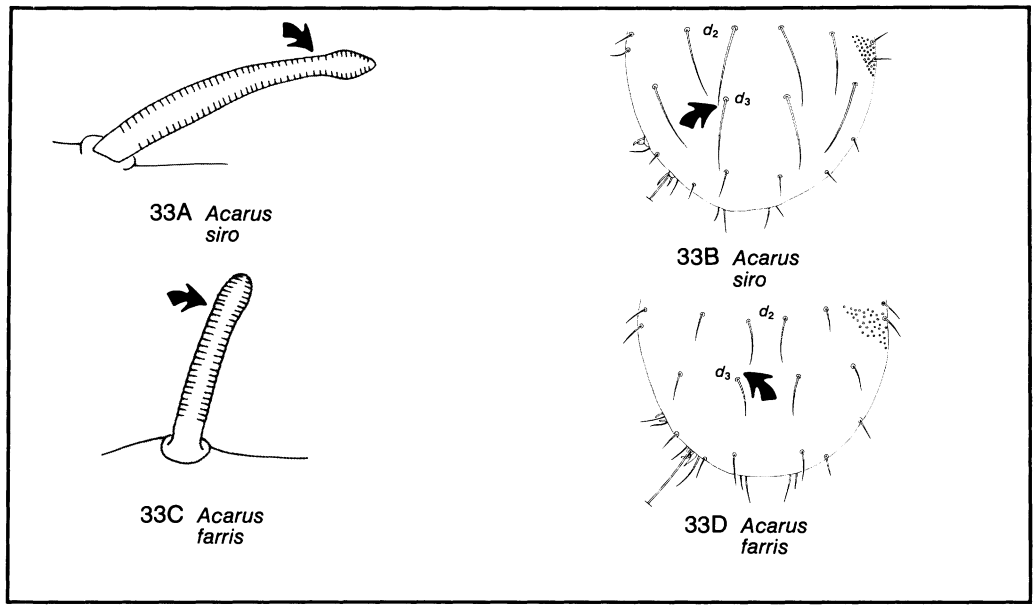
See references *12* and *13* for setal terminology as applied to the Acaridae.



33 Solenidion ω_1 of tarsus II recumbent, with a distinct constriction proximal to terminal expansion (33A); seta d_2 of hypopus extending beyond base of d_3 (33B); pl. 18
---------- **grain mite,** *Acarus siro*

Distribution: cosmopolitan. Foods: processed grains, fungi.

Solenidion ω_1 of tarsus II not recumbent and without a distinct constriction (33C); seta d_2 of hypopus not extending beyond base of d_3 (33D) ---------- 34

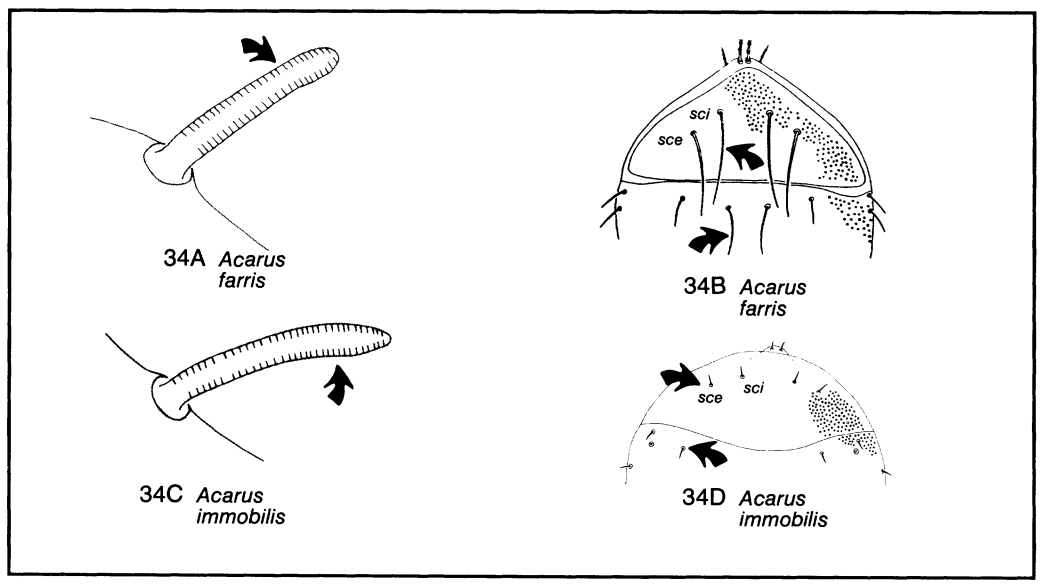


34 ω_1 of tarsus II with sides expanding gradually from base, then narrowing to an indistinct neck before expanding into a terminal head; width of widest part of head equal to width of stem (34A); setae *sci* and *sce* of hypopus about 2 times as long as hysterosomal setae (34B); pl. 19----------*Acarus farris*

Distribution: East Africa, Europe, United States. Foods: cheese; grains in the field.

ω_1 with sides almost parallel and with a distinct egg-shaped head that is wider at its widest part than any part of the stem (34C); setae *sci* and *sce* of hypopus subequal in length to hysterosomal setae (34D); pl. 20A---------- *Acarus immobilis*

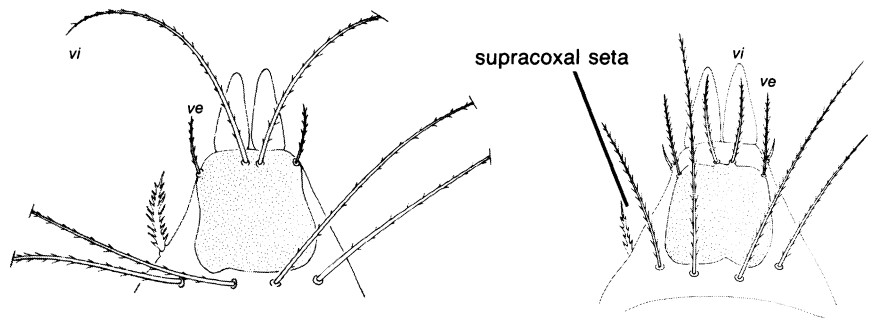
Distribution: Europe, United States. Foods: farm-stored grains; cheese. Couplets 32-34 adapted from *13, 18.*



35 Seta *vi* more than 4 times longer than seta *ve* (35A); pl. 20B ----------**cheese mite,** *Tyrolichus casei*

Distribution: cosmopolitan. Foods: many stored foods, including cheese.

Seta *vi* less than 3 times as long as seta *ve* (35B). Genus *Tyrophagus* ---------- 36



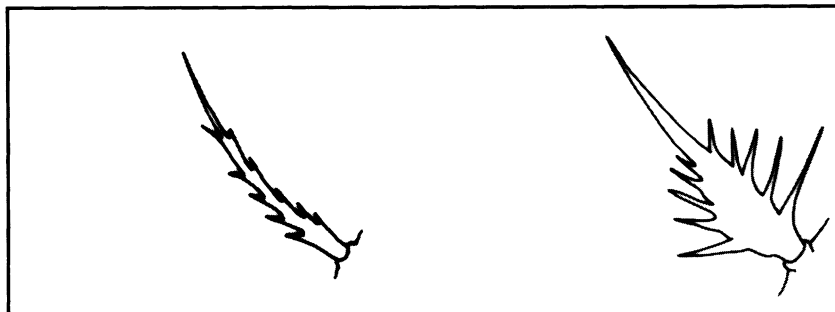
35A *Tyrolichus casei* 35B *Tyrophagus longior*

36 Supracoxal seta (see 35B) slender, with short, stout spicules (36A); seta d_2 not surpassing base of d_3 (pl. 21A)----------*Tyrophagus longior*

Distribution: cosmopolitan. Foods: cheese, grains, and many other stored foods.

Supracoxal seta stout, bulbous, with long, slender spicules (36B); seta d_2 extending well beyond base of d_3 (pl. 21B)---------- **mold mite,** *Tyrophagus putrescentiae*

Distribution: cosmopolitan. Foods: fungi; foods with high protein and fat content (dried eggs, cheese, copra, nuts, flour and many other stored foods). Another species, *T. tropicus,* which has been found in copra and rice, would also key out at this point. *T. tropicus* has been collected in Africa, Europe, New Britain, and the United States. According to Hughes (*18*), *T. tropicus* differs from *T. putrescentiae* in having seta *la* almost twice as long as d_1 (*la* and d_1 are subequal in length in *T. putrescentiae*).

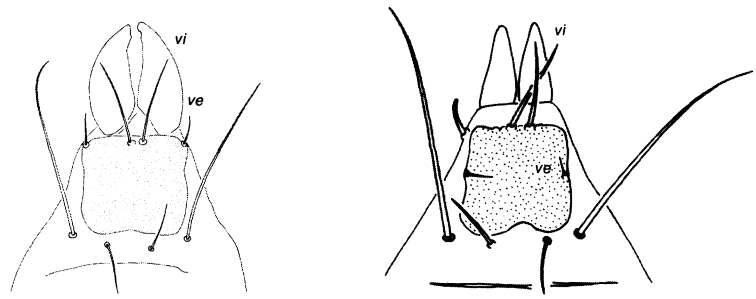


36A *Tyrophagus longior* 36B *Tyrophagus putrescentiae*

37 Seta *ve* nearly level with *vi* (37A)----------**brownlegged grain mite,** ***Aleuroglyphus ovatus***

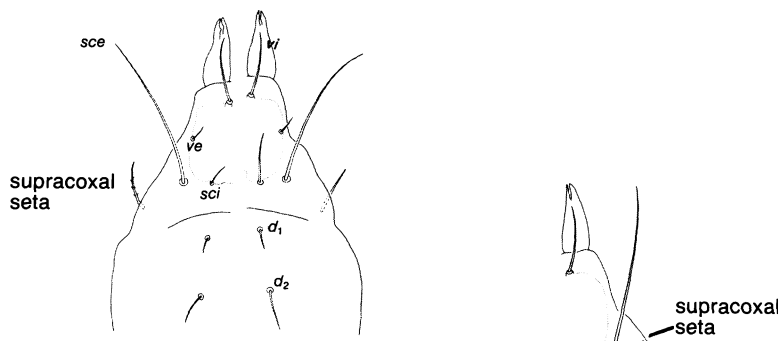
Distribution: Europe, Japan, North America, Russia.
Foods: probably feeds on fungi associated with wheat, bran, flour, chicken meal, and dried fish products.

Seta *ve* absent (see 31B) or, if present, then not on a level with *vi* (37B; see also 31C)---- 38

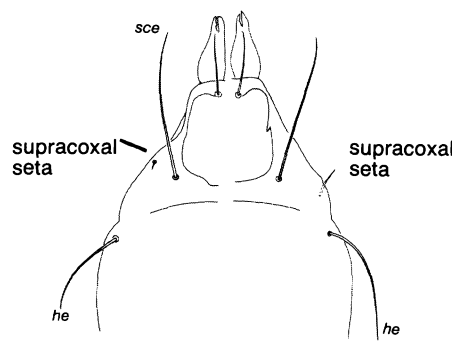


37A *Aleuroglyphus ovatus* 37B *Caloglyphus*

38 Setae *sci*, d_1-d_5 present (38A, 38B)---------- 39
Setae *sci*, d_1, d_2, and d_5 absent (38C, 38D, 38E)---------- 40



38A *Rhizoglyphus* 38B *Caloglyphus* 38E *Schwiebia*



38C *Histiogaster* 38D *Thyreophagus*

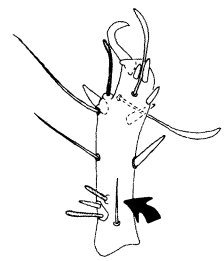
39 Tarsus I with a large, spinelike seta adjacent to ω_1 and ω_2 (39A)---------- *Rhizoglyphus*

Members of this genus are sometimes called bulb mites. They are associated with decaying plant and animal matter. Three species, *R. robini* (pl. 22B, 23), *R. echinopus,* and *R. callae,* all widely distributed, have been mentioned in the literature as potential food contaminants. References: *18, 21.*

Tarsus I with a simple seta adjacent to ω_1 and ω_2 (39B)---------- *Caloglyphus*

C. [= *Sancasania*] *berlesei* (pl. 24), a virtually cosmopolitan species, feeds on fungi associated with damp, out-of-condition foods. Reference: *18.*

39A *Rhizoglyphus*



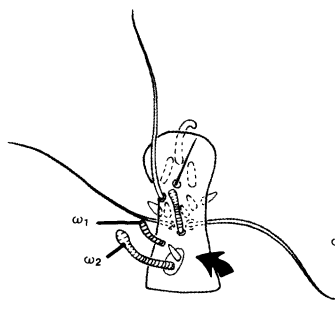
39B *Caloglyphus*

40 Tarsus I without spinelike seta in front of ω_1 and ω_2 (40A) ---------- *Thyreophagus entomophagus*

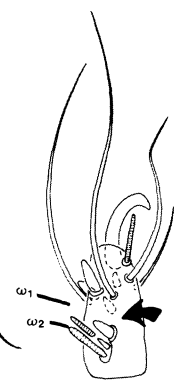
Opisthosomal shield of male simple (unlobed) (40B). Distribution: Europe, North America. Foods: flour, dried insects.

Tarsus I with spinelike seta (*ba*) in front of ω_1 and ω_2 (40C) ---------- 41

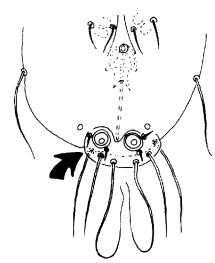
Opisthosomal shield of male, when present, with 4 lobes (40D).



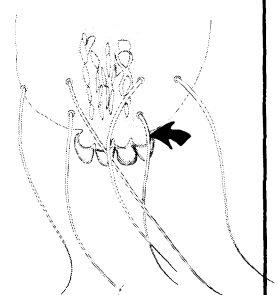
40A *Thyreophagus entomophagus*



40C *Histiogaster*



40B *Thyreophagus entomophagus*



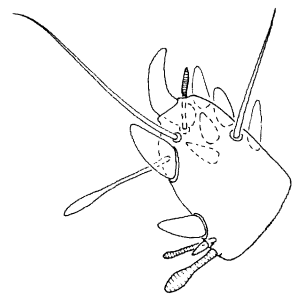
40D *Histiogaster*

41 Tarsus I short and stubby, about as long as wide (41A); opisthosomal shield absent from male---------- *Schwiebia*

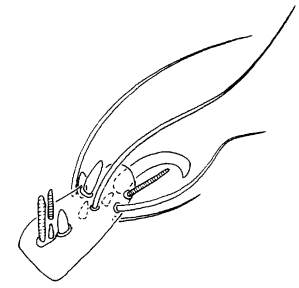
Distribution: cosmopolitan. Foods: cottonseed meal, ginger (rotting), taro, yams. Reference: see Manson (*C009*) in chapter 28.

Tarsus I elongate, more than twice as long as wide (41B); opisthosomal shield present on male (see 40D)---------- *Histiogaster*

Distribution: Europe, Hong Kong, North America. Foods: dried fish, tomatoes; also found in wine. Reference: see Woodring (*C018*) in chapter 28.



41A *Schwiebia*



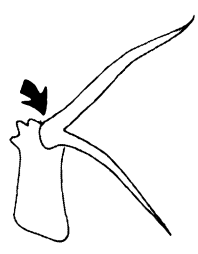
41B *Histiogaster*

42 Palpal tarsus with apical sensillae forming a V-shaped process (42A); metapodosomal venter with prominent, strongly-sclerotized, ringlike structures (42B); hypopodial stage present (pl. 25)---------- histiostomatid mites, Histiostomatidae

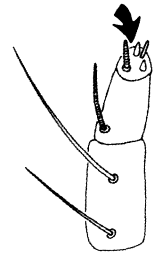
Some members of this family are associated with the production of cultivated mushrooms. *Histiostoma heinemanni* (pl. 25-27) is typical of the family.
42B adapted from *15*.

Palpal tarsus without V-shaped process (42C); metapodosomal venter without ringlike structures (genital papillae may be present, as in 42D, but they are small and weakly sclerotized); hypopodial stage absent. Pyroglyphidae (pyroglyphid mites)---------- 43

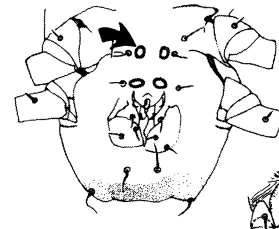
References: *5, 10, 11*.



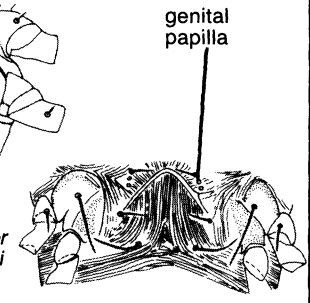
42A *Histiogaster heinemanni*



42C *Dermatophagoides farinae*



42B *Histiogaster heinemanni*

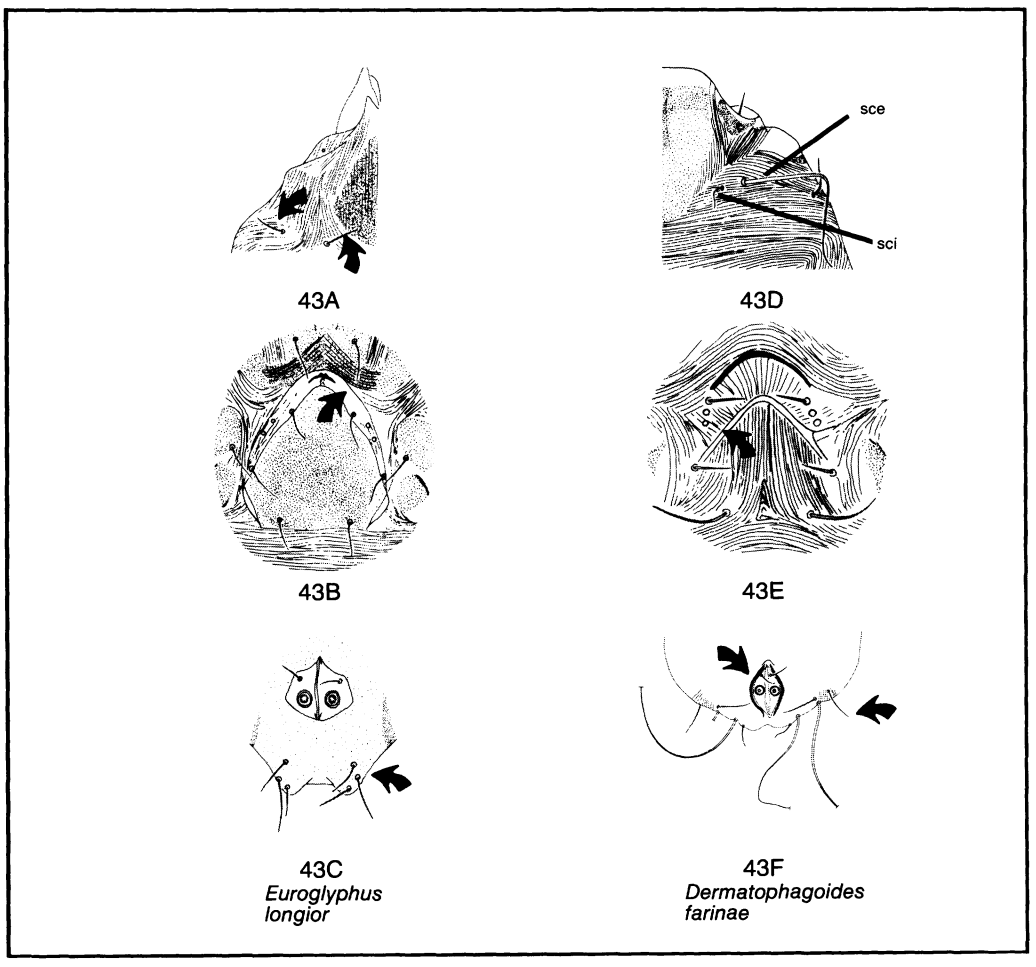


42D *Dermatophagoides farinae*

43 Seta *sce* as long as *sci* (43A); vulva covered with a membrane (43B); posterior margin of idiosoma of male with 3 to 6 setae (43C); anal sucker plate not surrounded by sclerotized arcs (43C). Genus *Euroglyphus* ---------- 44

Seta *sce* at least 5 times longer than *sci* (43D); vulva not covered with a membrane (43E); posterior margin of idiosoma of male with 10 setae (43F); anal sucker plate surrounded by sclerotized arcs (43F). Genus *Dermatophagoides* ---------- 45

The species of *Dermatophagoides* considered here are associated with "house dust."
43A-C adapted from *10;* 43D from *11.*



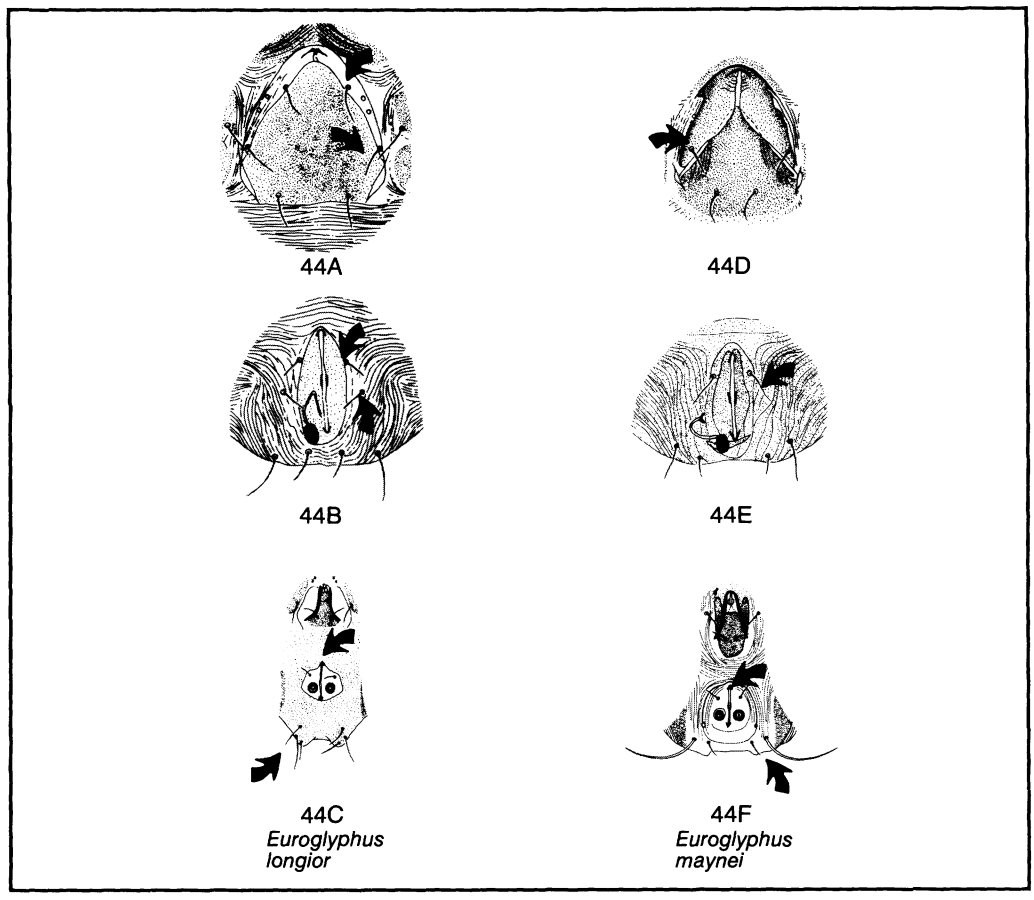
44 Genital sclerite with 2 pairs of setae (44A); with 2 pairs of setae near anal aperture (44B); anal plate of male pointed and located approximately equidistant between genital plate and posterior margin of opisthosoma (44C); ventral opisthosoma of male with 3 pairs of setae near posterior margin (44C); pl. 28, 29 ---------- *Euroglyphus longior*

Distribution: England, France, Sweden, United States (Ohio). Food: granary debris.

Genital sclerite with 1 pair of setae (44D); with 1 pair of setae near anal aperture (44E); anal plate of male rounded and located closer to the posterior margin of

body than to the genital plate (44F); ventral opisthosoma of male with 2 pairs of setae near posterior margin (44F); pl. 30, 31----------*Euroglyphus maynei*

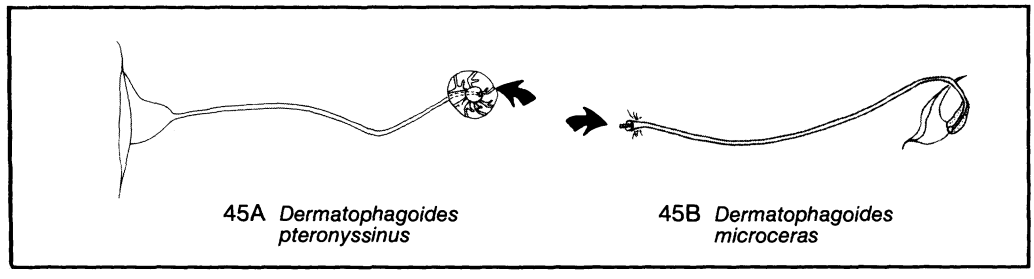
Distribution: Europe, Japan. Substrates: decomposing cottonseed oil; house dust.
44A-F adapted from *10*.



45 Seminal receptacle of bursa copulatrix (see pl. 32) with daisylike sclerotized base (45A) ----------**European house dust mite,** *Dermatophagoides pteronyssinus*

Distribution: essentially cosmopolitan. See also couplet illustration 17B.

Base of seminal receptacle not daisylike in shape (45B)---------- 46

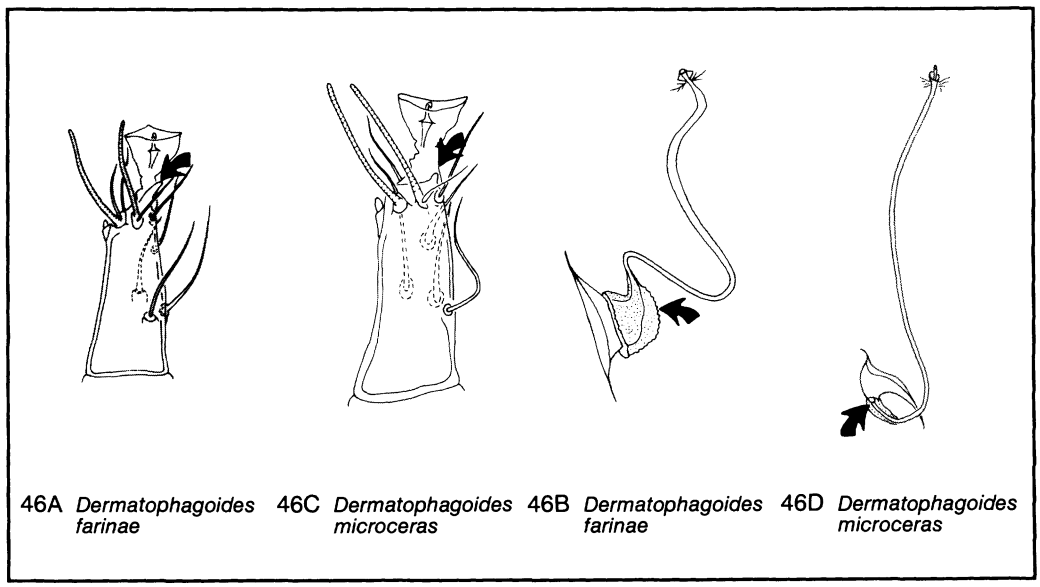


46 Sclerotized process at apex of tarsus I large and sharp (46A); bursa copulatrix heavily sclerotized (46B); pl. 32----------**American house dust mite,** *Dermatophagoides farinae*

Distribution: England, Japan, Netherlands, Russia, Sierra Leone, United States.

Sclerotized process at apex of tarsus I small and blunt (46C); bursa copulatrix lightly sclerotized (46D)----------*Dermatophagoides microceras*

Distribution: England, Spain, United States (Louisiana).



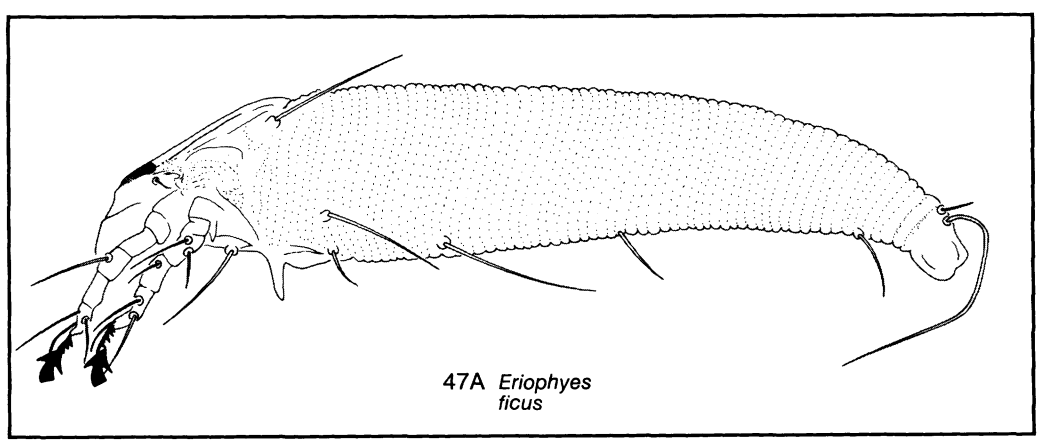
46A *Dermatophagoides farinae* 46C *Dermatophagoides microceras* 46B *Dermatophagoides farinae* 46D *Dermatophagoides microceras*

Suborder Prostigmata

47 With 2 pairs of legs (47A) ----------eriophyoid mites, Eriophyoidea

The **fig mite,** *Eriophyes ficus* (47A) (Eriophyidae), is representative of this superfamily. Eriophyoids are phytophagous and cosmopolitan. They are variously called bud mites, gall mites, blister mites, or rust mites, depending on where they locate in the host or on the kind of reaction they cause in the host (*20*).

With 3 (pl. 33A) or 4 (pl. 33B) pairs of legs ---------- 48



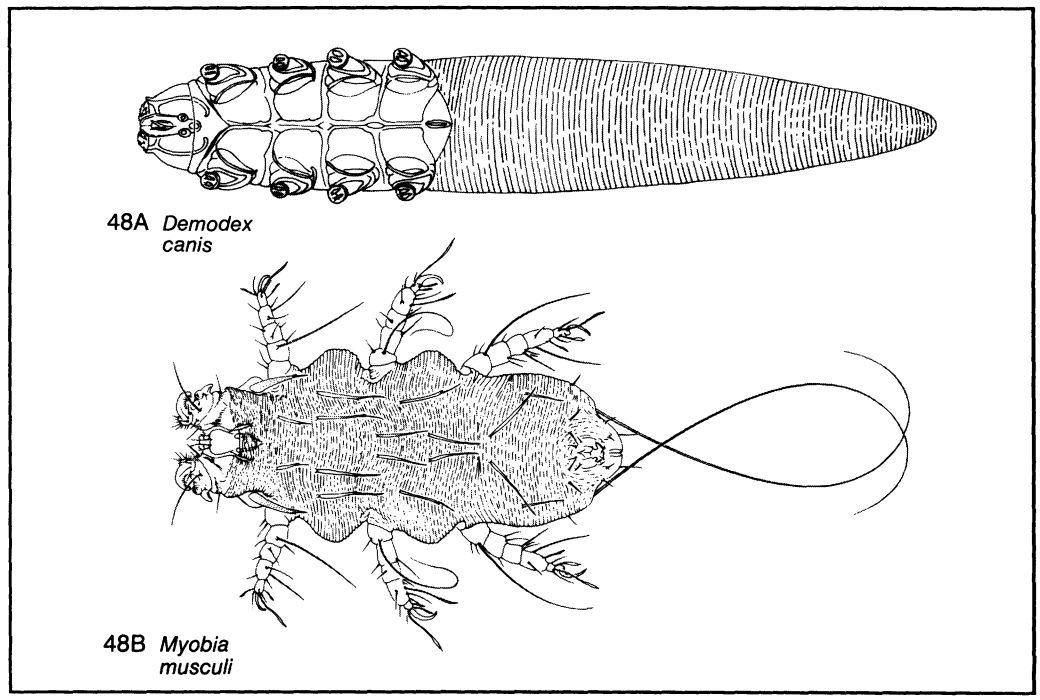
47A *Eriophyes ficus*

48 Body wormlike (48A) ---------- **follicle mites,** Demodicidae

The **dog follicle mite,** *Demodex canis* (48A), is representative of the many host-specific demodicids that parasitize many kinds of mammals. Most follicle mites have all 4 pairs of legs short and stubby. Nematalycid mites (Nematalycidae) are also wormlike in form but they have long legs. They are widely distributed in soils around the world (*20*).

48A&B redrawn by C. Feller from *3* and *1*, respectively.

Body not wormlike (48B) ---------- 49



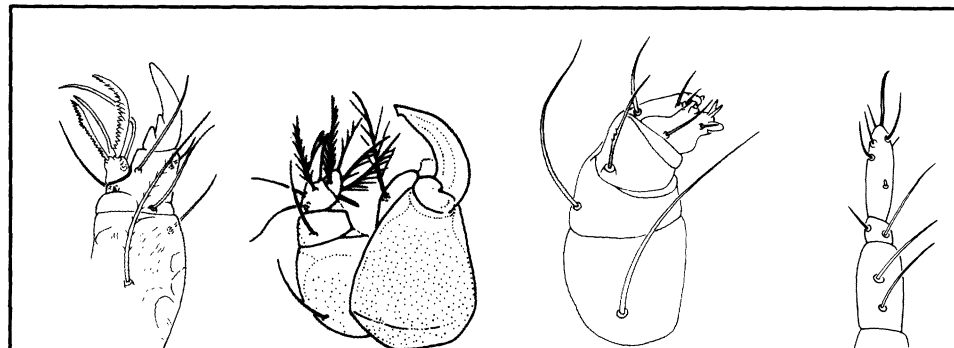
48A *Demodex canis*

48B *Myobia musculi*

49 Palpal tarsus with thumb-claw complex (49A-C) ---------- 50

49C adapted from *3*.

Palpal tarsus without thumb-claw complex (49D) ---------- 54



49A *Cheyletus eruditus*

49B *Leptotrombidium akamushi* (larva)

49C *Byrobia praetiosa*

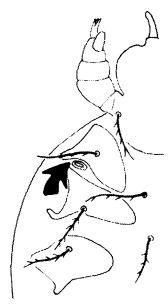
49D *Tydeus*

50 Larva with urstigma (Claparède organ) (50A); adult with crista metopica (50B; see also 50C)----------Trombidioidea

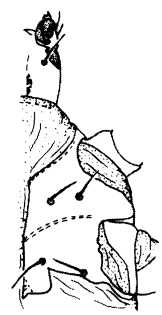
Although it is possible that other members of this superfamily might become associated with food, the form of special interest here is the chigger, the parasitic, six-legged larval stage of the Trombiculidae. Members of the genus *Leptotrombidium* (pl. 33A) are parasitic on vertebrates, including certain birds and mammals that may become pests in warehouses.
50A adapted from *3*, 50B from *1*, 50C from *24*, and 50D from *22*.

Larva without urstigma (50D); adult without crista metopica (50E)---------- 51

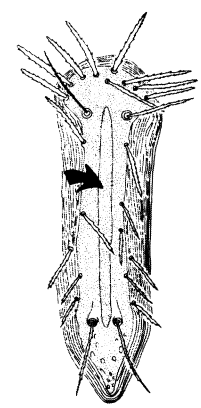
Larvae of the superfamily Erythraeoidea would key out at this point; adults (50C) would key out in the first half of this couplet. Larval erythraeoid mites differ from tetranychids and cheyletids in having a structure resembling a crista metopica. The movable chelae of adult erythraeoids are long and straight and the chelicerae are retractable. Adult trombidioids have nonretractable chelicerae and short, curved, movable chelae. At least one kind of erythraeoid, *Balaustium murorum*, invades buildings in Europe and North America (*20*).



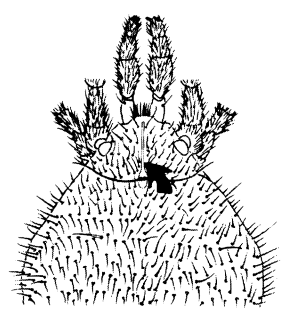
50A *Trombicula microti*



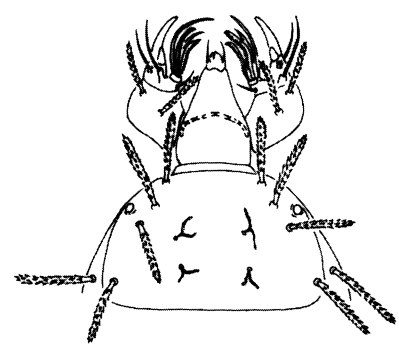
50D *Scutacarus baculitarsus agaricus*



50C *Balaustium putnami*



50B trombidiid mite



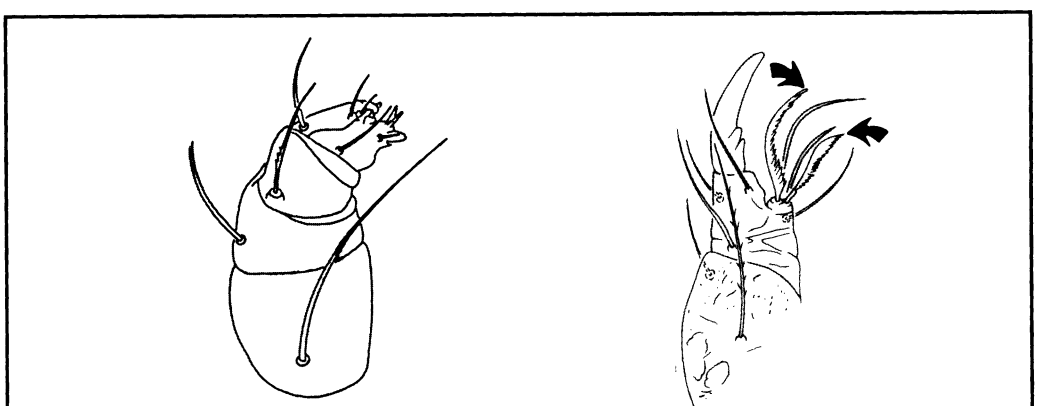
50E *Cheletomorpha lepidopterorum*

51 Palpus without comblike setae (51A)----------**spider mites,** Tetranychidae

The **clover mite,** *Bryobia praetiosa* (pl. 33B), has the anterior margin of the idiosoma marked by 4 lobes, each bearing a single fringed seta. Note that legs I seem disproportionately long. Clover mites are found in Europe and the United States. They feed on grasses and on other herbaceous plants. They sometimes invade houses and other buildings where they find shelter or lay eggs.

Palpus with comblike setae (51B). Cheyletidae (cheyletid mites)---------- 52

Cheyletid mites prey on small arthropods, especially acarid mites. Their distribution is essentially cosmopolitan. They are often found where foods are stored.

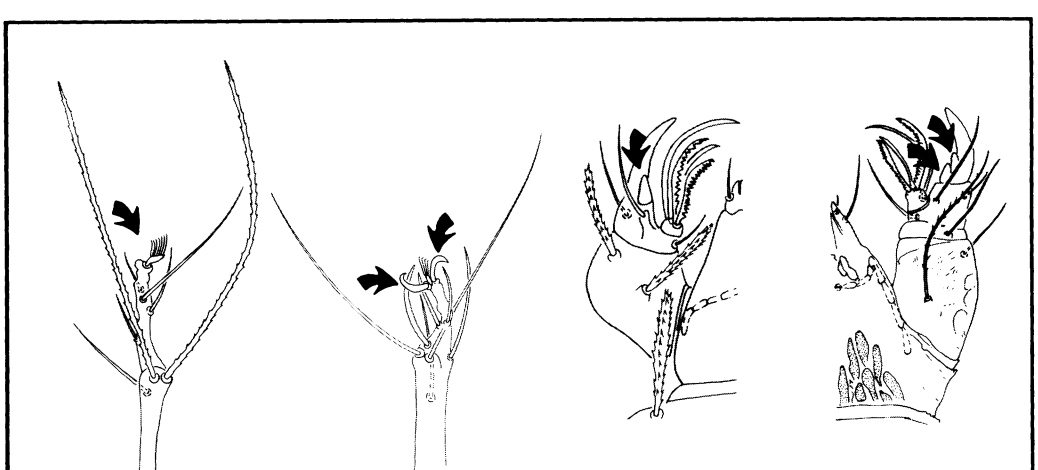


51A *Byrobia praetiosa*

51B *Cheyletus eruditus*

52 Tarsus I without paired claws (52A); palpal claw with 1 basal tooth (52B); pl. 34----------*Cheletomorpha lepidopterorum*

Tarsus I with paired claws (52C); palpal claw with 2 basal teeth (52D) ---------- 53



52A *Cheletomorpha lepidopterorum*

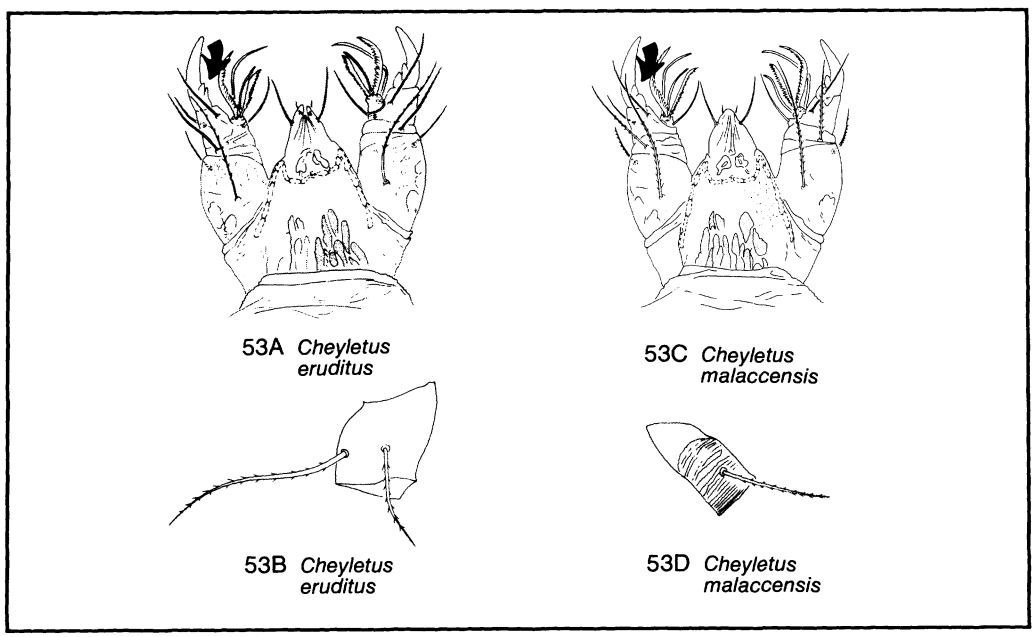
52C *Cheyletus malaccensis*

52B *Cheletomorpha lepidopterorum*

52D *Cheyletus eruditus*

53 Basal teeth of palpus similar in form (53A); femur IV with 2 setae (53B) ---------- *Cheyletus eruditus*

Basal teeth dissimilar (51C); femur IV with 1 seta (53D)----------*Cheyletus malaccensis*



53A *Cheyletus eruditus*

53C *Cheyletus malaccensis*

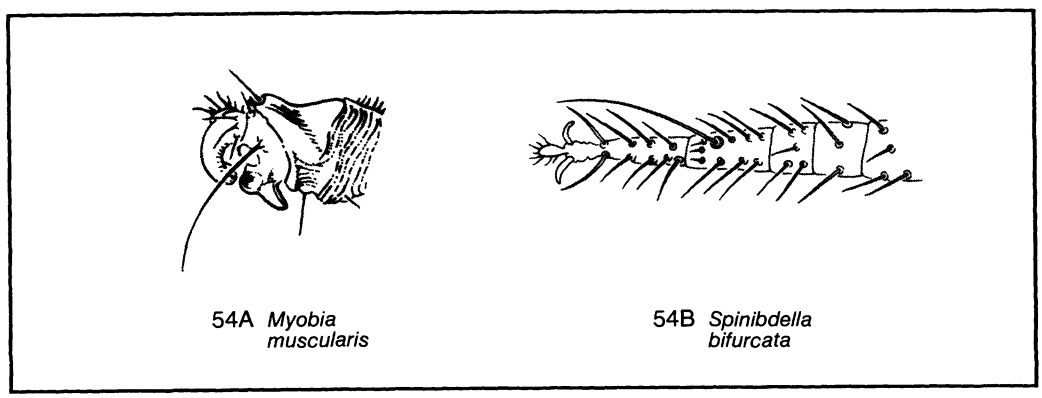
53B *Cheyletus eruditus*

53D *Cheyletus malaccensis*

54 Leg I modified for clinging to hairs (54A) ----------myobiid mites, Myobiidae

Myobia muscularis (see couplet illustration 48B), *Radfordia affinis,* and *R. ensifera* commonly occur as parasites on wild and laboratory rats and mice.

Leg I not modified for clinging to hairs (54B) ---------- 55



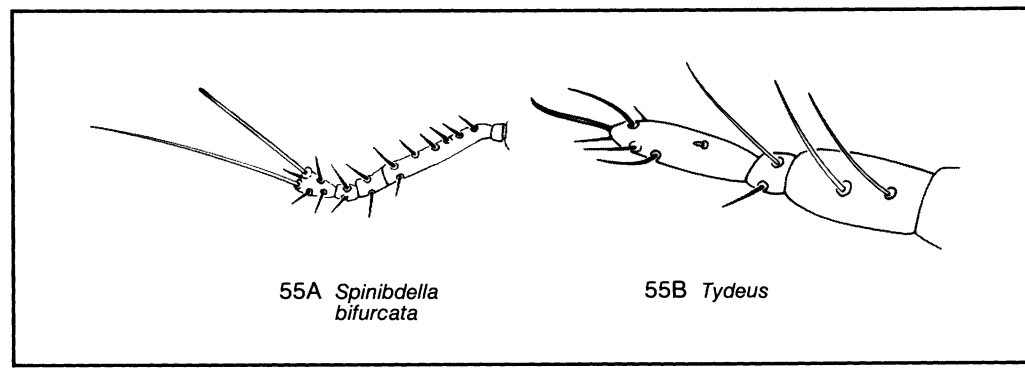
54A *Myobia muscularis*

54B *Spinibdella bifurcata*

55 Palpus somewhat elbow-shaped, with 2 long apical setae, the longer being at least 4 times as long as the palpal tarsus (55A)----------snout mites, Bdellidae

Spinibdella bifurcata (pl. 35A) is a predator on mites associated with grains and flours in Mexico and the United States (Texas).

Palpus not elbowed; apical setae variable, but none longer than palpal tarsus (55B) 56

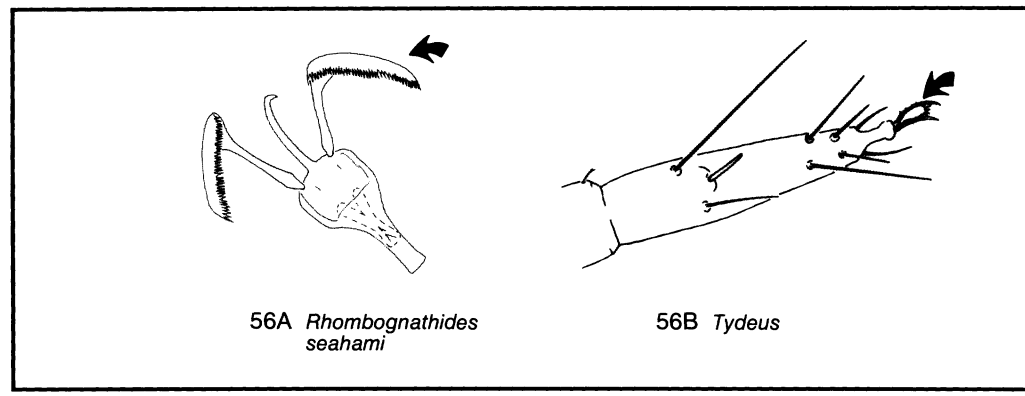


55A *Spinibdella bifurcata* 55B *Tydeus*

56 Tarsal claw both pectinate and scythe-shaped (56A) ---------- halacarid mites, Halacaridae

Distribution: marine habitats. *Rhombognathides seahami* (pl. 35B) is found on dulse, a coarse red seaweed used as a condiment.

Tarsal claw not pectinate or, if pectinate, then not scythe-shaped (56B) ---------- 57

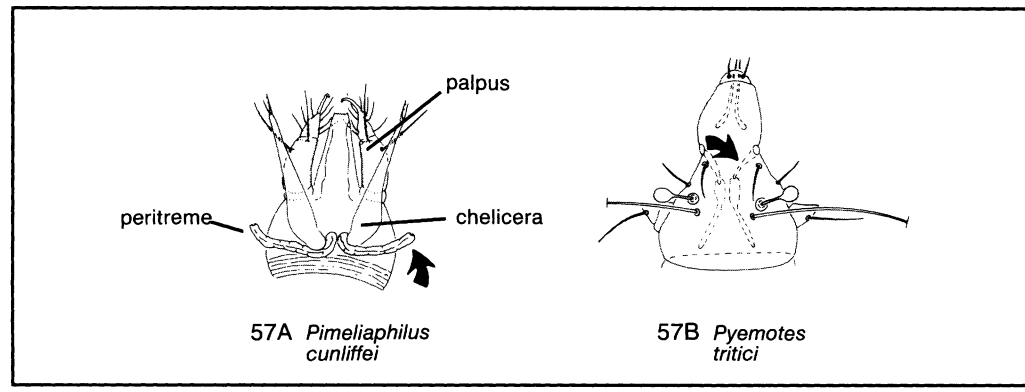


56A *Rhombognathides seahami* 56B *Tydeus*

57 External peritreme present (57A); pl. 36A. Pterygosomatidae (pterygosomatid mites) ---------- cockroach mite, *Pimeliaphilus cunliffei*

These mites, formerly called *P. podapolipophagus* Trägårdh, are ectoparasites of cockroaches. Their distribution coincides with that of their hosts.
Reference: *19*.
57A from *1*, courtesy E. W. Baker.

External peritreme absent (57B) ---------- 58

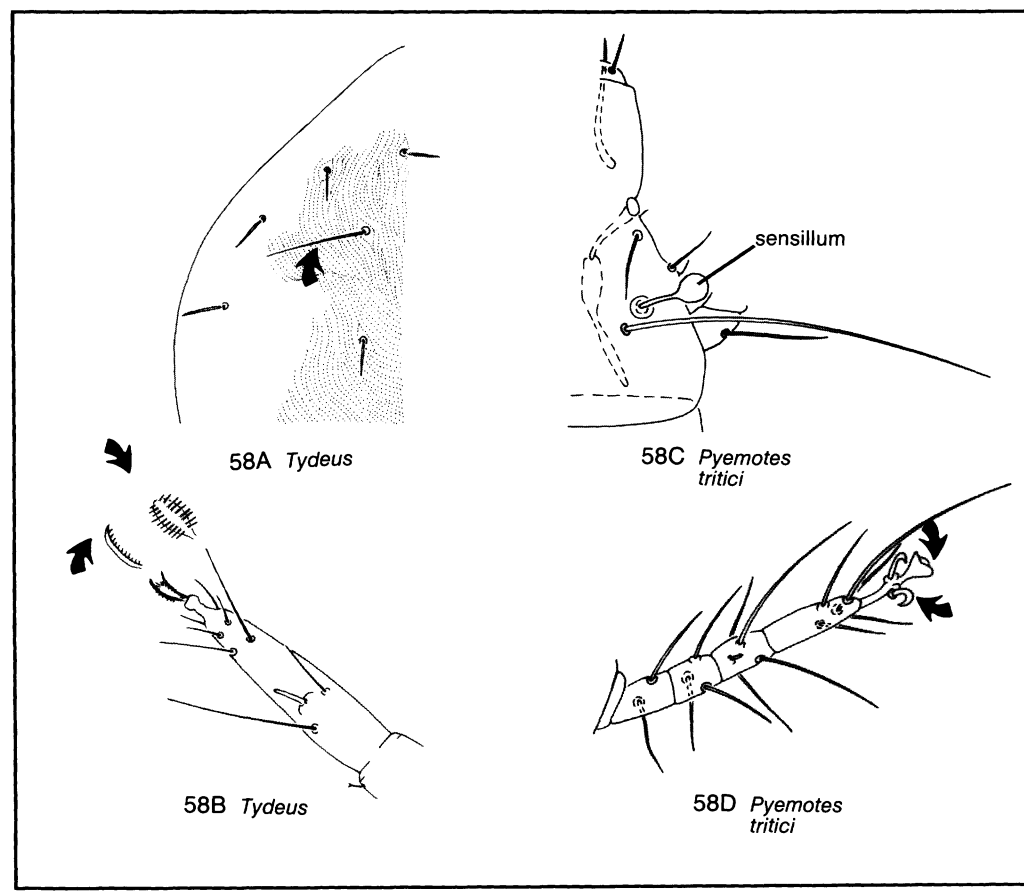


57A *Pimeliaphilus cunliffei* 57B *Pyemotes tritici*

58 Sensillum (prodorsal trichobothrium) of female setaceous (58A); tarsal claw and empodium either smooth or pectinate; rayed hairs present (58B) ----------**tydeid mites,** Tydeidae

Tydeid mites, especially members of the genus *Tydeus* Koch (pl. 36B), occasionally occur in association with stored foods, but their role there is uncertain; probably they prey on insects and on other mites.

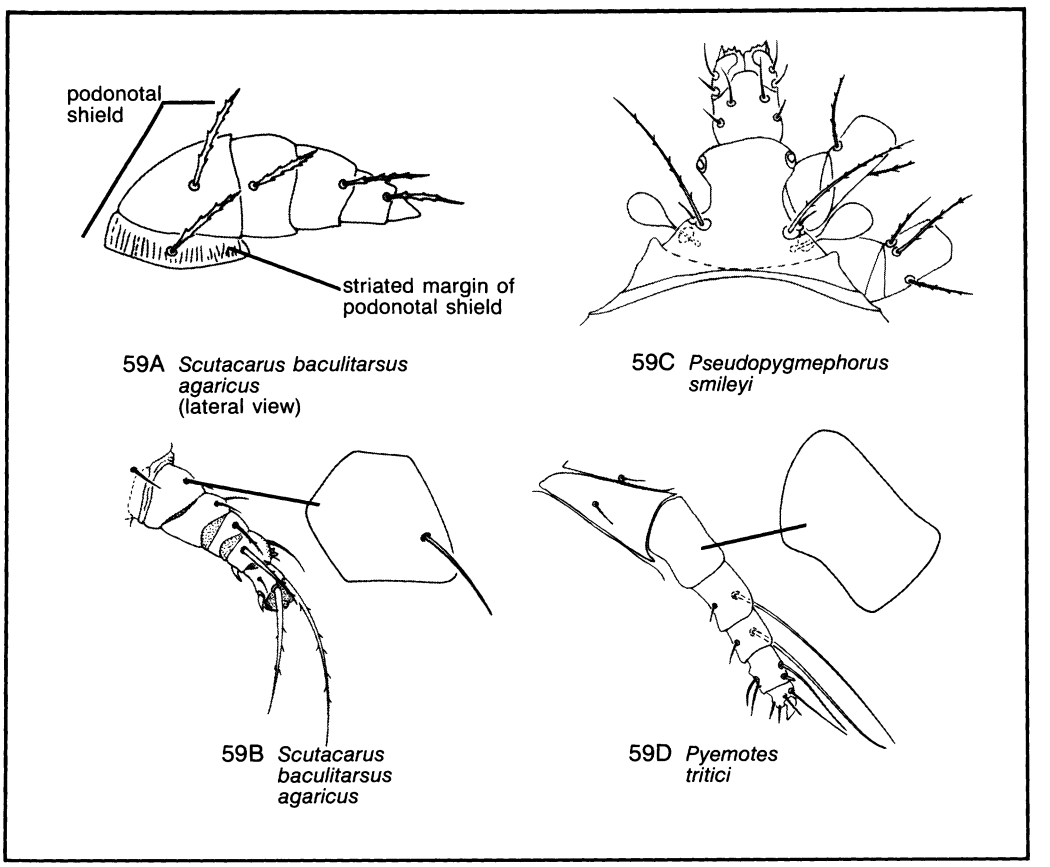
Sensillum of female globular (58C); tarsal claw and pulvillus smooth, without rayed hairs (58D) ---------- 59



59 Female with hoodlike podonotal shield covering propodosoma and gnathosoma (margin of podonotal shield striated) (59A); trochanter IV of male subtriangular (59B) ----------scutacarid mites, Scutacaridae

Scutacarus baculitarsus agaricus (22) (pl. 37, 38) is representative of the family. This subspecies has been found in commercial mushroom beds in Pennsylvania and Delaware. The adults are phoretic on phorid flies. The family includes other soil mites that are widely distributed around the world.

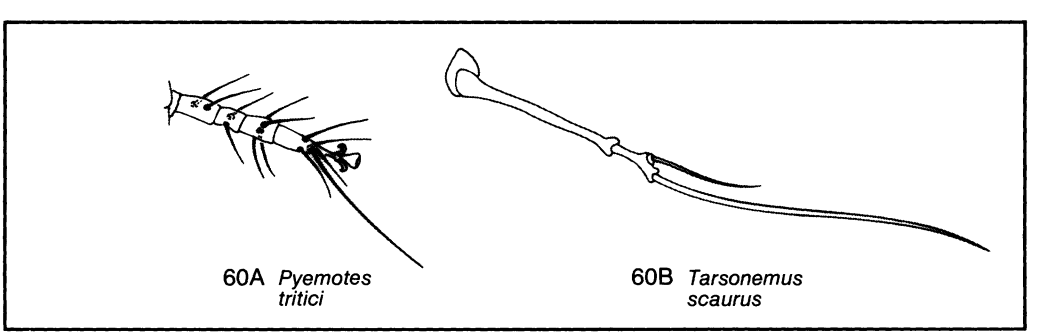
Female without hoodlike podonotal shield (59C); trochanter IV of male subrectangular (59D) ---------- 60



60 Leg IV of female with pretarsus, claw, and pulvillus, but without apical whiplike setae (60A); idiosoma elongate; palpus of male reduced in size or absent, never forming an elongate beak (pl. 39); gravid female with saclike hysterosoma (pl. 40A)------ 61

Leg IV of female without pretarus, claw, and pulvillus, but with apical whiplike setae (60B); idiosoma oval; male palpus always present but variable in shape, sometimes forming an elongate beak; gravid female without saclike hysterosoma (pl. 44). Tarsonemidae (**tarsonemid mites**)---------- 62

Certain tarsonemid mites live on fungi, some of which are associated with stored grains. Two species, *Tarsonemus mercedesae* and *T. lukoschusi,* have been associated with commercial mushroom production in Pennsylvania (*16*). Other tarsonemids feed on the eggs of bark beetles and tetranychoid mites (*26*).

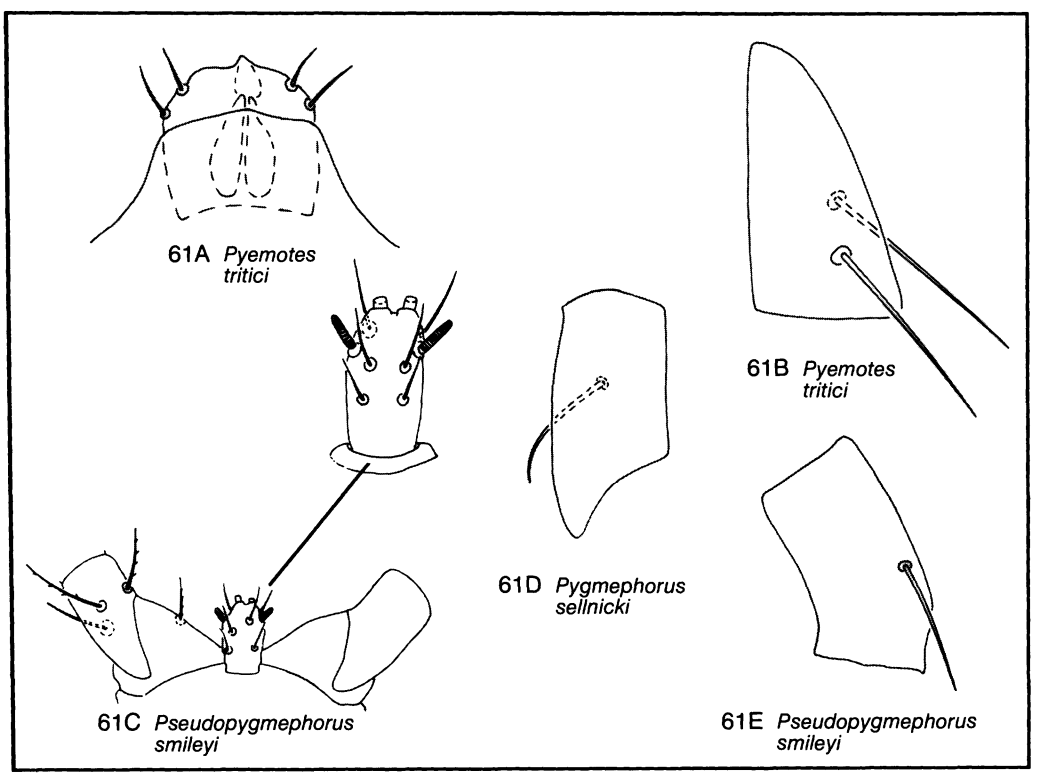


61 Gnathosoma of male about as wide as long (61A); trochanter IV of female triangular (61B)----------**pyemotid mites,** Pyemotidae

The **straw itch mite,** *Pyemotes tritici* (*6*) [= *P. ventricosus* (Newport)] (pl. 39, 40), is a parasite of various insects including *Oryzaephilus surinamensis, Sitophilus oryzae, Callosobruchus maculatus,* and *Sitotroga cerealella.*

Gnathosoma of male longer than wide (61C); trochanter IV of female quadrangular (61D, 61E)----------mushroom mites, Pygmephoridae

Pygmephorus sellnicki (pl. 41), a European species introduced into the United States, is common on cultivated mushrooms (*25*). *Pseudopygmephorus smileyi* (pl. 42, 43) is a mushroom pest in Pennsylvania (*17*).
61C&E adapted from *17*.

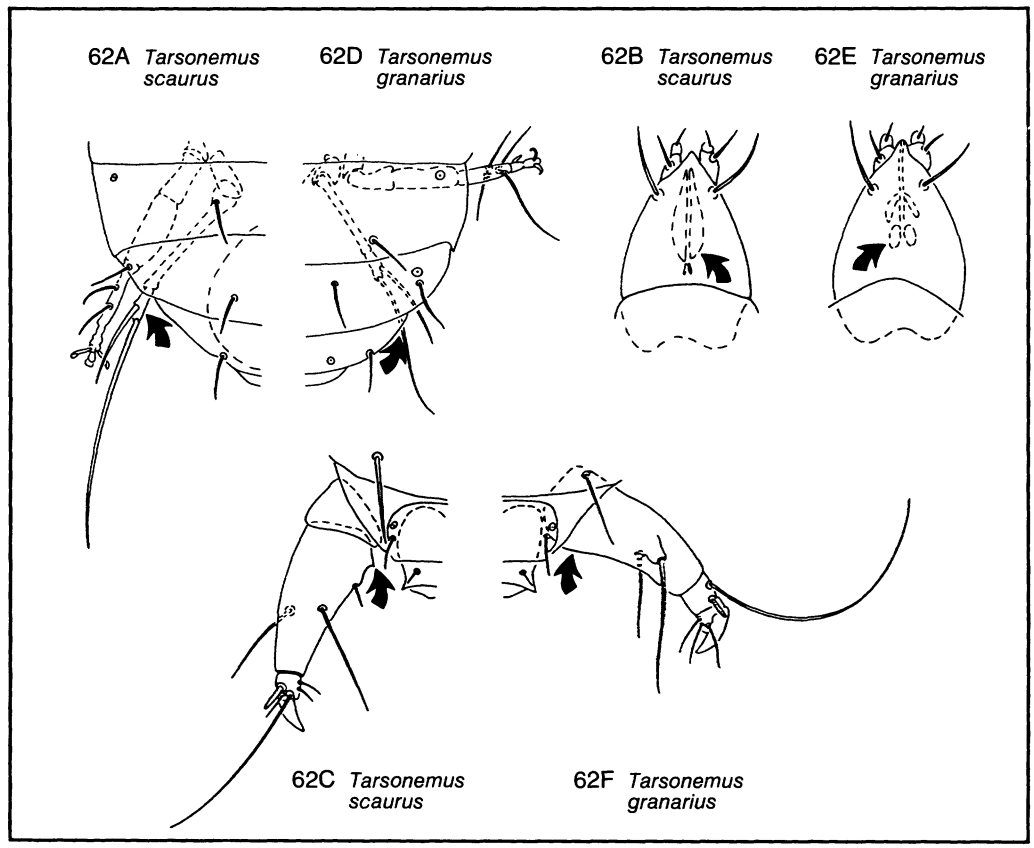


62 Leg IV of female extending beyond margin of opisthosoma (62A); pharyngeal structure strongly sclerotized, without conspicuous glands at base (62B); femur IV of male with angulation on inner surface near base (62C); pl. 44
----------*Tarsonemus scaurus*

Distribution: United States.

Leg IV of female not extending beyond margin of opisthosoma (62D); pharyngeal structure weakly sclerotized, with conspicuous glands at base (62E); femur IV of male without angulation near base (62F); pl. 45
----------*Tarsonemus granarius*

Distribution: Canada, England, Japan.



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Notes and Sketches

2 COCKROACHES (BLATTARIA, DICTYOPTERA)

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This key to the adults and egg cases (oothecae) of the species most likely to infest food products is intended primarily for taxa occurring in the United States. It will be helpful for many other countries also because most of the species discussed here are cosmopolitan or nearly so.

The basic classification of cockroaches followed here is that of McKittrick (*31*). Her system, which has been endorsed widely, recognizes five families: Cryptocercidae, Polyphagidae, Blattidae, Blattellidae, and Blaberidae. Some earlier classifications recognized a larger number of families, some of which are still used by a few writers. In an older, traditional sense, a single family, "Blattidae," includes all cockroaches; this usage still appears in some textbooks and general entomological literature.

The species included in this key are listed here according to their family affiliation and in the order in which they appear in the following key to adult cockroaches.

Blattidae: *Periplaneta fuliginosa* (pl. 46D); *P. australasiae* (pl. 47A); *P. americana* (pl. 47B); *P. brunnea* (pl. 47C); *Neostylopyga rhombifolia* (pl. 47D); *Blatta orientalis* (pl. 51A&B); *Eurycotis floridana* (pl. 51C&D); *Blatta lateralis* (pl. 48).

Blattellidae: *Blattella vaga* (pl. 52B); *B. germanica* (pl. 52C-E); *Supella longipalpa* (pl. 54C-E); *Ectobius pallidus* (pl. 55A); *E. sylvestris* (pl. 55D); *Parcoblatta* spp. (pl. 56A-C).

Polyphagidae: Keyed to family level only (pl. 56D&E).

Cryptophagidae: Keyed to family level only (pl. 57A).

Blaberidae: *Panchlora nivea* (pl. 57B); *Pycnoscelus surinamensis* (pl. 57C&D); *Nauphoeta cinerea* (pl. 59); *Blaberus* spp. (pl. 60); *Leucophaea maderae* (pl. 61).

Although any of these species may be important at times, four species are the most serious pest cockroaches in the United States: *Blattella germanica, Periplaneta americana, Blatta orientalis,* and *Supella longipalpa.* In the southern third of the United States, *Periplaneta brunnea* is quite prevalent, sometimes more common than *P. americana.* In foreign countries with tropical or subtropical climates, as well as on board ships carrying fruit or other commercial foodstuffs, several other species often attain considerable stature as pests, notably *P. australasiae* and *Leucophaea maderae.*

The recent—and hopefully ephemeral—appearances of *Blatta lateralis* (*6, 52*), *Blattella asahinai, Ectobius sylvestris* (*26*), and *Epilampra maya* in the United States have prompted us to include in this chapter illustrations of selected species that might become domiciliary in the United States, either by invasion from natural habitats or by importation of cockroaches that are sometimes domestic in their home territories. Those species represented in this chapter only by illustrations are listed here according to their family affiliation.

Blattidae: *Deropeltis erythrocephala* (pl. 50A); *Lamproblatta* spp. (pl. 49A&B); *Methana marginalis* (pl. 49C&D); *Pelmatosilpha* spp. (pl. 50B); *Periplaneta japonica* (pl. 46A&B).

Blattellidae: *Aglaopteryx gemma* (pl. 54A&B); *Blattella lituricollis* (pl. 52A); *Ectobius lapponicus* (pl. 55B&C); *Lupparia* sp. (pl. 53A); *Nyctibora noctivaga* (pl. 53D&E); *Shawella couloniana* (pl. 53B&C).

Polyphagidae: *Arenivaga* spp. (pl. 56D&E).

Cryptocercidae: *Cryptocercus punctulatus* (pl. 57A).

Blaberidae: *Blaberus craniifer* (pl. 60A&B); *B. discoidalis* (pl. 60C); *B. giganteus* (pl. 60D); *Pycnoscelus indicus* (pl. 58).

For readers wishing information on aspects other than those dealt with here, the following publications from among those listed at the end of the chapter are suggested (others are mentioned in the key): Cockroaches in general, *9, 20;* life history information, especially the duration of the stages of the better known species, *14, 47, 53, 54;* applied aspects, *10, 11, 30;* ecology, *48, 51;* identification, *21, 23-25, 29, 32, 34, 38, 42* (see also chapter 28); approved common names, *8.*

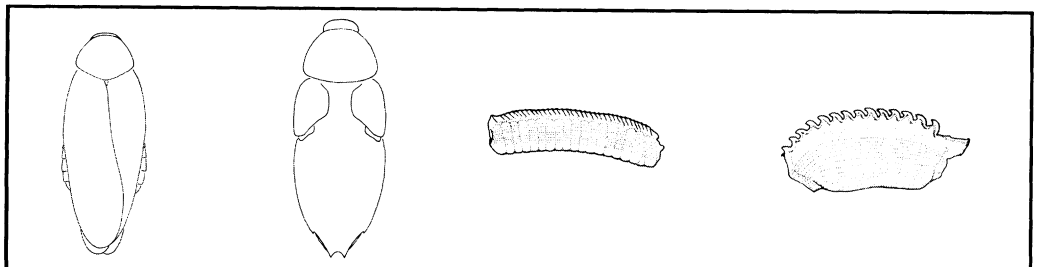
KEY
Drawings by A.D. Cushman unless otherwise noted.

1 Adult cockroach---------- 2

This key to adults is adapted from Pratt and Stojanovich (*35*). Adults of all the species (or genera in the case of *Parcoblatta* and *Blaberus*) included in this key bear wings (1A), though some have only very short ones (1B). Younger nymphs show no sign of wings (pl. 52C); wing pads (sheaths) appear as nymphs mature (pl. 52D). Since nymphal and adult cockroaches share many morphological features, it is possible also to identify with this key the nymphal stages of many of the species; care should be taken when the key is applied to nymphs. Some wingless cockroaches of lesser economic importance, e.g., *Lamproblatta* spp. (Blattidae, see couplet 3) of the Neotropics, *Arenivaga* spp. (only males winged; Polyphagidae, see couplet 16) of the southwestern deserts (USA), *Polyphaga* spp. (males winged; Polyphagidae) of southern Asia and North Africa, and *Cryptocercus punctulatus* (Cryptocercidae, see couplet 17) of North America, are not covered here.
Drawings 1A-D by C. Feller.

Ootheca---------- 22

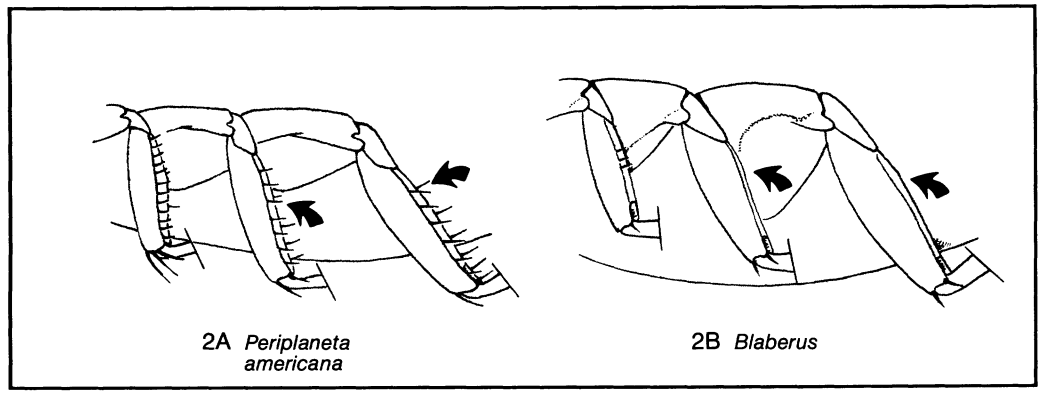
Roth and Willis (*47*) and Roth (*44*) discussed types of reproduction, and Roth (*42, 45*) illustrated the oothecae of many species. Several entomologists (V.E. Adler, H.G. Scott, L.M. Roth, and D.E. Weidhaas) cooperated in this effort by generously loaning us egg cases associated with adults. Dr. Roth also loaned us his notes on identification of egg cases of the common species, and we benefited greatly from his photographs (*42*). We take full responsibility, however, for the distinctions brought out in this key. Although neither polyphagid nor cryptocercid oothecae are likely to be found in domestic or industrial environments, we offer these brief descriptive notes to show that they cannot be easily confused with the egg capsules that are keyed out below. The well-sclerotized ootheca of *Cryptocercus punctulatus* (1C) is elongate, about 8 to 10 mm long by 2.3 mm high, has a well-developed keel with broad dentition, and has about 17 well-defined egg chambers; respiratory pores (one in each denticle) are present but there are no respiratory tubes. Polyphagid oothecae are well-sclerotized. The structure of the keel and the occurrence of respiratory tubules vary among the many species. The end of the ootheca that is held by the female bears a flattened flange (1D), a structure that makes the polyphagid ootheca unique among the Blattaria (*42*). The flange of some species is elongate and beaklike.



1A *Panchlora nivea* 1B *Blatta lateralis* 1C *Cryptocercus punctulatus* 1D *Polyphaga aegyptiaca*

Adults

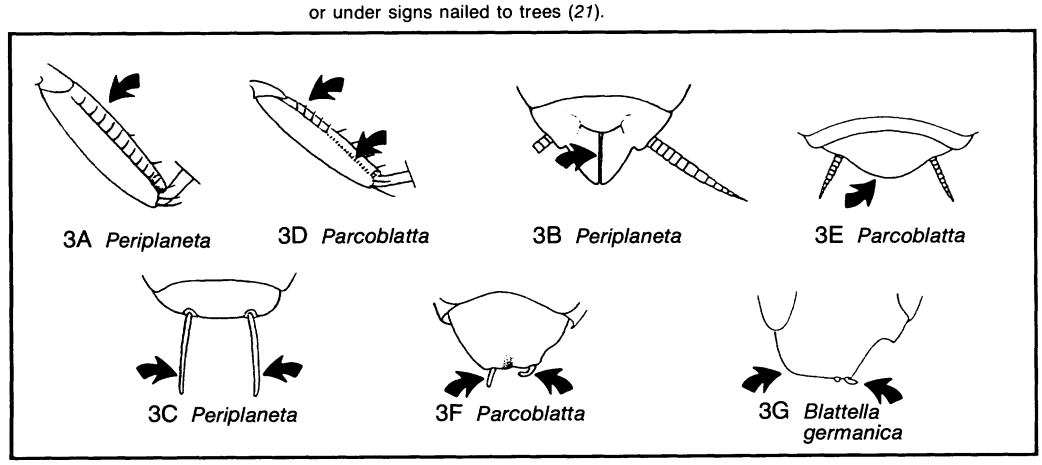
2 Femora II and III with both ventral margins (anterior and posterior) bearing numerous, similarly-arranged, strong spines (2A) ---------- 3
Femora II and III lacking strong spines on ventral margin (2B) ---------- 16



2A *Periplaneta americana* 2B *Blaberus*

3 Large species (pl. 47A), length 18 mm or more (including folded wings); anteroventral margin of femur I always with only large, robust spines (3A); subgenital plate (terminal ventral segment) of female divided longitudinally, appearing valvular (3B); both styli on male subgenital plate similar, symmetrical, elongate, and nearly straight (3C). Blattidae (blattids, blattid cockroaches)---------- 4
Smaller species (pl. 54), usually less than 18 mm long, or, if longer, the anteroventral margin of femur I bears large, robust spines on the basal part, and small, more delicate spines on the distal half (3D); female subgenital plate simple, undivided (3E); styli on male subgenital plate not symmetrical, sometimes unequal in size (3F, 3G). Blattellidae (blattellids, blattellid cockroaches)---------- 12

See pl. 53 and 54A&B for illustrations of *Shawella couloniana, Lupparia* sp., *Nyctibora noctivaga,* and *Aglaopteryx gemma,* all blattellid cockroaches not included in this key. *S. couloniana* (Australia, New Zealand) may occasionally enter human dwellings, but it is essentially an outdoor species (*7*). *L. vilis* (Iwo Jima and other western Pacific islands and adjacent land masses) is probably an arboreal cockroach; it is reported to have invaded houses on Iwo Jima (*7*). *N. noctivaga* (Neotropics) and other species of this genus are sometimes exported on bananas from their native territories. *A. gemma* (Bahama Islands; Florida to Texas) has been found in a house in southern Georgia (*13*); normally it is arboreal, living under bark or under signs nailed to trees (*21*).



3A *Periplaneta* 3D *Parcoblatta* 3B *Periplaneta* 3E *Parcoblatta*

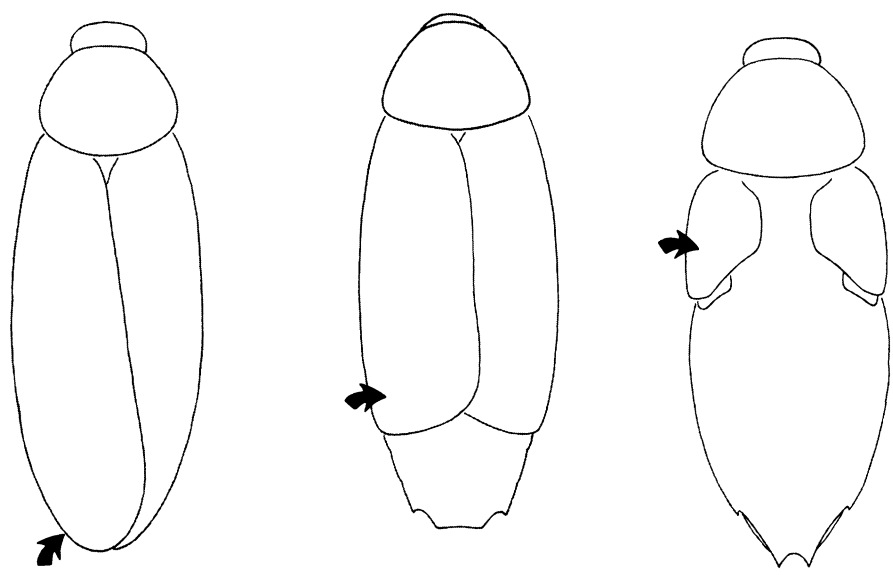
3C *Periplaneta* 3F *Parcoblatta* 3G *Blattella germanica*

4 Front wings (tegmina), when folded (the position usually seen), extending beyond the tip of abdomen (4A) ---------- 5

See pl. 46A-C for *Periplaneta japonica,* an exotic species not included in this key. *P. japonica* (China, Japan, USSR) vaguely resembles *Blatta orientalis.* It is an outdoor species, but some populations have become adapted to houses in northern Japan (*7*).
Drawings 4A-C by C. Feller.

Front wings not reaching tip of abdomen (4B), sometimes very short (4C)---------- 9

See pl. 49 and 50 for other blattids, *Lamproblatta* spp., *Methana marginalis, Deropeltis erythrocephala,* and *Pelmatosilpha* sp., not included in this key. *Lamproblatta* spp. (Australia, Neotropics) are outdoor in habit but may become domiciliary on occasion. *M. marginalis* (Australia) lives under the bark of standing or fallen trees. It is an opportunistic invader of human dwellings. *D. erythrocephala* (South Africa) is an outdoor cockroach similar in its house-invading habits to *Parcoblatta* spp. *Pelmatosilpha* spp. (Neotropics, New Zealand) are sometimes shipped with bananas from tropical Latin American countries to many places outside their normal range.

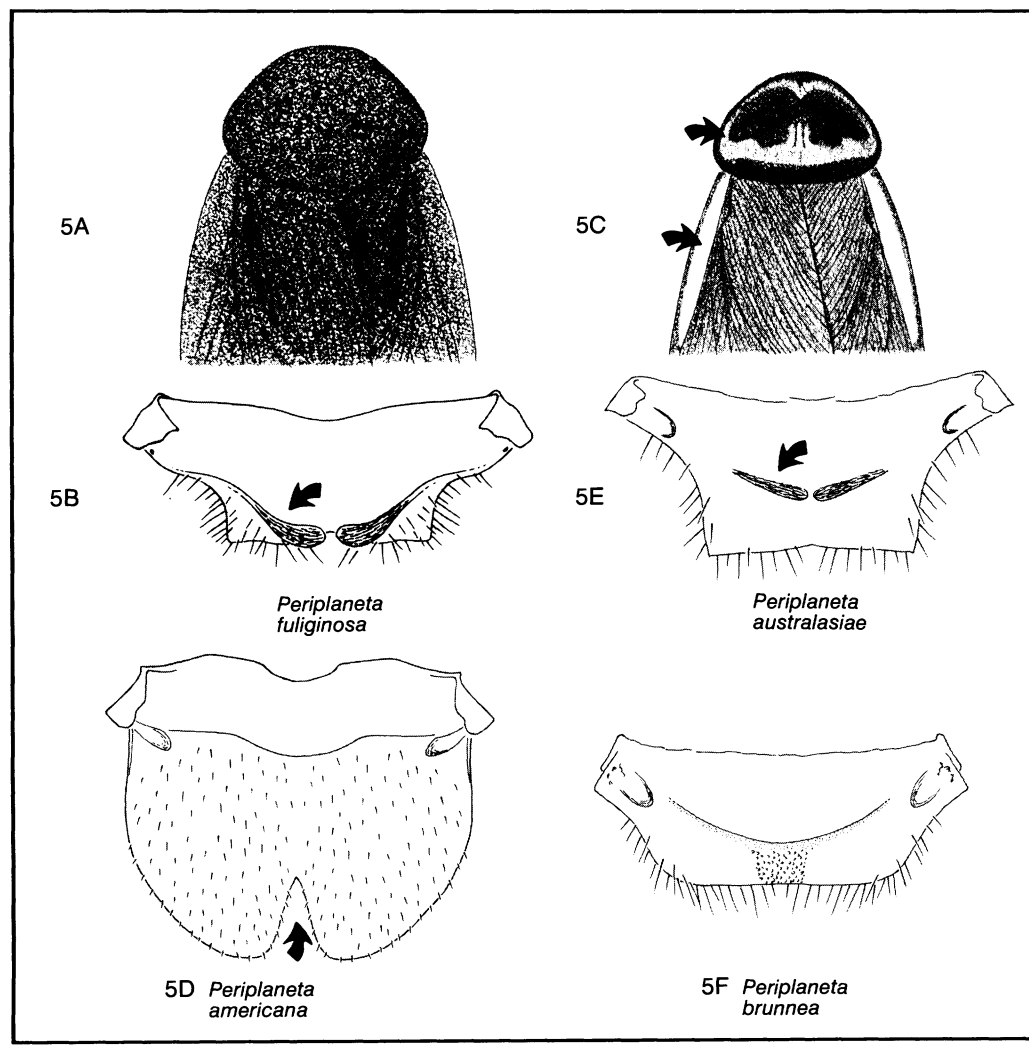


4A *Blatta lateralis*♂ 4B *Blatta orientalis*♂ 4C *Blatta lateralis*♀

5 Color entirely dark, blackish-brown, sometimes shining black (5A); male supraanal plate (terminal abdominal tergite) with thickened structures on ventral surface near apex (5B); pl. 46D ----------**smokybrown cockroach,** *Periplaneta fuliginosa*

Except for the southern United States, where it is rather common, and California, this species occurs primarily in eastern Asia (*1*); it may have originated there. Although it sometimes is quite important as a pest in buildings, it lives mainly outdoors; sometimes it flies actively. Although smokybrown and American cockroaches sometimes occur together, smokybrowns usually avoid habitats used by *P. americana,* apparently in reaction to pheromones produced by the latter (*33*). Medium- to large-sized nymphs are colored a shining dark chocolate overall, like the adults, but very young nymphs show some white markings.
Drawings 5A&C by C. Feller.

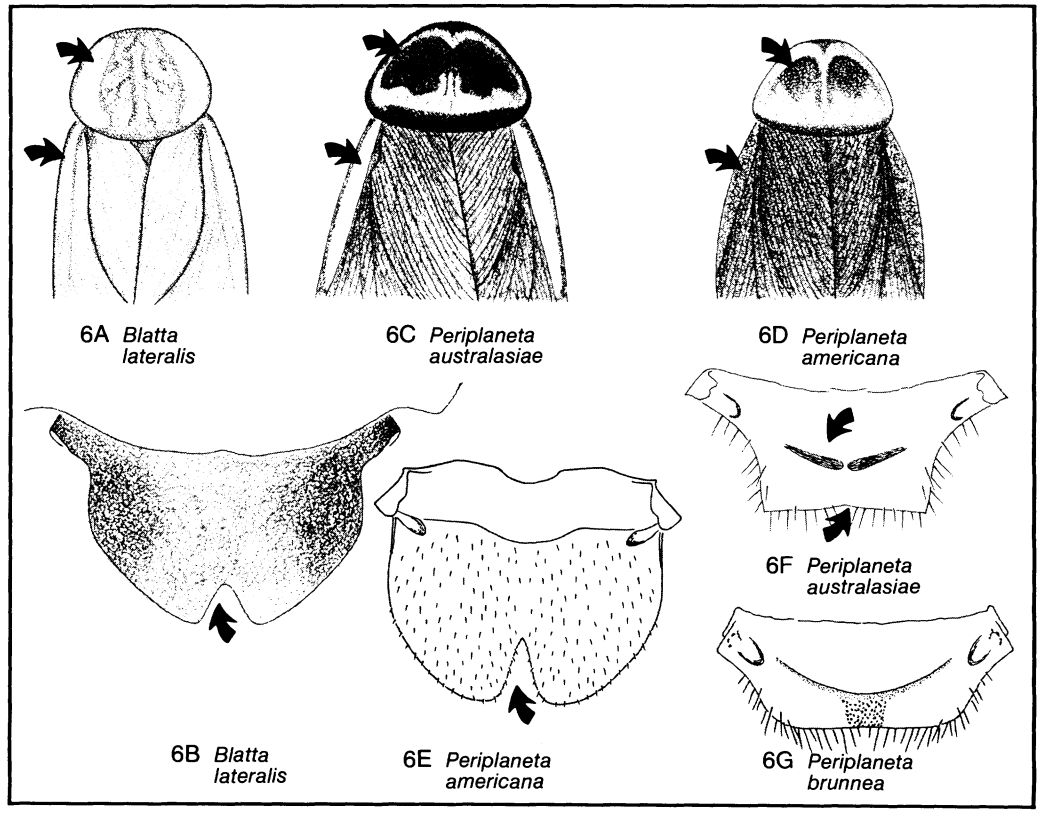
Color not entirely dark, but with some yellowish markings on pronotum or front wings, sometimes on both (5C), or front wings straw-colored (pl. 48♂); male supraanal plate notched (5D), ridged distant from apex (5E), or neither notched nor ridged (5F) 6



6 Front wing brownish-yellow (straw-colored), with a lateral pale stripe; pronotum reddish-brown centrally, with wide margins of transparent yellow (6A); male supra-anal plate with apex broadly notched (6B); pl. 48♂. Genus *Blatta* (in part) ---------- male, **Turkestan cockroach,** *Blatta lateralis*

Blatta (*Shelfordella*) *lateralis* [*Shelfordella tartara*] is found both outdoors and in buildings in the arid regions of Central Asia, the Near East, and in North Africa as far west as Libya. Infestations have been discovered in Arizona and at military bases in Texas and California (*6, 52*). Although the exact origin of these imported populations is uncertain, it is known that the bases had received shipments from points within the range of this species in the Old World. Nymphs mature in 118-137 days at temperatures of 30-35 C. The adults may live as long as 300 days (*7*). The males have long, fully-functional, brownish-yellow wings. The wings of the nearly black females are represented by short flaps (as they are also in the closely-related *B. orientalis*). Males and females are so dissimilar in appearance that they are treated separately in this key (see couplet 11). The drawings (6A&B, pl. 48) are based on specimens kindly provided by Dr. D.G. Cochran. See also 4A.
Drawings 6A-D by C. Feller.

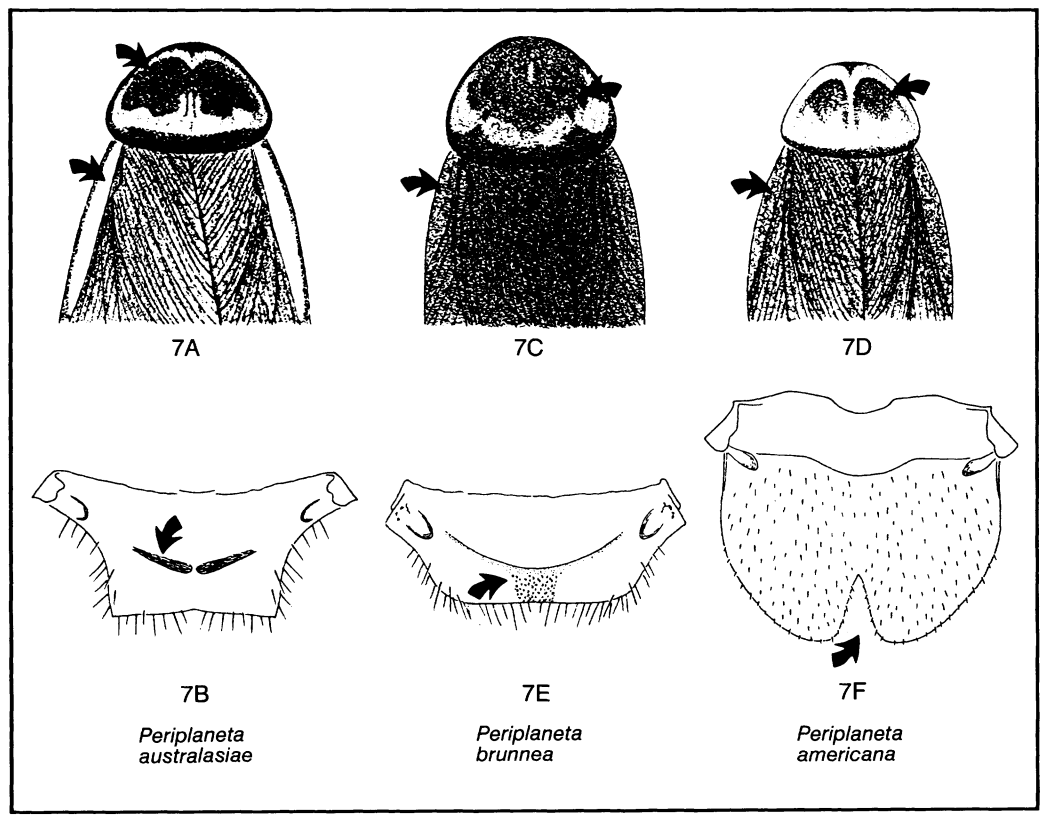
Front wing chestnut-brown, with (6C) or without (6D) a short yellow stripe near base; pronotum a darker color than brownish-yellow, usually with some yellowish markings (6C&D); male supraanal plate with apex deeply notched (6E), or with transverse ventral ridges (6F), or neither notched nor ridged (6G) ---------- 7



7 Front wing with a short yellow stripe near base; pronotum with blackish central spot and blackish margins in decided contrast to pale areas (7A); male supraanal plate with thickened transverse ridges on ventral surface distant from posterior margin (7B); pl. 47A----------**Australian cockroach,** *Periplaneta australasiae*

This species is apparently native to Africa; now widely distributed, often seen in tropical and subtropical countries. In the United States it is usually restricted to the southern states; it can survive in greenhouses or other favorable situations in colder localities. The nymphs have yellowish spots on the lateral margins of the abdomen and thorax that contrast with the general brown color; the spots on the thorax extend as incomplete stripes toward the middle of the body.
Drawings 7A&C&D by C. Feller.

Front wing entirely chestnut-brown; pronotum with brown markings often not in sharp contrast with pale areas (7C, 7D); male supraanal plate truncate (7E) or deeply notched (7F) but not conspicuously ridged on ventral surface ---------- 8

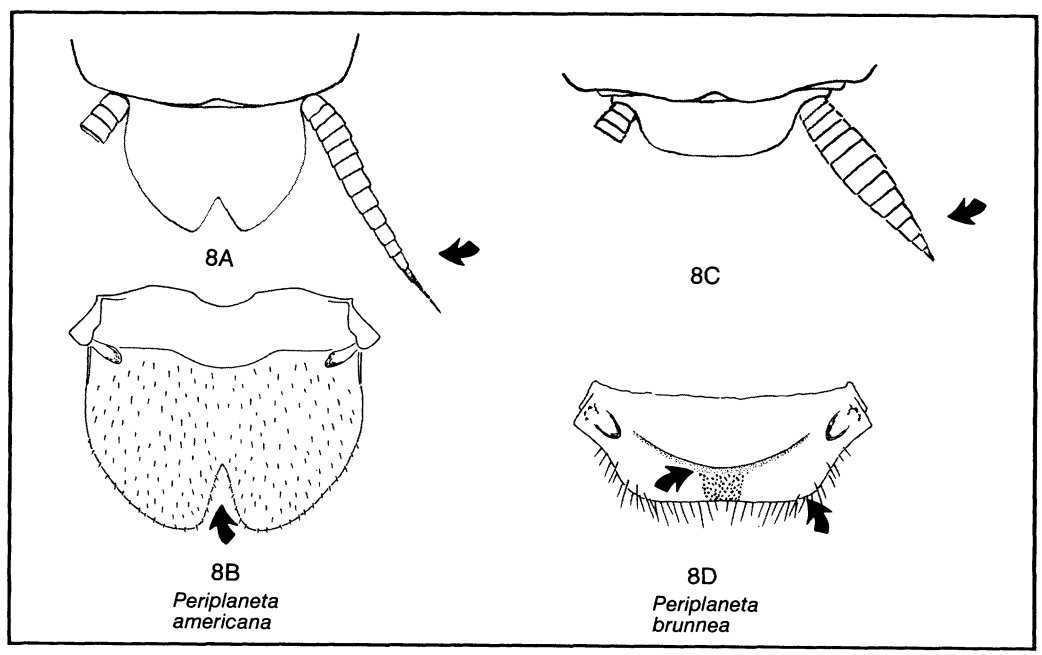


8 Cercus very long and slender (especially the apical segments of males) (8A); male supraanal plate long and papery thin near deeply-notched tip, with ventral surface simple, bearing no specialized structures (8B); pl. 47B
---------- **American cockroach,** *Periplaneta americana*

This cosmopolitan species, probably native to Africa, is one of the most frequently reported cockroaches in domestic situations. Among the species of *Periplaneta,* this one ranges farthest north in the United States. The nymphs are mostly a uniform chestnut color, though the pronotum of large nymphs has a dark posterior border and two large patches of darker reddish-chestnut toward the front. The duration of the complete life cycle ranges from six months to two years, with one year being the more usual. The nymphal stages usually occupy about six months. Caged adults sometimes live as long as three years. See also 2A, 7D.

Cercus stouter, the segments near apex not so slender (8C); male supraanal plate short, truncate or feebly notched at tip, and only slightly specialized on the ventral surface (8D); pl. 47C----------**brown cockroach,** *Periplaneta brunnea*

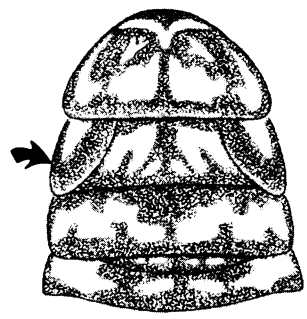
This species, which is often confused with the American cockroach, is considered to be a native of Africa, but it is widespread in tropical and subtropical countries and is rather abundant in the southern United States. The nymphs have cream-colored spots on the lateral margins of some abdominal segments. Adult size averages less than that of *P. americana,* but the cerci usually permit separation. Unequivocal separation of the two species requires examination of the supra-anal plate of adult males. This is a rather long-lived species. Incubation requires 35 to 59 days at 27 C, and nymphal development, 182 to 192 days. Adult life averages 219 days for females and 244 days for males. A female produces about 30 oothecae (*54*).



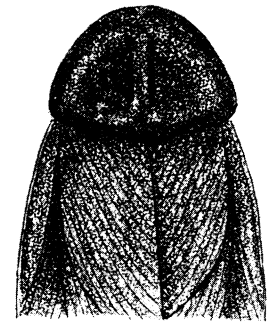
9 Color dark brown, with a conspicuous pattern of yellowish areas (9A); both sexes with vestigial front wings present as small triangular pads separated from each other by a wide mesonotal space (9A); pl. 47D
---------- **harlequin cockroach,** *Neostylopyga rhombifolia*

This species, readily recognized by its distinctive color pattern, has apparently not become established in the United States; it is intercepted occasionally along the Mexican border. Rehn (*39*) discussed its probable southeastern Asia origin and its spead to the west coast of Mexico and to certain other tropical areas. Nymphs longer than 10 mm usually have the distinctive markings of the adult, but small ones frequently have only poorly defined markings.
Drawings 9A-D by C. Feller.

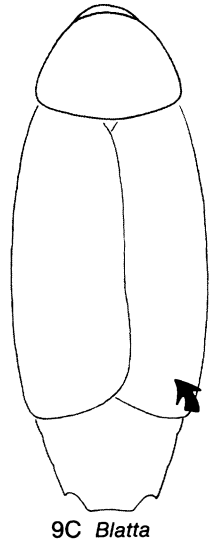
Color either uniformly dark or with a few pale marks, but lacking a conspicuous pattern of yellowish areas (9B); front wing either normal (but not reaching tip of abdomen) (9C) or vestigial (9D) ---------- 10



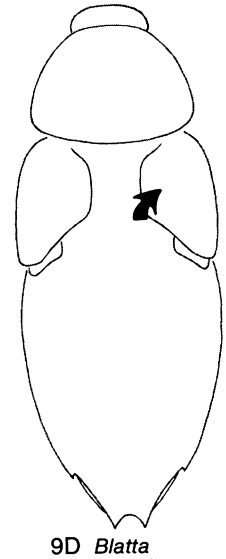
9A *Neostylopyga rhombifolia*



9B *Blatta orientalis*



9C *Blatta orientalis*

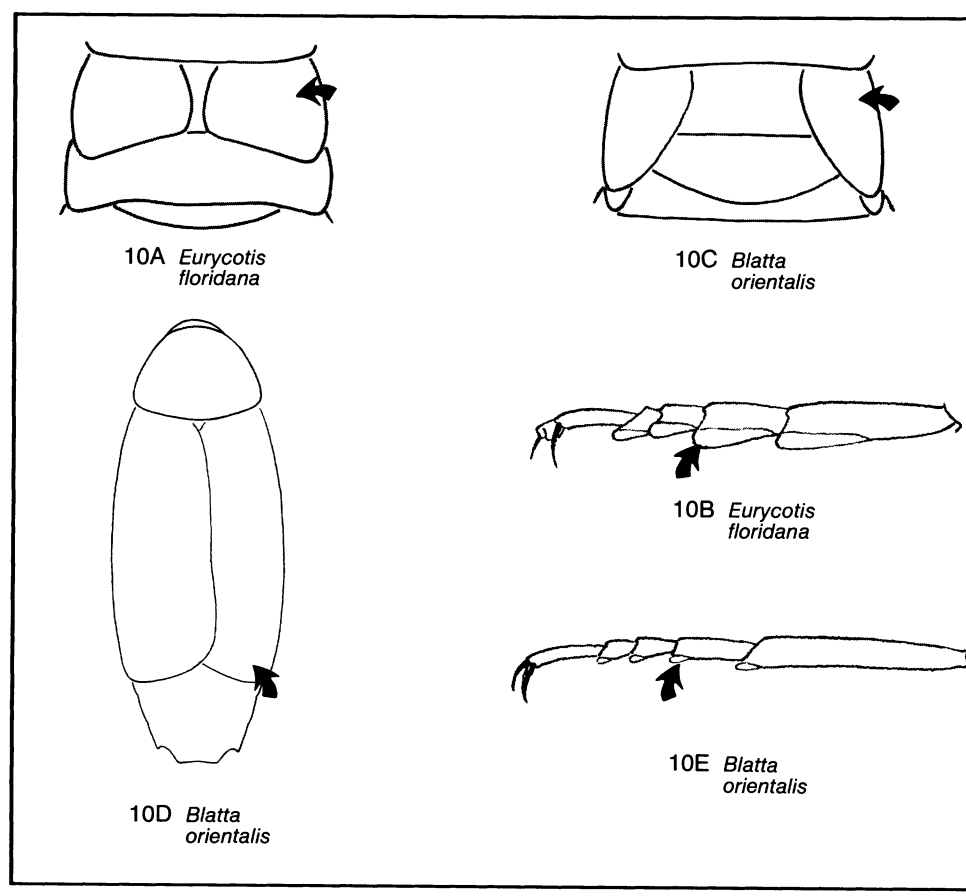


9D *Blatta lateralis*

10 Body length 30 to 40 mm; body color a dark reddish-brown to nearly black (occasionally with a few yellowish areas laterally); front wings same in both sexes, vestigial, and present as short, transverse, subrectangular pads, usually almost touching along midline (10A); segment I of tarsus III shorter than segments II to V combined, with pulvilli (small pads on tarsal segments) of segments II and III large, about as long as their respective tarsal segments (10B); pl. 51C&D
---------- Florida stinkroach, *Eurycotis floridana*

This large, flightless cockroach, native to the United States, occurs only in the Southeast. It usually lives outdoors, but sometimes enters buildings (*19, 30, 51*). When adults are disturbed, they often emit an extremely vile-smelling fluid. The color of very young nymphs is usually a uniform pale brown on the dorsal surface; later they become darker and often have conspicuous pale or yellow lateral markings (pl. 51C). See also 17B.
Drawings 10A&C&D by C. Feller.

Body length 15 to 27 mm; body color blackish or dark chocolate-brown, either solidly colored or with pale pronotal markings and lateral wing stripes; front wings of females vestigial, present as small, widely separated, triangular pads (10C); front wings of males longer (10D); segment I of tarsus III as long as or slightly longer than segments II to V combined, with pulvilli of segments II and III small, much shorter than their respective tarsal segments (10E). Genus *Blatta* (in part)-------- 11



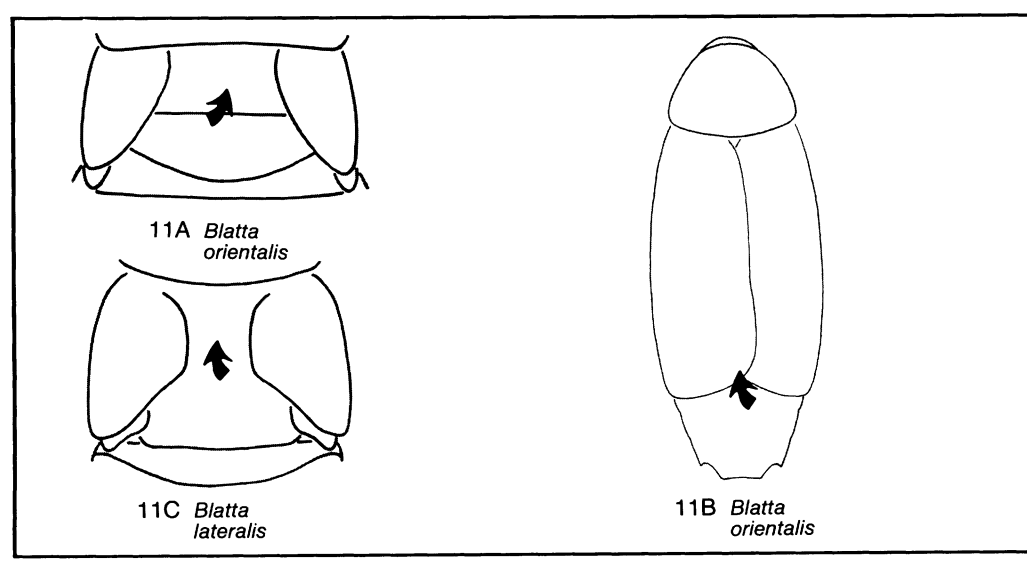
11 Body color of both sexes a solid dark brown to black; front wings of females separated by a distance greater than width (11A); front wings of males overlapping and covering 1/2 to 2/3 of abdomen (11B); pl. 51A&B ---------**oriental cockroach,** *Blatta orientalis*

This very well known cockroach occurs mainly in relatively temperate zones (northern United States, England and northern Europe, southern Australia, southern South America), though it appears in port cities throughout the world. Rehn (*39*) thought that north Africa was its most likely original homeland, but Princis (*36*) suggested that southern Russia, in the vicinity of the Black and Caspian Seas, was its center of origin. Oriental cockroaches, which have been spread widely through commerce, are usually limited to the lower levels of dwellings where moisture is readily available and temperatures are not too warm. They are partial to moist or leaky water pipes, floor drains, and sewers. Their ability to withstand temporary submersion in water enables them to pass through water traps. This association with water is responsible for their being called "waterbugs" more than other domestic cockroaches. Like the adults, the nymphs are reddish-brown to black, though young nymphs are often paler. The pad (arolium) between the tarsal claws is small, even in adults. This is especially true of females, but the arolium is of variable size in adult males. Females and some males are unable to climb some vertical walls. Oriental cockroaches are notably less proficient climbers than many other kinds of domestic cockroaches (*46*). Eggs of *B. orientalis* usually hatch in a month or slightly more under warm conditions (much longer when cold). Nymphal growth takes from five to ten months, with nymphal females requiring more time than males to reach maturity. Adults live from one to several months. See also 9B, 10E.

Body of female dark brown to black, with pale lateral wing stripes and scattered pronotal markings; front wings separated by a distance less than width of wing (11C); pl. 48----------female, **Turkestan cockroach,** *Blatta lateralis*

See couplet 6. See also 9D.

Drawings 11A&C by C. Feller.

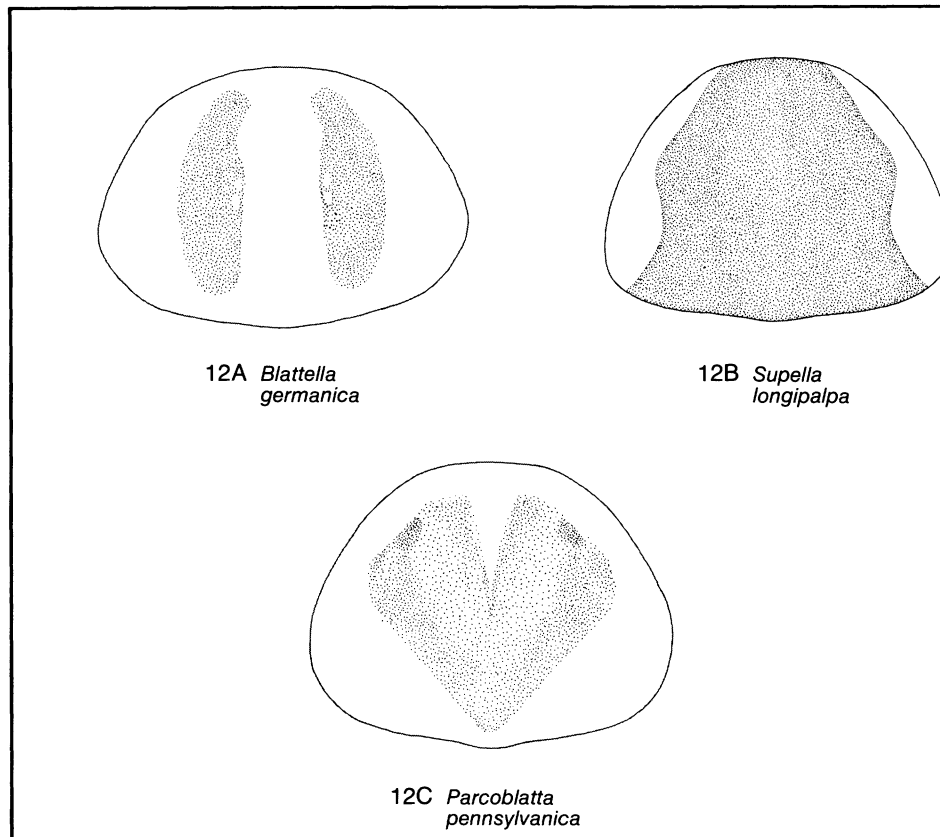


12 Pronotum with 2 conspicuous longitudinal black bars on a pale background (12A). Genus *Blattella* ---------- 13

Although only *Blattella germanica* and *B. vaga* are represented in this key, several other members of this genus should be mentioned in passing. In addition to *B. germanica* and *B. vaga,* Princis (*37*) listed 15 species of *Blattella* for the world. Now more than 40 species are recognized worldwide, from southern Asia, Japan, various Indo-Malaysian and Pacific islands, and Africa, including several African species sometimes placed in the genus *Symploce* (L. M. Roth, personal communication). Almost all of them are outdoor species of little economic concern. However, the **false German cockroach,** *B. lituricollis* (pl. 52A), which occurs in Burma, China, the Philippines, and on various islands north to Japan and east to Hawaii, occasionally is a pest, though it too occurs mostly outdoors (*3, 55*). Another outdoor species, *B. nipponica* Asahina (*2*), closely resembles *B. germanica,* except that it flies readily (*B. germanica* does not). Laboratory crosses have not produced offspring. *B. nipponica* occurs in southwestern Japan in grassy areas near the coast, under dead leaves of forest margins, and under decayed vegetation in cultivated areas.

Drawings 12A-C by C. Feller.

Pronotum without 2 conspicuous longitudinal bars (12B, 12C) ---------- 14



12A *Blattella germanica*

12B *Supella longipalpa*

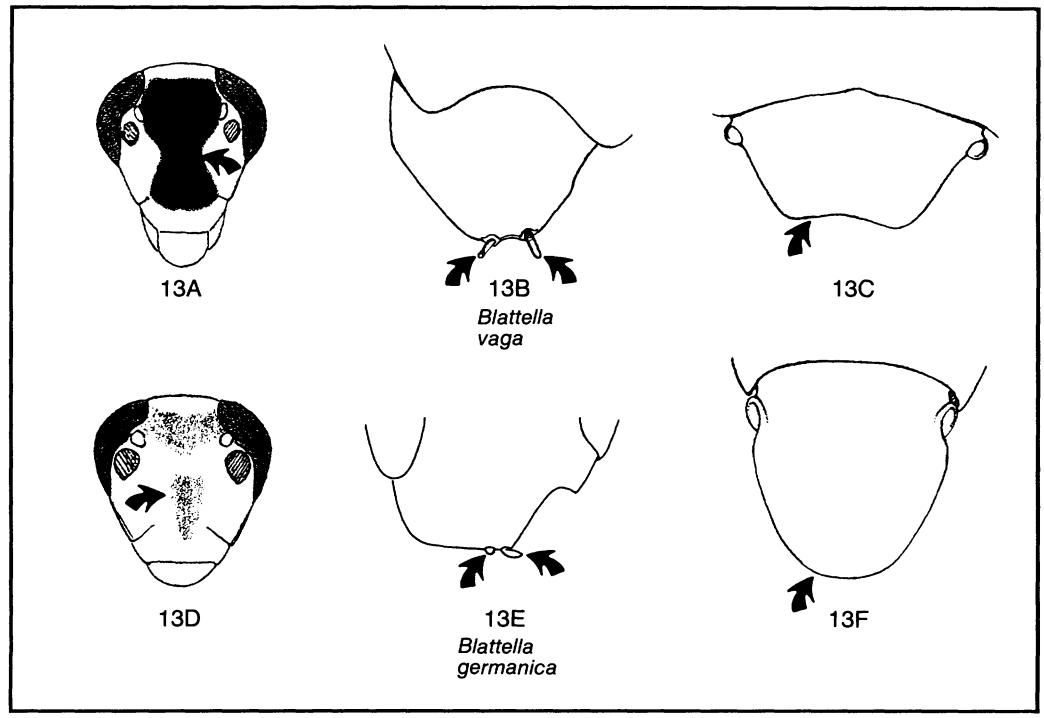
12C *Parcoblatta pennsylvanica*

13 Face with a conspicuous, longitudinal black bar (13A); styli on male subgenital plate elongate, nearly equal in size (13B); male supraanal plate short, broadly emarginate at apex (13C); usually found outdoors, only occasionally in buildings; pl. 52B ---------- field cockroach, *Blattella vaga*

Although it was found first in Arizona (*22*), *Blattella vaga* (*5, 12, 40, 51*), a primarily outdoor-living relative of the German cockroach, originated in Asia (Afghanistan, India, Sri Lanka). In the United States, it occurs in Arizona, California, New Mexico, Texas, and Utah. During especially dry weather, it sometimes enters houses by way of suitable nearby accumulations of decomposing vegetation, such as leaf mulch.

Face pale or with indefinite brownish areas (13D); styli on male sugenital plate short and rounded, of unequal size (13E); male supraanal plate elongate, rounded at apex (13F); usually found indoors; pl. 52C-E --**German cockroach,** *Blattella germanica*

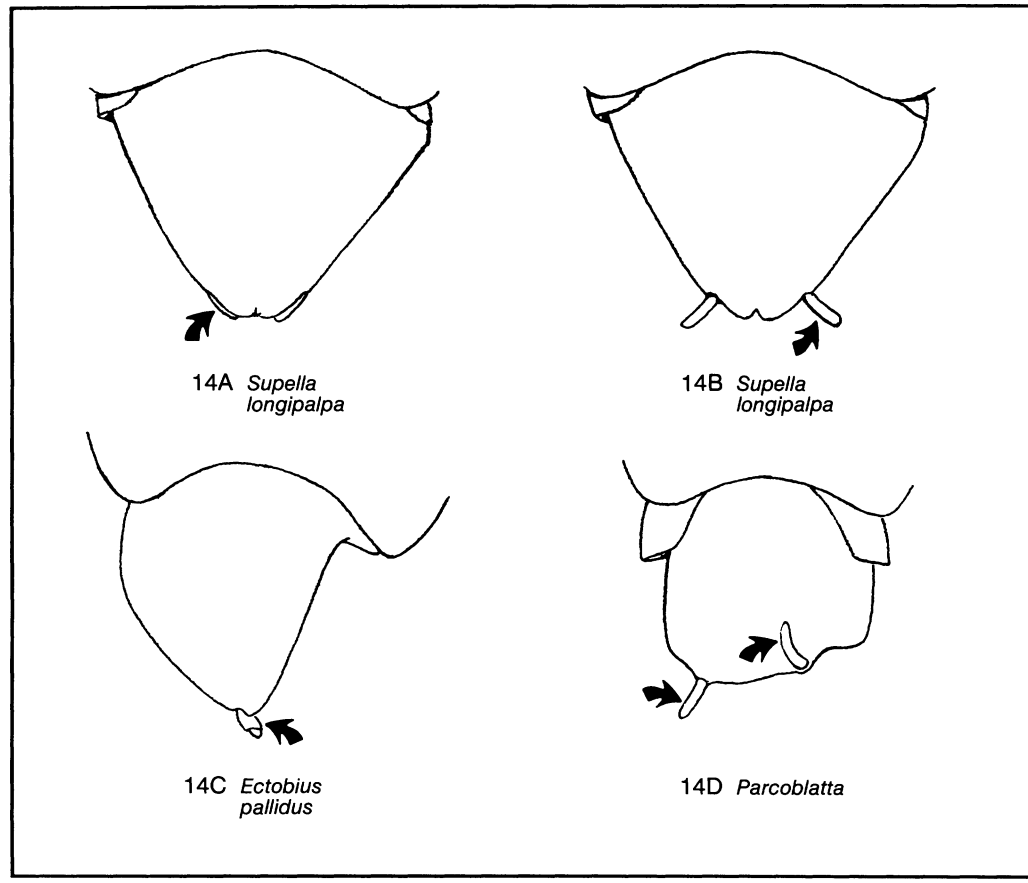
This species, probably the most important pest cockroach, has spread from Africa (*9, 39*) and is now thoroughly cosmopolitan. In medium-sized to nearly mature nymphs the longitudinal pronotal bars are as evident as they are in the adults; the bars are fused in very young numphs (pl. 52C). In these, immediately posterior to the large central black spot on the pronotum, there is a large central pale area that occupies portions of all three thoracic nota. Nymphs molt five to seven times over a period of one or two months if conditions are favorable (longer if unfavorable). Adults live about 100 days usually (less under poor conditions). Caution: *B. asahinai*, the **Asian cockroach**, recently discovered in Florida, is very similar in appearance to *B. germanica*. Consult current literature for comparative descriptions of these two species. See also 12A.



14 Pronotum with uniformly dark central area and pale lateral margins; front wings (in usual folded position) with 2 transverse brownish bars or bands (pl. 54D&E) (inconspicuous on some specimens); width of pronotum usually not more than 4.5 mm; male styli inconspicuous (14A), unless artificially displayed (14B); pl. 54C-E ----------**brownbanded cockroach,** *Supella longipalpa*

This cockroach, formerly called *S. supellectilium* (*18*), is a native of Africa, but it is now a widely-distributed indoor pest in warm temperate countries. It also occurs outdoors in subtropical areas. Spread through human activities, its distribution has greatly increased in recent decades. It was first reported in the United States at Miami FL in 1902; now it probably occurs in every state. Even so, it is not encountered as frequently as the German cockroach; its rate of infestation in California homes is only 5% of that of the German cockroach (*11*). The color pattern of the nymphs, especially the pale lateral margins of the pronotum and the two separate, irregularly-transverse pale areas of the thoracic notum posterior to the pronotum, is distinctive (pl. 54C). The six to eight nymphal stages occupy about 55 days, and the adults usually live from 90 to 115 days (range is from 67 to 141 days). A complete life cycle takes 100 to 200 days. See also 12B.

If pronotum has paler lateral margins, then its width is more than 4.5 mm; front wings without 2 transverse bands (pl. 55, 56A-C); 1 (14C) or 2 (14D) conspicuous styli present---------- 15

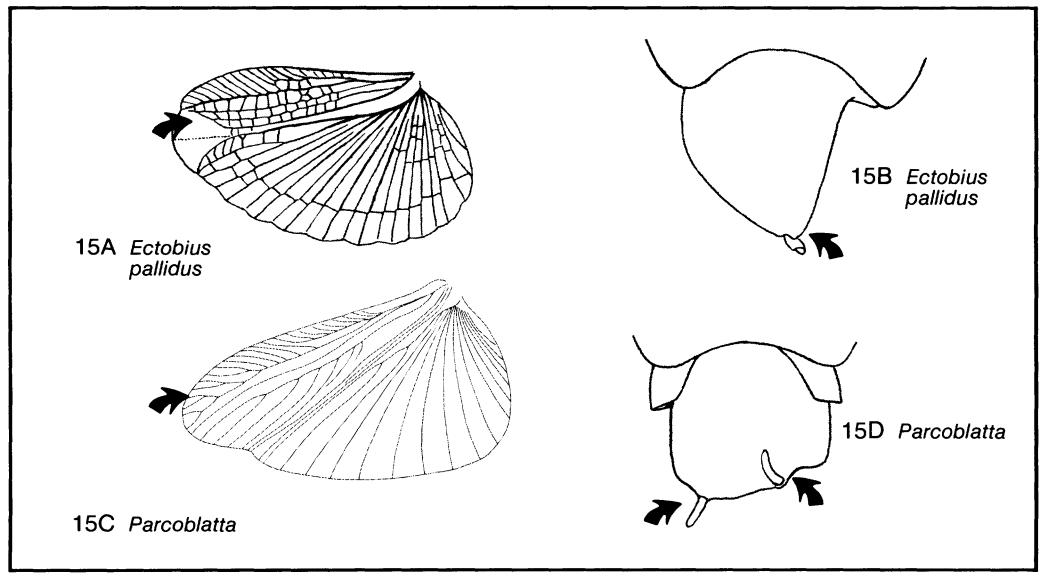


15 A small pale cockroach rarely more than 9 mm long; hind wing with a triangular apical area devoid of veins (15A); subgenital plate narrow at apex, bearing a single stylus (15B); pl. 55A----------**spotted Mediterranean cockroach,** *Ectobius pallidus*

This species, called the tawny cockroach in England, occurs chiefly in southern Europe and parts of North Africa. Recently, it has become established in Massachusetts and Michigan (*15, 17*). It is mainly an outdoor species, but it occasionally invades buildings (*49*) in rural areas. Several other species of *Ectobius,* among which *E. lapponicus* (pl. 55B&C) is the best known and most widely distributed (*37*), occur chiefly outdoors in Europe, but may be found occasionally in domestic situations. *E. sylvestris* (pl. 55D), the forest cockroach, was found in a house in New York state in 1980. See reference *26* for a key to separate *E. sylvestris* from *E. pallidus.*

Specimens almost always more than 9 mm long; hind wing with apex veined (15C); male subgenital plate with broad apex, the 2 styli elongate and well separated (15D); pl. 56A-C---------- wood cockroaches, *Parcoblatta*

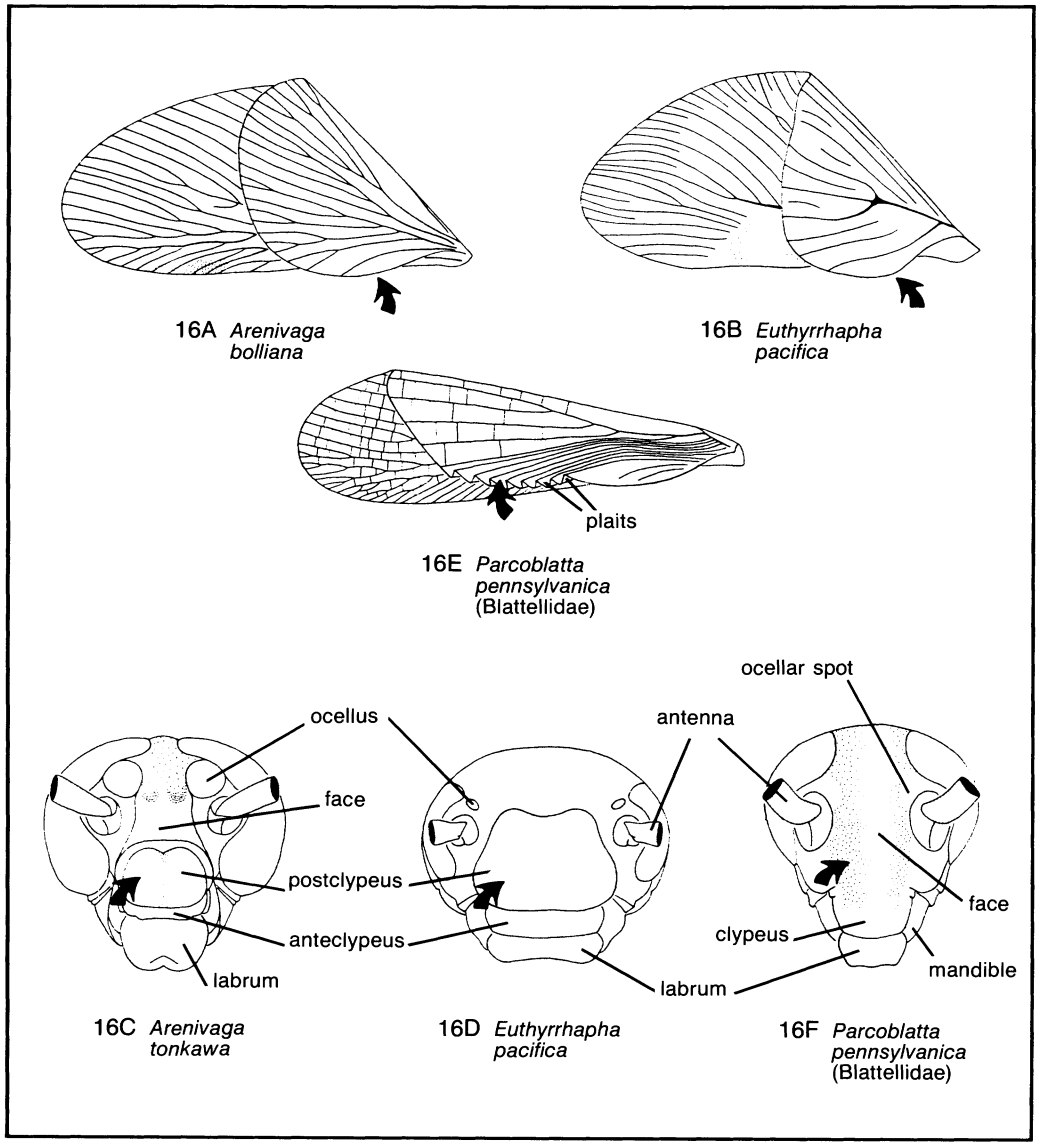
There are 13 species of *Parcoblatta*, 12 of which are outdoor-living, native North American insects (*21*). The species differ in size, body proportions, color pattern of the pronotum and tegmina, and in certain small structural details. They occur most often in or near wooded areas, on the ground in leaf mold, beneath loose bark, in decomposing logs, or in other plant debris (*28*). The males often fly to lights, especially in spring and early summer; thus they are likely to enter buildings adjacent to wooded areas. Nearly all the females are flightless (short wings); they are seen less often indoors. Established breeding colonies are uncommon in houses; occasionally, specimens are brought into homes with firewood. *P. kyotensis,* widespread in and near Japan, and also primarily an outdoor species (although it has been found in buildings), was described recently (*4*). See also 3D&E, 12C, 16E&F.
Drawing 15C by C. Feller.



16 With anal area of hind wings (if present) folded in a single flat fold when wings are closed (16A, 16B); postclypeus notably thick and bulging, and often very large (16C, 16D); pl. 56D&E ----------polyphagids, polyphagid cockroaches, Polyphagidae

The numerous polyphagid species are distributed nearly worldwide. In the continental United States, polyphagids occur chiefly in the southwestern states and in Florida. None of the United States species (*Arenivaga* spp.) has any economic importance, but in parts of northern Africa and southern Asia, a few species (e.g., *Polyphaga aegyptiaca* and *P. saussurei*) are occasional minor domestic pests (*7*).
Drawings 16A-F by C. Feller.

With anal area of hind wings (if wings are fully developed) folded like a fan when wings are closed (as in 16E); postclypeus not notably large or thick (as in 16F) 17



16A *Arenivaga bolliana*

16B *Euthyrrhapha pacifica*

16E *Parcoblatta pennsylvanica* (Blattellidae)

16C *Arenivaga tonkawa*

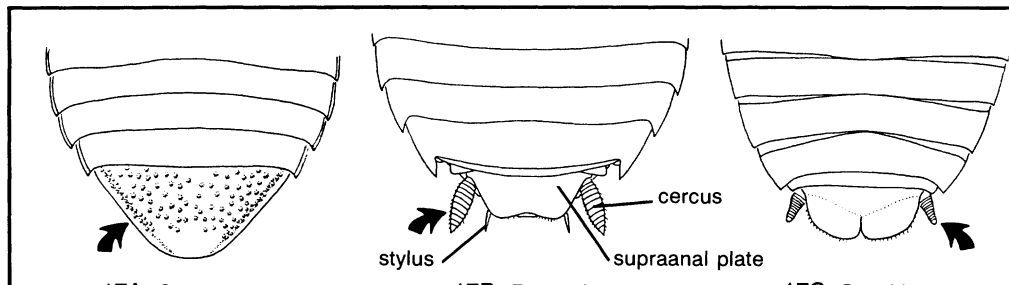
16D *Euthyrrhapha pacifica*

16F *Parcoblatta pennsylvanica* (Blattellidae)

17 Wingless; integument black, strongly sclerotized; cerci concealed by surrounding terminal tergum and sternum (17A); pl. 57A
---------- cryptocercids, cryptocercid cockroaches, Cryptocercidae

In contrast to the condition of hidden cerci of cryptocercid adults, the cerci of the whitish or brownish nymphs protrude beyond the margins of the terminal abdominal sclerites. Two species of *Cryptocercus* inhabit China and Manchuria. The third species in this family, the brownhooded cockroach, *C. punctulatus* (pl. 57A), occurs as family groups in rotten logs in the mountains of eastern (Georgia to New York) and western (California to Washington) United States. The three cryptocercid species are of little or no economic importance.
Drawings 17A-C by C. Feller.

Usually with wings, at least in males; cerci visible externally (as in 17B), but may be very small (17C). Blaberidae (blaberids, blaberid cockroaches)---------- 18

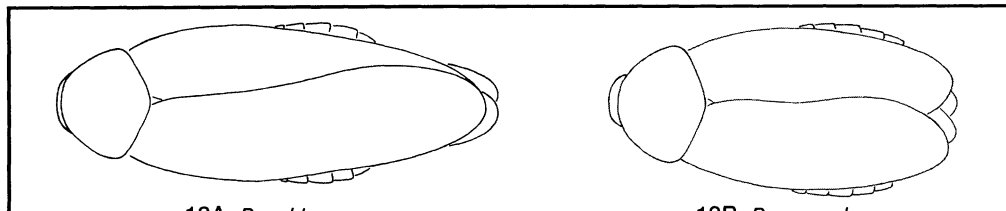


17A *Cryptocercus punctulatus* 17B *Eurycotis floridana* (Blattidae) 17C *Panchlora nivea*

18 Body relatively slender (18A) and colored a nearly uniform pale green; pl. 57B
---------- **Cuban cockroach,** *Panchlora nivea*

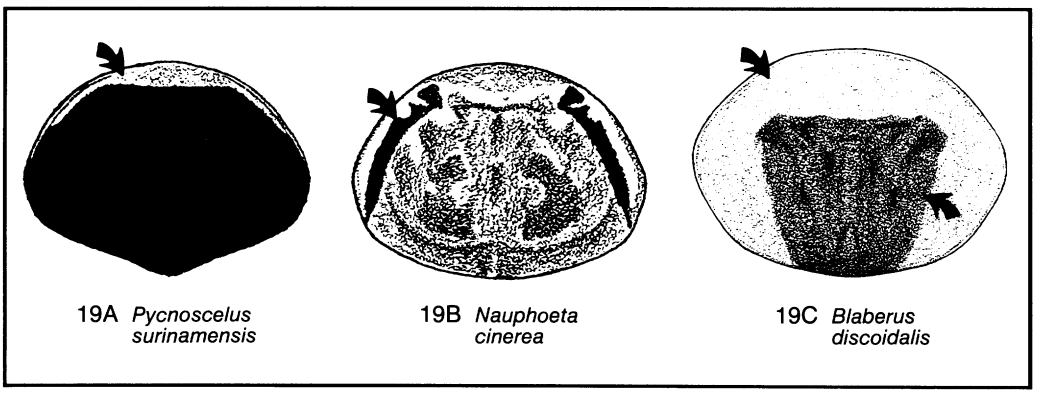
This cockroach of tropical American origin, the common name of which is based on the type locality of a synonymous species (*16*), is one of several pale green species often carried about on banana ships. Although some outdoor breeding colonies are established in the Gulf states, primarily Texas (*23*), most specimens are adventive, having been recently introduced with fruit (*50*). Unlike the adults, the nymphs are brown. In contrast to the related *Pycnoscelus surinamensis,* the dorsal surfaces of the terminal abdominal segments of nymphs are smooth and shiny.
Drawings 18A&B by C. Feller.

Body relatively broad (18B) and not green in color---------- 19



18A *Panchlora nivea* 18B *Pycnoscelus surinamensis*

19 Body medium-sized, 30 mm or less in length; pronotum solid black with pale anterior margin (19A) or pronotum with a complex central pattern bordered on each side by a longitudinal black band (19B)---------- 20
Body large, 40 mm or more; pronotum pale except for dark design in central area (19C) 21



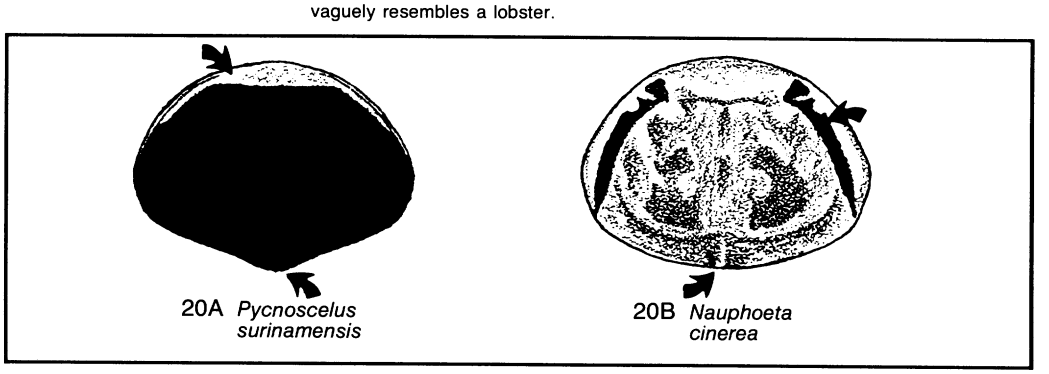
19A *Pycnoscelus surinamensis* 19B *Nauphoeta cinerea* 19C *Blaberus discoidalis*

20 Pronotum blackish except for a narrow yellow band of variable width along lateral and anterior margins; posterior margin of pronotum forming a definite obtuse angle (20A); pl. 57C&D ----------**Surinam cockroach,** *Pycnoscelus surinamensis*

This widespread, parthenogenetic species of warm countries probably originated in the Malayan area. Now it is established outdoors in several Gulf states (USA). It has been found in greenhouses in northern United States and northern Europe (*9*). The dorsal surface of the last 5 abdominal segments of the nymph is roughened and dull, not glossy like the rest of the body (pl. 57C). In some other species of *Pycnoscelus,* including *P. indicus* (Burma, Hawaii, Indonesia, Malaysia) (*41*; pl. 58), functional males and females occur. See also 18B.

Pronotum pale, with irregular brown blotches in central area, and a submarginal black band on each side; posterior margin of pronotum not angulate, only somewhat broadly protruding (20B); pl. 59. ----------**cinereous cockroach,** *Nauphoeta cinerea*

This species, evidently originally from tropical Africa, has spread widely through commerce to warm countries around the world. It has become established in a few localities, especially in Florida (*15*), in the continental United States. Food warehouses and grain-milling plants are frequently infested. The name lobster cockroach is based on the pronotal pattern which vaguely resembles a lobster.



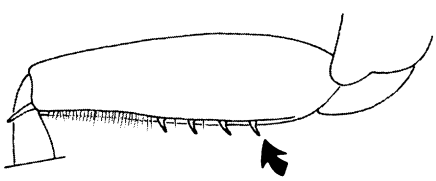
20A *Pycnoscelus surinamensis* 20B *Nauphoeta cinerea*

21 Pronotum with sharply-defined, blackish, shieldlike central design, sometimes solidly black, sometimes patterned (pl. 60); femur I with 1 or more short robust spines on ventral margin (21A) ----------giant cockroaches, *Blaberus*

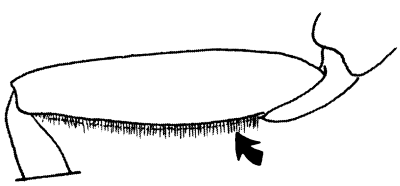
Blaberus (*43*), a tropical American genus with about a dozen very large species, is represented in the United States by two species (*B. craniifer,* pl. 60A&B, and *B. discoidalis,* pl. 60C) established in extreme southern Florida. Both of these species and some others (such as *B. giganteus,* pl. 60D) are often maintained in laboratory cultures for scientific and demonstration purposes. In the United States members of this genus are rarely of economic importance, though in some tropical countries they sometimes are pests (*9*). See also 2B, 19C.

Pronotum with brownish central design, darkened in outline only, often not sharply defined (pl. 61); femur I without spines on ventral margin, only a line of stiff fine hairs (21B)
---------- **Madeira cockroach,** *Leucophaea maderae*

These large, distinctive cockroaches, apparently native to West Africa (*39*), are now circumtropical in distribution. Madeira cockroaches are especially abundant in those countries south of the United States which border the Caribbean Sea. Fruit stores are especially likely to be infested. Sometimes, as in New York City around 1950, they infest heated buildings in colder areas (*15*).



21A *Blaberus*



21B *Leucophaea maderae*

Egg Cases (Oothecae)

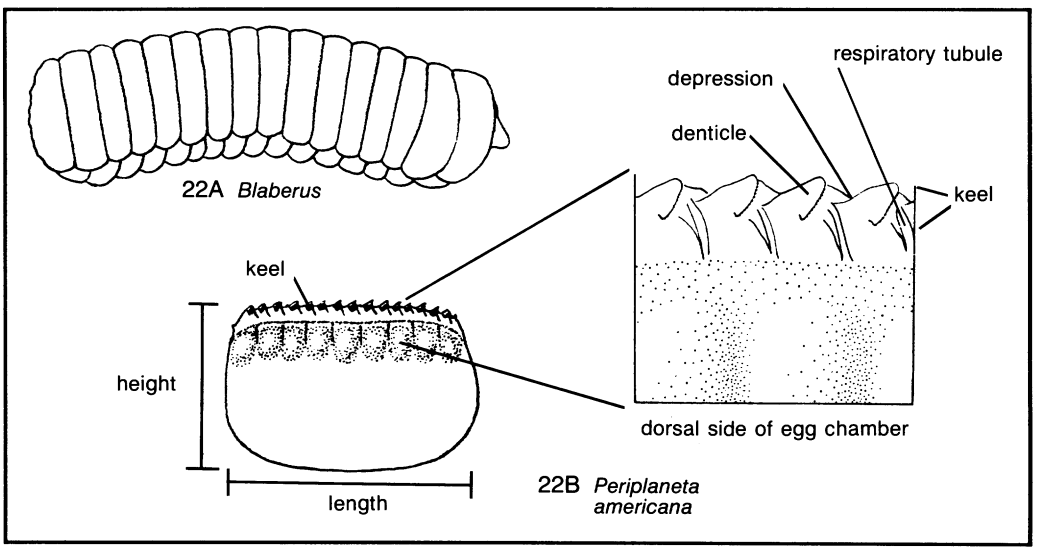
22 Ootheca a poorly-sclerotized, whitish or light brown packet, often more than 17 mm long, without a distinct keel (22A)----------blaberids, Blaberidae

Embryonic development in other families of cockroaches (and generally of most other insects) is *oviparous,* i.e., offspring develop in and eventually hatch from eggs that are produced by the mother, charged with nutrients, and deposited (oviposition) somewhere outside the body of the mother. In the Blaberidae the eggs are enclosed in a soft membranous ootheca which protrudes briefly from the mother's body. Then it is retracted and incubated in a special sac until the eggs hatch; the nymphs appear to be "born alive." In the more typical blaberids there is no further access to maternal nutriments after the ootheca is retracted for incubation. This type of development is termed *ovoviviparous.* A more specialized type of blaberid development occurs in the Diplopterinae, a subfamily of about ten Oriental and African species, the best known of which is *Diploptera punctata* (Eschscholtz), the **Pacific beetle cockroach,**

a species now widely distributed, especially in the Pacific area. The ootheca of *D. punctata* protrudes for a shorter time than is the case in other blaberids. The ootheca is then withdrawn into the mother's body. This kind of development, termed *viviparous,* is characterized by the continued access of the embryos to nutrients from the mother, a phenomenon superficially similar to the mammalian fetal support system (*44*). We have not attempted to differentiate the egg cases of the various blaberids. Their egg cases are seldom seen by the ordinary observer, and distinctions between species, so far as they are known in regards to egg cases, are less marked than in other families of cockroaches.

Ootheca a well-sclerotized, brown to black packet, not more than 17 mm long, with a distinct keel along the dorsal margin (22B)---------- 23

See also couplet 1 for descriptions of the oothecae of Polyphagidae and Cryptocercidae.

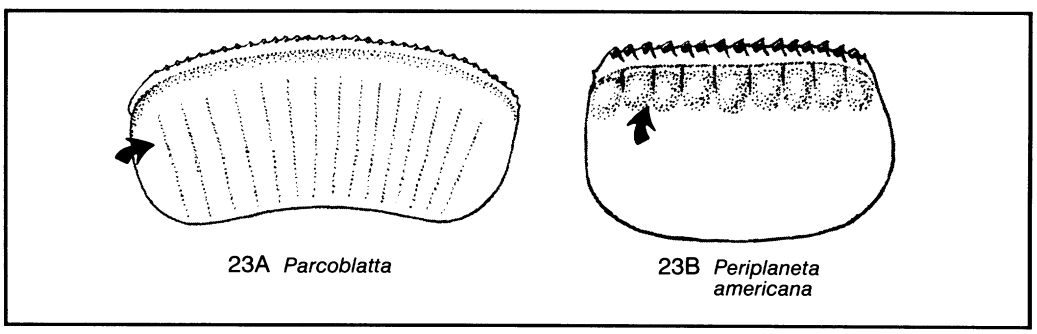


22A *Blaberus*

22B *Periplaneta americana*

23 Egg chambers marked by lines, usually plainly evident, extending completely across ootheca; keel sometimes low, with respiratory tubules usually not evident upon casual inspection (23A); height seldom more than 4 mm. Blattellidae (blattellids) 24

Egg chambers plainly marked only by indentations near the keel, not by definite lines extending completely across the ootheca; keel usually high, with oblique respiratory tubules plainly evident (23B); height usually at least 5 mm. Blattidae (blattids)-- 28

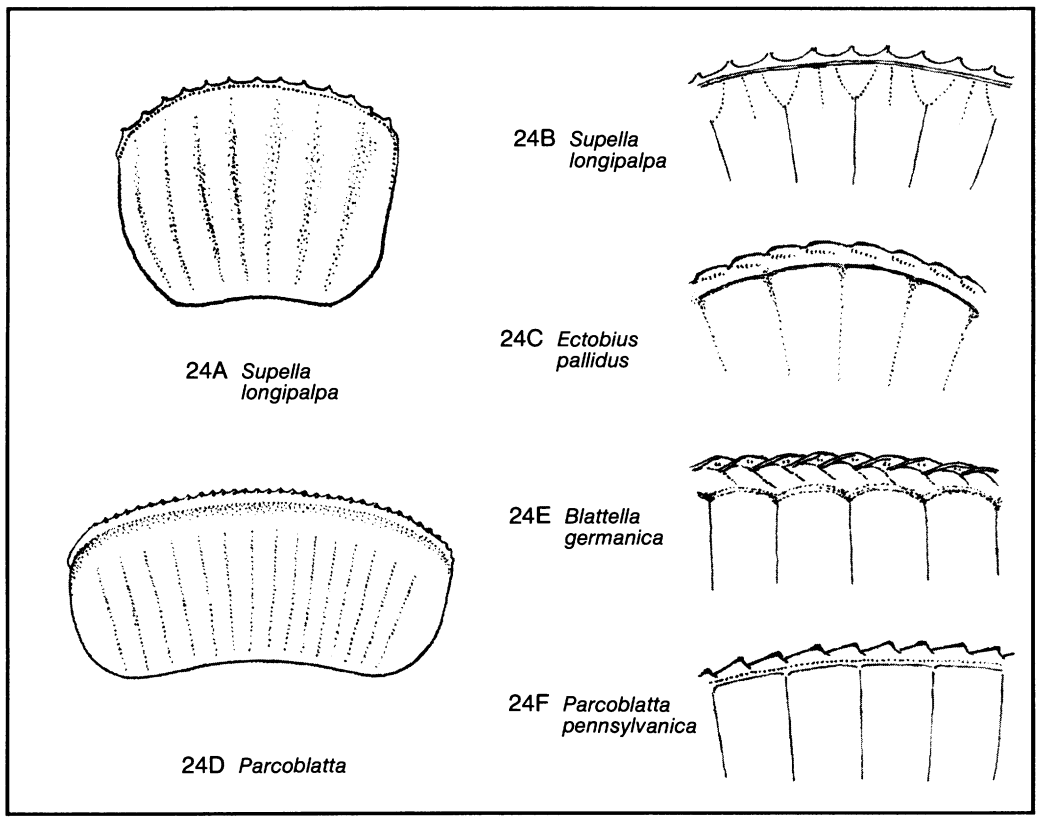


23A *Parcoblatta*

23B *Periplaneta americana*

24 Ootheca short, not more than 4.5 mm long, usually with no more than 10 egg compartments on a side (24A); denticles on keel usually prominent though small (24B), sometimes more rounded (24C) ---------- 25

Ootheca usually more than 4.5 mm long, usually with more than 10 egg compartments on a side (24D); denticles on keel usually not prominent (24E), sometimes distinct (24F) ---------- 26



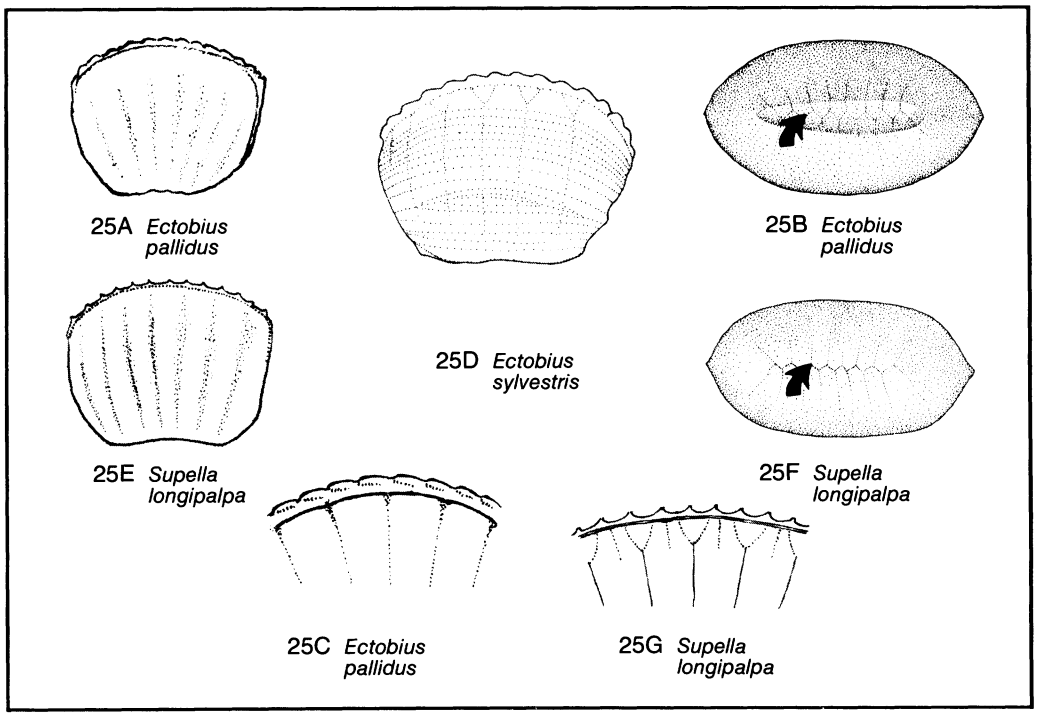
25 Ootheca (25A) 2 to 3 mm long; ventral surface usually with a distinct longitudinal concavity or invagination (most conspicuous in ventral view) where the sides meet (25B); keel serrate with blunt denticles separated by unevenly-rounded depressions (25C) ---------- **spotted Mediterranean cockroach,** *Ectobius pallidus*

The ootheca of *Ectobius sylvestris* is similar to that of *E. pallidus* in size and shape, and it also has a ventral depression. However, the longitudinal grooves of the ootheca of *E. sylvestris* (25D) make it easy to distinguish from that of *E. pallidus.* See also couplet 15.

Drawings 25B&D&F by C. Feller.

Ootheca (25E) at least 4 mm long; ventral surface without distinct concavity (25F); denticles on keel prominent, with the depressions between them evenly rounded (25G) ---------- **brownbanded cockroach,** *Supella longipalpa*

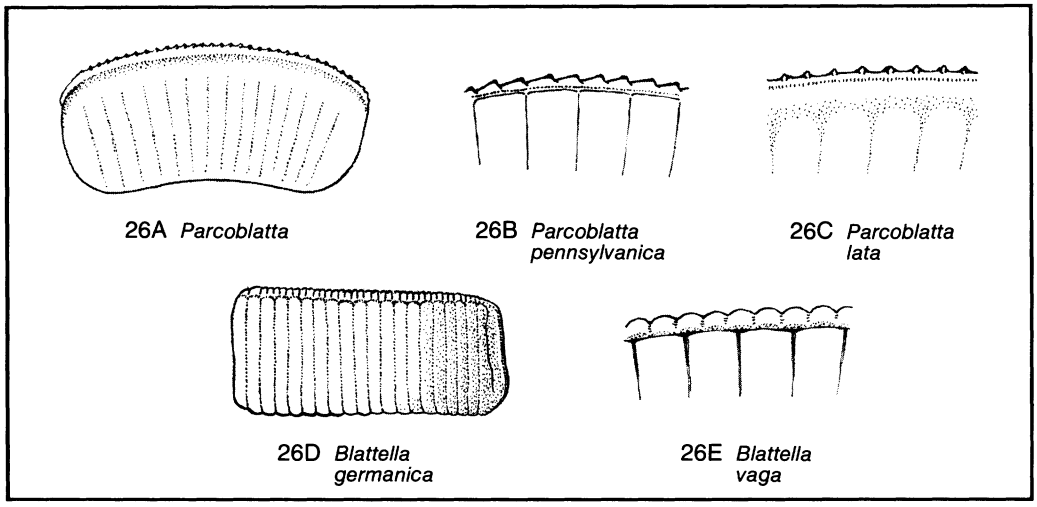
Females often glue the oothecae to surfaces, such as the insides of cabinets or drawers. This habit accounts for much of the distributional spread of this species. Incubation takes 37 days at 30 C (longer if colder). A female usually produces about ten oothecae, but the number ranges from five to twenty.



26 Ootheca of uniform color; curvature usually distinct (26A); denticles of keel distinct, usually sharply serrate (26B, 26C)---------- wood cockroaches, *Parcoblatta*

The egg cases of the several species of *Parcoblatta* show considerable differences in size and proportion of length and height (*42*). The ootheca of *P. uhleriana* (Saussure) is unusual in this genus in that it has a deep longitudinal groove on each side of the keel just below the denticles (*27*).

Ootheca not of uniform color, one end (the one that was held by the ovipositor) paler than the other; ootheca straight or slightly curved (26D); denticles on keel low, well-rounded (26E). Genus *Blattella*---------- *27*

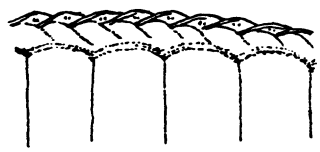


27 Usually about 20 egg compartments on each side; length more than 7 mm; denticles of keel very low and gradually curved (27A); found indoors in most countries ----------**German cockroach,** *Blattella germanica*

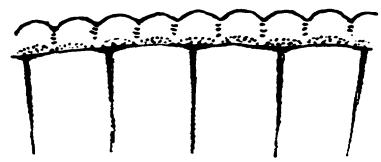
Of the common domestic cockroaches that form well-sclerotized oothecae, this is the only one in which (during a period of 17 to 35 days, depending on the temperature) the female carries the ootheca until, or to within a few hours of, hatching (*53*). A female is likely to produce four to eight egg cases during her life, the later ones usually being smaller. See also 26D.

Usually about 16 egg compartments on each side; length seldom more than 6 mm; denticles slightly higher and curved more abruptly (27B); usually found outdoors ----------field cockroach, *Blattella vaga*

B. vaga carries the ootheca until (or to just shortly before) hatching (*53*).



27A *Blattella germanica*

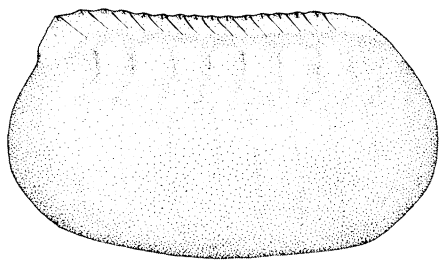


27B *Blattella vaga*

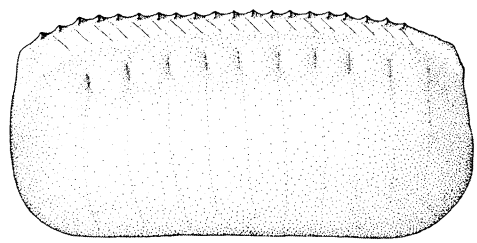
28 Number of denticles in keel seldom more than 17 (28A); ootheca almost always less than 13 mm long---------- 29

Number of denticles more than 17 (28B); oothecal size variable, sometimes more than 13 mm long---------- 31

Drawings 28A&B by C. Feller.



28A *Blatta orientalis*

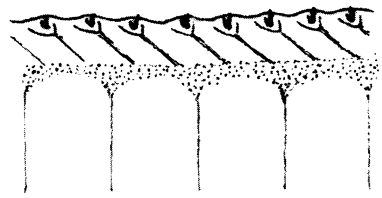


28B *Periplaneta brunnea*

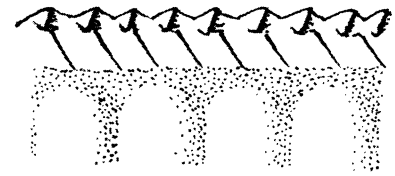
29 Ootheca usually 10 to 12.5 mm long, usually with 14 denticles; depressions between denticles shallow (29A)---------- **oriental cockroach,** *Blatta orientalis*

See also 28A.

Ootheca 8 to 12 mm long, with 14 to 22 denticles; depressions between denticles deep (29B) or shallow ---------- 30



29A *Blatta orientalis*

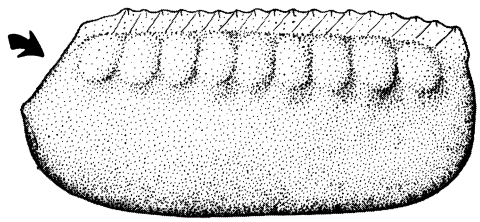


29B *Periplaneta americana*

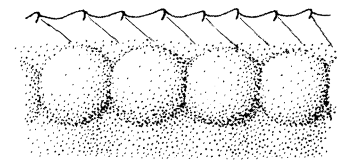
30 Ootheca 9 to 12 mm long, with 14 to 22 denticles; ootheca rounded at one end, truncated dorsally at the other (30A); depressions between denticles shallow (30B) ----------**Turkestan cockroach,** *Blatta lateralis*

Ootheca 8 to 9 mm long, usually with 16 denticles; ootheca rounded at both ends (30C); depressions between denticles deep (30D) ---------- **American cockroach,** *Periplaneta americana*

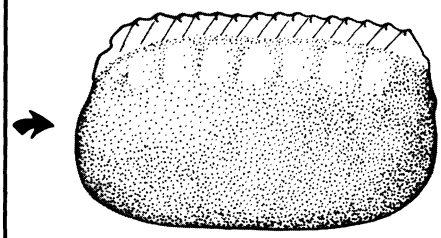
Drawings 30A-C by C. Feller.



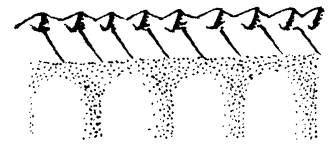
30A *Blatta lateralis*



30B *Blatta lateralis*



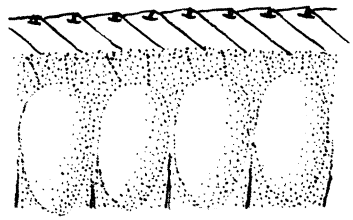
30C *Periplaneta americana*



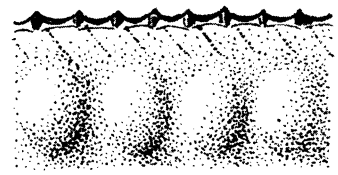
30D *Periplaneta americana*

31 Spaces between denticles almost straight, with depressions so shallow as to not be clearly evident (31A)----------**harlequin cockroach,** *Neostylopyga rhombifolia*

Spaces between denticles with conspicuous depressions (31B)---------- 32



31A *Neostylopyga rhombifolia*



31B *Periplaneta brunnea*

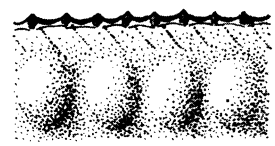
32 Ootheca large, measuring 13.5 to 16 mm long and 6.4 to 7.5 mm high; keel with 18 to 24 denticles (32A)---------- Florida stinkroach, *Eurycotis floridana*

Of the oviparous cockroaches occurring in the United States, this species has the largest ootheca. Larger oothecae are produced by some of the ovoviviparous blaberids (see couplet 22).

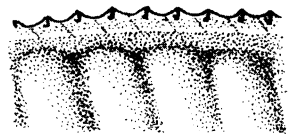
Ootheca from 9.5 to 13 mm long; keel (32B-D) with 20 to 26 denticles
---------- **Australian cockroach,** *Periplaneta australasiae*
brown cockroach, *Periplaneta brunnea*
smokybrown cockroach, *Periplaneta fuliginosa*

There are some average differences among these species of *Periplaneta* in oothecal size, number of eggs contained, and number and structural details of, and distances between denticles, but these are too variable to be practical in a key. All three species have well-developed denticles (usually at least 20) separated by deep depressions. The oothecae of these species are generally more than 9.5 mm long, in contrast to the shorter oothecae of *Periplaneta americana*. See also 28B.

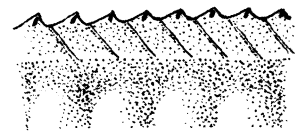
32A *Eurycotis floridana*



32C *Periplaneta brunnea*



32B *Periplaneta australasiae*



32D *Periplaneta fuliginosa*

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3 ADULT BEETLES (COLEOPTERA)

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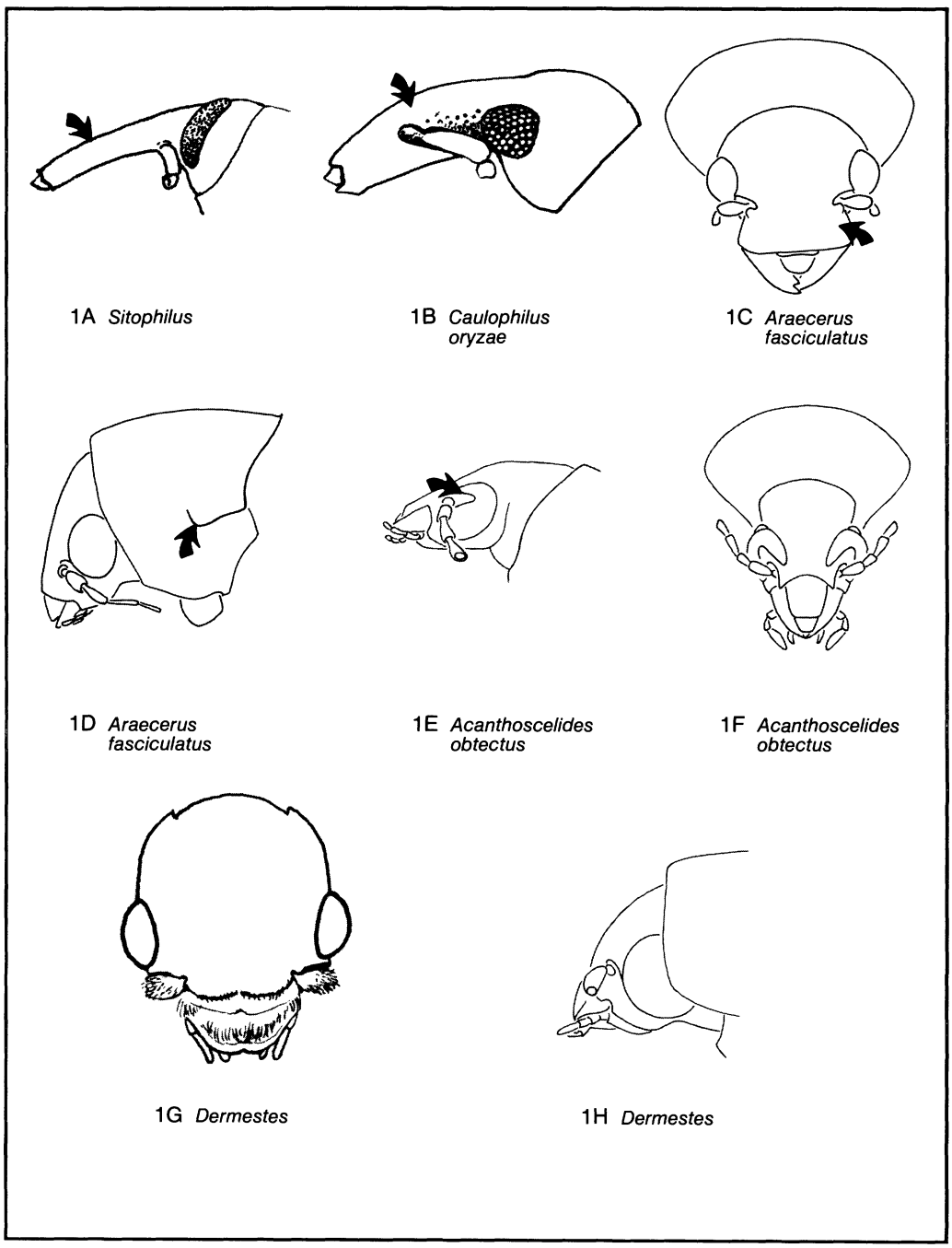
Most of the important species of stored-food beetles (other than those treated elsewhere in this handbook) are included in this key. Adult and larval bruchids, dermestids, and tenebrionids, and adult clerids, cryptophagids, curculionids, lathridiids, and ptinids are treated in subsequent chapters. The general key to the larval beetles is given in Chapter 4.

KEY

Drawings by A.D. Cushman unless otherwise noted.

1 Head with slender (1A, 1B) or broad beak (1C, 1D); if broad, with transverse carina on basal margin of pronotum extending to side margins (1D) ---------- 2
Head without beak (1E-1H) ---------- 3

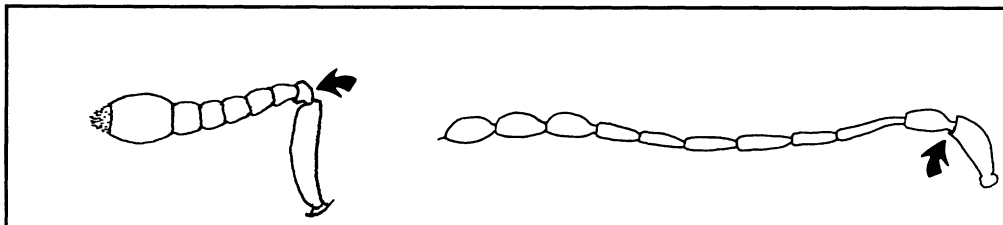
The head in Bruchidae may be interpreted as beaked but the eye is medially emarginate (1E) and the base of the pronotum lacks a carina, features that cannot be used to describe the Anthribidae and Curculionidae.
Drawings 1C-F&H by C. Feller.



2 Antenna elbowed (2A); pl. 110B ---------- **snout beetles** or **weevils,** Curculionidae
SEE KEY, CHAPTER 13

Antenna not elbowed (2B); pl. 62B. Anthribidae (**fungus weevils**)
---------- **coffee bean weevil,** *Araecerus fasciculatus*

Distribution: cosmopolitan; in a wide variety of dry seeds, fruits, stalks, and twigs; especially damaging to coffee beans. See also 1C.
Drawing 2B by J.M. Kingsolver.



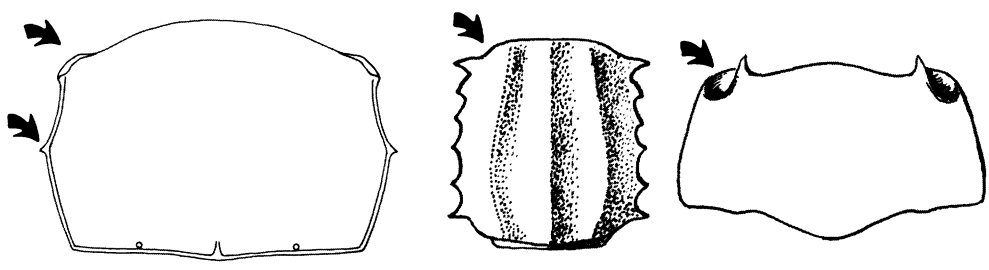
2A *Sitophilus* 2B *Araecerus fasciculatus*

3 Anterior angle of pronotum with thickened callosity, and lateral margin of pronotum with a single tooth (3A); pl. 93B. Cryptophagidae (cryptophagid beetles)
---------- *Cryptophagus*
SEE KEY, CHAPTER 9

Body length 1.5 to 3 mm; antenna with a three-segmented club.
Drawing 3A by C. Feller.

Anterior angle of pronotum without thickened callosity, and lateral margin of pronotum either without teeth or with several teeth (3B, 3C) ---------- 4

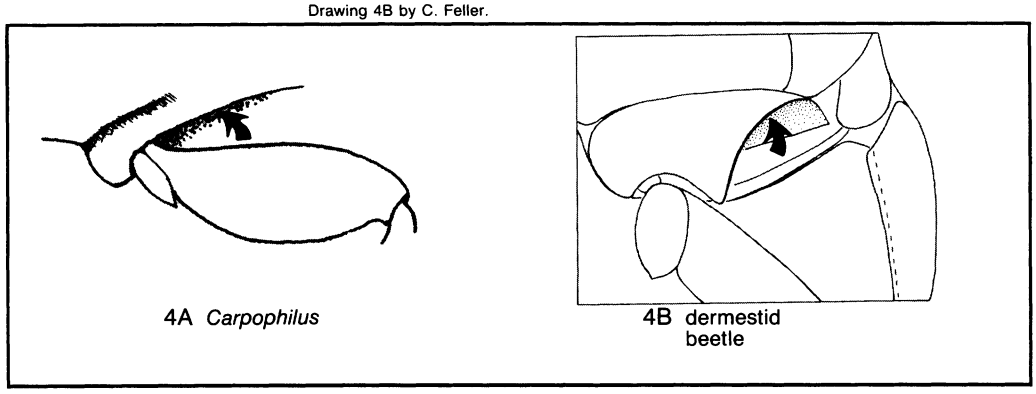
Antennal club and body length variable.



3A *Cryptophagus* 3B *Oryzaephilus* 3C *Murmidius ovalis*

4 Face of coxa III flat or at most with a shallow groove (4A)---------- 5
Face of coxa III concave (receives femur III) (4B)---------- 15

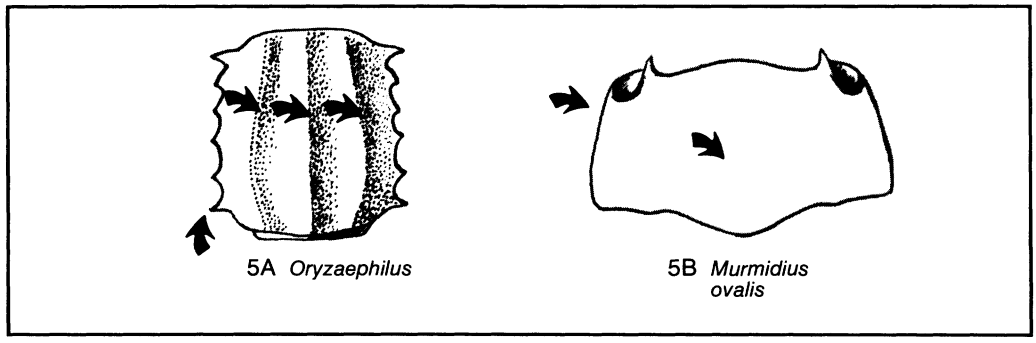
Drawing 4B by C. Feller.



4A *Carpophilus*

4B dermestid beetle

5 Lateral margin of pronotum with 6 large teeth; dorsal surface of pronotum with 3 longitudinal ridges (5A). Cucujidae (**cucujid beetles**) (in part)---------- 6
Lateral pronotal margin without prominent teeth (but may be finely serrate) or with only 1 or 2 teeth; no ridges on pronotum (5B) ---------- 7



5A *Oryzaephilus*

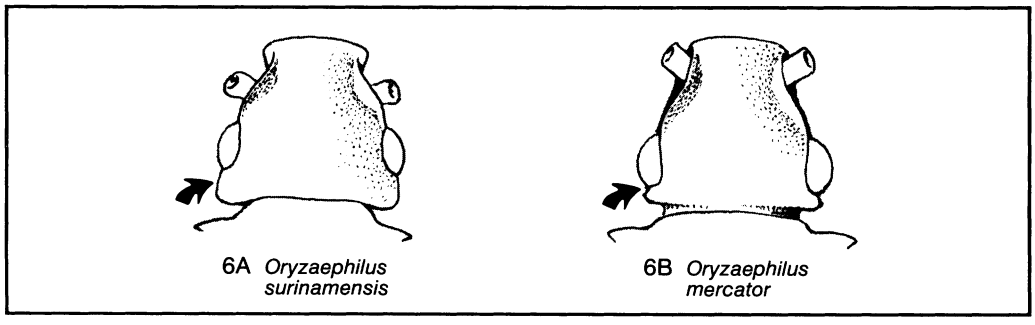
5B *Murmidius ovalis*

6 Length of temple (region directly behind eye) equal to more than one-half vertical diameter of eye (6A); pl. 63C------**sawtoothed grain beetle,** *Oryzaephilus surinamensis*

Distribution: cosmopolitan; in a wide variety of grain products and dried fruit. See also 5A.

Length of temple much less than half of vertical diameter of eye (6B); pl. 63D
----------**merchant grain beetle,** *Oryzaephilus mercator*

Distribution: cosmopolitan; in a wide variety of grain products, dried fruits, and nuts. See also 5A.



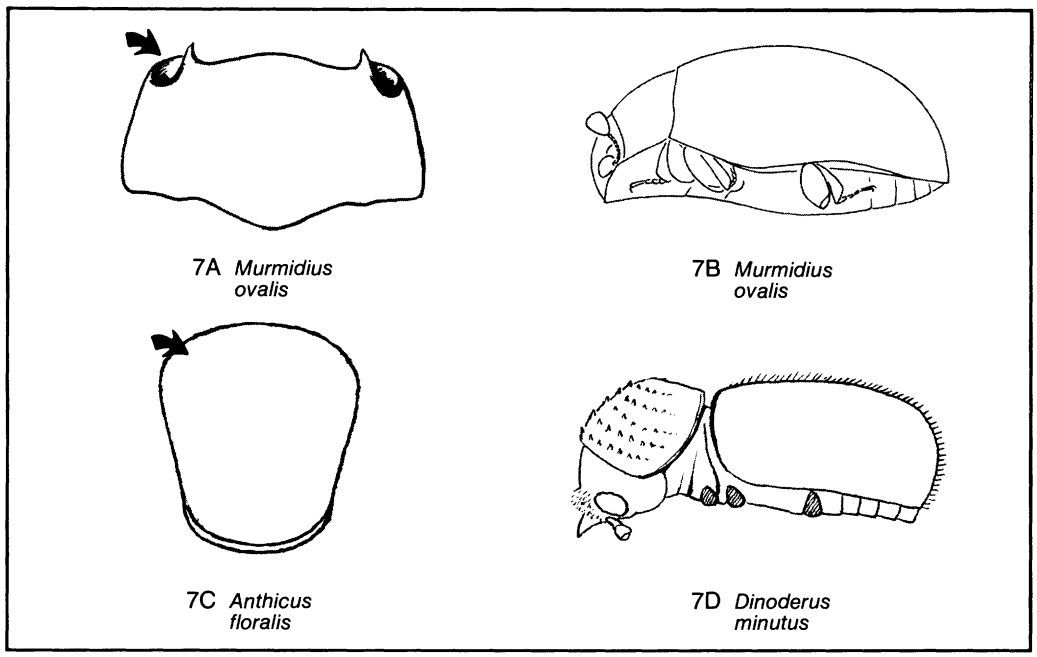
6A *Oryzaephilus surinamensis*

6B *Oryzaephilus mercator*

7 Anterolateral antennal sulcus on pronotum (near eye) (7A); body shape hemispherical, tortoiselike, without spots or stripes (7B); pl. 64B. Cerylonidae (= Murmidiidae) (cerylonid beetles)----------oval grain beetle, *Murmidius ovalis*

Body reddish brown; antenna capitate. Distribution: cosmopolitan; in various dry seeds and fruits.
Drawing 7B by C. Feller.

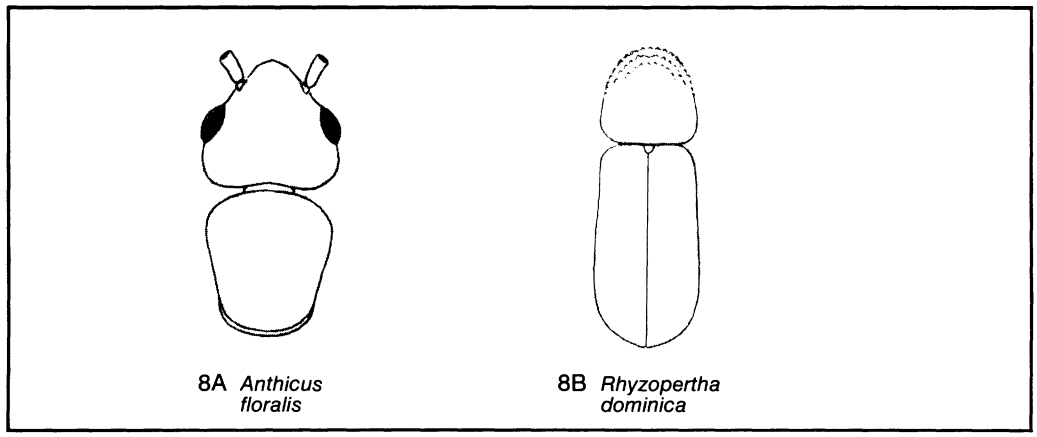
Pronotal sulcus absent (7C); spots and/or stripes may be present if body is not tortoiselike (7D); spots and/or stripes present if body is hemispherical (see pl. 65B) 8



8 Body slender, antlike, with pronotum roughly ovate in dorsal view (8A); pl. 64D. Anthicidae (**antlike flower beetles**) --------**narrownecked grain beetle,** *Anthicus floralis*

Body color reddish brown; head broad; eyes oval (not emarginate); antenna not clubbed. Distribution: cosmopolitan; in grain and dried fruit.

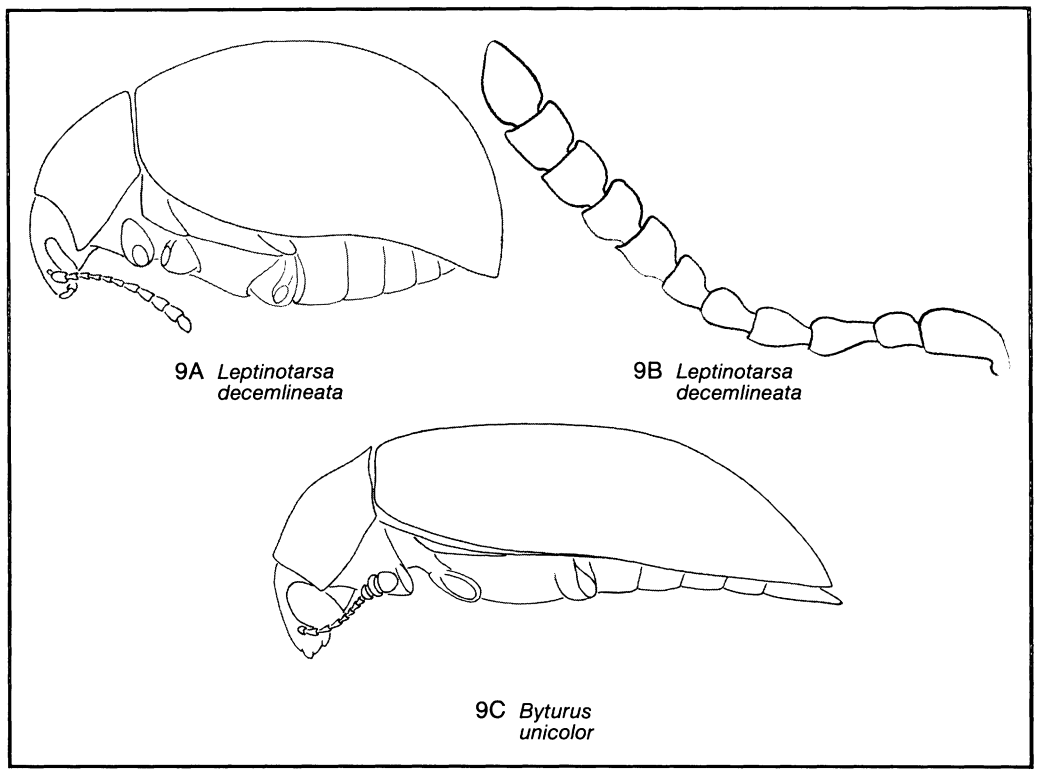
Body not antlike; pronotum not ovate (8B) ---------- 9



9 Body very convex (9A); body pale yellow, with 10 dark brown stripes on elytra and small brown spots on pronotum (pl. 65B). Chrysomelidae (**leaf beetles**) (in part) ---------- **Colorado potato beetle,** *Leptinotarsa decemlineata*

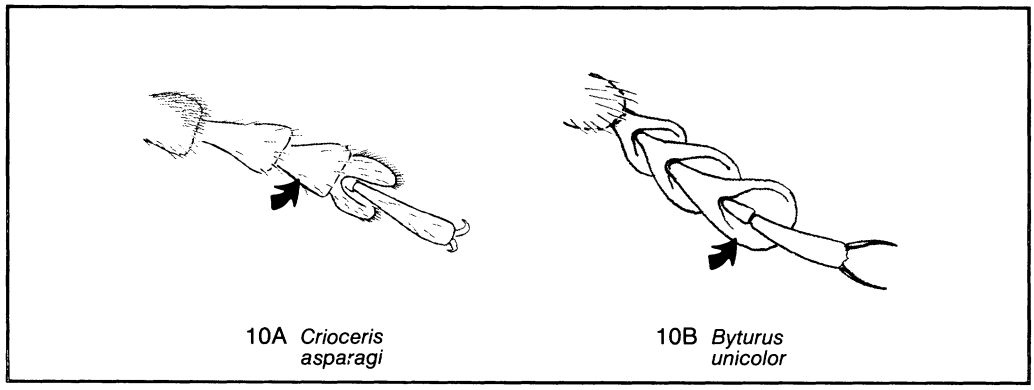
Antenna gradually clubbed (9B). Distribution: North America and, by introduction, Europe. Hosts: foliage of eggplant, potato, and tomato.
Drawings 9A&C by C. Feller.

Body shape not strongly convex (9C); without or with no more than 2 elytral stripes and pronotal spots (pl. 66B) ---------- 10



10 Tarsal segments without flaps (10A) ---------- 11
Tarsal segments II and III with broad, membranous flaps (10B) ---------- 24

Drawing 10A by C. Feller.

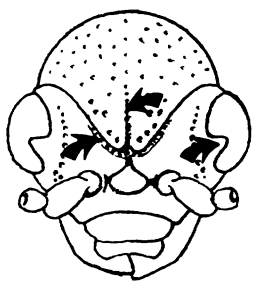


11 Front of head with a medial groove and with a lateral groove over each eye (11A). Chrysomelidae (**leaf beetles**) (in part)---------- 12

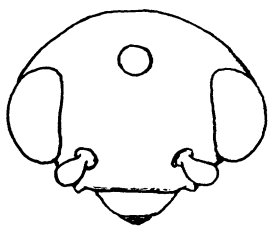
Antenna not clubbed; eye with mesal emargination (11A).

Front of head without medial and lateral grooves (11B) ---------- 13

Antennal form variable; eye without mesal emargination except in Bruchidae, most Tenebrionidae, some Anobiidae, and some Dermestidae (*Anthrenus scrophulariae*).



11A *Crioceris*



11B *Trogoderma variabile*

12 Body color orange, with 12 black spots on elytra; legs orange, with black knees and tarsi (pl. 1M) ----------**spotted asparagus beetle,** *Crioceris duodecimpunctata*

Body length: 6-6.5 mm. Distribution: Europe, United States. Host: asparagus. See also 11A.

Body colors reddish orange, dull red, and dark metallic blue; elytra with a broad sutural stripe and 3 transverse bars (sometimes separated from sutural stripe into lateral spots) (pl. 1N)----------**asparagus beetle,** *Crioceris asparagi*

Body length: 5.6-6.5 mm. Distribution: Europe, United States. Host: asparagus. See also 11A.

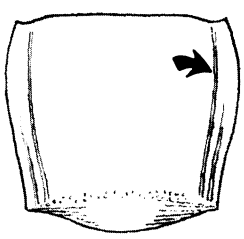
13 Tarsal formula 5-5-4 ---------- 14
Tarsal formula 3-3-3, 4-4-4, or 5-5-5 ---------- 18

14 Pronotum with a raised line parallel to margin (14A); pl. 66B. Cucujidae (**cucujid beetles**) (in part) ----------males, *Cryptolestes*

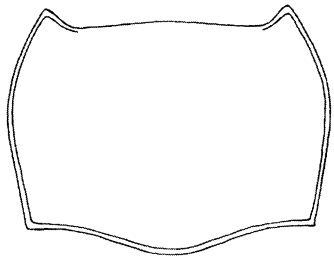
Seven species, all with minute, depressed bodies, in grain, grain products, and other stored foods, and all difficult to identify: Cape grain beetle, *Cryptolestes capensis,* in Africa and Europe; **rusty grain beetle,** *C. ferrugineus,* cosmopolitan; *C. klapperichi* in Asia and widely distributed in commerce; *C. pusilloides* in Africa, Australia, North America, South America; **flat grain beetle,** *C. pusillus* (pl. 66D), cosmopolitan; Turkish grain beetle, *C. turcicus,* in the Middle East and Europe; *C. ugandae* in Africa. References: *1, 2.*

Pronotum without raised line parallel to margin (14B); pl. 98 ----------**darkling beetles,** Tenebrionidae
SEE KEY, CHAPTER 11

Body form and size variable.
Drawing 14B by C. Feller.



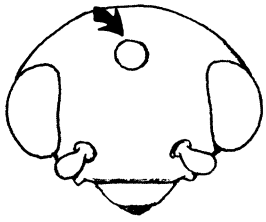
14A *Cryptolestes*



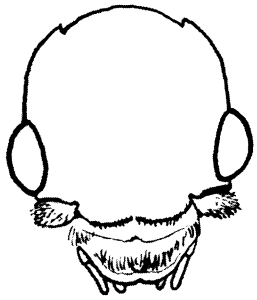
14B *Tribolium brevicorne*

15 Median ocellus present (15A) ----------**dermestid beetles,** Dermestidae (in part)
SEE KEY, CHAPTER 5

Median ocellus absent (15B) ---------- 16



15A *Trogoderma variabile*



15B *Dermestes*

16 Body length 8 to 10 mm. Dermestidae (**dermestid beetles**) (in part) ----------*Dermestes*
SEE KEY, CHAPTER 5.

Body length 3 to 4 mm. Anobiidae (**deathwatch** and **drugstore beetles**) ---------- 17

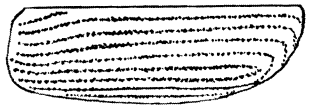
Although *Stegobium paniceum* and *Lasioderma serricorne* (couplet 17) are the anobiids of greatest concern here, 3 other species, all members of the genus *Tricorynus* (=*Catorama*) and all roughly comparable in appearance to *S. paniceum* and *L. serricorne,* should be mentioned in passing: *T. confusus* (eastward from Texas and Kansas in the United States); *T. herbarius,* the Mexican book beetle (Brazil, Fiji, Florida, Hawaii, Mexico); and *T. tabaci* (Belize, Cuba, Dalmatia, Florida, France, Germany, Mexico, Texas). All 3 species have been associated with stored products and all have some potential for spread through commerce. *L. serricorne* differs from all the other anobiids mentioned here in having serrate antennae (the others have a 3-segmented, asymmetrical club). Neither *L. serricorne* nor *T. tabaci* has elytral striations. *T. tabaci* has coarse punctures in front of the eye. *T. confusus* and *T. herbarius* have no punctures in front of the eye and have elytral striations only on the posterolateral portions of the elytra. *T. confusus* is shorter (1.8-2.6 mm) than either *T. herbarius* (2.7-3.5 mm) or *T. tabaci* (3.4-4.6 mm) (*3*).

17 Elytron distinctly striate (17A); pl. 67B----------**drugstore beetle,** *Stegobium paniceum*

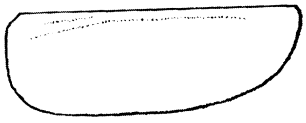
Distribution: cosmopolitan; in dried plant material, leather, cork, flour, and meal.

Elytron without striae (17B); pl. 67D----------**cigarette beetle,** *Lasioderma serricorne*

Distribution: cosmopolitan; in tobacco leaves, spices, seeds, and cereal products.



17A *Stegobium paniceum*

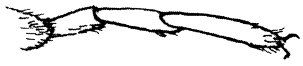


17B *Lasioderma serricorne*

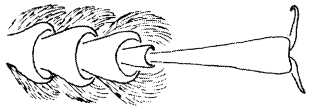
18 Tarsal formula 3-3-3 (18A); pl. 94B---------**minute brown scavenger beetles,** Lathridiidae
SEE KEY, CHAPTER 10

Body length 1 to 2.5 mm; body elongate; antenna clubbed.
Drawing 18B by C. Feller.

Tarsal formula 4-4-4 or 5-5-5 (18B)---------- 19



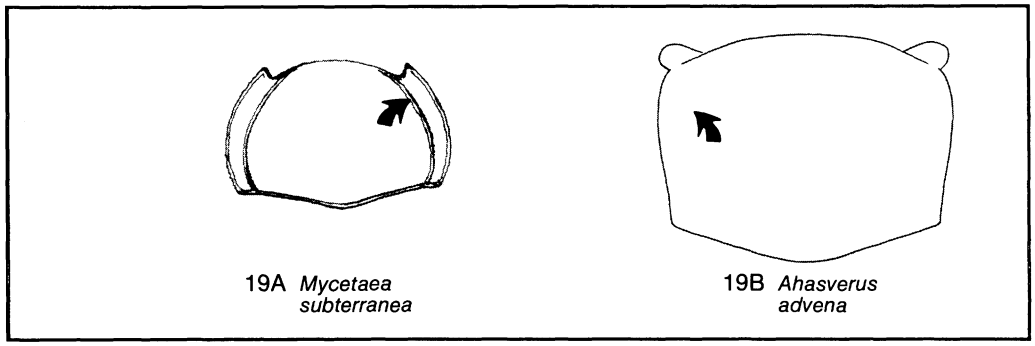
18A lathridiid beetle



18B *Glischrochilus fasciatus*

19 Pronotum with lateral raised line on each side parallel to margin (19A) ---------- 20
Pronotum without lateral raised lines (19B) ---------- 21

Drawing 19B by C. Feller.



20 Tarsal formula 4-4-4; pl. 68B. Endomychidae (=Mycetaeidae) (handsome fungus beetles) ----------hairy cellar beetle, *Mycetaea subterranea*

Synonym: *M. hirta*. Distribution: Asia, Europe, Hawaiian Islands, North America; in moldy grain.

Tarsal formula 5-5-5. Cucujidae (**cucujid beetles**) (in part)----------females, *Cryptolestes*

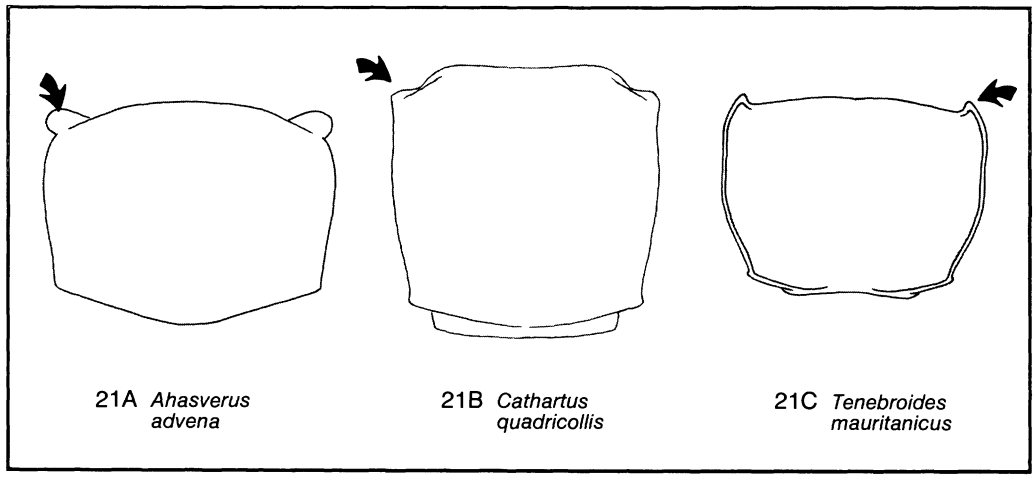
See couplet 14.

21 Pronotum with a small, laterally-directed lobe at each anterior corner (21A, 21B). Cucujidae (**cucujid beetles**) (in part) ---------- 22

Small, depressed beetles, 2 to 3 mm long.

Pronotum without lobes or with lobes hooklike and directed forward (21C)---------- 25

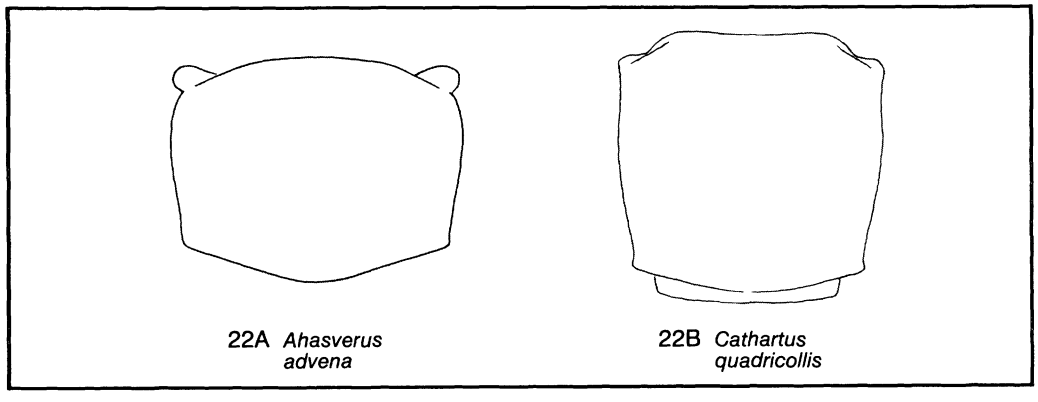
Form and size variable.
Drawings 21A-C by C. Feller



22 Pronotum wider than long (22A); pl. 68C ----------**foreign grain beetle,** *Ahasverus advena*

Distribution: cosmopolitan; in peanuts and in moldy foods (cocoa, grains, and many others). *Ahasverus rectus* (LeConte) is similar in appearance to *A. advena,* but the lobes at the pronotal angles are rudimentary, and the apical antennal segment is circular in shape (subtriangular in *A. advena*).

Pronotum longer than wide (22B) ---------- 23



22A *Ahasverus advena*

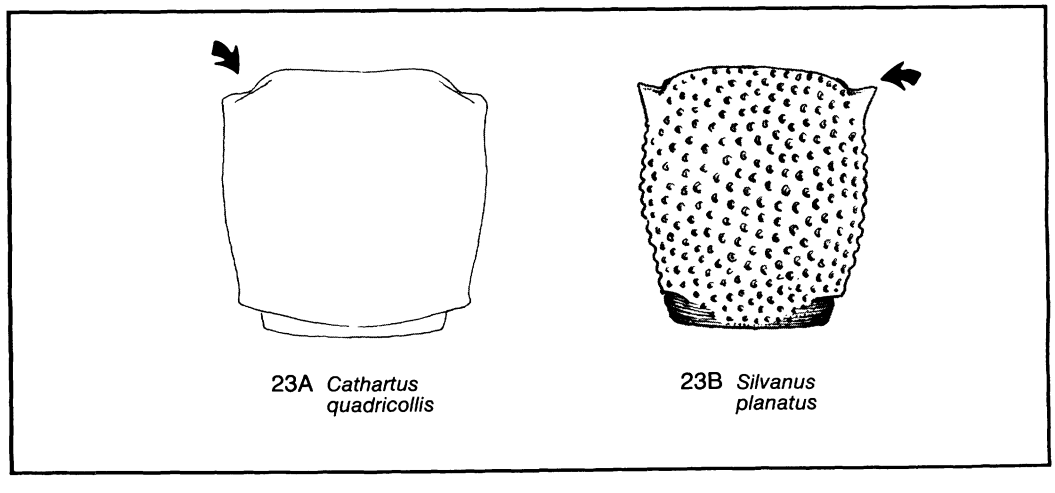
22B *Cathartus quadricollis*

23 Pronotum nearly rectangular, with side margin lacking teeth except for blunt tubercle at anterior corner (23A); pl. 68D
---------- **squarenecked grain beetle,** *Cathartus quadricollis*

Distribution: cosmopolitan; in corn in field and in seeds.

Pronotum strongly narrowed posteriorly, with side margin serrate, and a sharp, triangular tooth at anterior corner (23B); pl. 68E ----------*Silvanus planatus*

Pronotum densely punctate. Distribution: Nearctic; in stored corn in California.



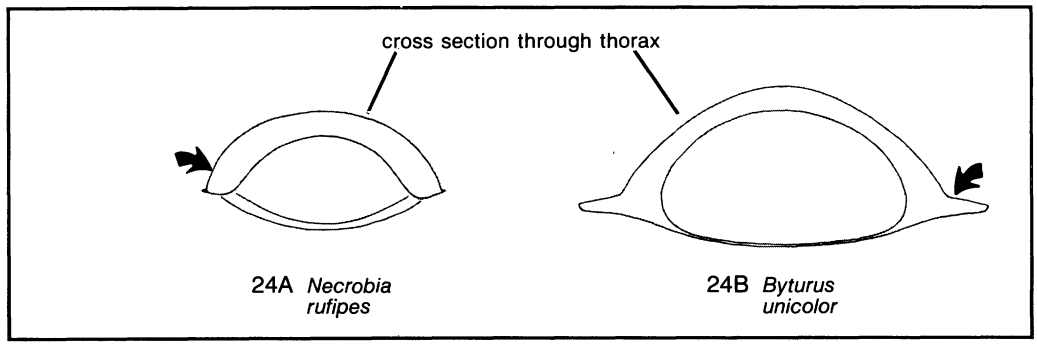
23A *Cathartus quadricollis*

23B *Silvanus planatus*

24 Body color in part metallic blue or green (pl. 1G-I); body with erect setae; pronotum convex but not thin and flattened along lateral margins (24A) ---------- **checkered beetles,** Cleridae
SEE KEY, CHAPTER 7.

Body color not metallic; body setae flat against surface; pronotum convex in middle but flattened along lateral margins (24B); pl. 69B. Byturidae (**fruitworm beetles**) ---------- raspberry fruitworm, *Byturus unicolor*

Antennal club with 3 segments. Distribution: widespread in North America. See also 9C, 10B.

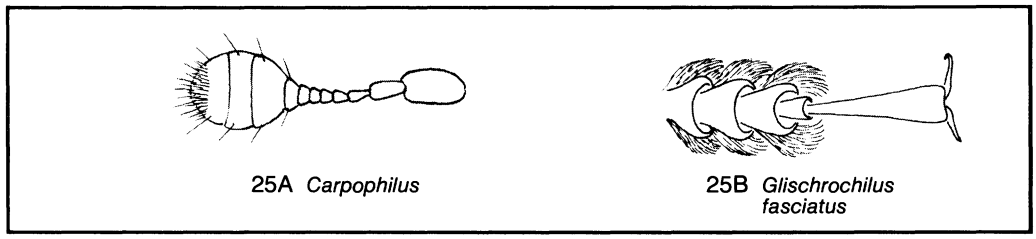


24A *Necrobia rufipes*

24B *Byturus unicolor*

25 Body flattened; elytra often short, exposing pygidium (as in 27A); antennal club composed of 3 symmetrical, closely connected segments (25A); tarsal formula 5-5-5, with segments bristly (25B); pl. 88 ---------- **sap beetles,** Nitidulidae
SEE KEY, CHAPTER 8

Lacking the above combination of characters ---------- 26



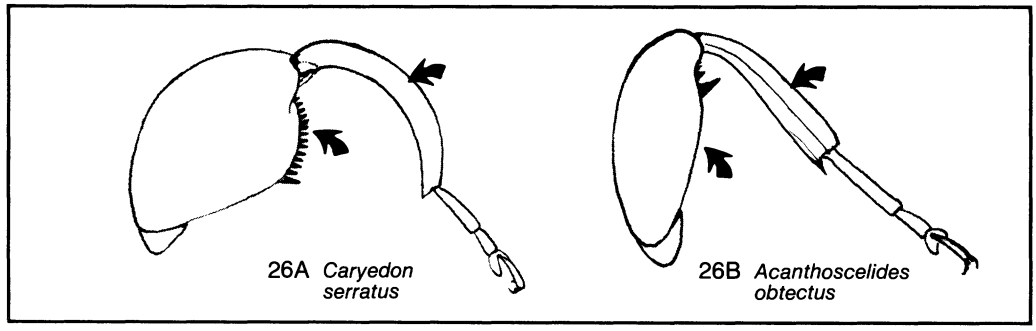
25A *Carpophilus*

25B *Glischrochilus fasciatus*

26 Femur III greatly enlarged and bearing 1 large tooth next to 1 to 12 smaller teeth on the ventral margin; tibia III curved, matching ventral margin of femur (26A); pl. 108B. Bruchidae (**seed beetles**) (in part) ---------- groundnut bruchid, *Caryedon serratus*

This species is also included in the key in Chapter 12.

Femur III only slightly enlarged or not at all; tibia III only slightly curved or not at all (26B) 27



26A *Caryedon serratus*

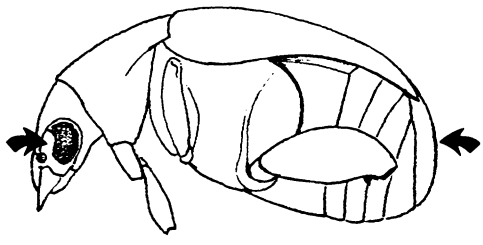
26B *Acanthoscelides obtectus*

27 Pygidium exposed beyond truncate elytra; eye emarginate at antennal insertion (27A); pl. 108C ---------- **seed beetles,** Bruchidae (in part)
SEE KEY, CHAPTER 12

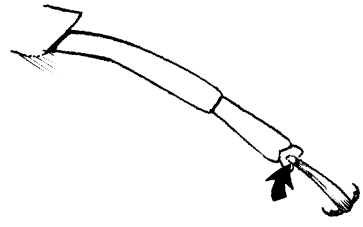
Tarsal formula 5-5-5, with segment IV very small (27B); head vertical (27A).

Pygidium largely or completely concealed by elytra; eye not emarginate at antennal insertion (27C) ---------- 28

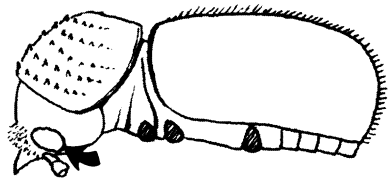
Tarsal formula variable, but segment IV not very small (27D), except in Scolytidae; head vertical (27C) or horizontal (see 28B).
Drawing 27D by C. Feller.



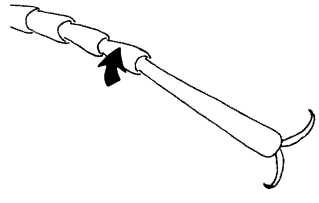
27A *Acanthoscelides obtectus*



27B *Acanthoscelides obtectus*



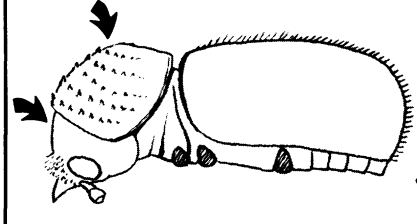
27C *Dinoderus minutus*



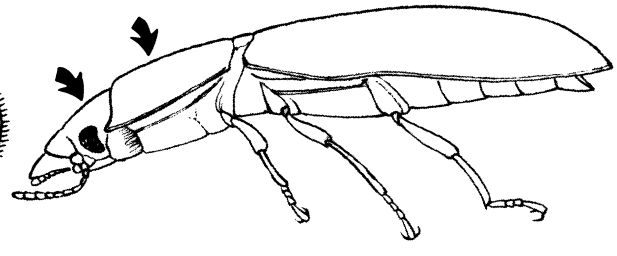
27D *Rhyzopertha dominica*

28 Pronotum hoodlike; head vertical, apparently suspended beneath pronotum, and often not visible in dorsal view (28A) ---------- 29

Pronotum not hoodlike; head horizontal (28B) ---------- 34



28A *Dinoderus minutus*



28B *Tenebroides mauritanicus*

29 Antenna without club (29A); pl. 82----------**spider beetles,** Ptinidae
SEE KEY, CHAPTER 6

Antenna with distinct club of 2 to 4 segments (29B)---------- 30

29A ptinid beetle

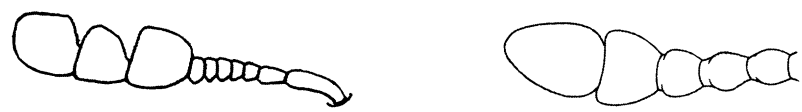
29B *Dinoderus minutus*

30 Antennal club lopsided (30A); pl. 70B. Bostrichidae (**false powderpost beetles**)-- 31

Antennal club of 3 segments; body cylindrical.

Antennal club symmetrical (30B) ---------- 33

Antennal club of 2 or 3 segments; body elongate, depressed, or cylindrical.
Drawing 30B by C. Feller.



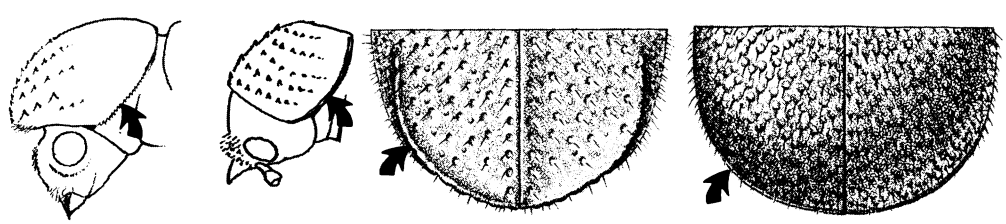
30A *Dinoderus minutus*

30B *Lyctus brunneus*

31 Pronotum with a basal row of teeth (31A); pronotum in dorsal view pointed anteriorly; apex of elytron with a strong carina (31B); pl. 70B
---------- **larger grain borer,** *Prostephanus truncatus*

Distribution: Arizona, California, District of Columbia, Missouri, New Jersey, New York, Texas (generally throughout the Southern States, USA), tropical America; tropical Africa; in corn.
Drawings 31B&D by C. Feller.

Pronotum with basal carina (31C); pronotum in dorsal view broadly rounded anteriorly; apex of elytron without carina (31D)---------- 32



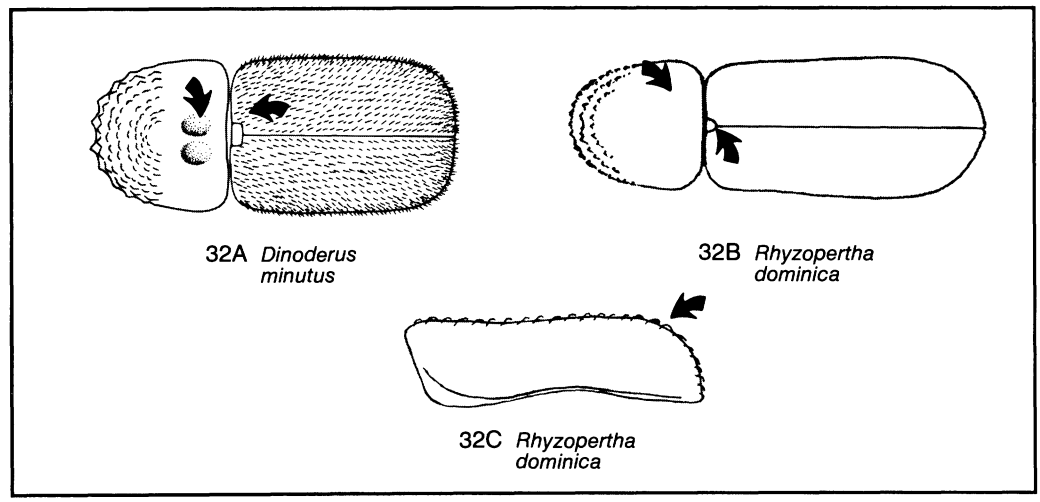
31A *Prostephanus truncatus* 31C *Dinoderus minutus* 31B *Prostephanus truncatus* 31D *Dinoderus minutus*

32 Pronotum with a pair of shallow depressions; scutellum transversely rectangular; elytral setae straight (32A); pl. 70D----**bamboo powderpost beetle,** *Dinoderus minutus*

Distribution: cosmopolitan; in dried foods, seeds, and roots, and in corn. See also 28A, 30A.
Drawing 32A by C. Feller.

Pronotum without depressions; scutellum square (32B); elytral setae curved (32C); pl. 71A----------**lesser grain borer,** *Rhyzopertha dominica*

Distribution: cosmopolitan; in a wide variety of stored foods, chiefly cereals, seeds, and dried fruit.

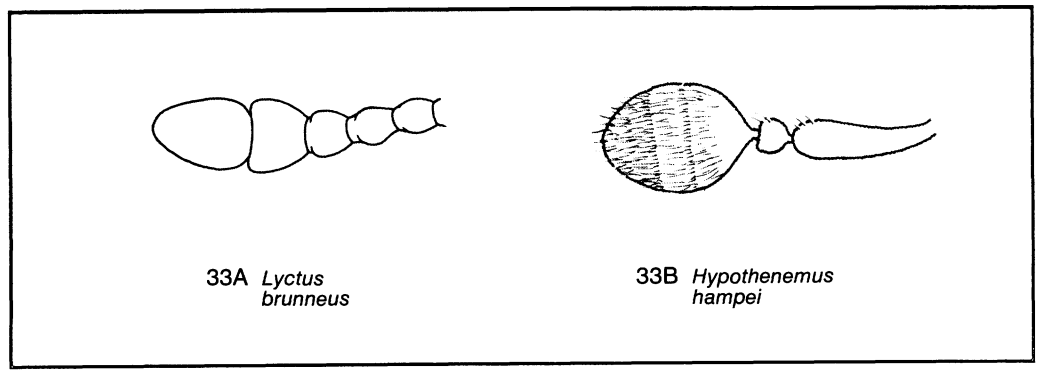


33 Antennal club of 2 segments (33A); antennal segment I shorter than club; body elongate and depressed; pl. 71D. Lyctidae (**powderpost beetles**)
----------brown powderpost beetle, *Lyctus brunneus*

Distribution: cosmopolitan; in vegetable drugs, seeds, and spices.

Antennal club of 3 closely-united segments (33B); antennal segment I longer than club; body cylindrical; pl. 72B. Scolytidae (**bark beetles**)
---------- **coffee berry borer**, *Hypothenemus hampei*

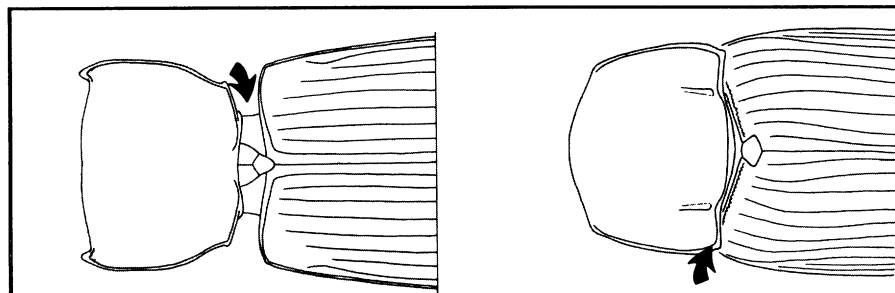
Distribution: circumtropical in most coffee-growing areas; in coffee beans.



34 Distinct constriction at base of pronotum (34A); pl. 72D. Trogositidae (= Ostomatidae) (**trogositid beetles**) (in part) ----------**cadelle,** *Tenebroides mauritanicus*

Distribution: cosmopolitan; in flour, meal, and grains.
See also 28B.
Drawings 34A&B by C. Feller.

Without distinct constriction between pronotum and elytra (34B)---------- 35



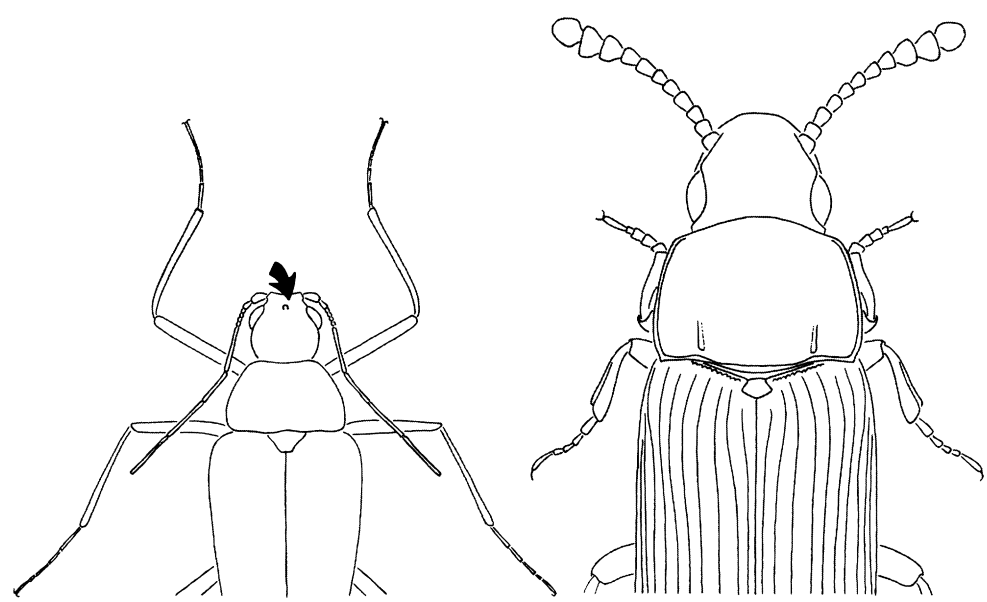
34A *Tenebroides mauritanicus*

34B *Pharaxonotha kirschi*

35 Median ocellus present; antenna not clubbed; legs long and slender (35A); Dermestidae (**dermestid beetles**) (in part)----------**odd beetle,** *Thylodrias contractus*

Females are wingless. This species is also included in the key to the Dermestidae, Chapter 5.
Drawings 35A&B by C. Feller.

Median ocellus absent; antenna clubbed; legs not unusually long and slender (35B) 36

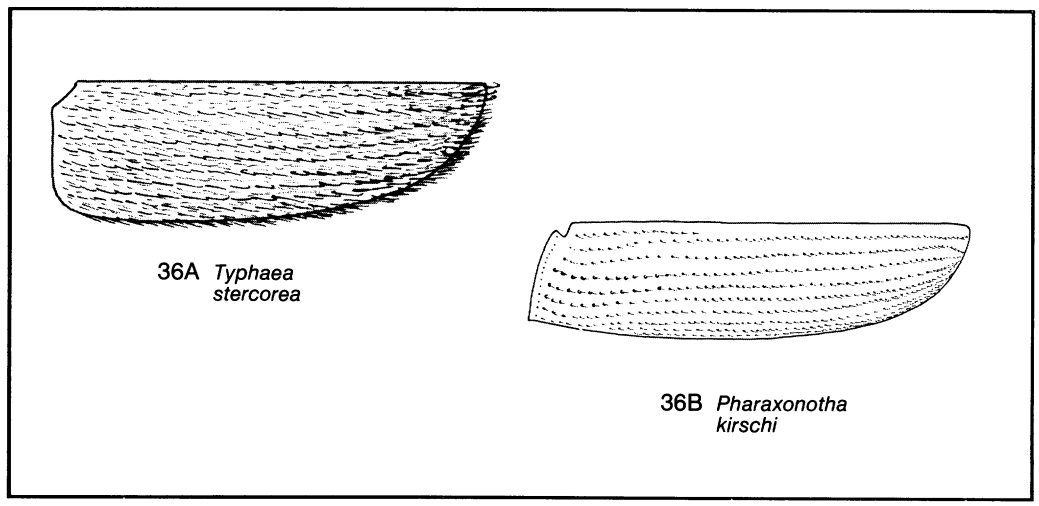


35A *Thylodrias contractus*

35B *Pharaxonotha kirschi*

36 Elytron with silky hair (36A); tarsal formula 4-4-4. Mycetophagidae (**hairy fungus beetles**) ---------- 37
Elytron with, at most, short, fine, scarcely visible setae (36B); tarsal formula 5-5-5 38

Drawing 36B by C. Feller.

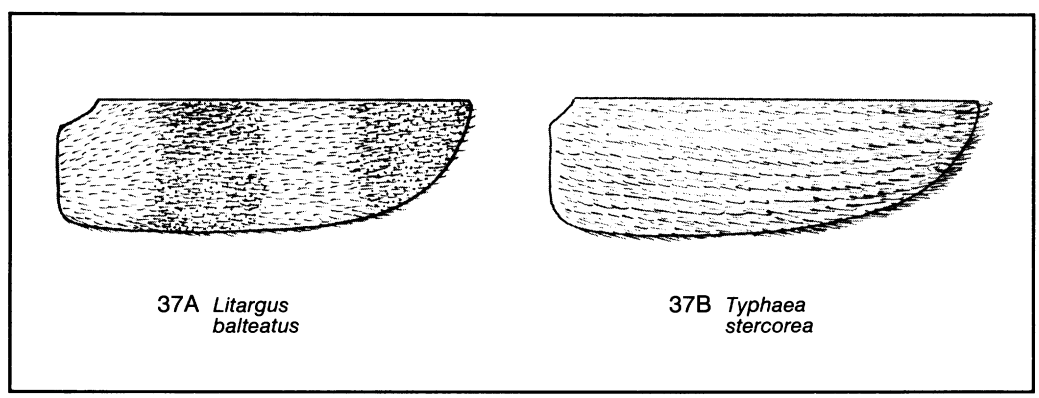


37 Elytral pattern of light and dark transverse bands; elytral setae not in rows (37A); pl. 73A ----------*Litargus balteatus*

Distribution: Australia, central Europe, Hawaii, North and Central America; in corn and stored grain.

Elytral color a uniform yellowish brown, without pattern; elytral setae in definite rows (37B); pl. 73C ----------**hairy fungus beetle,** *Typhaea stercorea*

Distribution: cosmopolitan; feeds on mold hyphae in stored grain, seeds, peanuts, and cacao.

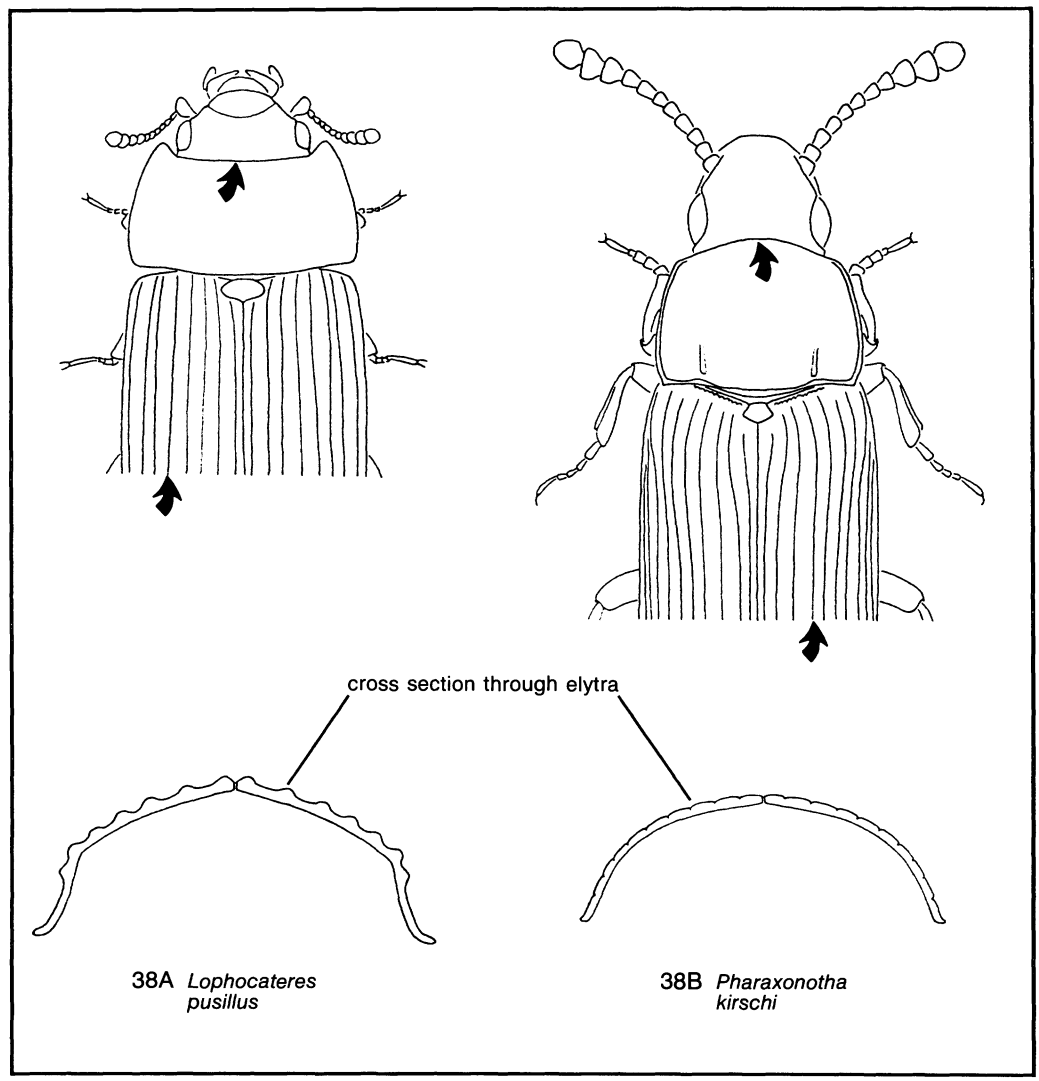


38 Elytron with longitudinal ridges (38A); anterior margin of pronotum broadly emarginate (38A); pl. 74B. Trogositidae (=Ostomatidae) (**trogositid beetles**) (in part)
---------- Siamese grain beetle, *Lophocateres pusillus*

Distribution: tropicopolitan; in stored grain, flour, seeds, spices, beans, and dried fruit.

Elytron without longitudinal ridges (38B); anterior margin of pronotum somewhat rounded (38B); pl. 74D. Languriidae (languriid beetles)
----------Mexican grain beetle, *Pharaxonotha kirschi*

Distribution: central Europe, Guatemala, Mexico, United States; in corn and cornmeal.
Drawings 38A-D by C. Feller.



38A *Lophocateres pusillus*

38B *Pharaxonotha kirschi*

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1 Banks, H.J.
1979. Identification of stored product *Cryptolestes* spp. (Coleoptera: Cucujidae): A rapid technique for preparation of suitable mounts. Jour. Australian Ent. Soc. 18(3)217-222.

2 Green, M.
1979. *Cryptolestes klapperichi* Lefkovitch in stored products and its identification (Coleoptera: Cucujidae). Jour. Stored Prod. Res. 15(2)71-72.

3 White, R.E.
1971. *Tricorynus confusus* (Coleoptera: Anobiidae) in tobacco warehouses, with notes on natural hosts. Ann. Ent. Soc. America 64(3)752.

4 LARVAL BEETLES (COLEOPTERA)

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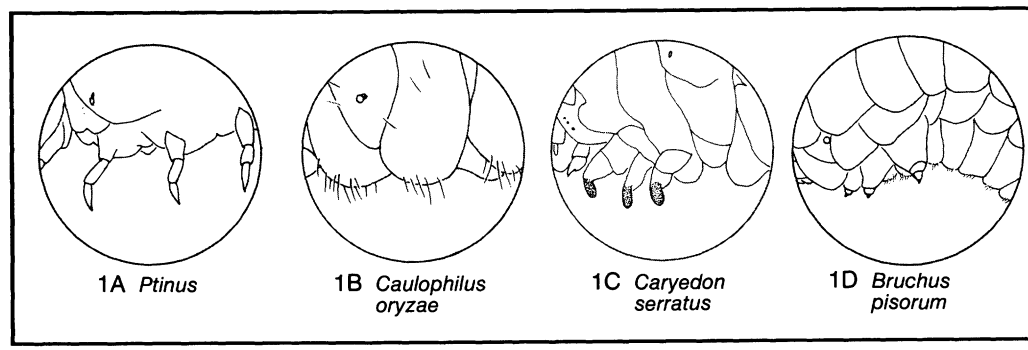
KEY
Drawings by C. Feller unless otherwise noted.

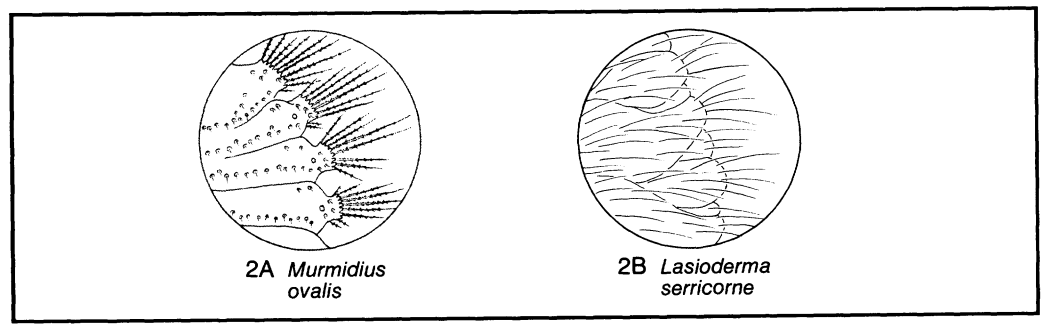
1 With distinct, jointed legs (1A)---------- 2
Without legs (1B) or with greatly reduced legs (1C, 1D)---------- 11



2 Body depressed, fringed at sides (2A); head entirely concealed in dorsal view. Cerylonidae (=Murmidiidae) (cerylonid beetles); pl. 64A
----------oval grain beetle, *Murmidius ovalis*

Distribution: cosmopolitan; in stored rice, wheat, and corn, and in other dry plant materials, such as hay and leaves. Reference: *5*.

Body not flattened and fringed (2B); head not entirely concealed from above ----- 3

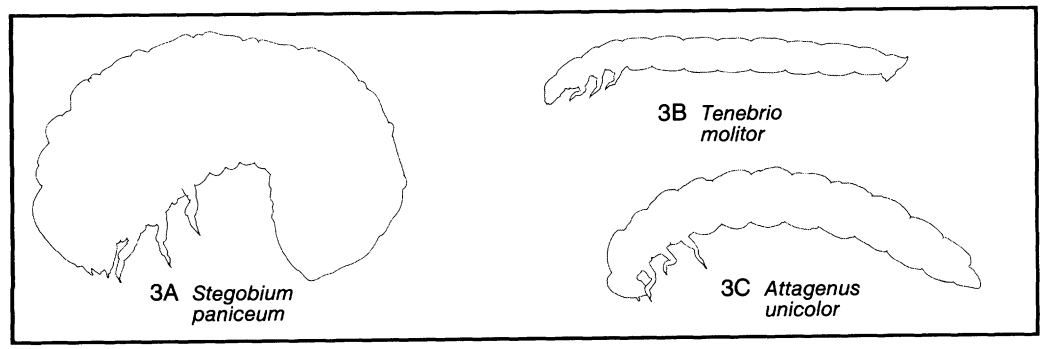


3 Body grublike, distinctly curved (C-shaped) (3A)---------- 4

Urogomphi absent.

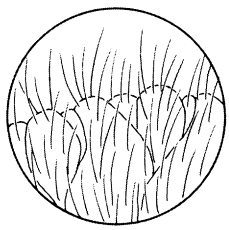
Body long and slender, nearly straight (3B) (if apparently curved, then not grublike) (3C)---------- 13

Urogomphi present or absent.

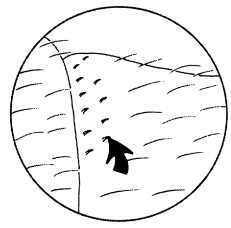


4 Body and head (of dry specimen) with numerous long, soft, hairlike setae (4A)---- 5
Body and head with distinct short and sometimes numerous setae (4B)---------- 6

Hook-shaped, dorsal asperities sometimes present on thorax and/or abdomen (4B).



4A *Lasioderma serricorne*



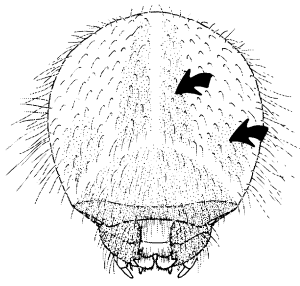
4B *Stegobium paniceum*

5 Color pattern apparent over much of dorsal surface of head (5A); thoracic spiracle distinctly distant from anterior margin of prothorax (5B). Anobiidae (**drugstore beetles**) (in part); pl. 67C----------**cigarette beetle,** *Lasioderma serricorne*

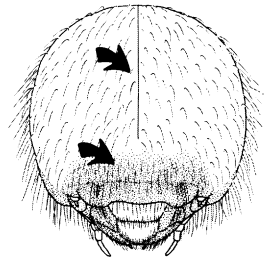
Distribution: cosmopolitan; infests a wide variety of dried plant and animal products, but is best known for its destructiveness to tobacco. References: *2, 10.*

Dorsum of head without color pattern except for a broad pigmented anterior band (5C); thoracic spiracle near anterior margin of prothorax (5D); pl. 85A
----------**spider beetles,** Ptinidae

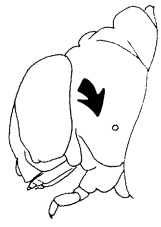
For a key to the larval ptinids attacking stored products, see Hall and Howe *(4).* For bionomic notes, see key to adult ptinids.



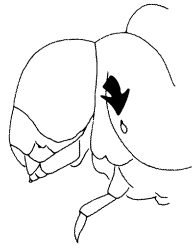
5A *Lasioderma serricorne*



5C *Ptinus*



5B *Lasioderma serricorne*

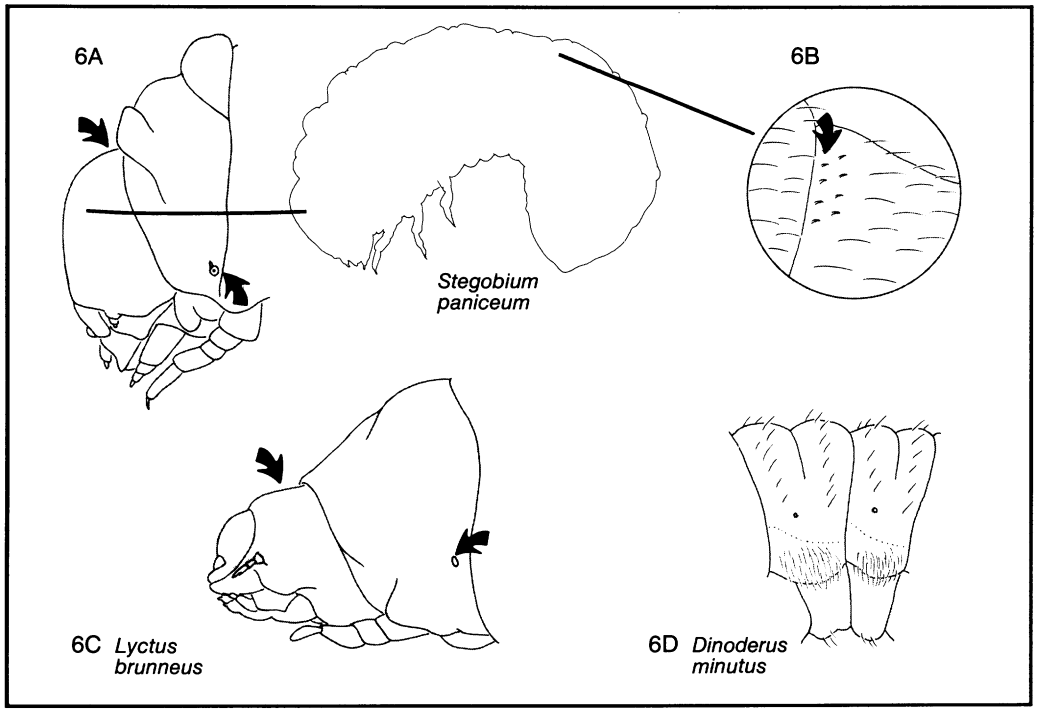


5D *Ptinus*

6 Head not retracted into prothorax; spiracles with a spoutlike process (6A); hook-shaped asperities present (6B). Anobiidae (**drugstore beetles**) (in part); pl. 67A
----------**drugstore beetle,** *Stegobium paniceum*

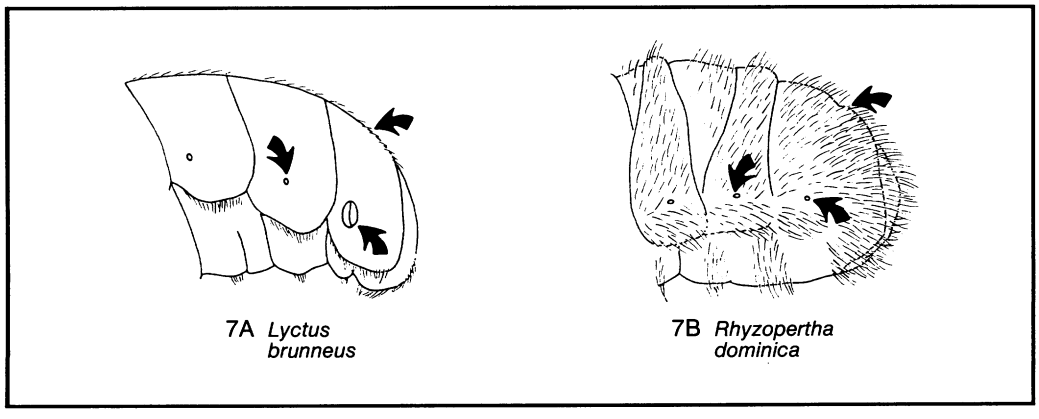
Distribution: cosmopolitan; infests a wide variety of dry plant products. References: *2, 10.*

Head retracted (6C); spiracles oval or round (6C); hooklike asperities absent (6D)---------- 7



7 VIII abdominal spiracle (the most posterior one) about three times bigger than other abdominal spiracles; setae very sparse on most of body surface (7A)
----------**powderpost beetles,** Lyctidae

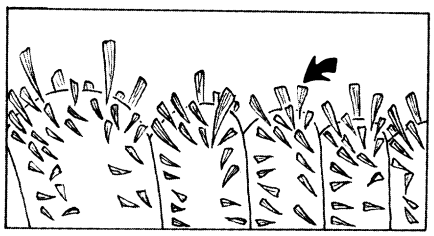
VIII abdominal spiracle subequal in size to other abdominal spiracles; dorsal setae numerous (7B)---------- 8



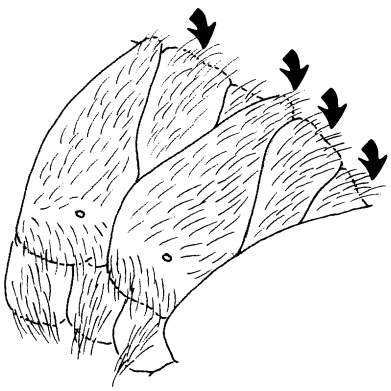
8 Body setae flat, spatulate; segments of thorax and abdomen with dorsal surface undivided (8A). Endomychidae (= Mycetaeidae) (handsome fungus beetles); pl. 68A ----------hairy cellar beetle, *Mycetaea subterranea*

Distribution: Europe, Hawaiian Islands, Java, North America, USSR; feeds on molds in warehouses, granaries, and wine cellars. Reference: *5.*

Body setae hairlike, bristly; dorsal surface of meso- and metathorax and abdomen divided into 2 or more folds (8B). Bostrichidae (**false powderpost beetles**)------ 9



8A *Mycetaea subterranea*

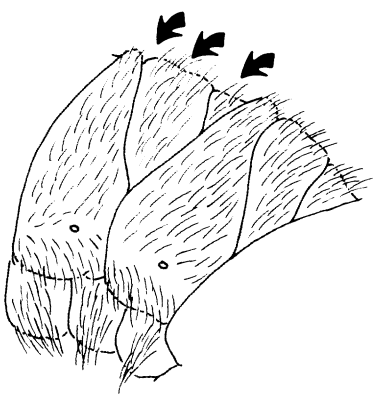


8B *Rhyzopertha dominica*

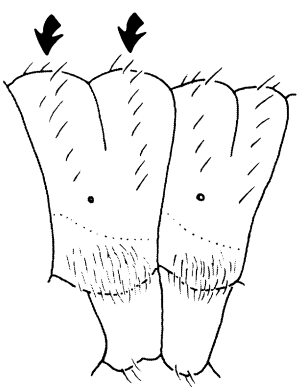
9 Abdominal segments I to V each with 3 dorsal folds; body covered with numerous hairlike setae (9A); pl. 71A----------**lesser grain borer,** *Rhyzopertha dominica*

Distribution: cosmopolitan; in a wide variety of stored foods, chiefly cereals, seeds, and dried fruit.

Abdominal segments I to V each with 2 dorsal folds; hairlike setae concentrated on dorsal and lateral areas of body, sparse or absent on other body regions (9B)- 10



9A *Rhyzopertha dominica*



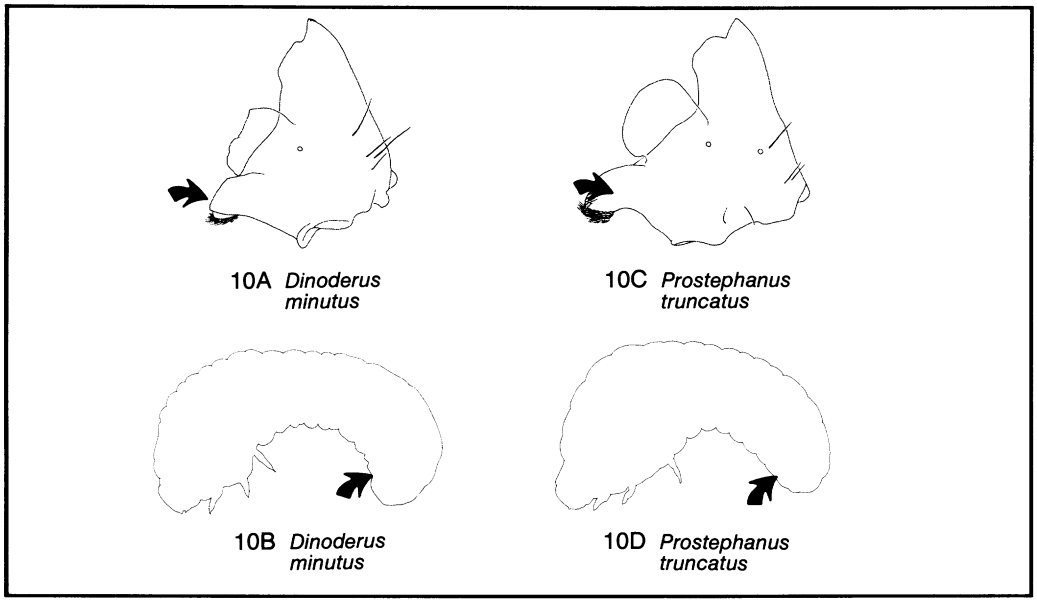
9B *Dinoderus minutus*

10 Mandible with a stubby molar process (10A); posterior end of body strongly curved (10B); pl. 70C----------**bamboo powderpost beetle,** *Dinoderus minutus*

Distribution: cosmopolitan; although the adults are polyphagic on a wide variety of plant materials, the larvae are strongly stenophagic, thriving only in the stems of various bamboos and canes.

Mandible with an elongate molar process (10C); posterior end of body slightly curved (10D); pl. 70A----------**larger grain borer,** *Prostephanus truncatus*

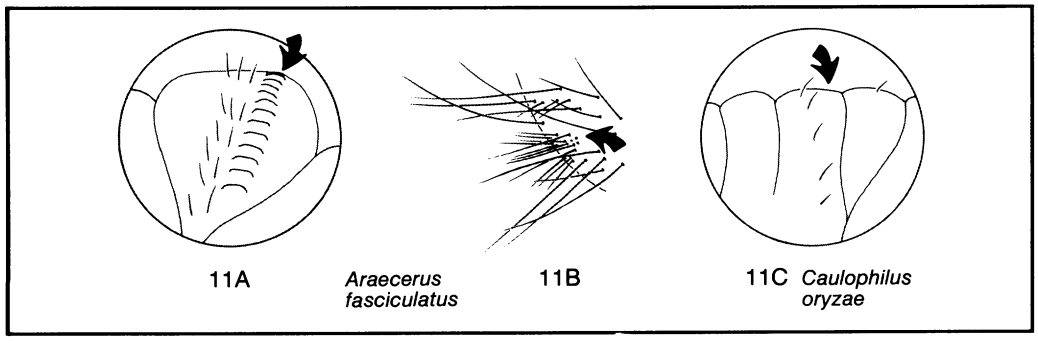
Distribution: cosmopolitan; usually in stored grain.



11 Body covered with hairlike setae; some dorsal folds of abdomen with transverse rows of longitudinal ridges (11A). Anthribidae (**fungus weevils**); pl. 62A ----------**coffee bean weevil,** *Araecerus fasciculatus*

Legs very small (vestigial), barely visible under high magnification (11B). Distribution: cosmopolitan; in a wide variety of dry plant materials. References: *1, 10.* 11B redrawn from *1.*

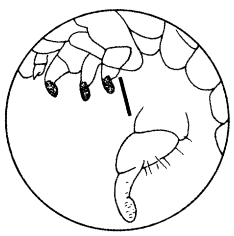
Body sparsely covered with a few short setae; dorsal folds of abdomen without transverse rows of longitudinal plicae (11C)---------- 12



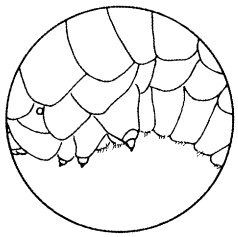
12 Legs present (12A, 12B)----------**seed beetles,** Bruchidae (in part)

The larvae of the **pea weevil,** *Bruchus pisorum* (pl. 109A), the groundnut bruchid, *Caryedon serratus* (pl. 108A), and certain other bruchids have 3 pairs of short legs (12A, 12B); other bruchid larvae are legless. References: *8, 10.*

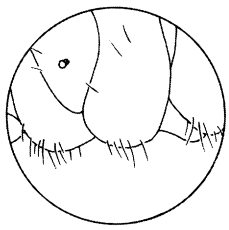
Legs absent (12C)---------- 29



12A *Caryedon serratus*



12B *Bruchus pisorum*



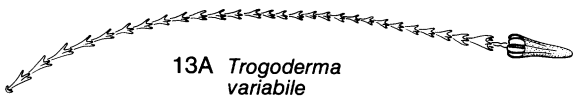
12C *Caulophilus oryzae*

13 Body covered with long, barbed (13A) or flattened (13B, 13C) setae ----------**dermestid beetles,** Dermestidae
SEE KEY, CHAPTER 5

Urogomphi often absent (13D). References: *5, 7.*
13B&C redrawn from *5.*

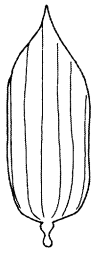
Body setae simple, hairlike (13E)---------- 14

Urogomphi often present (13E).

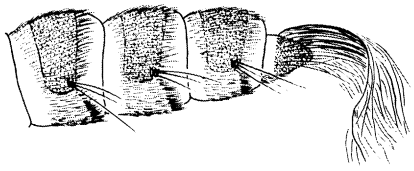


13A *Trogoderma variabile*

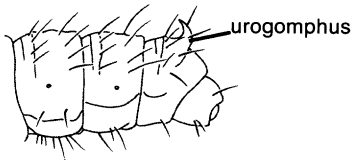
13B *Attagenus*



13C *Attagenus*



13D *Attagenus unicolor*

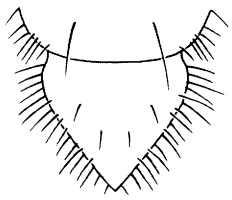


13E *Byturus*

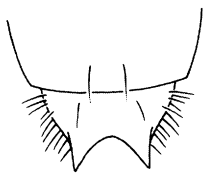
14 Abdominal tip pointed (14A) or bearing urogomphi (14B)---------- 15

Drawings 14A&B by A.D. Cushman.

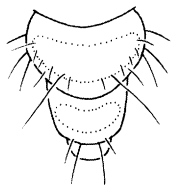
Abdominal tip neither pointed nor bearing urogomphi (14C)---------- 26



14A *Alphitobius laevigatus*



14B *Tribolium audax*



14C *Oryzaephilus surinamensis*

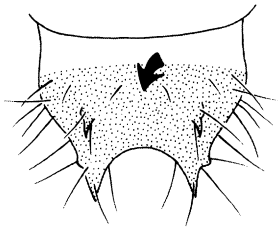
15 Yellowish or brownish body integument largely sclerotized, rigid (but may yield to light pressure), and hard (but may be thin and translucent); pl. 99A, 101A
----------**darkling beetles,** Tenebrionidae
SEE KEY, CHAPTER 11

Some have urogomphi; others have a pointed abdomen.

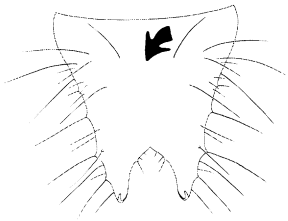
Body integument largely unsclerotized, soft, and flabby; color may be mostly whitish or yellowish, or may be mottled with brown, pink, or lavender on a light background---------- 16

Urogomphi present; abdomen not pointed.

16 Urogomphi arising from a pigmented plate that appears distinct from the rest of the last abdominal segment (16A)---------- 17
Last abdominal segment without distinct plate associated with urogomphi (16B)-- 20



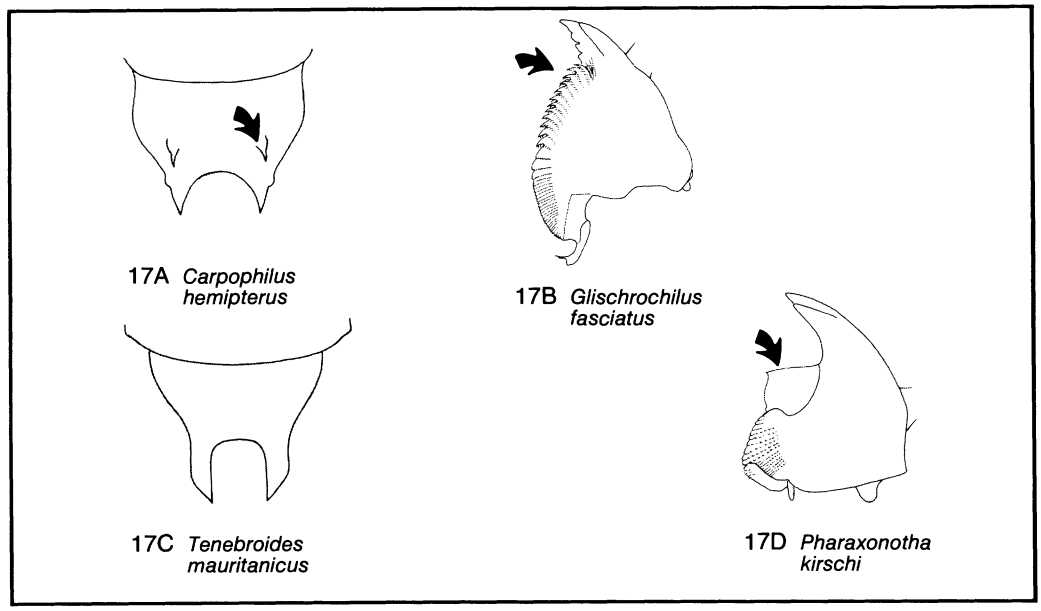
16A *Carpophilus hemipterus*



16B *Anthicus*

17 Pregomphus present (17A); mandible with serrate prostheca (17B); pl. 90A
----------**sap beetles,** Nitidulidae
SEE KEY, CHAPTER 8

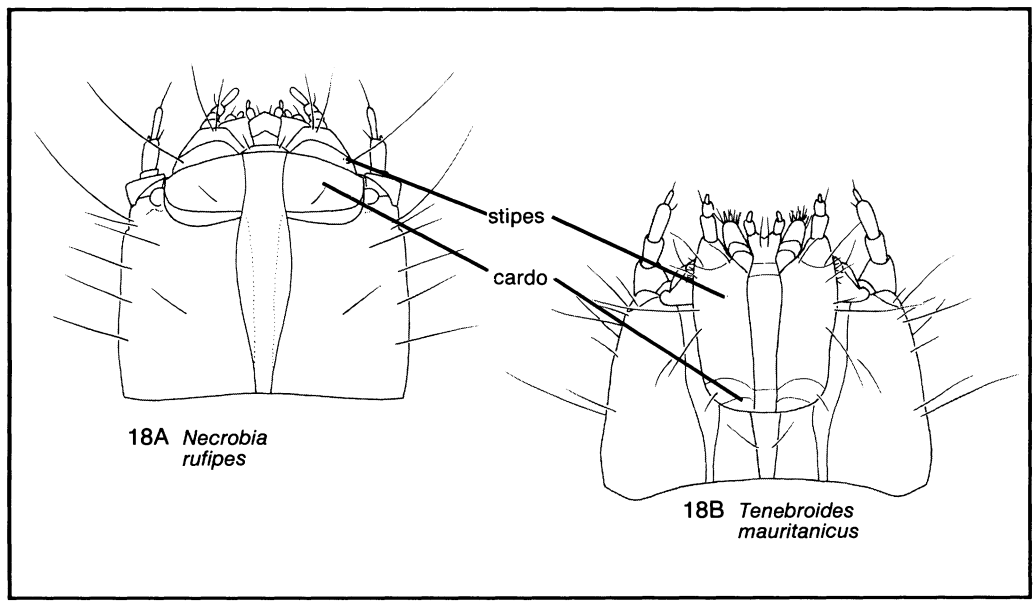
Pregomphus absent (17C); mandible without serrate prostheca (17D)---------- 18



18 Ventral mouthparts only slightly retracted into underside of head; maxilla with cardo as large as or larger than stipes (18A); body color a mottled pink or lavender or brown on a light background (pl. 87A). Cleridae (**checkered beetles**) ----------ham beetles, *Necrobia*

Distribution: cosmopolitan; larvae feed on many dried or cured animal products, such as ham, fish, cheese, and egg yolk. References: *10, 11* (includes key to species).

Ventral mouthparts deeply retracted into underside of head; cardo much smaller than stipes (18B); membranous portions of integument uniformly whitish or yellowish. Trogositidae (=Ostomatidae) (**trogositid beetles**)---------- 19

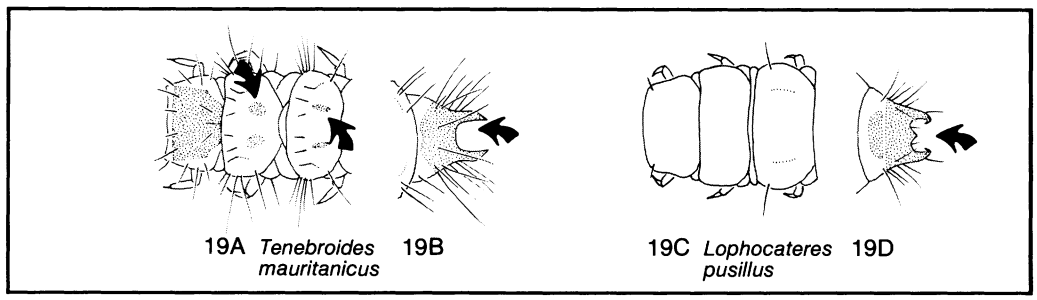


19 Thorax with dorsal dark-colored areas, a large one on the pronotum and 2 each on the meso- and metanota (19A); urogomphi not strongly incurved; space between urogomphi not marked by a tubercle (19B); pl. 72C
----------**cadelle,** *Tenebroides mauritanicus*

Distribution: cosmopolitan; in flour, meal, and grains.
See also 18B.

Thoracic dorsum without dark-colored areas (19C); tubercle located between strongly-incurved urogomphi (19D); pl. 74A----------Siamese grain beetle, *Lophocateres pusillus*

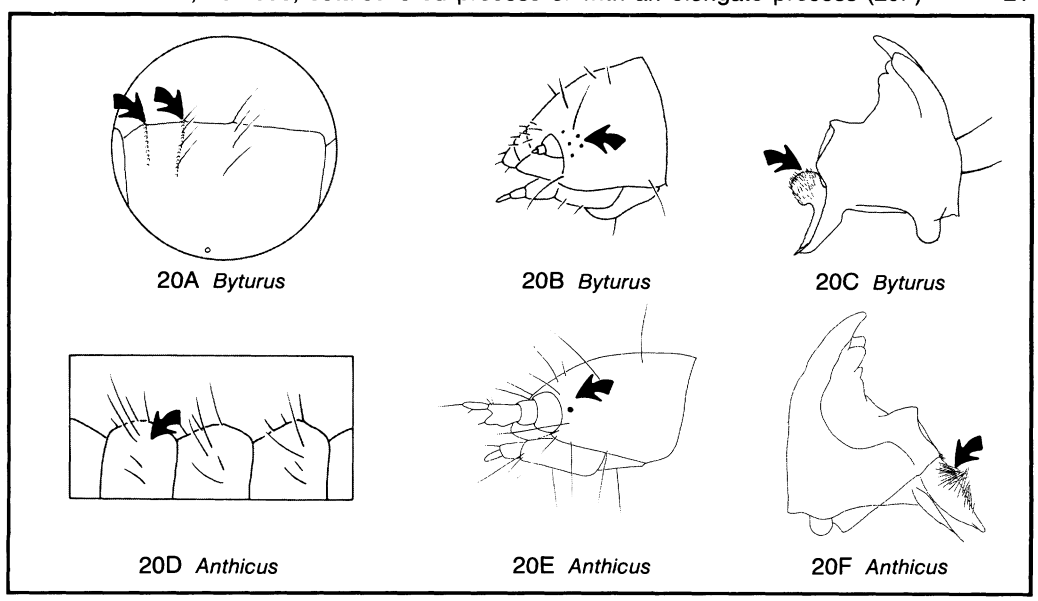
Distribution: tropicopolitan; in stored grain, flour, seeds, spices, beans, and dried fruit.



20 Abdominal terga with 2 transverse carinae (composed of fused tubercles) (20A); head with 5 ocelli (in a compact group) on each side (20B); mandible with a soft bulbous process covered with short setae (20C). Byturidae (**fruitworm beetles**); pl. 69A
----------raspberry fruitworms, *Byturus*

Distribution: Europe, North America; in various berries, especially raspberries and loganberries in northeastern United States. Reference: *10.*

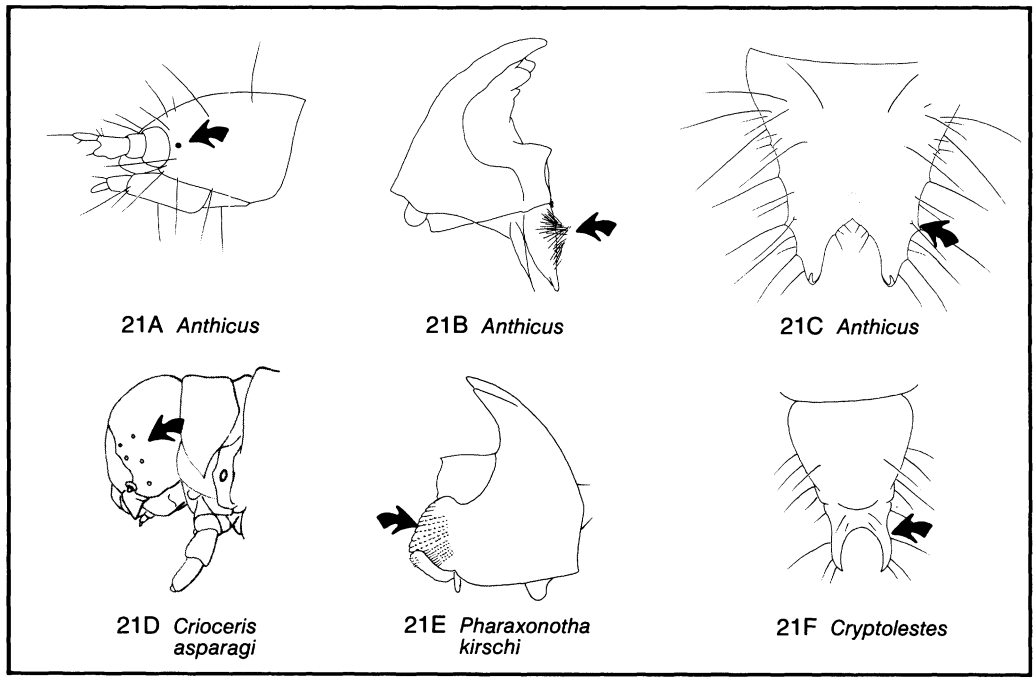
Dorsal carinae absent (20D); head with less than 5 ocelli on each side (20E) (if there are 5 ocelli, they are widely scattered, not compactly grouped); mandible either without a soft, bulbous, seta-covered process or with an elongate process (20F)---- 21



21 1 ocellus on each side of head (21A); molar area of mandible with a soft, elongate process bearing hairs (21B); lateral setae of urogomphi arise from tubercles (21C). Anthicidae (**antlike flower beetles**); pl. 64C----------*Anthicus*

Distribution: *Anthicus floralis,* **narrownecked grain beetle,** is cosmopolitan; infests diverse plant materials —haystack refuse, manure piles, stored wheat, and stored cacao; adults and larvae feed on decaying plants and fungi. Reference: *5.*

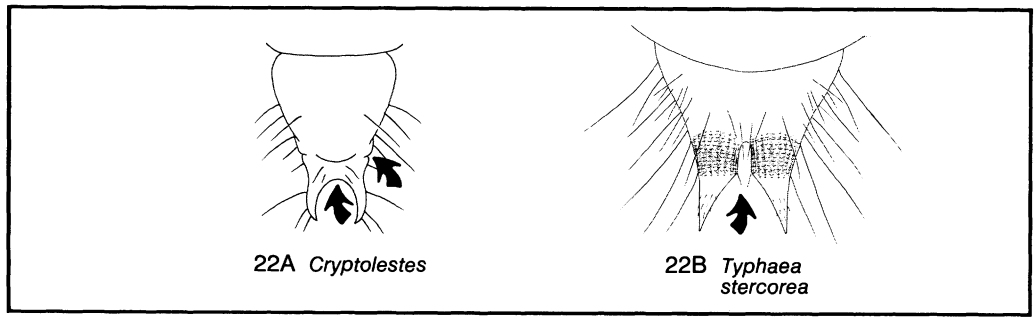
2 or more ocelli on each side (21D); molar area of mandible without a soft, elongate process (21E); lateral urogomphal setae not arising from tubercles (21F)--------- 22



22 Urogomphi joined at their bases and hinged to the last abdominal segment by a joint on each side (22A). Cucujidae (**cucujid beetles**) (in part); pl. 66A----------*Cryptolestes*

Cucujid species in other genera associated with stored products do not have urogomphi. For bionomic and taxonomic notes, see key to adult beetles (Chapter 3).

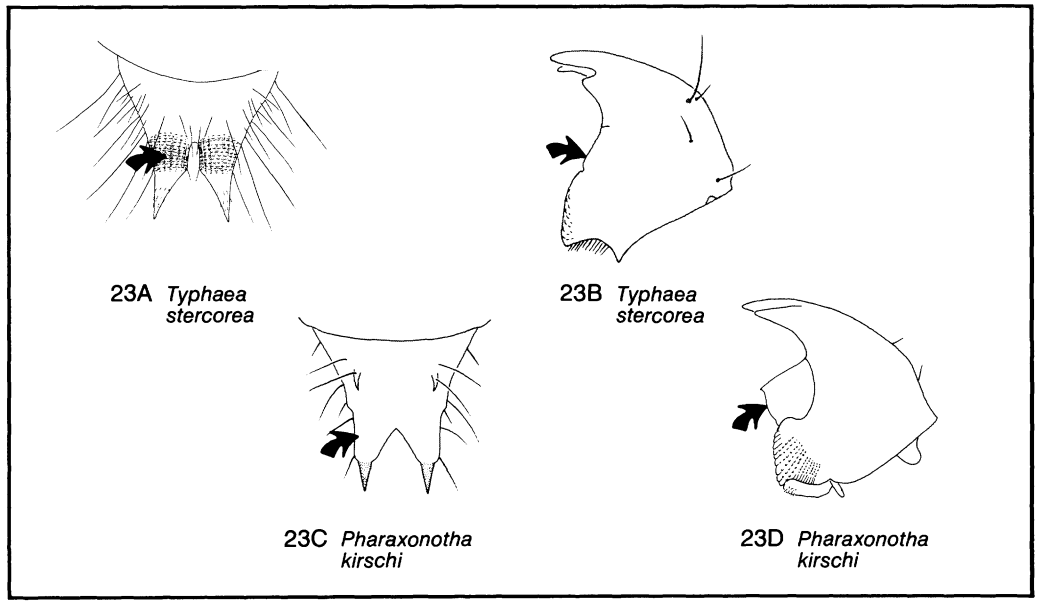
Urogomphi distinctly separated at their bases and solidly fused to the VIII abdominal segment (22B)---------- 23



23 Urogomphus stout, conical (curved only at the tip if at all), with granular surface often longitudinally ridged (23A); mandible without a retinaculum or prostheca (23B). Mycetophagidae (**hairy fungus beetles**)---------- 24

23B redrawn from *5*.

Urogomphus slender, smooth-surfaced, without granulation or ridges (23C); mandible with a distinct retinaculum or prostheca (23D)---------- 25

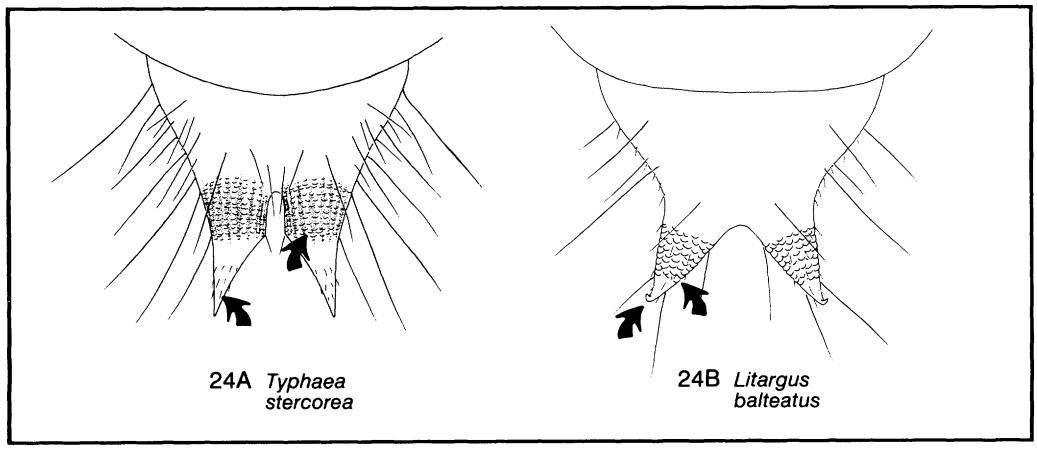


24 Urogomphus tapering to a straight point (not curved), with several longitudinal ridges on basal half (24A); pl. 73B----------**hairy fungus beetle,** *Typhaea stercorea*

Distribution: cosmopolitan; feeds on mold hyphae in stored grain, seeds, peanuts, and cacao.

Urogomphus distinctly curved at tip; longitudinal ridges absent (24B)---*Litargus balteatus*

Distribution: Australia, central Europe, Hawaii, North and Central America; in corn and stored grain.

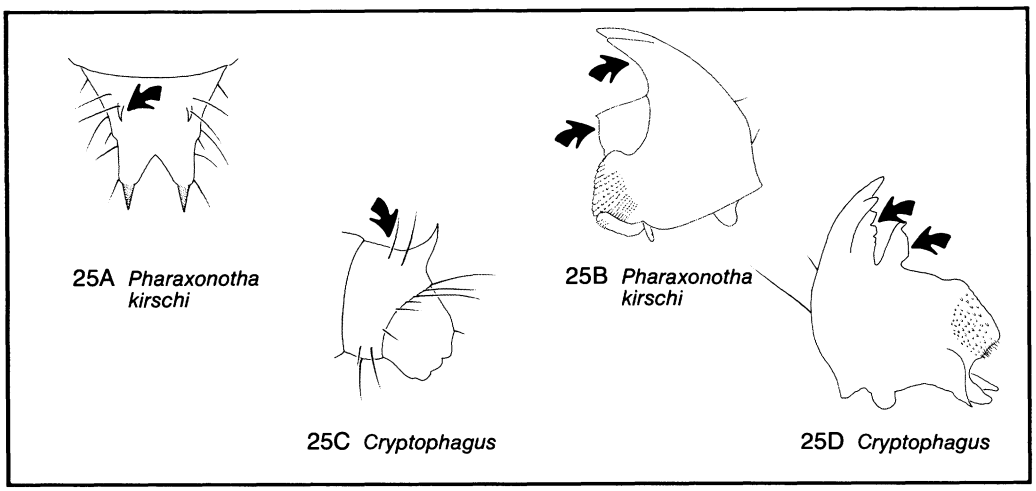


25 Pregomphus present (25A); mandible with no teeth on cutting edge and with a broad, membranous prostheca (25B). Languriidae (languriid beetles); pl. 74C
----------Mexican grain beetle, *Pharaxonotha kirschi*

Distribution: Europe, North and South America; in stored plant products, such as corn, wheat, beans, and flour. Reference: *5*.

Pregomphus absent (25C); mandible with a serrate cutting edge, and an elongate, pointed retinaculum (25D). Cryptophagidae (**cryptophagid beetles**); pl. 93A
----------*Cryptophagus*

For bionomic information, see key to adult cryptophagids (Chapter 9). Reference: *5*.

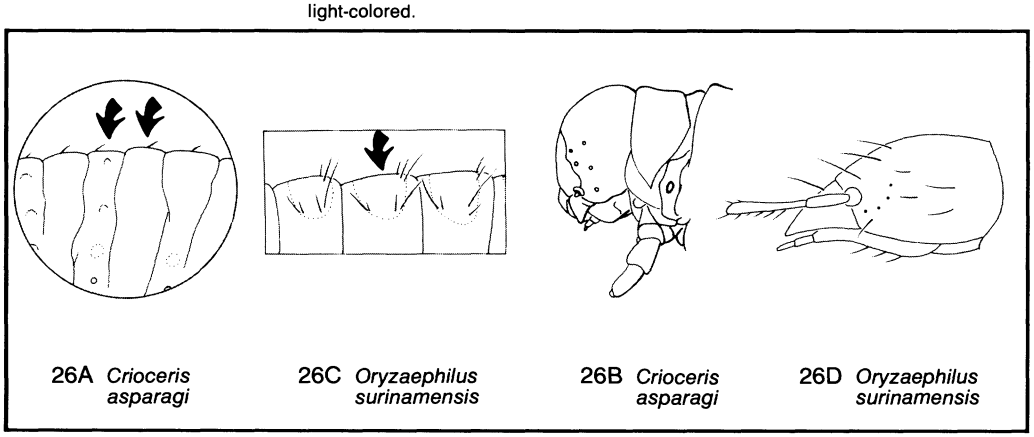


26 Body stout, convex dorsally, with 2 folds visible on most abdominal terga (26A); head hypognathous, vertex rounded (26B). Chrysomelidae (**leaf beetles**)---------- 27

Head, legs, and other sclerotized body parts often dark-colored.

Body slender and straight with only 1 dorsal fold or plate on each abdominal segment (26C); head prognathous, vertex at most slightly convex (26D)---------- 28

Head, legs, and other sclerotized body parts light-colored.



27 Body very stout, strongly convex dorsally; abdomen with 3 parallel rows of darkly-pigmented plates (pl. 65A)----------**Colorado potato beetle,** *Leptinotarsa decemlineata*

Distribution: North America and, by introduction, Europe; adults and larvae on foliage of eggplant, potato, and tomato.

Body moderately stout, moderately convex dorsally: abdomen without pigmented lateral plates (pl. 65C)----------asparagus beetles, *Crioceris*

Distribution: Europe, United States; feeding by the larvae of *C. asparagi* causes scarring of growing shoots of asparagus; larvae of *C. duodecimpunctata* develop and feed mainly in the berries of asparagus.

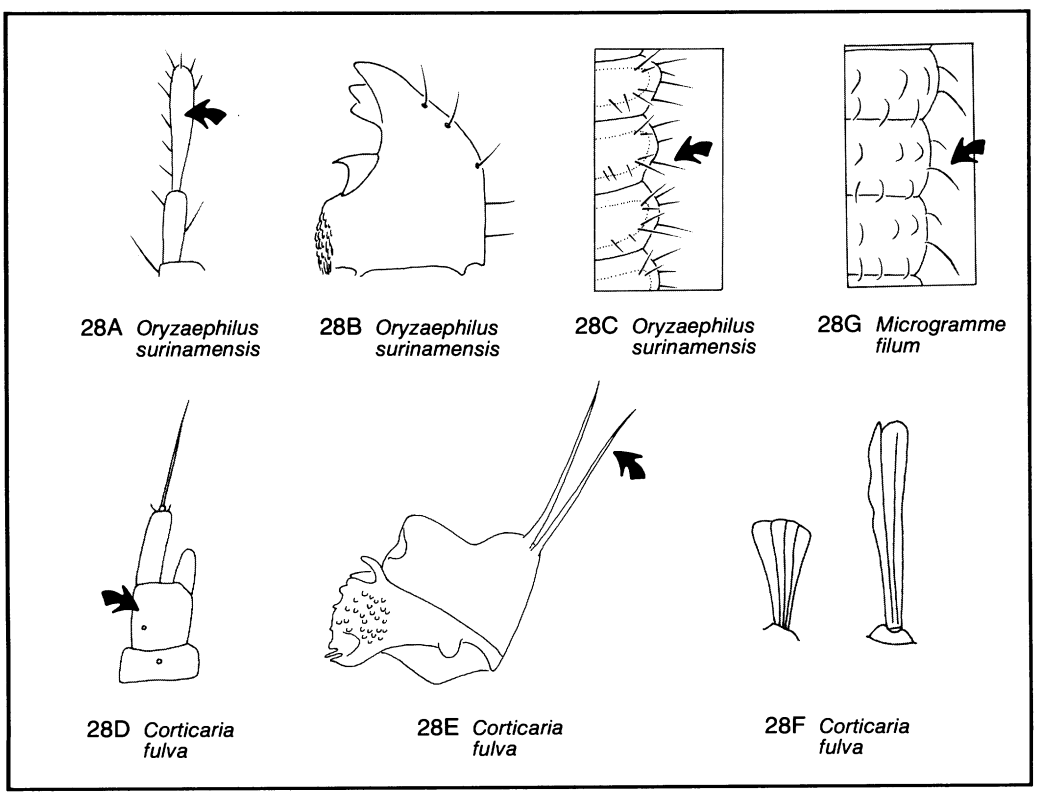
28 Antennal segment II elongate, club-shaped (28A); mandible not partly fleshy nor bearing long setae (28B). Cucujidae (**cucujid beetles**) (in part); pl. 63A&B--------Silvaninae

Body setae sparse, straight, sharply-pointed (28C); Reference: *3* (includes key to genera and species).

Antennal segment II short (28D); fleshy portion of mandible bearing 2 long setae (28E); pl. 94A----------**minute brown scavenger beetles,** Lathridiidae

Body setae either short and widened apically (28F) or curved and pointed (28G). Distribution: cosmopolitan (at least the economically-important species); in situations which favor the growth of fungi upon which the adults and larvae feed.

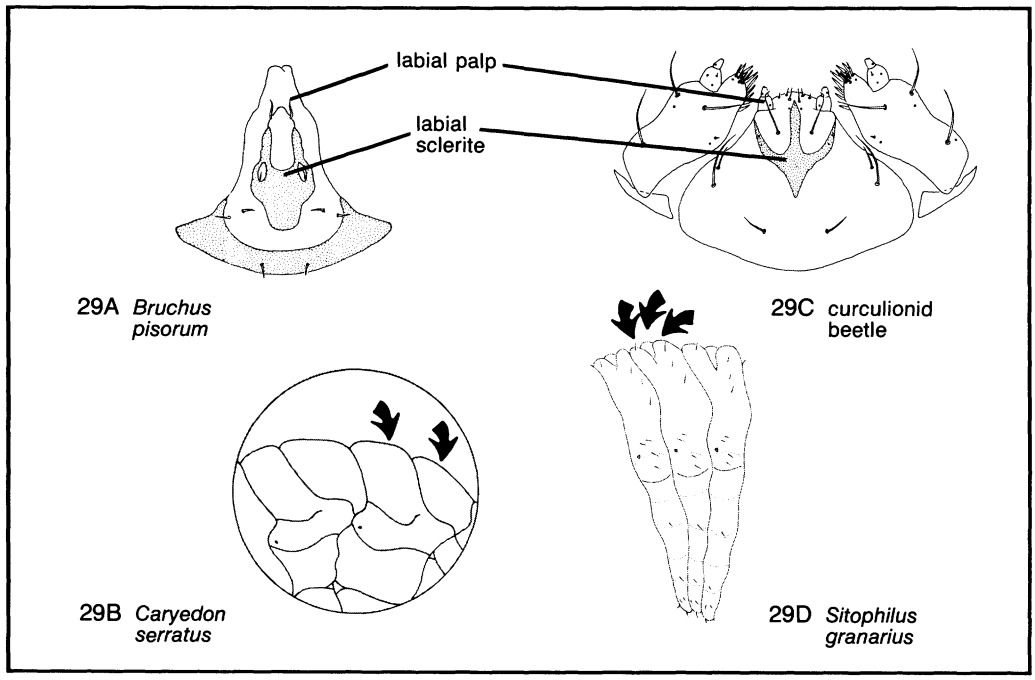
28D-G redrawn from *5*.



29 Labial sclerite forked (29A), heart-shaped, or oval; labial palp setalike (29A); most abdominal terga with 2 folds (29B); pl. 107A----------**seed beetles,** Bruchidae (in part)

Labial sclerite trident; labial palp with 1 or 2 segments (29C); most abdominal terga with 3 folds (29D)---------- 30

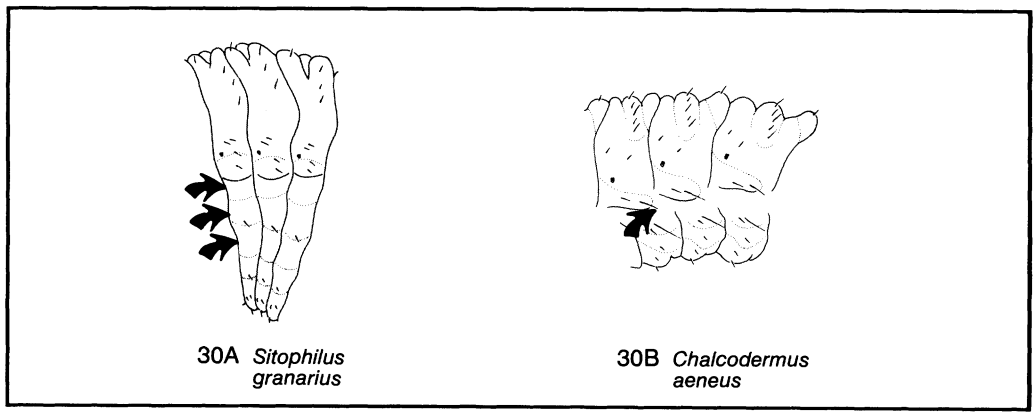
Curculionids cannot be separated from scolytids in the larval stage, and the larvae of both of these families are easily confused with the few species of bruchids with legless larvae.



30 Body very stout and very convex dorsally (pl. 113B); abdomen with 3 rows of pleural folds (30A). Curculionidae (**weevils**) (in part). Genus *Sitophilus*---------- 31

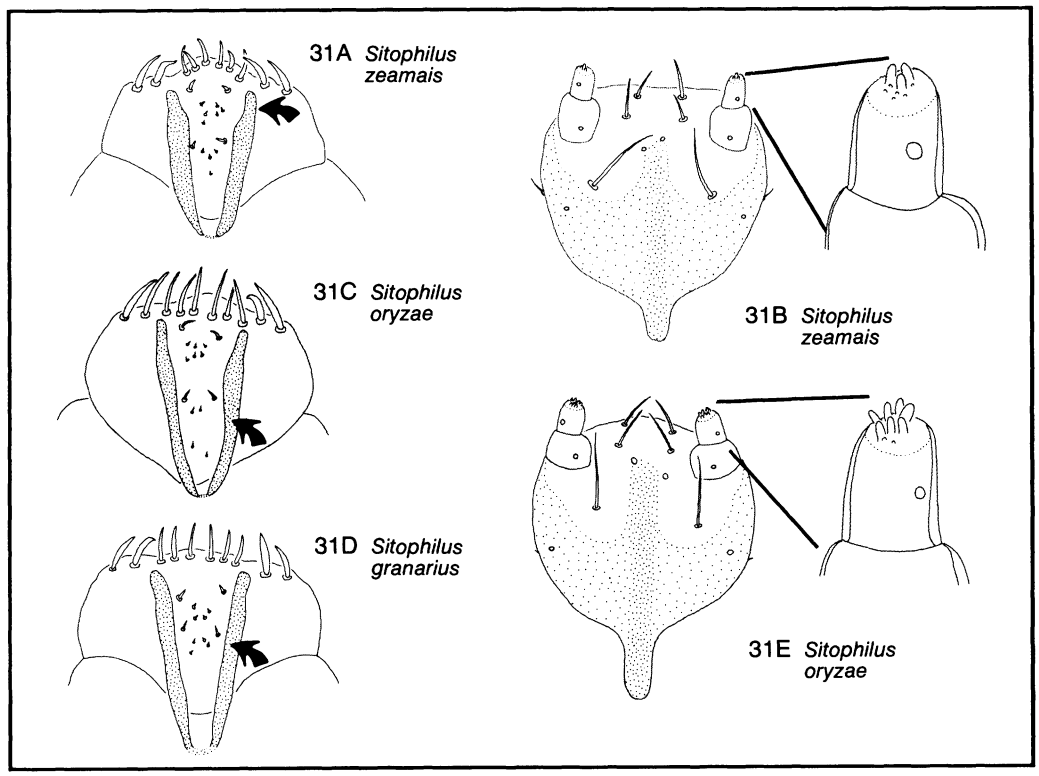
For bionomic notes, see key to adult weevils.
References: *6, 8* (includes keys to species).

Body only moderately stout and convex (pl. 110A); abdomen with 1 row of pleural folds (30B)---------- 33



31 Epipharyngeal rod not uniformly wide but with narrower anterior and wider basal regions (31A); labial palp with less than 5 (usually 3) apical sensory papillae (31B) ----------**maize weevil,** *Sitophilus zeamais*

Epipharyngeal rod slender, of more or less uniform width throughout its length (31C, 31D); labial palp with at least 5 apical sensory papillae (31E)---------- 32

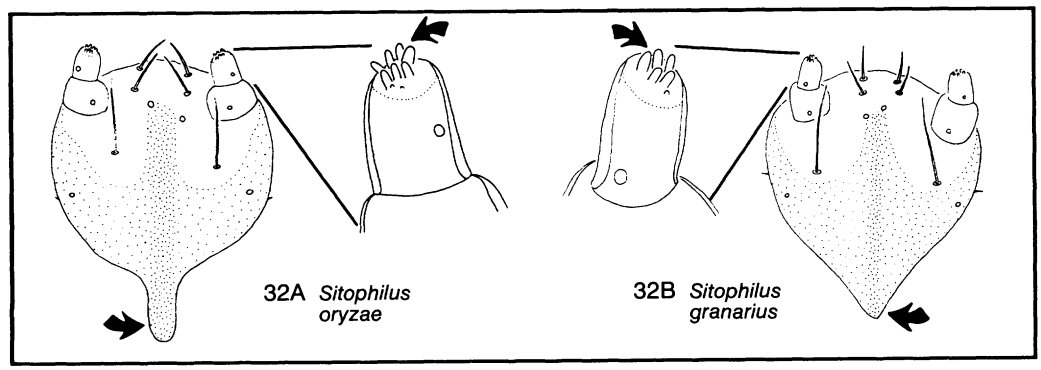


32 Labial palp usually with 7 or 8 apical sensory papillae (32A); premental (labial) sclerite with an elongate posterior process (32A)----------**rice weevil,** *Sitophilus oryzae*

See also 31C.

Labial palp with less than 7 (usually 5) apical sensory papillae (32B); premental sclerite lacking elongate posterior process (32B); pl. 113B------**granary weevil,** *Sitophilus granarius*

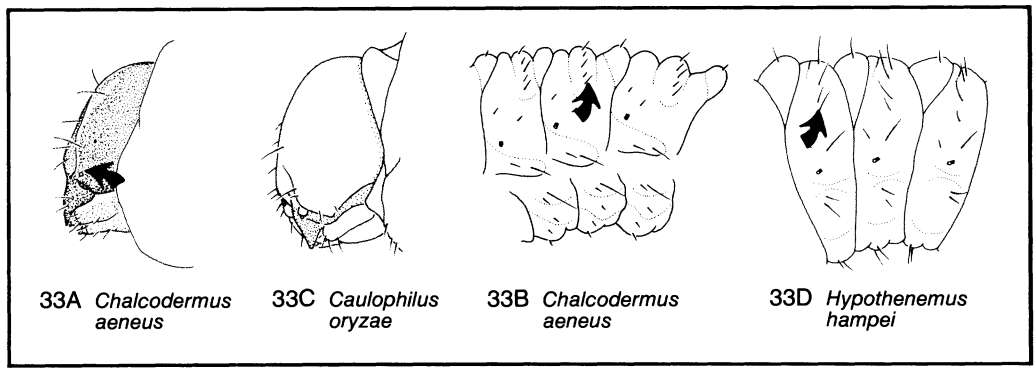
See also 31D.



33 Ocelli present; head distinctly pigmented on dorsal and lateral surfaces (33A); outer 4 postdorsal setae alternately long and short on abdominal segments I to VII (33B). Curculionidae (**weevils**) (in part)---------- 34

For bionomic notes on the species included here, see key to adult weevils.

Ocelli absent; head pale except for dark anterior margins and mandibles (33C); postdorsal setae subequal in length (33D)---------- 35

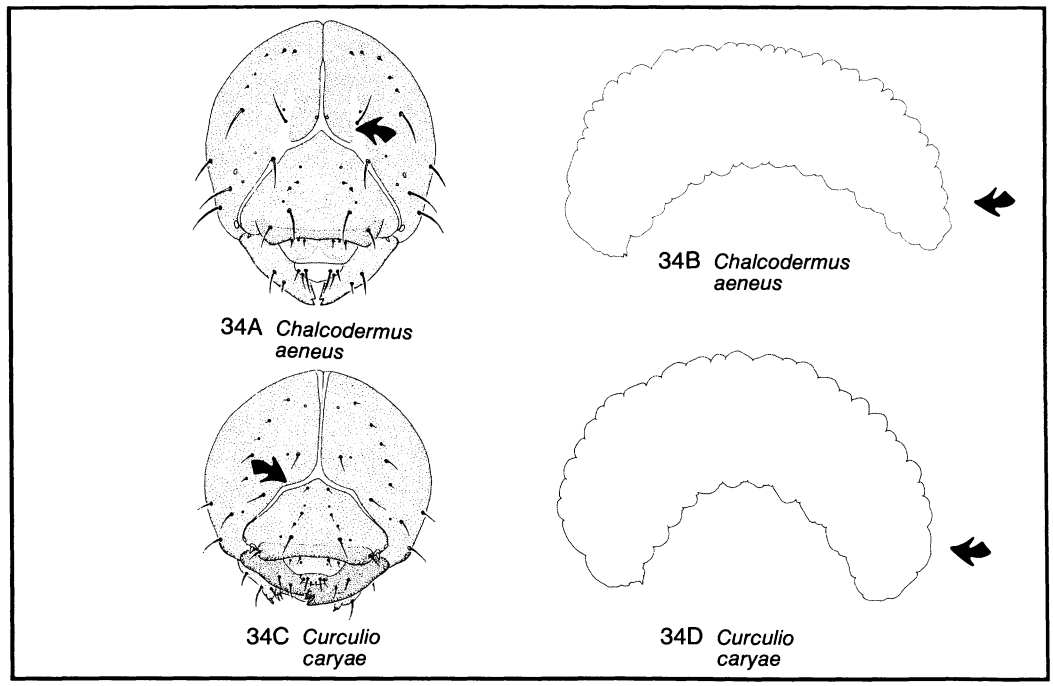


33A *Chalcodermus aeneus* 33C *Caulophilus oryzae* 33B *Chalcodermus aeneus* 33D *Hypothenemus hampei*

34 Head with a pair of white stripes projecting posteriorly from frontal suture; head setae mostly long (about equal to greatest width of labrum) (34A); body distinctly tapered from thorax to abdominal apex (34B); pl. 110A-----**cowpea curculio,** *Chalcodermus aeneus*

Head without white stripes (but may have an unpigmented lobe on angle of frontal suture); head setae mostly short (about equal to greatest width of labrum) (34C); body not tapered posteriorly (34D); pl. 111A----------nut weevils, *Curculio*

Drawings 34A&C by M. Ryan and C. Feller.

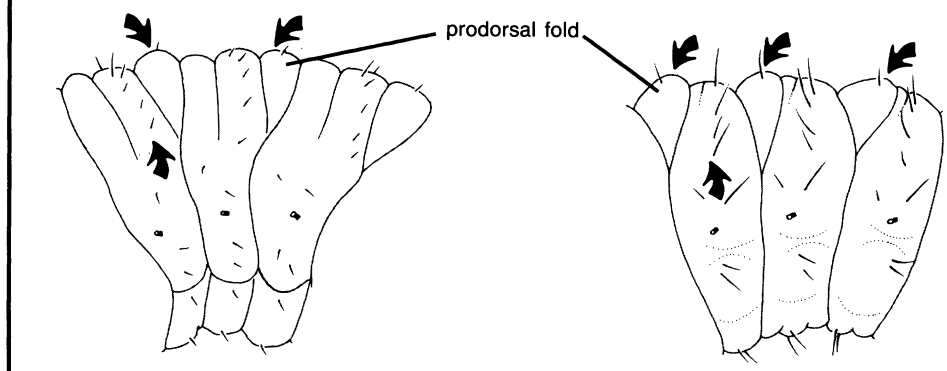


34A *Chalcodermus aeneus* 34B *Chalcodermus aeneus* 34C *Curculio caryae* 34D *Curculio caryae*

35 Abdominal segments I to VII with 5 postdorsal setae; prodorsal folds on segments I to VI projecting (in profile) about as much as other dorsal folds (35A). Curculionidae (**weevils**) (in part); pl. 112A----------**broadnosed grain weevil,** *Caulophilus oryzae*

Abdominal segments I to VI with 4 postdorsal setae; prodorsal folds on segments I to VI distinctly more prominent (in profile) than other dorsal folds (35B). Scolytidae (**bark beetles**); pl. 72A----------**coffee berry borer**, *Hypothenemus hampei*

Distribution: Africa, Brazil, Colombia, East Indies, Ecuador, Guatemala, Jamaica, Mexico, Nicaragua, Peru, Micronesia, Sri Lanka; in coffee beans.



35A *Caulophilus oryzae*

35B *Hypothenemus hampei*

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Notes and Sketches

5 DERMESTID BEETLES (DERMESTIDAE, COLEOPTERA)

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KEY

Adults

Drawings by A.D. Cushman unless otherwise noted.

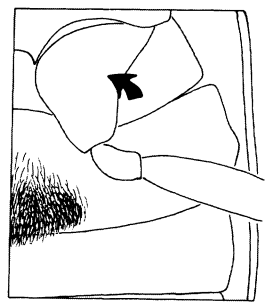
1 Adults ---------- 2
Larvae ---------- 19

2 Face of coxa III not concave; coxa III elongate (2A); antenna long, slender, not clubbed (2B); body slender (pl. 75B&C)----------**odd beetle,** *Thylodrias contractus*

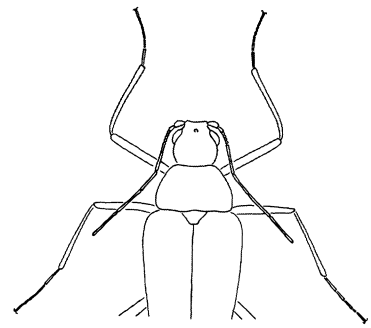
Males winged; females wingless. Distribution: England, North Africa, North America, USSR; in homes (in clothing and bedding) and museums (in dried animal specimens); probably occurs in food only as an accidental contaminant.

Face of coxa III concave (receives femur III); coxa III short (2C); antenna short, thick, and clubbed (2D); body broad (pl. 76A) ---------- 3

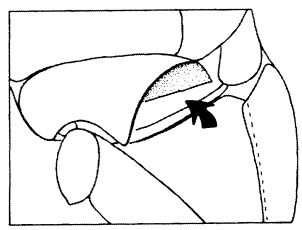
Drawings 2A-D by C. Feller.



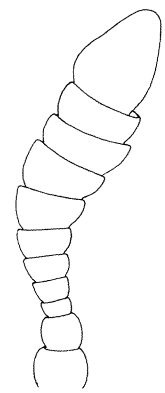
2A *Thylodrias contractus*



2B *Thylodrias contractus*

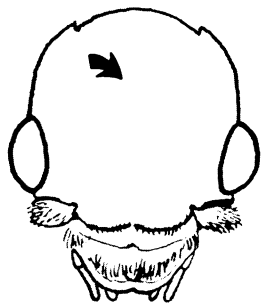


2C dermestid beetle

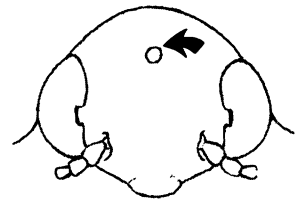


2D *Trogoderma versicolor*

3 Median ocellus absent (3A). Genus *Dermestes* ---------- 4
Median ocellus present (3B) ---------- 9



3A *Dermestes*

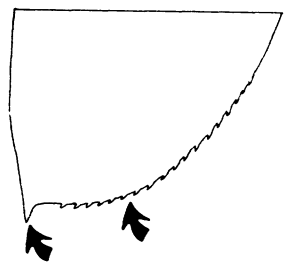


3B *Trogoderma inclusum*

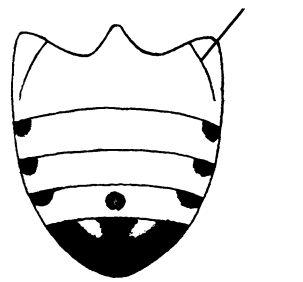
4 Elytral apex serrate, with a small terminal spine (4A); pl. 76A
---------- **hide beetle,** *Dermestes maculatus*

Ventral abdominal color pattern and sulcus shown in 4B. Distribution: cosmopolitan; usually in stored hides and skins, but occasionally in hams.
Drawing 4A by C. Feller.

Elytral apex entire, lacking serrations and spines (4C) ---------- 5



4A *Dermestes maculatus*



4B *Dermestes maculatus*

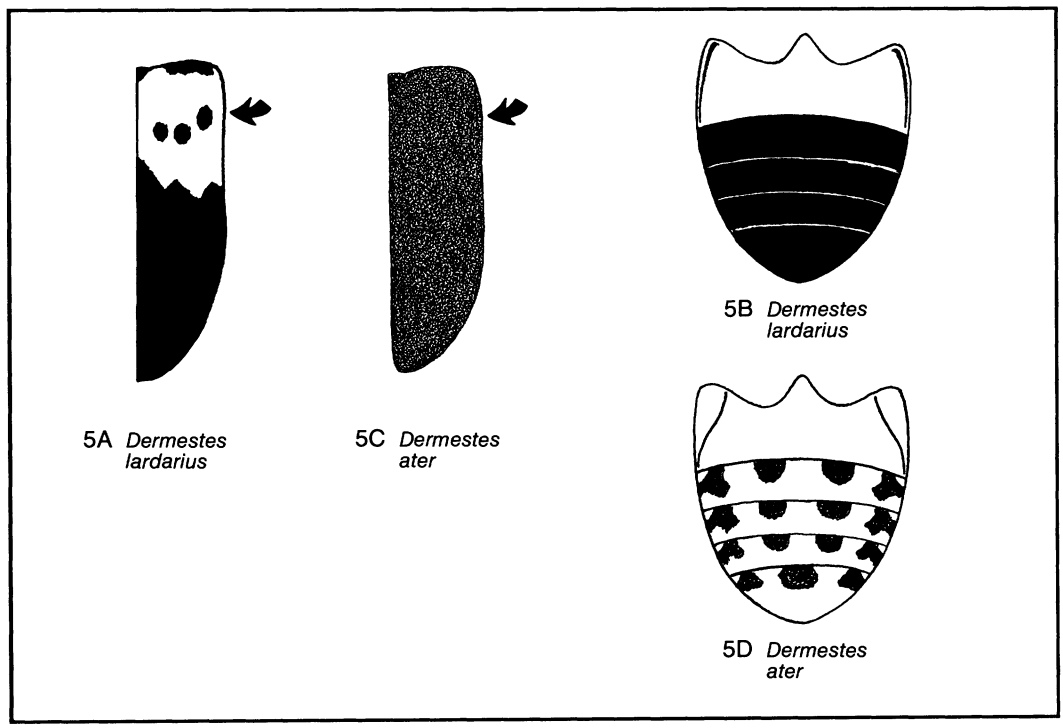
4C *Dermestes lardarius*

5 Elytron with yellowish basal area bearing 3 dark spots (5A); pl. 76B ---------- **larder beetle,** *Dermestes lardarius*

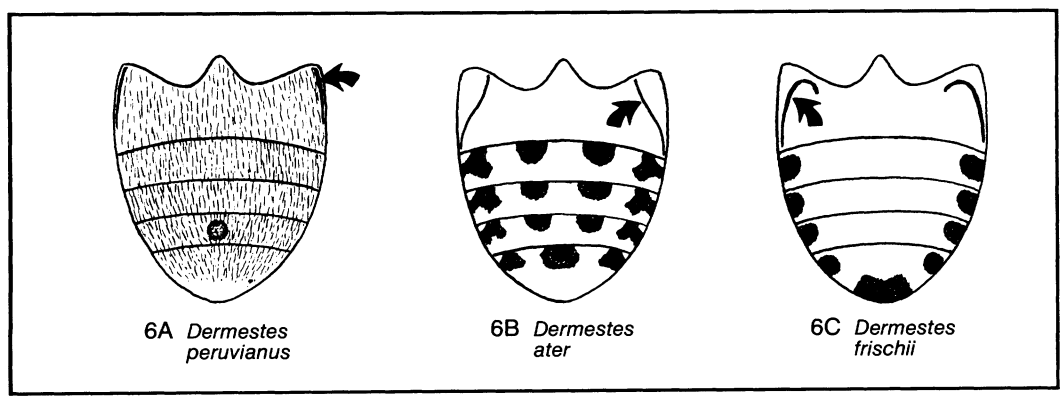
Abdominal venter uniformly colored, lacking a pattern (5B). Distribution: cosmopolitan; in bacon, ham, sausages, dried fish, and cheese.

Elytron without a basal band lighter in color than rest of elytron (5C) ---------- 6

Abdomen with (5D) or without (5B) pattern.
Drawing 5C by C. Feller.



6 Abdominal venter without pattern; lateral sulcus of abdominal sternum I closely parallel to lateral margin (6A) ---------- 7
Abdominal venter patterned; lateral sulcus not closely parallel to lateral margin (6B, 6C) 8

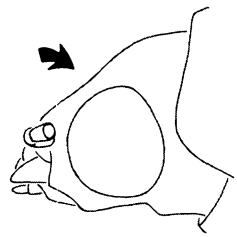


7 Elytral pubescence black, with scattered golden setae; head with rounded medial concavity (7A); pl. 76C----------*Dermestes haemorrhoidalis*

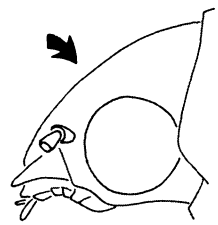
Distribution: England, middle and southern Europe; in kitchens, feeding on spillage; probably important only as an occasional accidental contaminant. Reference: *5*.

Elytral pubescence brown or yellowish, with or without scattered golden setae; front convex (not depressed) (7B); pl. 76D
----------Peruvian larder beetle, *Dermestes peruvianus*

Distribution: nearly cosmopolitan; in dried meat, hams, and sausage. Reference: *5*.
Drawings 7A&B by C. Feller.



7A *Dermestes haemorrhoidalis*



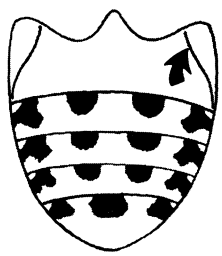
7B *Dermestes peruvianus*

8 Abdominal venter with medial and lateral brown spots on a yellowish background; anterior end of sinuous lateral sulcus located opposite outer limit of coxa III (8A); pl. 77B----------**black larder beetle,** *Dermestes ater*

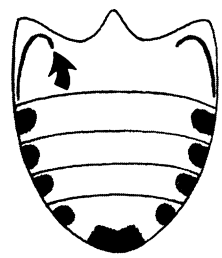
Distribution: cosmopolitan; in dried fish, cheese, and dried mushrooms; occurs in grains and cereals already infested with insects and rodents.

Abdominal color pattern of lateral dark spots on an ash-gray background; anterior end of lateral sulcus strongly curved toward midline (8B) ----------*Dermestes frischii*

Distribution: cosmopolitan; in dried fish; probably occurs also in other foods as an occasional accidental contaminant.

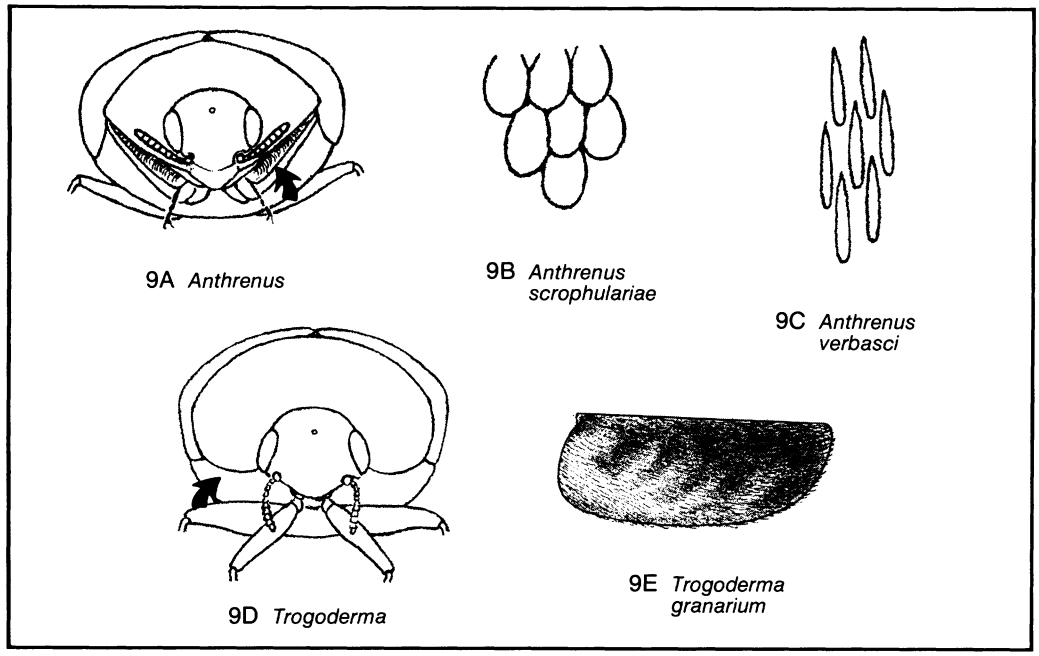


8A *Dermestes ater*



8B *Dermestes frischii*

9 Antennal cavity of anteroventral surface of prothorax fully visible in anterior view (9A); vestiture of flat scales (9B, 9C). Genus *Anthrenus* ---------- 10
Antennal cavity not (or only slightly) visible in anterior view (9D); vestiture of hairs (9E) 11

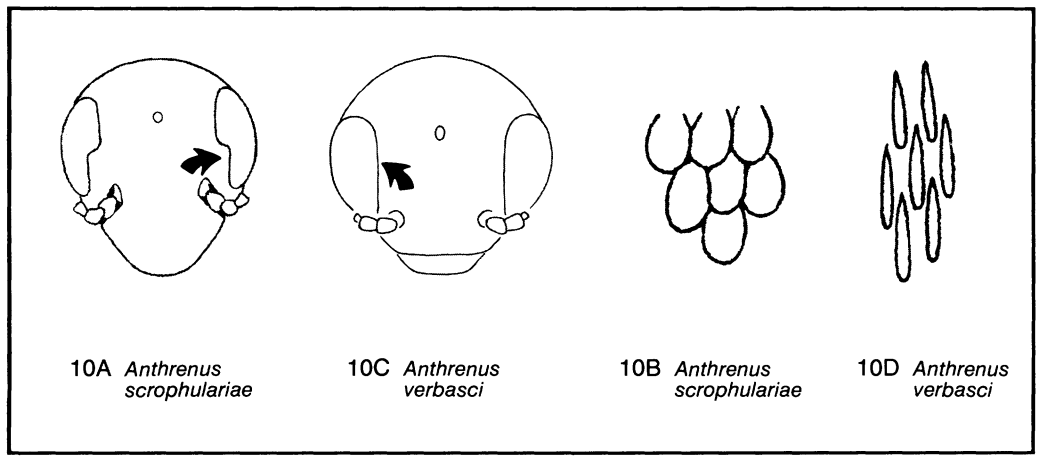


10 Eye notched (10A); elytral scales ovate (10B); pl. 1B
----------**carpet beetle,** *Anthrenus scrophulariae*

Distribution: cosmopolitan; in dried plants, flour, and wheat; probably important only as an accidental contaminant.

Eye entire (10C); elytral scales elongate, 2 to 3 times as long as wide (10D); pl. 1A
----------**varied carpet beetle,** *Anthrenus verbasci*

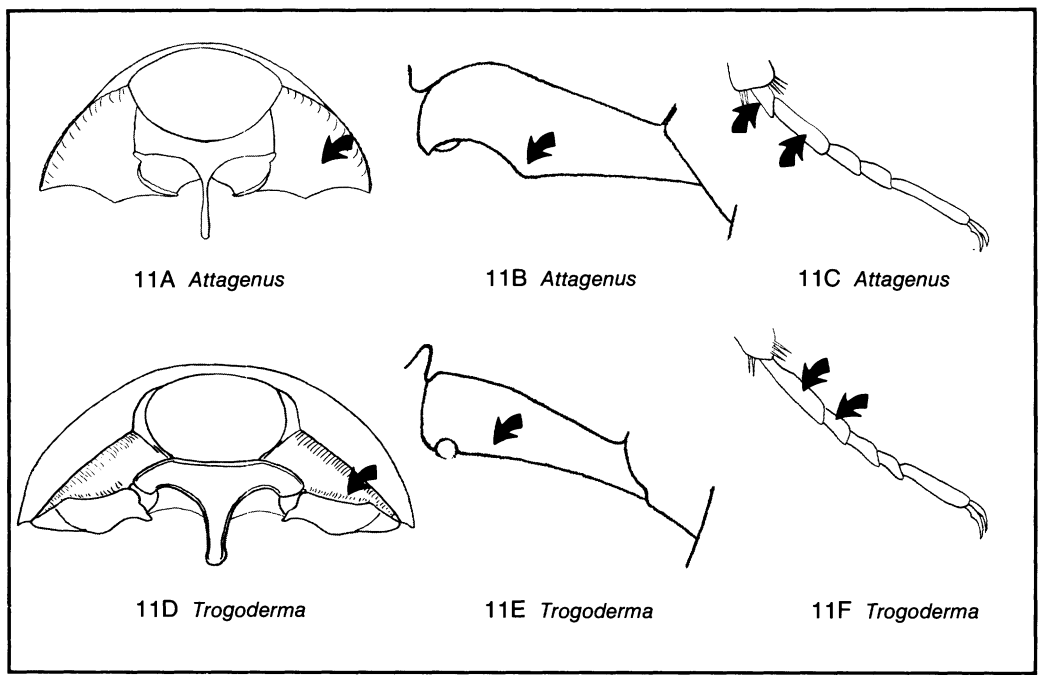
Distribution: cosmopolitan; in drugs, spices, flour, peanuts, wheat, corn, cereals, and seeds.
Drawing 10C by C. Feller.



11 Antennal cavity not carinate posteriorly (11A); posterior margin of coxal plate III with a blunt, toothlike angulation (11B); segment I of tarsus III shorter than segment II (11C). Genus *Attagenus* ---------- 12

Posterior margin of antennal cavity marked by a fine, transverse carina (11D); posterior margin of coxal plate III curved or sinuate (11E); segment I of tarsus III longer than segment II (11F). Genus *Trogoderma* ---------- 13

The species of *Trogoderma* are difficult to separate because of the color pattern variability of some species. Also, it is especially important to correctly identify the **khapra beetle,** *T. granarium,* and to avoid confusing it with less important species. Specimens of questionable identity, especially those originating in the southwestern United States, should be sent to the Taxonomic Services Unit, PSI, Beltsville Agricultural Research Center-West, Beltsville MD 20705. This key to *Trogoderma* is based on Beal (*1, 2*).



12 Dorsal coloration uniformly brown or brownish-black, except for 2 elytral white spots (pl. 79A) ---------- fur beetle, *Attagenus pellio*

Distribution: Africa, Asia, Europe, North America; in smoked meat, fish, casein, and cereal products.

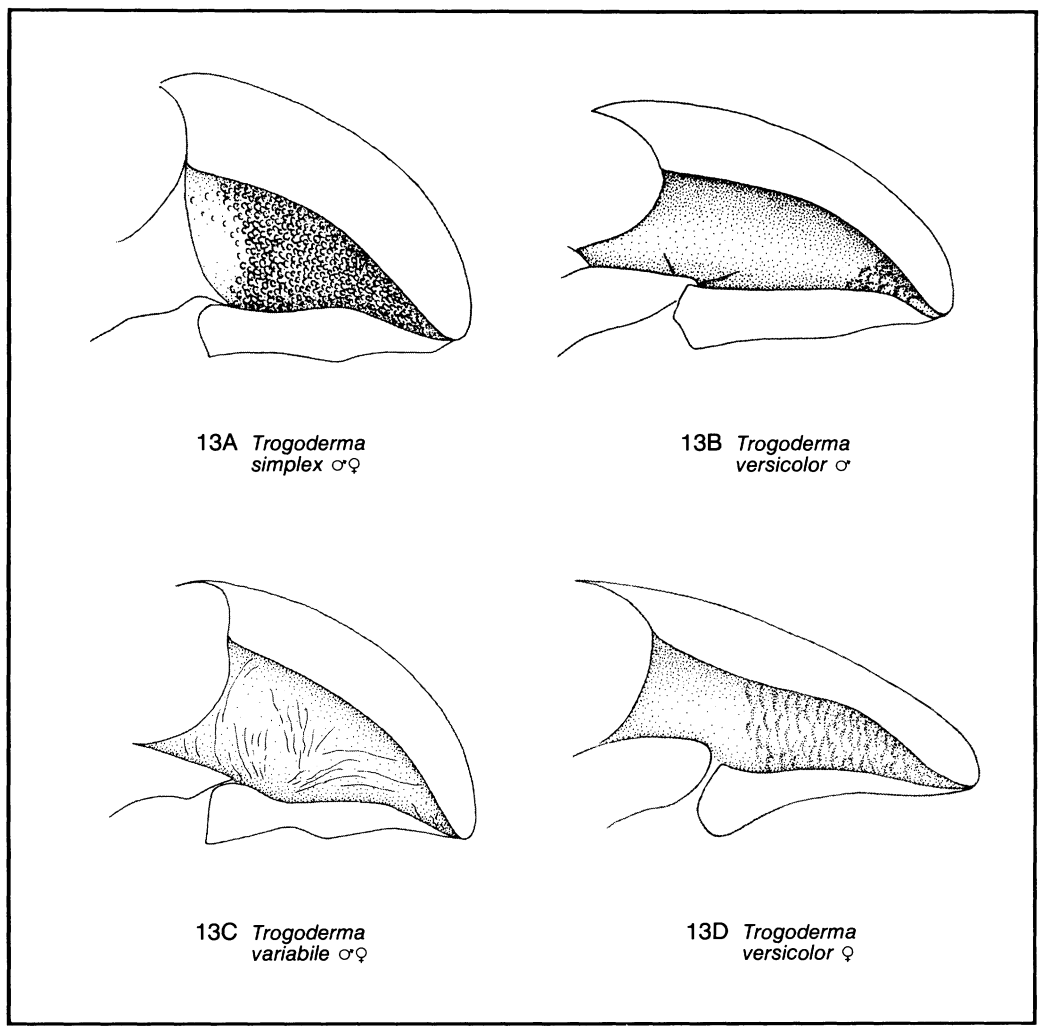
Dorsal coloration uniformly brown or black (pl. 79C) ---------- **black carpet beetle,** *Attagenus unicolor*
Attagenus brunneus

Distribution: *A. unicolor* (=*A. megatoma*), cosmopolitan in grain, flour, spices, and seeds; *A. brunneus* (=*A. elongatulus*), Afghanistan, Mediterranean Region, Pakistan, USA (in dried milk and peanuts), USSR.

13 Antennal cavity with coarse, confluent punctures, 2 to 3 times larger than eye facet, except for small smooth area near prosternum (13A); pl. 80A--------*Trogoderma simplex*

Distribution: Mexico, western United States; in stored grain.
Drawings 13A-D by C. Feller.

Antennal cavity finely punctate in mesal two-thirds (each puncture about the size of an eye facet) (13B), *or* antennal cavity shining and minutely striate (13C), *or* antennal cavity coarsely punctate or rugose in lateral one-half and striate or finely punctate mesally (13D) ---------- 14



13A *Trogoderma simplex* ♂♀

13B *Trogoderma versicolor* ♂

13C *Trogoderma variabile* ♂♀

13D *Trogoderma versicolor* ♀

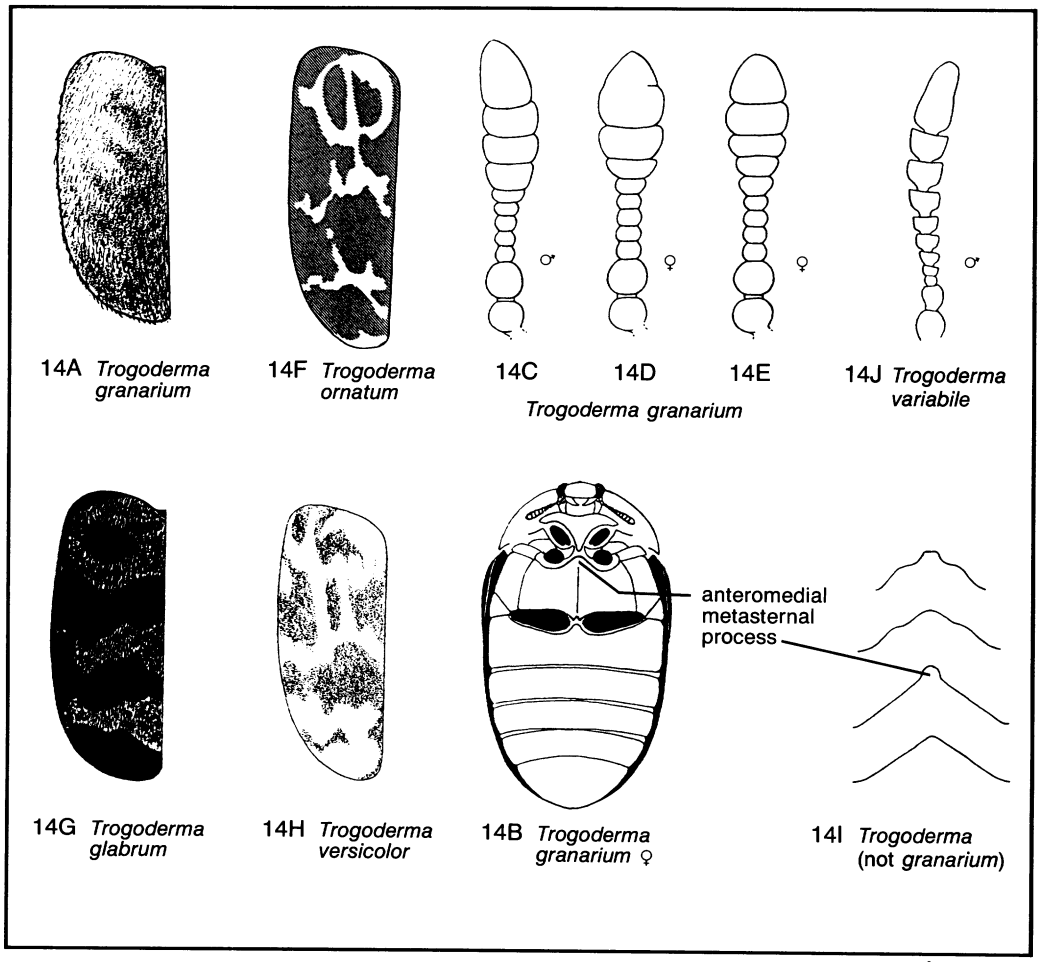
14 Elytron unicolorous or vaguely mottled, but without a clearly defined pattern (14A); anteromedial metasternal margin lacking nipplelike projection (14B); pl. 80B ---------- **khapra beetle,** *Trogoderma granarium*

Number of antennal segments varies from 9 to 11; antennal club of male with at most five segments (14C); antennal club of female with at least 3 segments (14D&E). Distribution: tropicopolitan in hot dry areas; in grain, cereal products, and malt.

Elytron with a definite color pattern (it may be fine and intricate) visible either in maculation or in pubescence or both (14F-H); anteromedial margin of metasternal lobe with a nipplelike projection (14I) ---------- 15

Number of antennal segments always 11; antennal club of male with at least five segments (14I); antennal club of female with at least four segments.

Drawings 14B&I by G.T. Okumura; 14C-E from *2*, 14F from *1*; 14G&H by C. Feller.



14A *Trogoderma granarium*

14F *Trogoderma ornatum*

14C 14D 14E *Trogoderma granarium*

14J *Trogoderma variabile*

14G *Trogoderma glabrum*

14H *Trogoderma versicolor*

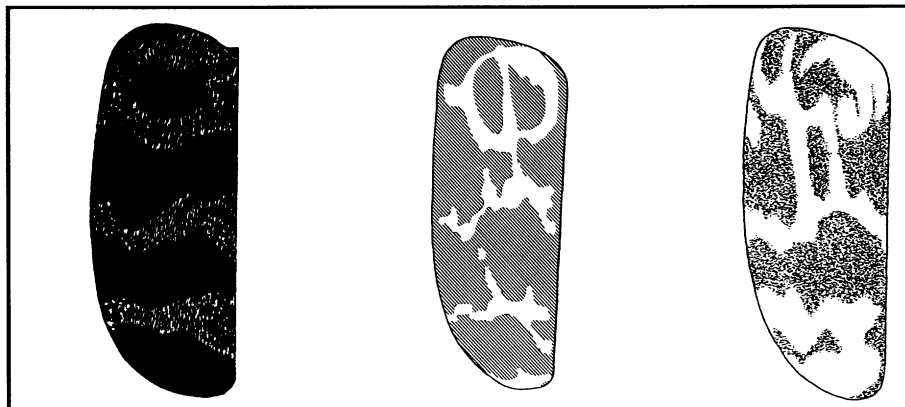
14B *Trogoderma granarium* ♀

14I *Trogoderma* (not *granarium*)

15 Integument unicolorous (black) or black with vague brownish maculations on humeri and apical margins only; never with distinct basal, submedian and subapical bands (if banding is present at all, it is indicated only very vaguely by light-colored pubescence) (15A); pl. 80C----------glabrous cabinet beetle, *Trogoderma glabrum*

Elytral pattern highly variable; elytral pubescence easily abraded. Distribution: Holarctic; in grain, cornmeal, cereal products, and dried milk.
Drawings 15A&C by C. Feller.

Integument bicolorous, at least with a pattern of basal, submedian, and subapical bands of lighter maculation on elytra (15B, 15C) ---------- 16

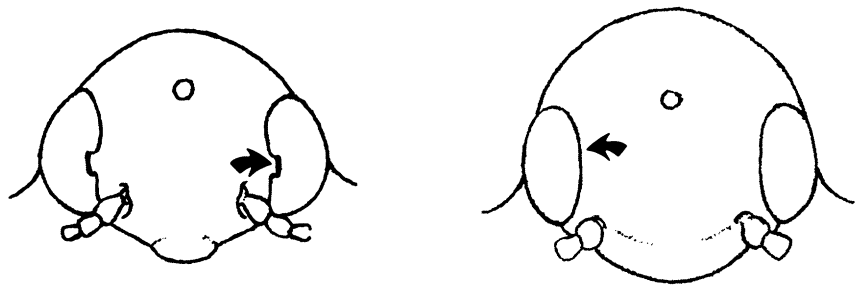


15A *Trogoderma glabrum* 15B *Trogoderma ornatum* 15C *Trogoderma versicolor*

16 Inner margin of eye distinctly notched (16A); pl. 1D
---------- larger cabinet beetle, *Trogoderma inclusum*

Distribution: England, United States; in grain, dried milk, and nuts.

Inner margin of eye straight or very slightly sinuate (16B)---------- 17



16A *Trogoderma inclusum* 16B *Trogoderma variabile*

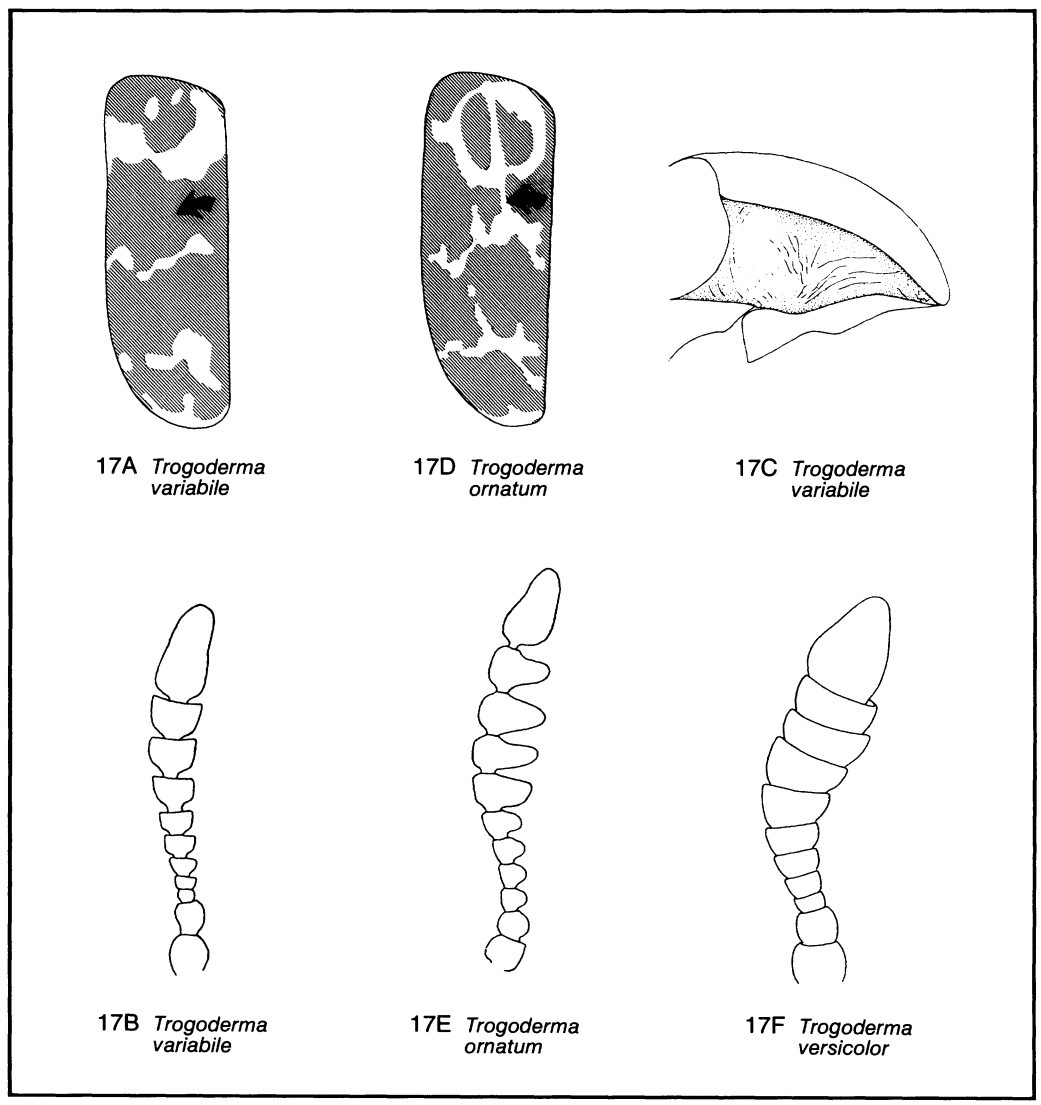
17 Basal band or loop of elytral maculation never connected to submedian band by a longitudinal band or bands (17A); pl. 1C--------**warehouse beetle,** *Trogoderma variabile*

Antennal club of male with segments more or less compactly joined, not serrate (17B); antennal cavity finely striate (17C); basal band or loop, submedian band, and subapical band of elytral maculation always present. Distribution: North America, USSR; in various seeds, cereals (corn, rice, wheat), nuts, dried milk, and fish meal. See also 13C, 14J, 16B.

Basal band or loop of elytral maculation always connected to submedian band by one or more longitudinal bands (17D) ---------- 18

Antennal club of male with (17E) or without (17F) serrations; antennal cavity finely striate (see 18B), partly punctate (see 18C), or vaguely punctate-striate (see 18E&F).

Drawings 17A&D from *1;* 17C&F by C. Feller

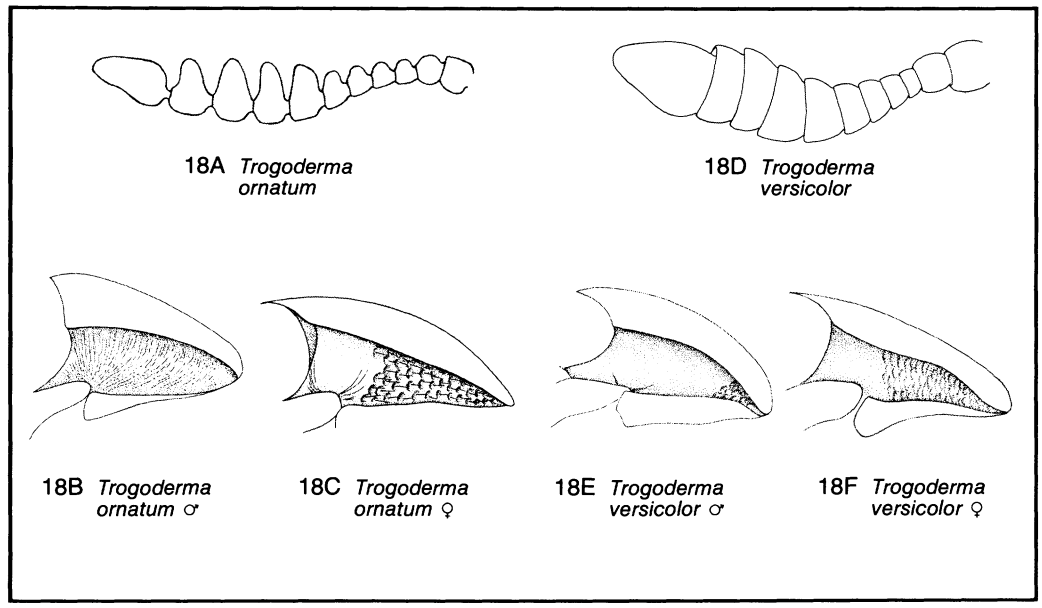


18 Antenna of male serrate (18A); antennal cavity of male polished and finely cross-striate (18B); antennal cavity of female polished and finely striate mesally but punctate in lateral two-thirds (18C); pl. 1E --------ornate cabinet beetle, *Trogoderma ornatum*

Distribution: North America; in cereals, seeds, and fish meal. See also 14F, 17E.

Antenna of male clavate (18D); antennal cavity dull and minutely punctate, but vaguely punctate-striate in lateral one-fifth in male (18E) and in lateral one-half to two-thirds in female (18F); pl. 80D ----------European larger cabinet beetle, *Trogoderma versicolor*

Distribution: Europe; in seeds, grain, rice, wheat, corn, and nuts. See also 13B, 15C.
Drawings 18B-F by C. Feller.

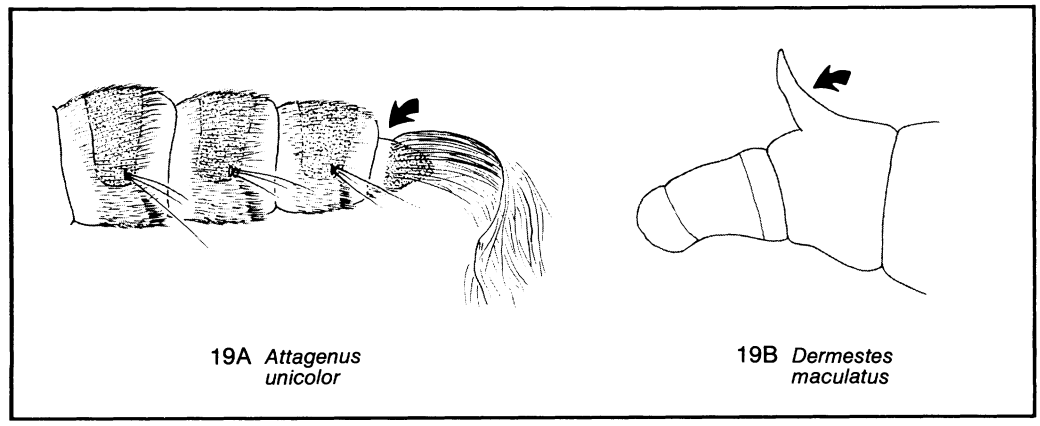


Larvae

Drawings by C. Feller

19 Urogomphi absent (19A)---------- 20
Urogomphi present (19B). Genus *Dermestes*---------- 23

References: *5, 6.*

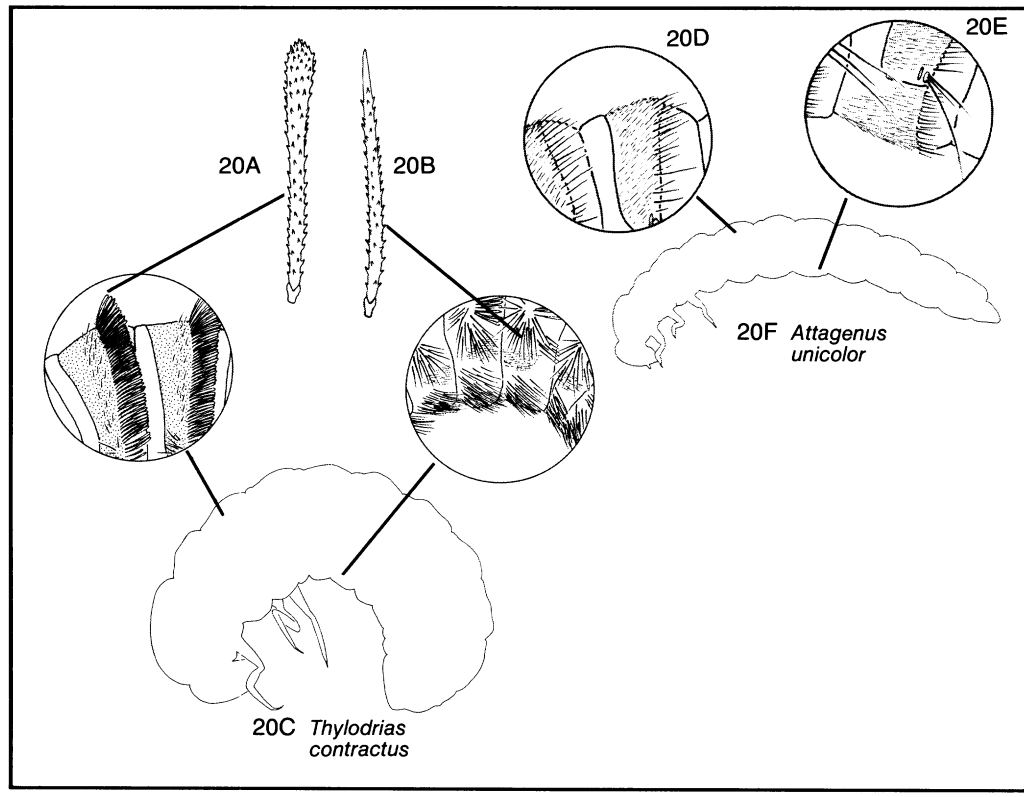


20 Each tergum with a row of coarse, spiny, club-shaped setae (20A) along posterior margin and a cluster of spiny, sharp-pointed setae (20B) on each side; pl. 75A ---------- **odd beetle,** *Thylodrias contractus*

Body short, stout, C-shaped (20C).

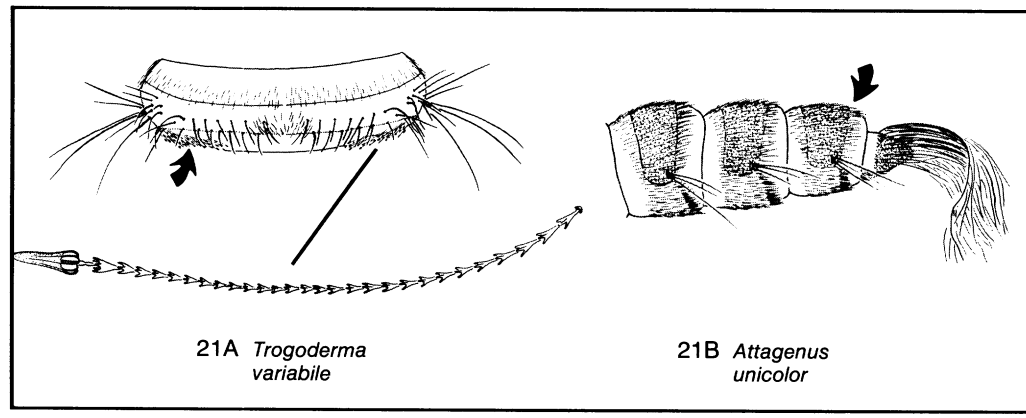
Sharp or club-shaped spiny setae absent (20D, 20E; see also 21A)---------- 21

Body slender (20F) or stout.



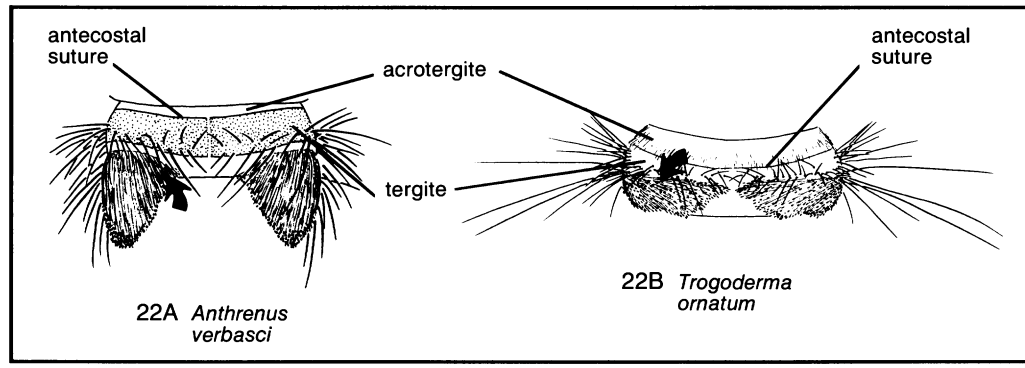
21 Hastisetae present (21A) ---------- 22
Hastisetae absent (21B). Genus *Attagenus*---------- 27

Reference: *4.*

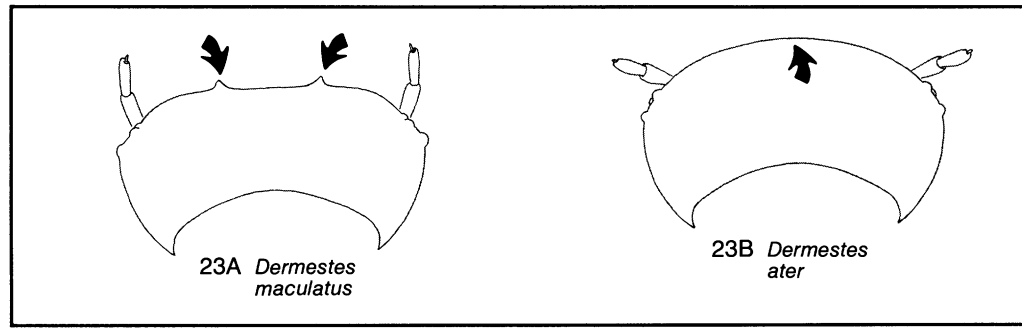


22 Hastisetal tufts inserted on "islands" in membrane behind strongly curved posterior margins of abdominal segments V, VI, and VII (22A). Genus *Anthrenus* ---------- 29
Hastisetal tufts inserted on tergal plates (22B). Genus *Trogoderma* ---------- 30

References: *3, 7.*



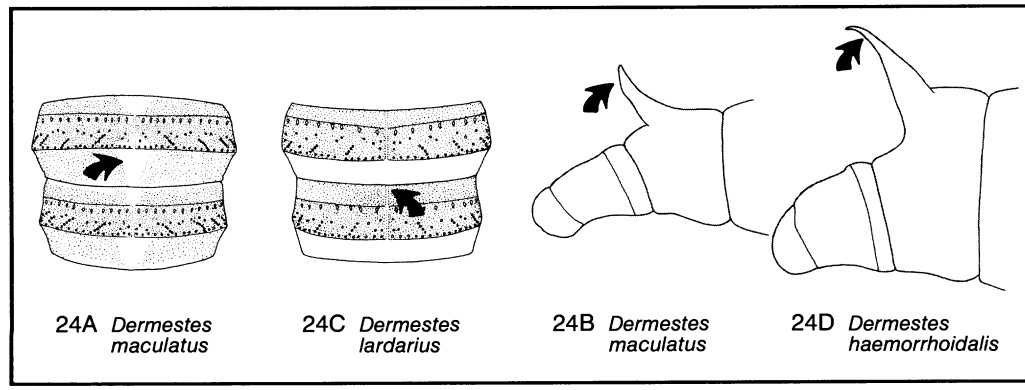
23 Frontal tubercles present (23A) ---------- 24
Frontal tubercles absent (23B) ---------- 26



24 Dorsal midline marked by a broad, yellow stripe (24A); apex of urogomphus curved anteriorly (24B) ----------**hide beetle,** *Dermestes maculatus*
Dermestes frischii

See also 19B, 23A.

Dorsal midline of thorax and abdomen marked only by a thin, unsclerotized line (24C); apex of urogomphus curved posteriorly (24D) ---------- 25

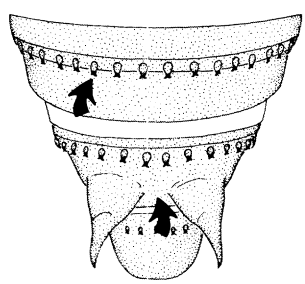


25 Urogomphi separated by a distance less than width at base of one urogomphus; retrorse tubercles (each bilobed and bearing a medial seta) large and conspicuous on abdominal terga III to X (25A); ventral sclerotized areas well-developed on last 5 abdominal segments (25B)----------*Dermestes haemorrhoidalis*

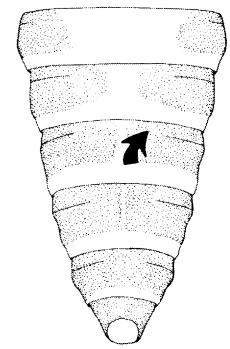
Head tubercles easily seen; urogomphi appear broad at base. See also 24D. Reference: *5*.

Urogomphi separated by a distance equal to width at base of one urogomphus; retrorse tubercles (usually neither bilobed nor setiferous) either absent or small and inconspicuous, especially on terga IX and X (usually absent on X) (25C); ventral sclerotized areas well-developed only on last 4 abdominal segments (25D) ---------- Peruvian larder beetle, *Dermestes peruvianus*

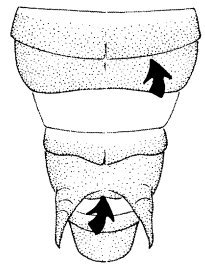
Head tubercles often flattened and inconspicuous; urogomphi appear narrow at base. Reference: *5*.



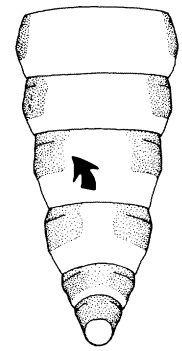
25A *Dermestes haemorrhoidalis*



25B *Dermestes haemorrhoidalis*



25C *Dermestes peruvianus*



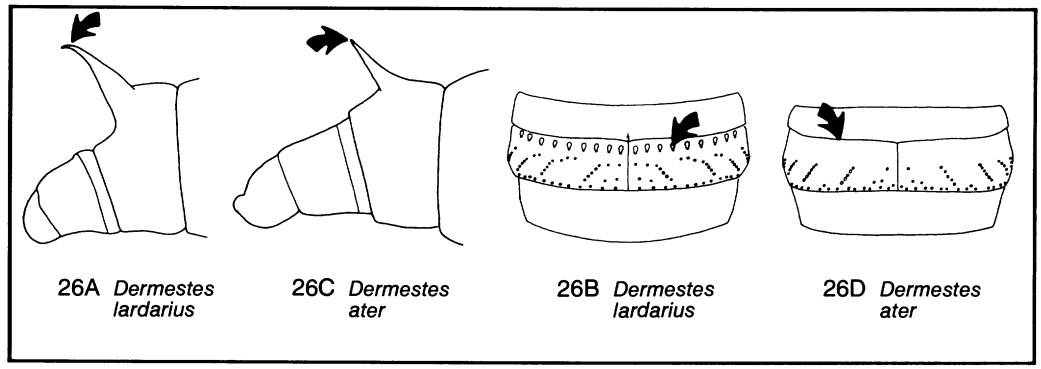
25D *Dermestes peruvianus*

26 Urogomphus curved posteriorly at apex (26A); retrorse tubercles present at least on abdominal tergum VI (26B); ----------**larder beetle,** *Dermestes lardarius*

See also 24C.

Urogomphus straight (26C); retrorse tubercles absent from all abdominal terga (26D); pl. 77A ----------**black larder beetle,** *Dermestes ater*

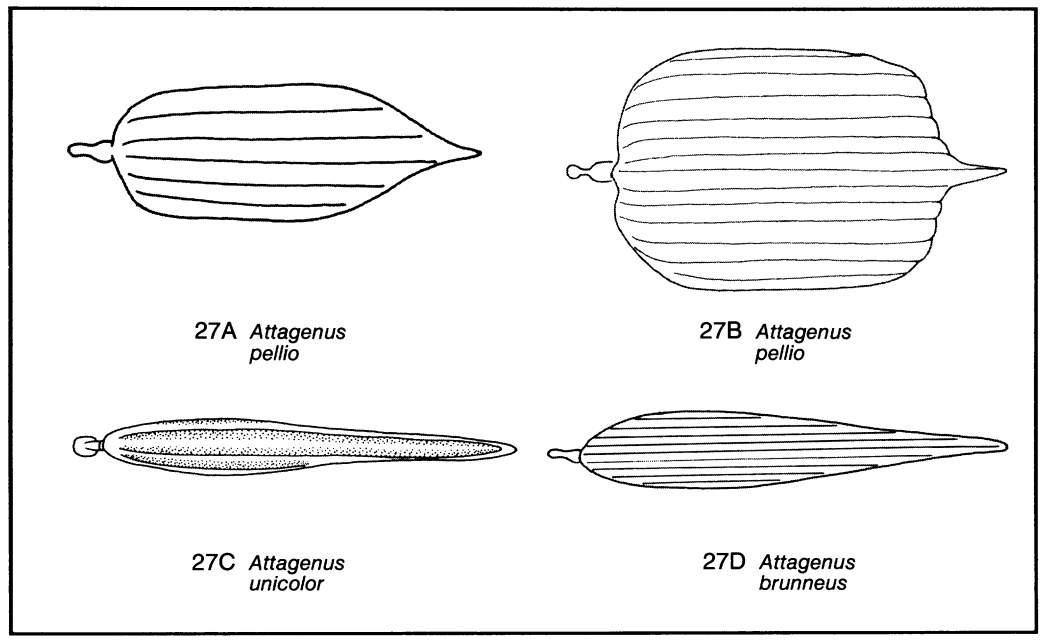
See also 23B.



27 Acrotergites with broad setae (each seta with 5 longitudinal ribs) (27A); abdominal tergite VIII with most setae subrectangular or ovate (27B) ----------fur beetle, *Attagenus pellio*

Acrotergites with slender setae only (each seta with no more than 3 longitudinal ribs) (27C); abdominal tergite VIII with either lanceolate or linear setae (27D) ---------- 28

27A-D redrawn from *4*.

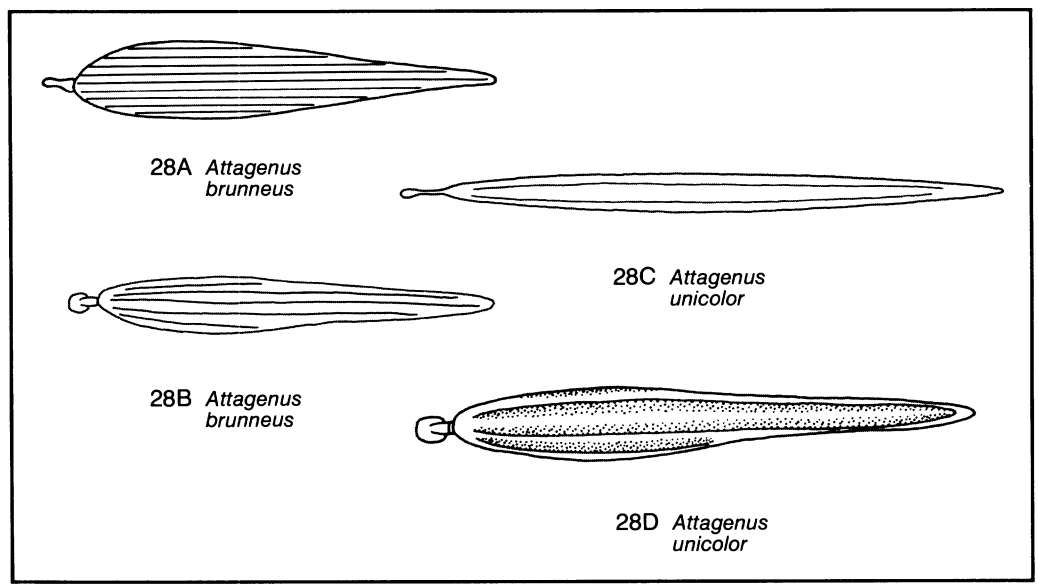


28 Integument of head and dorsum of body light brown; setae of VIII sternite with 8 to 12 ribs (28A)----------*Attagenus brunneus*

Tergal setae with up to 5 ribs between margins (28B).

Integument of head and dorsum of body reddish brown; setae of VIII sternite with 2 or 3 ribs (28C)----------**black carpet beetle,** *Attagenus unicolor*

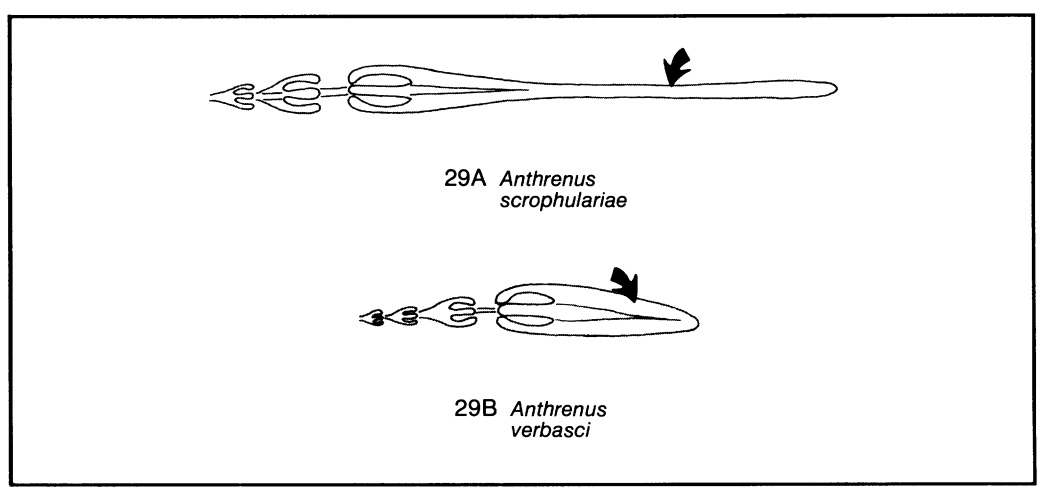
Tergal setae with 2 or 3 ribs between margins (28D). Both *A. megatoma* (now *A. unicolor*) and *A. elongatulus* (now *A. brunneus*) have been known previously as *A. piceus.* See also 21B.



29 With very long hastisetal heads (29A); abdominal sterna with yellowish sclerotized plates ----------**carpet beetle,** *Anthrenus scrophulariae*

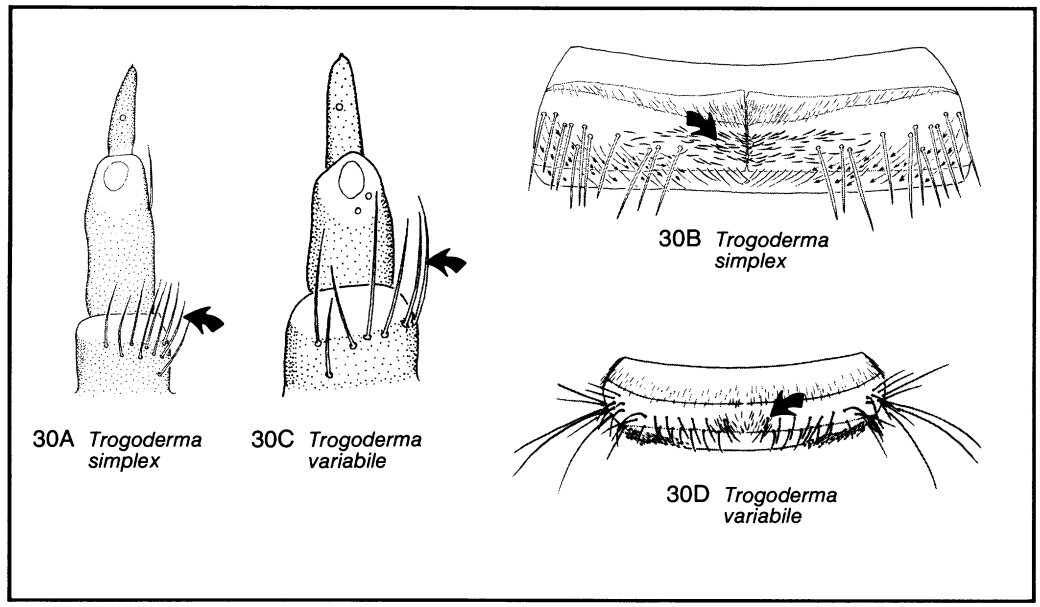
With short hastisetal heads (29B); abdominal sterna membranous (whitish or transparent); pl. 78 ----------**varied carpet beetle,** *Anthrenus verbasci*

See also 22A.



30 Setae of basal antennal segment less than half as long as antennal segment II (30A); tergites with short, flat, mesally-directed spicisetae (30B)----------*Trogoderma simplex*

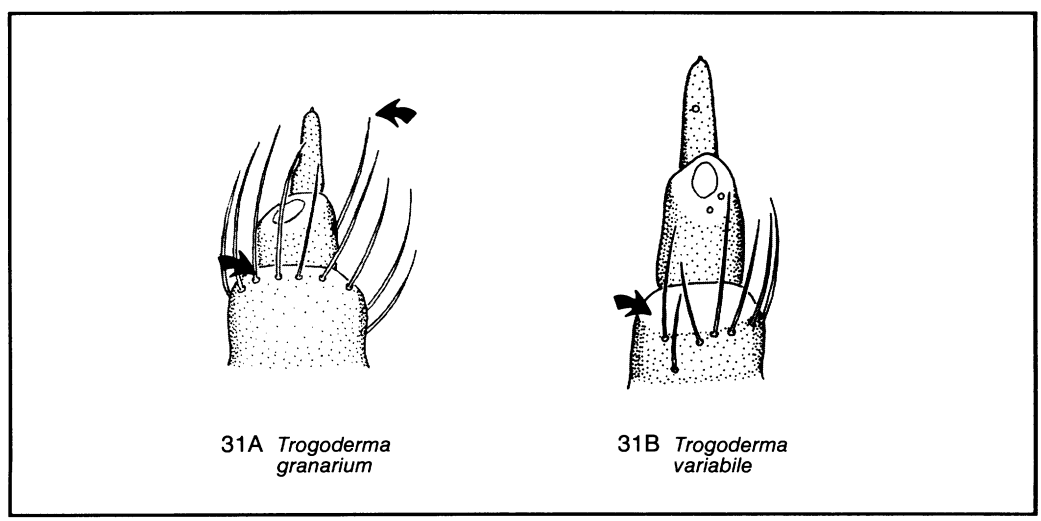
Setae of basal antennal segment at least three-fourths as long as antennal segment II (30C); mesally-directed tergal setae absent (30D) ---------- 31



31 Setae of basal antennal segment almost completely encircling segment (not bunched on mesal side); setae of antennal segment I reaching or surpassing apex of segment II when antenna is fully extended (31A) ---------- 32

Single seta (31A) on antennal segment II of *Trogoderma granarium* sometimes absent.

Setae of basal segment bunched on mesal side, leaving one-third or more of lateral surface bare; setae of segment I not reaching apex of segment II of fully-extended antenna (31B) ---------- 35

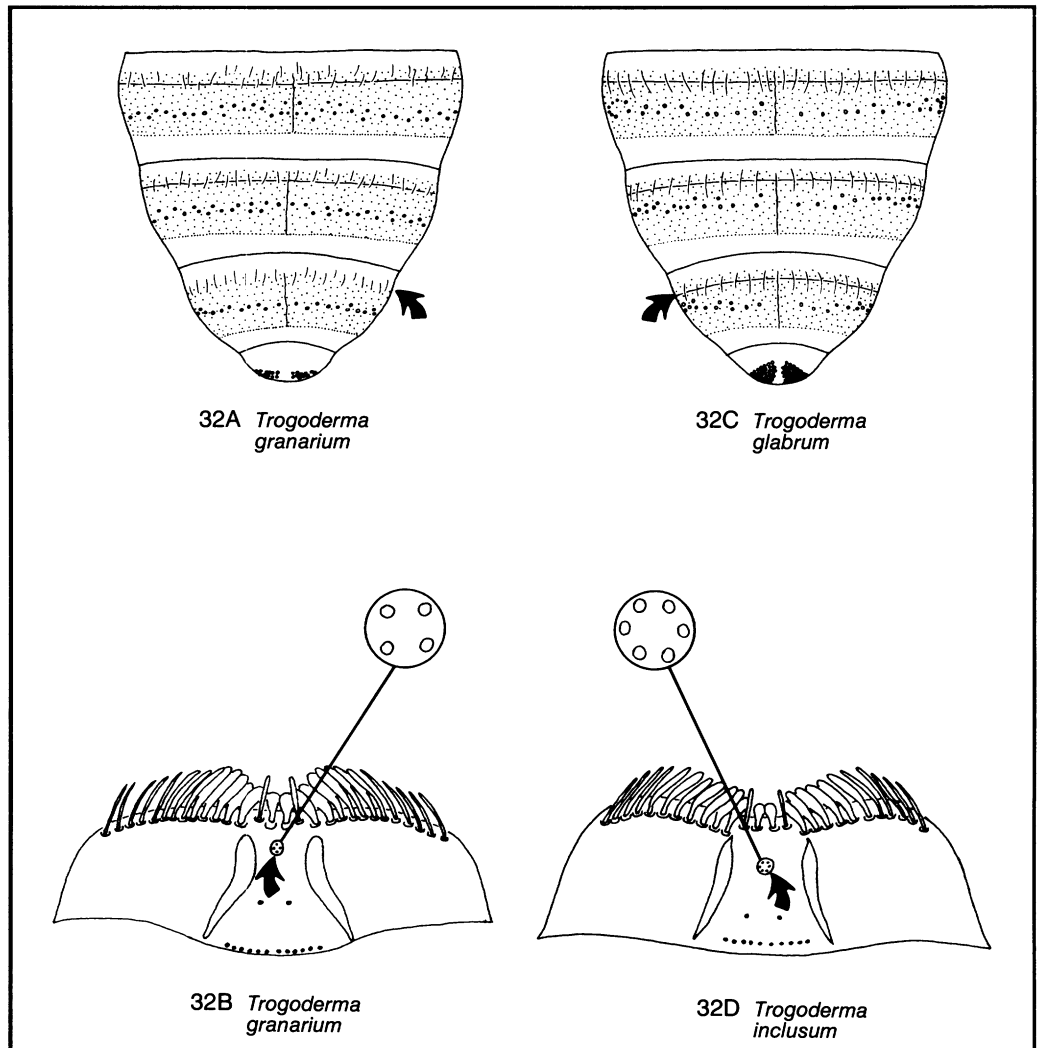


32 Antecostal suture of abdominal segment VIII usually absent (32A), but in those rare instances when it is present, it is weak and interrupted at several points ---------- **khapra beetle,** *Trogoderma granarium*

Labium with 4 epipharyngeal papillae in distal sensory cup (32B). See also 31A. See note at couplet 11.

Antecostal suture of abdominal segment VIII present (32C) ---------- 33

Distal sensory cup with 4 (32B) or 6 (32D) epipharyngeal papillae. Antecostal suture visible only if abdomen is distended (as in 32A&C).



33 Terga medium to dark brown or bluish gray; epipharyngeal papillae 4 (see 32B) ---------- glabrous cabinet beetle, *Trogoderma glabrum*

Terga creamy yellow; epipharyngeal papillae 6 (see 32D) ---------- 34

34 Western Hemisphere ---------- larger cabinet beetle, *Trogoderma inclusum*

See 32D.

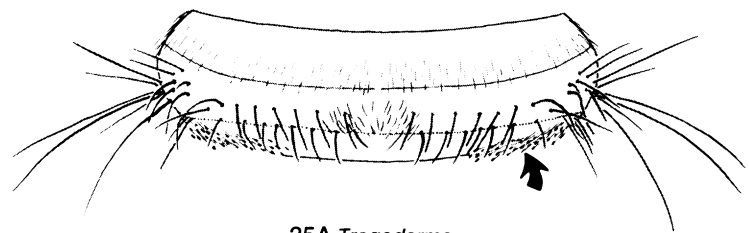
Eastern Hemisphere ---------- European larger cabinet beetle, *Trogoderma versicolor*

35 Disc of thoracic and anterior abdominal terga usually with very few hastisetae; terga usually with only a single row of large spicisetae (35A); pl. 81 ---------- **warehouse beetle,** *Trogoderma variabile*

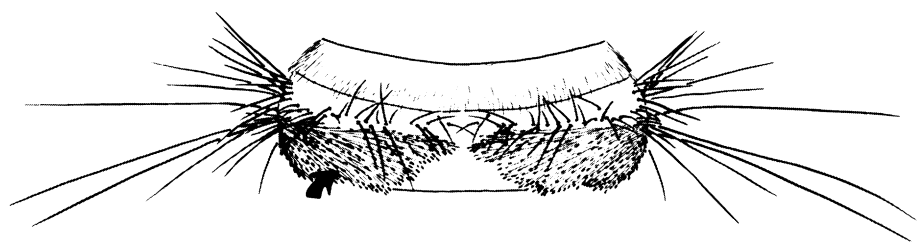
See also 21A, 30C.

Thoracic and anterior abdominal terga usually moderately dense with hastisetae; terga usually with 2 rows of large, erect spicisetae (35B) ---------- ornate cabinet beetle, *Trogoderma ornatum*

See also 22B.



35A *Trogoderma variabile*



35B *Trogoderma ornatum*

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Notes and Sketches

6 SPIDER BEETLES (PTINIDAE, COLEOPTERA)

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Because of their relatively small, globular, usually hairy bodies and slender legs, the ptinids resemble spiders, hence the common name. The family contains a moderate number of species, approximately 20 of which have been recorded as pests. Not all 20 are included here; those absent are very minor or rare pests that do not occur in North America, the geographic focus of the key presented here. Many of the pest species are widely distributed, even cosmopolitan, and are spread by commerce.

Ptinids often infest foods, but the actual loss of weight due to feeding is small unless the ptinid population is enormous. In addition to damaging food, ptinids indirectly cause spoilage by contaminating food with frass, with fragments of their dead bodies, and with the silk they use to spin cocoons. Ptinids are mainly scavengers, and many readily feed equally on plant or animal materials. Besides being found in human foods, they have been found in the nests of bees, wasps, birds, and mammals, bat caves, warehouses, food-handling businesses, and houses. They are especially attracted to moisture and to bird and mammal excrement. Ptinid infestations, therefore, often follow other kinds of infestations. Excellent accounts of the biology and habits of the species of economic importance were published by R.W. Howe and collaborators from 1949 to 1959 in a series of 17 articles entitled *Studies on Beetles of the Family Ptinidae*. All parts of the series are cited in the final summary article by Howe (*9*).

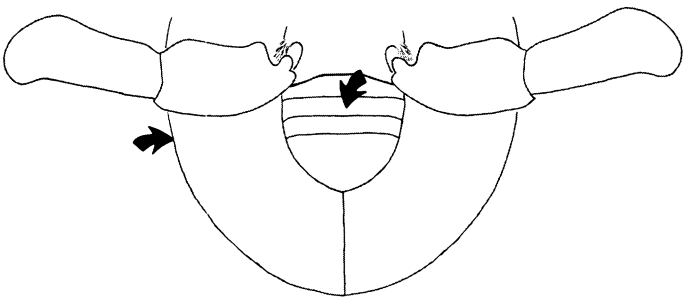
Identification to genus is rather simple, but sexual dimorphism in some species of *Ptinus,* the largest genus, complicates specific identification. The sexes can be so different—slender males (pl. 86A) and stout females (pl. 86B)—as to seem to be separate species. When sexual dimorphism is absent, both males and females are stout. In the past, the presence or absence of sexual dimorphism has been used sometimes as a key character; it was necessary, therefore, to have both sexes of the same species at hand to make the key work. In the following key sexual dimorphism as a character is not used; each sex of the sexually dimorphic species is determined separately. The shape and distribution of patches of white scales on the elytra of many species of *Ptinus* have often been used in keys, but since these scales are easily abraded, minimal use is made of them in this key.

The last complete treatment of the taxonomy and identification of the Ptinidae of North America was published by Fall in 1905 (*4*). The taxonomy of the Ptinidae of economic importance in the world, with keys and illustrations, was presented by Hinton (*7*). Keys and illustrations were published by Papp and Okumura (*10*) for California, by Hatch (*6*) for the Pacific Northwest, by Freude (*5*) for central Europe, and by Hisamatsu (*8*) for Japan. Several good, short taxonomic articles were published by Brown (*1-3*); one of them (*1*) includes a key to the ptinids that occur in houses and warehouses in Canada.

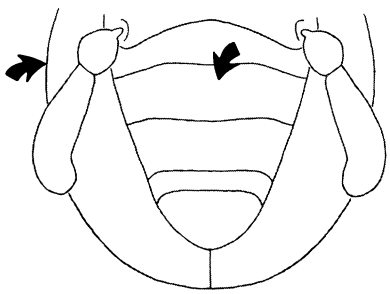
KEY TO ADULTS
Drawings by C. Feller unless otherwise noted.

1 Elytra more than 2 times as wide as abdominal sterna (1A); elytra polished, impunctate, without setae or with only a collar of dense setae at base and a few scattered setae posteriorly, and without striae or longitudinal rows of setae (pl. 82A&B)--- 2

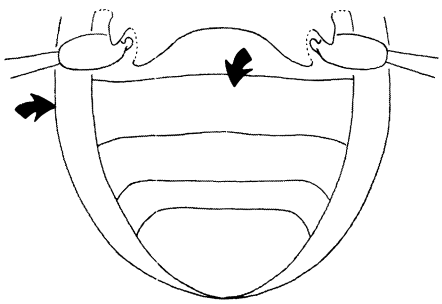
Elytra less than 2 times as wide as abdominal sterna (1B, 1C, 1D); elytra dull or moderately shiny, with appressed scales and/or striae or longitudinal rows of setae (pl. 83A, 85A, 86B)---------- 4



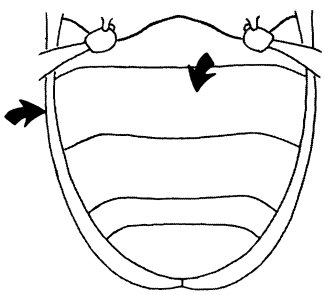
1A *Gibbium psylloides*



1B *Sphaericus gibboides*



1C *Pseudeurostus hilleri*



1D *Ptinus ocellus*

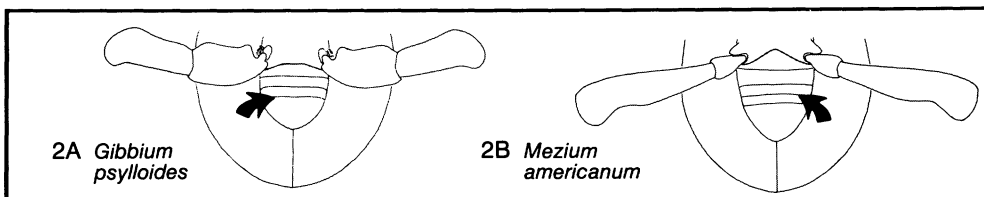
2 Abdomen with 4 visible sterna (2A); trochanter III almost as long as femur III (2A); pronotum and elytra without setae (pl. 82A)---------- *Gibbium*

Papers by Hisamatsu (*8*) and Bellés and Halstead (see reference *BW08* in Chapter 28) show that many specimens previously identified as *Gibbium psylloides* are actually *G. aequinoctiale.* This has made interpretation of past literature records of distributions and associations of these two species almost impossible. It now appears that *G. psylloides* is found mainly in Europe, southwest Asia, and North Africa. The distribution of *G. aequinoctiale* is wider and includes the Australian, Ethiopian, Nearctic, Neotropical, Oriental, and Palearctic regions. Both species have been associated with many kinds of stored foods. The two species may be separated as follows:

Median confluence of antennal fossas forming an acute angle; posterior border of antennal fossas strongly produced laterally and sloping on lateral third ----------hump beetle, *Gibbium psylloides*

Median confluence of antennal fossas forming a right angle; posterior border of antennal fossas weakly produced laterally and transverse on lateral third ----------*Gibbium aequinoctiale*

Abdomen with 5 visible sterna (2B); trochanter III less than one-third as long as femur III (2B); pronotum and base of elytra densely setose (pl. 82B), their integuments not visible ---------- 3



2A *Gibbium psylloides* 2B *Mezium americanum*

3 Elytra with basal tomentose collar deeply interrupted at middle and on each side of midline (3A); pl. 82B----------**American spider beetle,** *Mezium americanum*

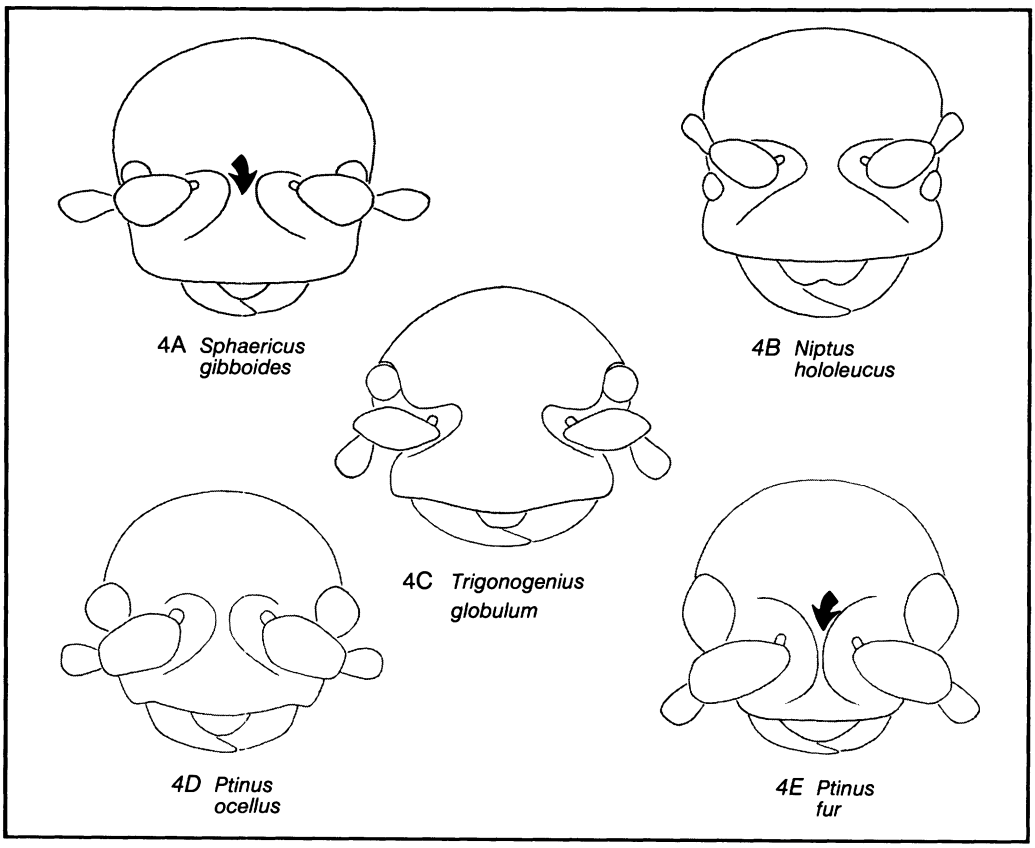
Distribution: cosmopolitan; associated with grains, mixed feeds, cayenne pepper; also reported from melon seeds, tobacco seeds, opium, wool carpet, dried animal products, rat nests. See also 2B.

Elytra with basal tomentose collar entire, not interrupted (3B) ----------northern spider beetle, *Mezium affine*

Distribution: Europe, north Africa, North America; associated with seeds, dead insects, decaying plant and animal matter.

3A *Mezium americanum* 3B *Mezium affine*

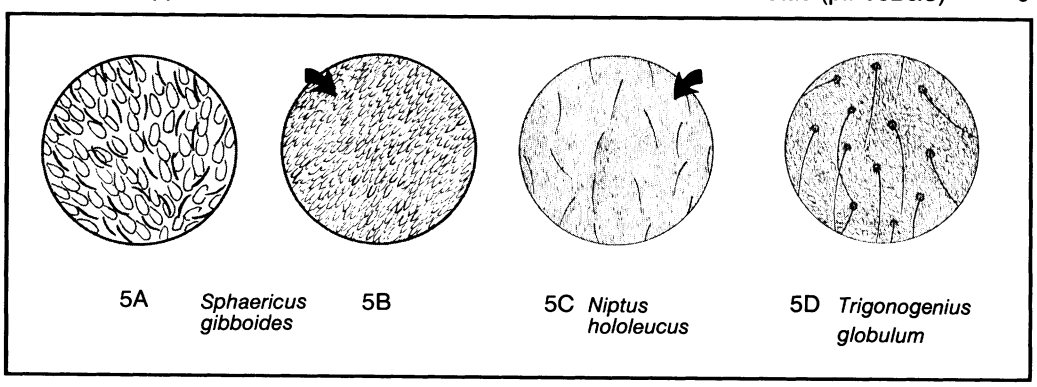
4 Area between antennal insertions broad and flat (4A, 4B, 4C) ---------- 5
Area between antennal insertions narrow and usually carinate (4D, 4E) ---------- 7



5 Scales of pronotum (5A) obviously broader than those of elytron (5B); elytra covered with appressed broad scales, without erect setae (pl. 83A) ---------*Sphaericus gibboides*

Distribution: Europe, north Africa, west coast of North America; associated with cumin seeds, red pepper, herbs, dried plants, dried valerian root. See also 1B, 4A.

Scales and setae of pronotum (5C) and elytron (5D) subequal in size; elytra covered with appressed narrow scales or broad setae and with erect setae (pl. 83B&C) 6

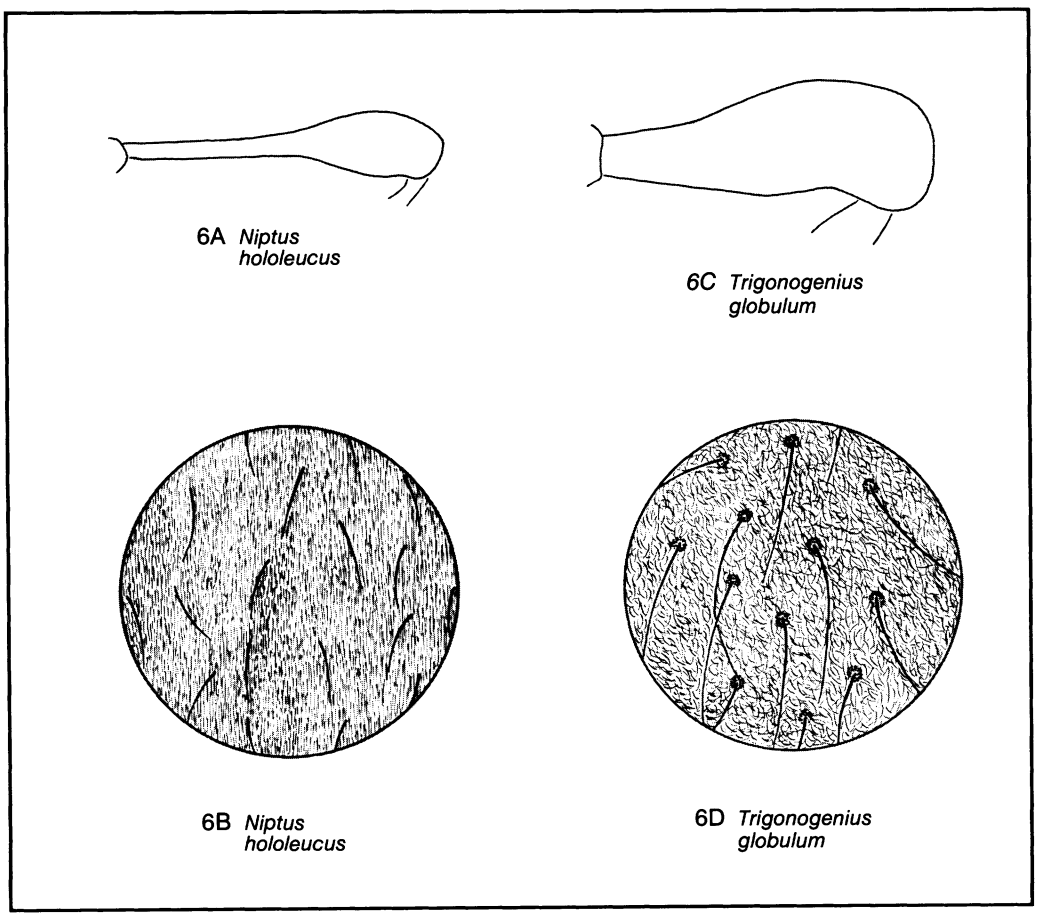


6 Femur III slender, but with apical one-third expanded (6A); pronotum evenly convex (pl. 83B), with uniform, appressed setae (6B); antenna long, extending to middle of visible abdominal sternum II; elytra and pronotum covered with golden appressed setae (pl. 1-O, 83B)----------**golden spider beetle,** *Niptus hololeucus*

Distribution: cosmopolitan, except for the tropics; associated with wheat, flour, bran, oats, barley, milo, grains, seeds, cacao, spices, tea, bread, casein, belladona roots, rhubarb roots; also reported from wool, cotton, linen, silk, artificial silk, paper, books, cork, bath sponges, brushes, feathers, leather, dead insects, rodent excreta. See also 4B.

Femur III stout, with apical one-half expanded (6C); pronotal surface irregular (pl. 83C), with a mat of confused, appressed setae (6D); antenna shorter, extending to coxa III; elytra and pronotum covered with gray and brown appressed setae (pl. 83C) ----------**globular spider beetle,** *Trigonogenius globulum*

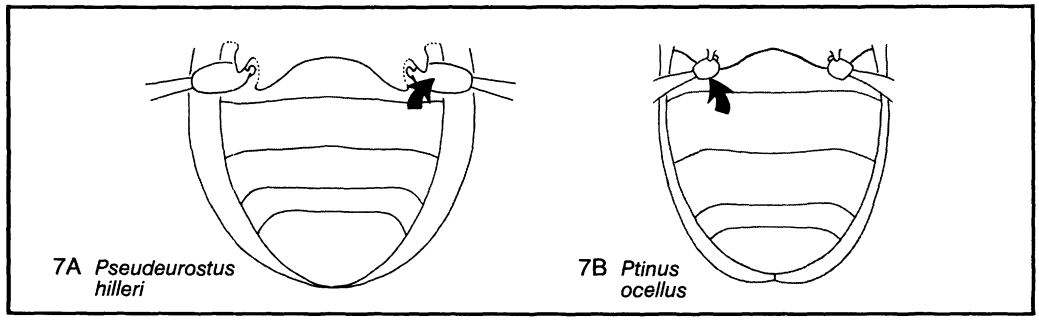
Distribution: Africa, Europe, North America, South America; associated with wheat, flour, corn, oats, beans, barley, raisins, dried pears, dried fruit, caraway seeds, spices, cottonseed meal, copra meal, tartar, argol, sugar, liver meal, botanical drugs; also reported from rice hulls, alfalfa seed, brome seed, cereal dust, cotton, burlap sacks, old clothing, manure piles. See also 4C.



7 Trochanter III long, apex reaching elytral margin (7A); pl. 84----------*Pseudeurostus hilleri*

Distribution: Canada, Europe, Japan; associated with whole wheat flour, oatmeal, animal feeds, brewers yeast, rodent excreta.

Trochanter III short, apex not reaching elytral margin (7B)---------- 8



8 Elytral surface completely obscured by vestiture of dark golden appressed setae; longitudinal rows of setae seen only vaguely because of background of appressed setae (pl. 85B)----------**Australian spider beetle,** *Ptinus ocellus*

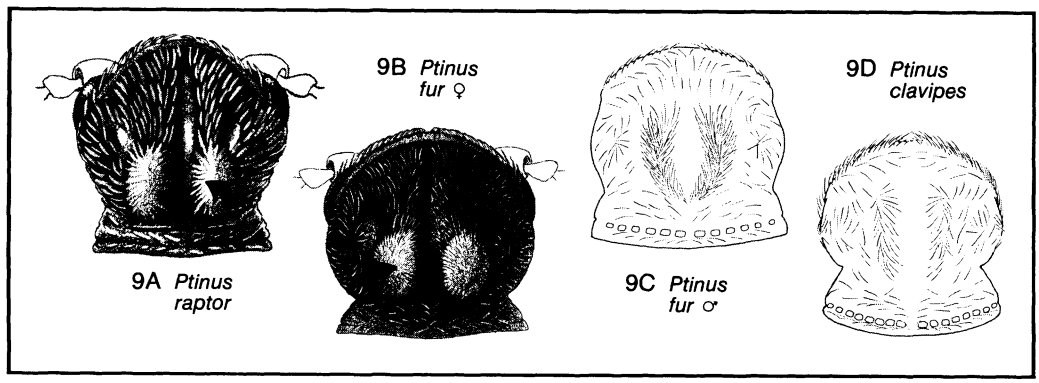
Synonym: *Ptinus tectus*. Distribution: cosmopolitan; associated with wheat, flour, bran, corn, oats, rye, barley, beans, soy grits, hops, nutmegs, cacao, chocolate powder, cayenne pepper, paprika pepper, poultry feed, turkey starter, cereal products, almonds, ginger, raisins, figs, dried apricots and pears, sultanas, calf feed, alfalfa hay, dried soup, fish food, fishmeal, herring meal, crab meat, casein, starch; also reported from flax, beet seeds, nasturtium seeds, sausage rusks, furs, carpets, dead insects, cat feces, dead rats, bird nests. See also 4D, 7B.

Elytral surface mostly visible and longitudinal rows of setae easily seen even though some appressed setae may be present (pl. 86A)---------- 9

9 Surface of pronotum partially obscured by 2 dense clumps of erect golden setae (9A, 9B)---------- 10

Drawing 9A by A.D. Cushman.

Surface of pronotum visible through vestiture of horizontal, inclined, or erect setae, some of which may form clumps (9C, 9D)---------- 11

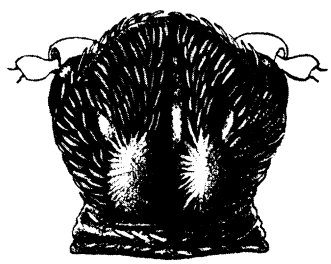


10 Pronotal surface between and laterad of dense setal clumps shiny and without punctures or granules (10A)----------Canadian spider beetle, *Ptinus raptor*

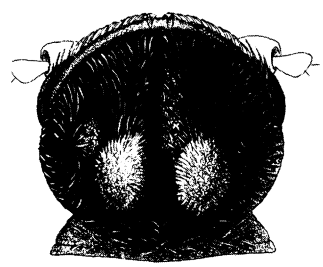
A sexually dimorphic species similar in body form to figures shown in pl. 86. Distribution: eastern USSR, Europe, northeastern North America; associated with flour, grains, pollen in beehives.

Pronotal surface dull, with punctures and/or granules between and laterad of dense setal clumps (10B); pl. 86B ----------female, **whitemarked spider beetle,** *Ptinus fur*

Distribution: cosmopolitan; associated with flour, whole wheat flour, ground barley, pepper, red pepper, paprika pepper, grains, cereal, ginger, cacao, dates, licorice roots, senna leaves and roots, fresh fruit, brewers yeast, rye bread, cantharides; also reported from henbane seeds, cotton seeds, tobacco seeds, tobacco, straw, pollen in beehives, herbarium specimens, bee pupae, animal skins, leather, furs, stuffed animals, feathers, wasp nests, bird nests, paper, books. See also 4E, 9C.



10A *Ptinus raptor*

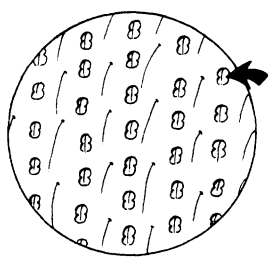


10B *Ptinus fur*

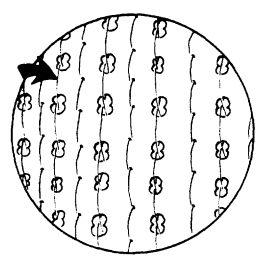
11 Seta of strial puncture of elytron very short, contained within puncture or extending only slightly beyond posterior border of puncture (11A) ----------*Ptinus gandolphei*

A sexually dimorphic species similar in body form to figures shown in pl. 86. Distribution: California; associated with raisins, mixed feeds, cotton seeds.

Seta of strial puncture longer, extending well beyond posterior border of puncture and reaching at least next puncture (11B) ---------- 12



11A *Ptinus gandolphei*

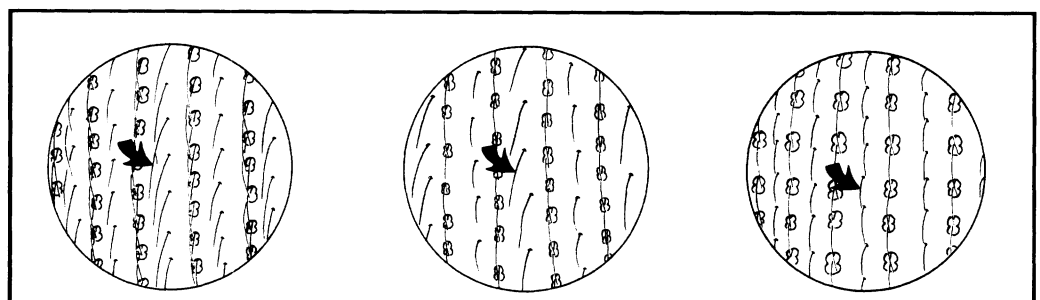


11B *Ptinus fur*

12 Longest erect setae on anterior two-thirds of elytral intervals as long as or longer than last segment of tarsus III (12A) ----------**hairy spider beetle,** *Ptinus villiger*

A sexually dimorphic species similar in body form to figures shown in pl. 86. Distribution: Asia, Europe, North America; associated with wheat, flour, farina, cornmeal, rye, mixed feeds, chamomile seeds.

Longest setae on anterior two-thirds of elytral intervals shorter than last segment of tarsus III (12B, 12C) ---------- 13



12A *Ptinus villiger* 12B *Ptinus clavipes* 12C *Ptinus fur*

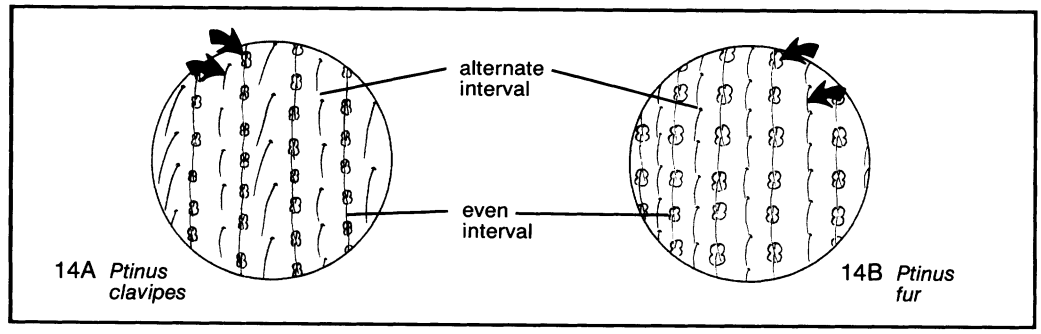
13 Body stout, elytra oval (pl. 86B) ---------- 14
Body slender, elytra parallel-sided (pl. 86A) ---------- 15

14 Erect setae of alternate intervals of elytron one-third to one-half as long as (and usually more erect than) setae of even intervals (14A) ----------female, **brown spider beetle,** *Ptinus clavipes*

A sexually dimorphic species similar in body form to specimens figured in pl. 86. Synonym: *Ptinus hirtellus*. Distribution: cosmopolitan; associated with wheat flour, oats, milo, barley, corn, cornmeal, beans, rice, soybean meal, cottonseed meal, mixed feeds, cacao, sugar, dried fruit, dried mushrooms, musk root, powdered leaves of senna and jaborandi, cantharides; also reported from seeds of cotton, sunflower, spinach, vetch, alfalfa, and dallisgrass, feathers, skins, books, dead animals, rodent excreta. See also 9D.

Erect setae of alternate and even intervals subequal in length and usually equally slanted (14B); pl. 86B----------female, **whitemarked spider beetle,** *Ptinus fur*

See couplet 10.



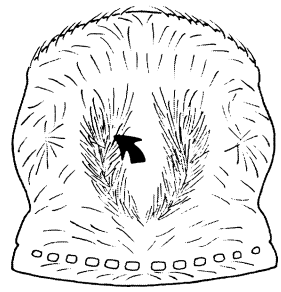
14A *Ptinus clavipes* 14B *Ptinus fur*

15 Pronotum with a slender, dense row of posteriorly-inclined yellowish setae, the 2 rows often joined forming a "U" or "V" (15A); pl. 86A
---------- male, **whitemarked spider beetle,** *Ptinus fur*

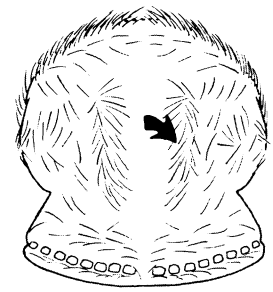
See couplet 10.

Pronotum with erect or anteriorly-directed, golden setae on either side of midline (these setae are not densely spaced and at most form only the vaguest suggestion of rows) (15B)----------male, **brown spider beetle,** *Ptinus clavipes*

See couplet 14.



15A *Ptinus fur*



15B *Ptinus clavipes*

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Notes and Sketches

7 CHECKERED BEETLES (CLERIDAE, COLEOPTERA)

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These three species, all cosmopolitan in distribution, are associated with spoiled meat, fish, cheese, and occasionally with cured ham and bacon. Both adults and larvae feed on larvae of other insects and on molds. *Necrobia violacea* is rarely seen in stored foods.

KEY TO ADULTS

1 Color of thorax, legs, and elytral shoulders reddish yellow; color of head and apical three-fourths of elytra metallic blue or green; pl. 1H ---------- **redshouldered ham beetle,** *Necrobia ruficollis*

Color of head, thorax, and abdomen metallic blue or green; color of legs reddish or dark ---------- 2

2 Legs reddish; pl. 1I, 87B ---------- **redlegged ham beetle,** *Necrobia rufipes*

Legs dark; pl. 1G ---------- blacklegged ham beetle, *Necrobia violacea*

8 SAP BEETLES (NITIDULIDAE, COLEOPTERA)

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The adults of those nitidulids that infest stored foods (*2-4*) have five tarsal segments on each leg. Segment IV is unmodified but comparatively small (see couplet illustration 6E); segments I to III have hairy pads on the underside (6E) and are usually dilated. The front coxae are always transverse; the associated trochantins are exposed (10B).

Some genera have truncate elytra that expose one or more segments of the abdomen (2B-D). This is a handy taxonomic feature, but it must be used with caution. Specimens with distended abdomens (from engorgement with food or from having been killed in fluids) generally present more than the normal number of exposed segments behind the elytra (9D). On the dorsum of each normally exposed segment is a large sclerite or tergite. The tergite of the apical segment is termed the pygidium (2B, 2C). The articulating surfaces and the membrane connecting a tergite to an adjoining segment are concealed under normal conditions. These structures become exposed when the abdomen is distended.

A normally concealed segment may have a dorsal sclerite but it consists of only a relatively narrow band at the posterior margin. *Haptoncus luteolus* (6A) is exceptional in that the last two terga are largely sclerotized whether concealed or not. Normally, only the pygidium of *H. luteolus* is exposed, but distended specimens are frequently encountered. The presence of a dorsal membranous area behind the elytra indicates abdominal distention (9D). With this information in mind, the taxonomist must judge how many segments, if any, would be exposed normally.

Male nitidulids have a small, discoidal supplementary segment on the ventral surface of the abdominal apex (11B). In some genera the supplementary segment is also visible on the dorsal side of the abdomen (6A); it does not occur in females (6B).

Hinton (*4*) discussed four species that do not occur in North America and are not included in this key: *Carpophilus flavipes, C. immaculatus, C. sexpustulatus,* and *Haptoncus flavidus*. Hinton also mentioned four other species that occur in North America but not in association with stored foods: *C. pallipennis* (Say), a symbiont of cactus flowers reported from stored foods as a result of misidentification; *Omosita colon* (L.), a carrion feeder not known to invade buildings; *Nitidula rufipes* (L.) and *N. carnaria* (L.). All members of the genus *Nitidula* feed on carrion. There are six species in our North American fauna but only the two recorded from stored foods (dried meats) are included in this key.

The immature stages of six species have not been described: *Carpophilus fumatus, C. maculatus, C. pilosellus, Glischrochilus fasciatus, Nitidula bipunctata,* and *N. ziczac*.

All the other nitidulids associated with stored foods have orthosomatic (or nearly so), prognathous larvae bearing urogomphi (pl. 90A). The urogomphi (22E) are continuous with a sclerite, the anal plate (23B), covering much of the dorsal surface of abdominal segment IX. A pair of pregomphi (23A) protrudes from the anal plate just in front of the urogomphi. Sap beetle larvae, especially those belonging to the genus *Carpophilus*, may often be difficult to identify to species.

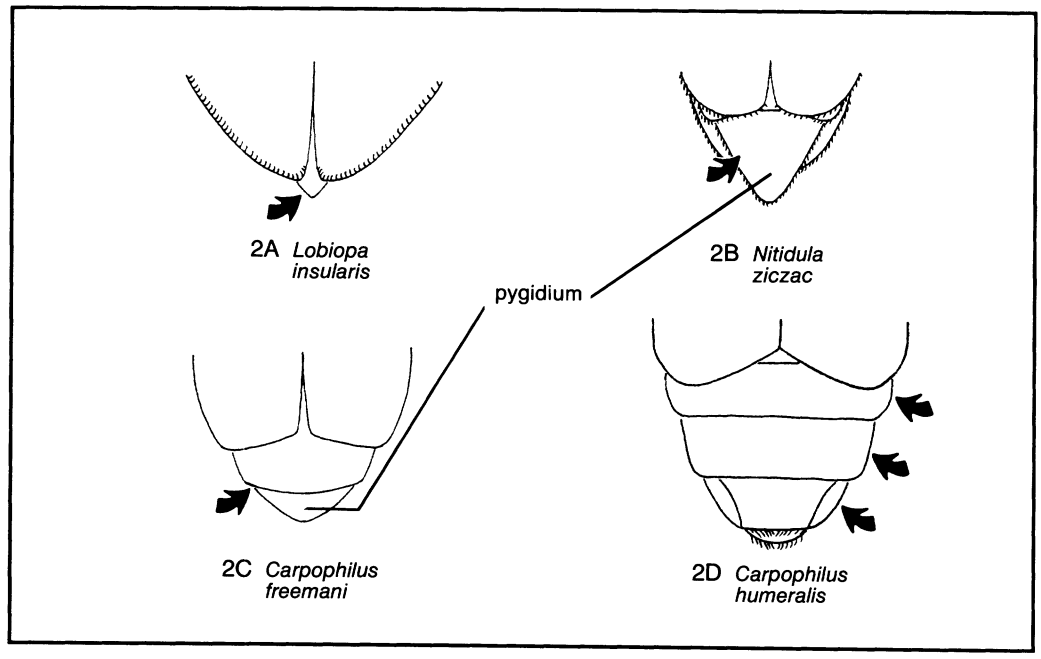
KEY
Drawings by W.A. Connell and C. Feller.

1 Adult specimen---------- 2
Larval specimen---------- 20

Adults

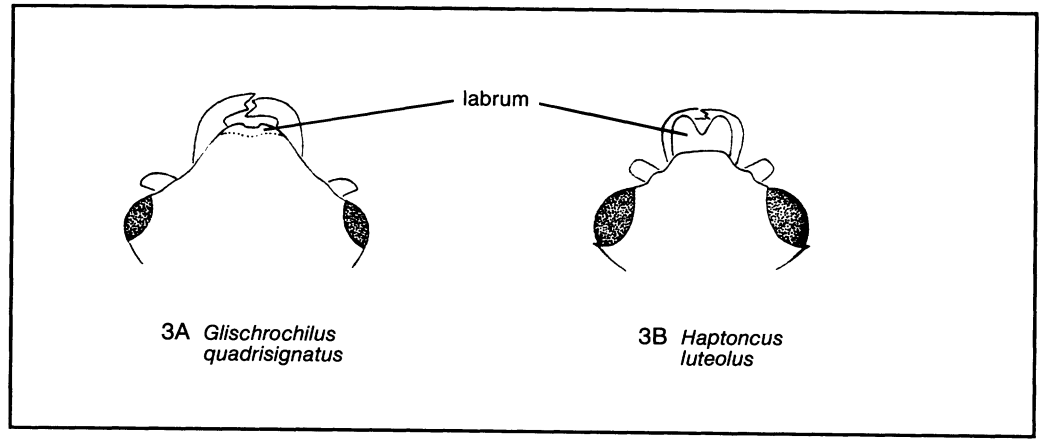
2 Abdomen normally entirely concealed by elytra (2A), or pygidium alone exposed (2B)---------- 3
Abdomen normally with apical 2 or 3 segments exposed dorsally behind elytra (2C, 2D)---------- 8

See also 9D which illustrates abnormal exposure of a third segment.



2A *Lobiopa insularis*
2B *Nitidula ziczac*
2C *Carpophilus freemani*
2D *Carpophilus humeralis*

3 Labrum fused to clypeus, the articulation marked by a fine, curved groove (3A)--- 4
Labrum free, usually with a median notch on anterior margin (3B)---------- 5



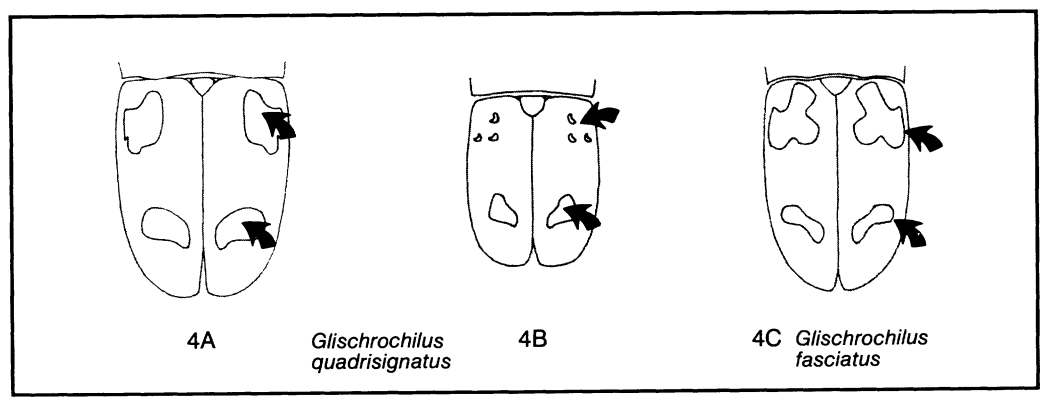
3A *Glischrochilus quadrisignatus*
3B *Haptoncus luteolus*

4 Elytron either with 2 conspicuous orange-yellow spots (4A) or with 1 conspicuous spot (posterior) and a group of a few small spots (humeral region) (4B); pl. 88A ----------*Glischrochilus quadrisignatus*

Body elongate, convex; color light brown to nearly black; integument weakly shiny; vestiture sparse and inconspicuous. Distribution: temperate North America. See also 3A.

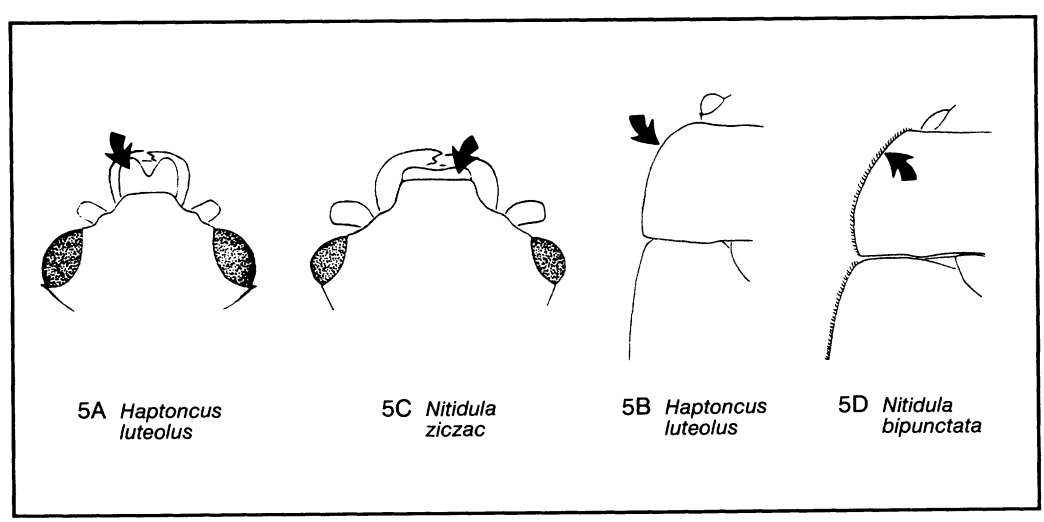
Elytron with 2 conspicuous spots, the humeral one with 3 blunt points (never appearing as a group of small spots) (4C); pl. 88B----------*Glischrochilus fasciatus*

Similar to *G. quadrisignatus* in size, appearance, and geographic distribution (except that there are no California records for *G. fasciatus*).



5 Labrum strongly notched and definitely bilobed (5A); marginal fringe on sides of pronotum narrow and inconspicuous or absent (5B)---------- 6

Labrum shallowly emarginate (5C); sides of pronotum and elytra fringed with hairs as long as or longer than the diameter of an eye facet (5D)---------- 7

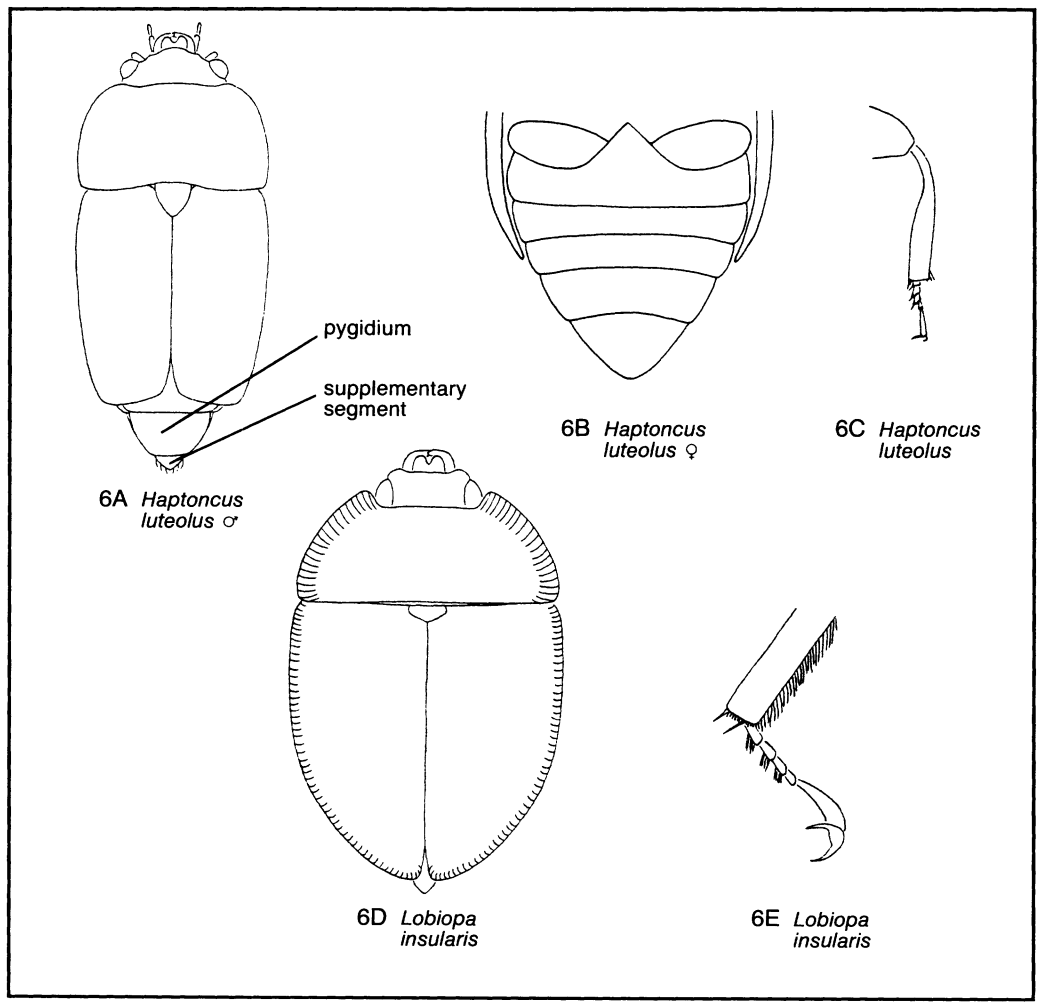


6 Body oblong in shape (6A); color a dull yellow to brown; length 1.7 to 2.8 mm; pl. 88C ----------yellowbrown sap beetle, *Haptoncus luteolus*

Elytra truncate and free from abdomen at apex; both pygidium and penultimate tergum sclerotized and either both or only pygidium visible from above; male supplementary segment visible from above (6A) (absent in female, 6B); apical two-thirds of male tibia III abruptly dilated (6C); one of several species of *Haptoncus* with small temples behind eyes. Distribution: tropical and subtropical; in North America, north to South Carolina and California (El Dorado County).

Body oval in shape (6D); color dark brown; dorsum with dull yellow margins and many ill-defined light yellow areas; length 4.5 to 8 mm; pl. 88D----------*Lobiopa insularis*

Pronotal and elytral margins explanate (6D); elytron with 7 rows of short, stout, backward-curving setae; apical two-thirds of tibia not dilated (6E). Distribution: tropics and subtropics of Western Hemisphere; in North America, north to South Carolina and California (El Dorado County).

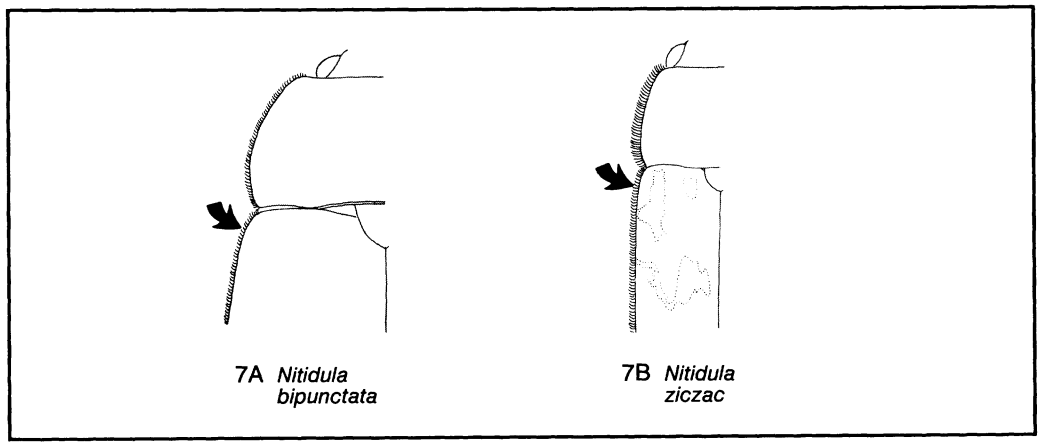


7 Elytral fringe narrow (7A); body color a dull brown to nearly black; each elytron with an obscure orange-red spot; pl. 89A----------*Nitidula bipunctata*

Distribution: widely occurring in Northern Hemisphere; in North America, from Virginia, Texas, and California to Quebec and Alaska.

Elytral fringe wide (equal to width of reflexed elytral flange) (7B); body color a dull light to dark brown; elytra with obscure, transverse, yellow zigzag bands; pl. 89B ----------*Nitidula ziczac*

Distribution: Western Hemisphere (Central America to southern Canada). See also 2B, 5C.



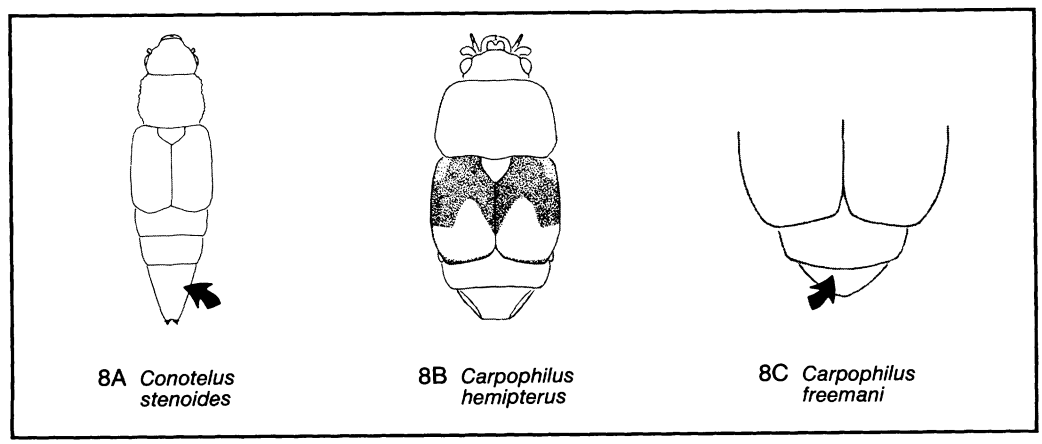
7A *Nitidula bipunctata*

7B *Nitidula ziczac*

8 Body form narrow, elongate; pygidium longer than wide (8A); pl. 89C ----------*Conotelus stenoides*

Pronotum nearly square, with narrow, crenulate margin, sinuate in front of acute posterior angles; 3 elongate segments exposed behind truncate elytra; body color a uniform red-brown to nearly black. Distribution: tropics and subtropics of Western Hemisphere; in North America, north to North Carolina and Oklahoma.

Body form broader, less elongate (8B); pygidium transverse (8C). Genus *Carpophilus*---------- 9



8A *Conotelus stenoides*

8B *Carpophilus hemipterus*

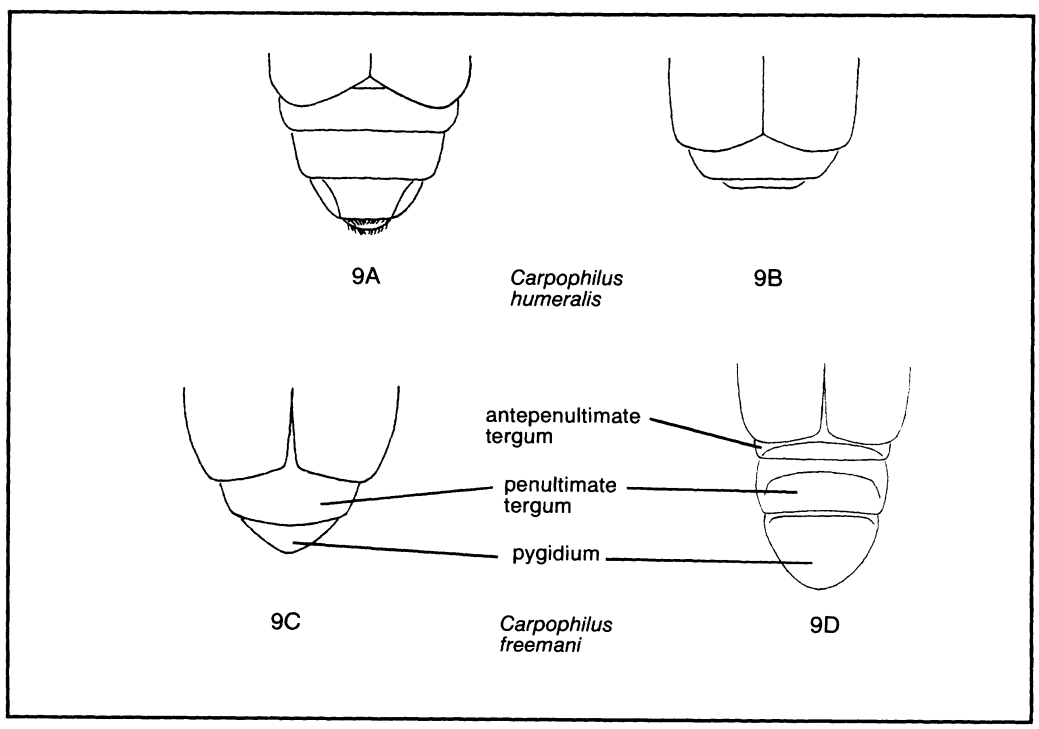
8C *Carpophilus freemani*

9 Normally 3 abdominal terga exposed (9A); dorsum feebly shining, smooth between punctures; body color black, tinged with red, with an obscure orange patch on each shoulder; pl. 89D----------pineapple sap beetle, *Carpophilus humeralis*

Teneral specimens brown in color; in starved individuals, the last abdominal segment may telescope into the penultimate segment (9B). Distribution: tropics and subtropics; in North America, north to North Carolina and California (Tehama County); first reported from Western Hemisphere (California) by H.C. Fall in 1910.

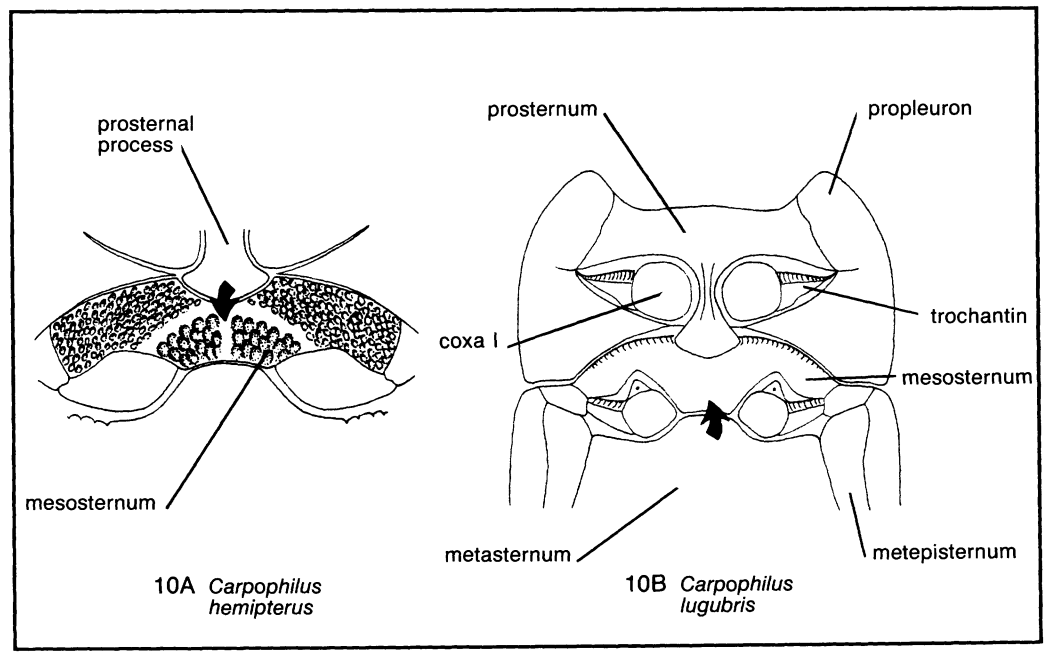
Normally 2 abdominal terga exposed (9C); dorsum dull and finely reticulate between punctures, or, rarely, smooth and shining (if so, then dorsal body color is uniformly dark red-brown)---------- 10

Note that the abdomen may be abnormally distended, exposing more than the usual number of terga (9D), or contracted, exposing fewer than the normal number (9B). In all beetles, the 3 most posterior terga, named in sequence starting from the hindmost, are the pygidium, the penultimate tergum, and the antepenultimate tergum. In *Carpophilus* the pygidium and penultimate tergum are completely sclerotized and normally exposed behind the elytra (9C). *C. humeralis* is exceptional among the pest species of this genus in that the antepenultimate tergum is also completely sclerotized and normally exposed. Moreover, its pygidium may sometimes telescope beneath the penultimate tergum (9B). In all other pest carpophilids the antepenultimate tergum is largely membranous, but it may be exposed by abnormal distention (9D). In such a case, the difference in texture, in comparison with the penultimate, should be obvious.



10 Mesosternal disc bisected by an impunctate medial longitudinal ridge or band (10A) ---------- 11
Mesosternal disc undivided down the middle (10B) ---------- 12

Mesosternal disc flat or slightly protuberant, finely or coarsely punctate.



10A *Carpophilus hemipterus*

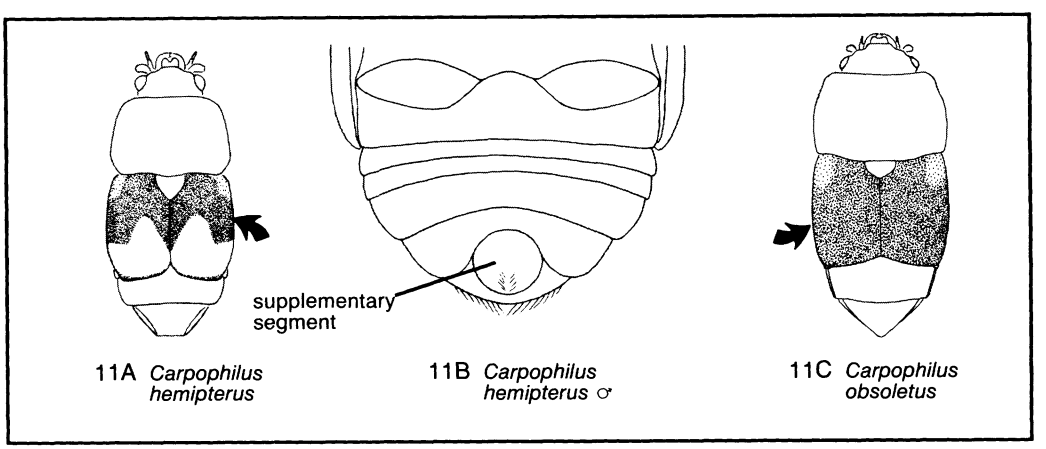
10B *Carpophilus lugubris*

11 Elytra with distinct pattern (11A) of light and dark areas; pl. 90B ----------**driedfruit beetle,** *Carpophilus hemipterus*

Dorsal background color brown to brownish black; cuticle dull (not shining) and moderately clothed with inconspicuous dark and light hairs; 11B shows the supplementary segment typical of all male nitidulids. Distribution: cosmopolitan, except for arctic and colder temperate regions; in North America, north to Massachusetts and British Columbia. See also 10A.

Elytra without distinct pattern, but humeral regions or entire elytra may be lighter in color than rest of dorsum (11C); pl. 90C----------*Carpophilus obsoletus*

Dorsal body color rusty brown to black, often black or dark brown, with rusty brown elytra; cuticle sometimes shining; moderate vestiture of inconspicuous pale yellow hairs. Distribution: tropics and subtropics; in North America, Mexico to California (Fresno County) (not established farther east).

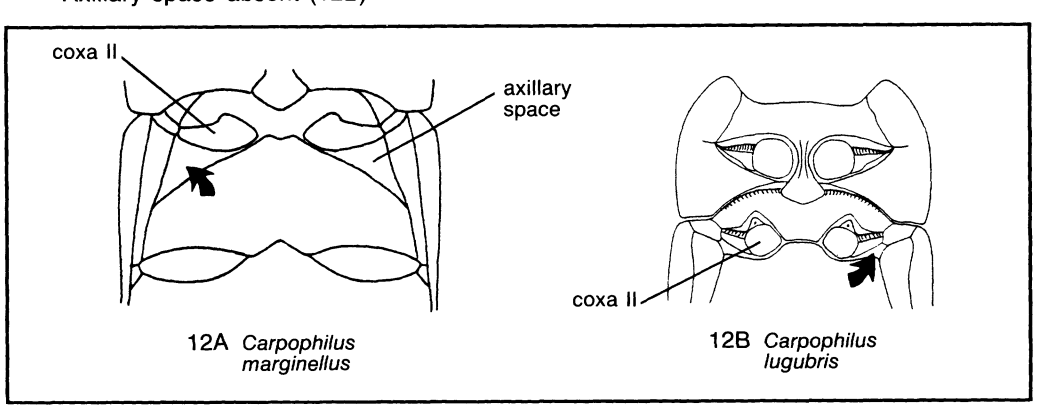


11A *Carpophilus hemipterus* 11B *Carpophilus hemipterus* ♂ 11C *Carpophilus obsoletus*

12 Axillary space present (12A)---------- 13

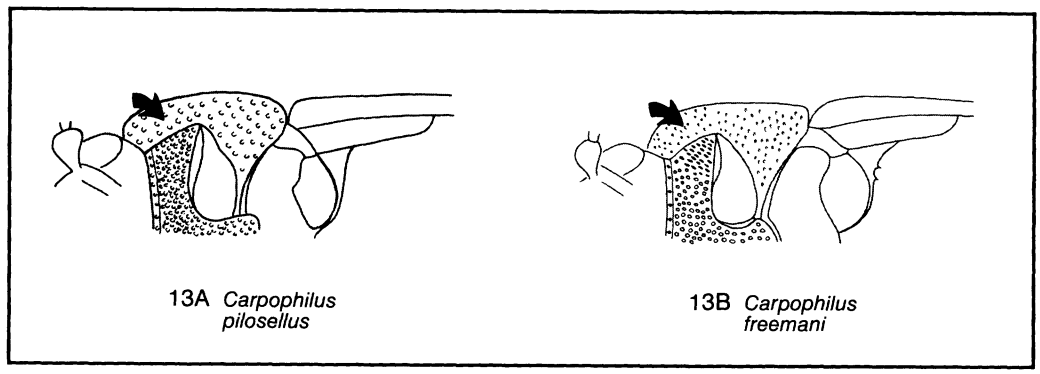
The axillary space, a pseudosclerite located at the anterior angles of the metasternum, is the posterolateral expansion of the posterior lip of each mesocoxal cavity.

Axillary space absent (12B)---------- 19



12A *Carpophilus marginellus* 12B *Carpophilus lugubris*

13 Propleuron punctate (punctures may be shallow, with indistinct margins) (13A)---- 14
Propleuron impunctate and either smooth or granulose (13B)---------- 15



13A *Carpophilus pilosellus*

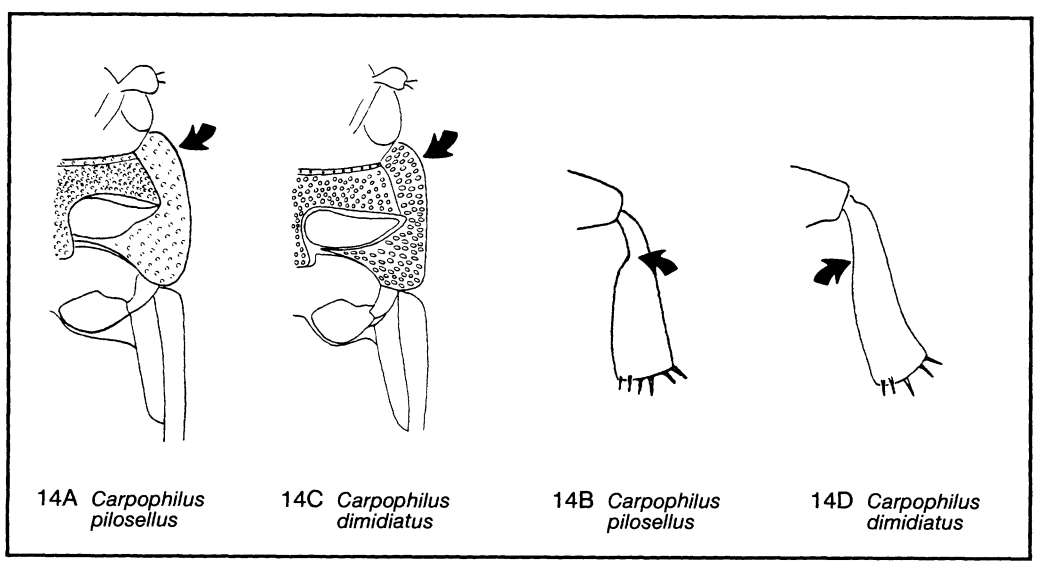
13B *Carpophilus freemani*

14 Propleural punctures shallow, with obscure margins (14A); tibia III of male abruptly enlarged distally (14B); pl. 91----------*Carpophilus pilosellus*

Antennal segment III only slightly longer than II; dorsal body color red-brown to dark brown, with the elytra a shade lighter than pronotum but rarely with a lighter median area on each elytron; cuticle dull and moderately clothed with conspicuous pale yellow hairs. Distribution: tropics and subtropics; in North America, north to South Carolina and California (Yolo County).

Propleural punctures deep, with distinct margins (14C); tibia III of male gradually enlarged distally (14D); pl. 91----------**corn sap beetle,** *Carpophilus dimidiatus*

Antennal segment III 25% (or more) longer than II; dorsal body color dark red-brown to nearly black; each elytron usually bears a large central dull orange-yellow spot with indefinite margins; cuticle dull, moderately clothed with conspicuous pale yellow hairs. Distribution: tropics and subtropics; in North America, north to North Carolina and California (Placer County).



14A *Carpophilus pilosellus*

14C *Carpophilus dimidiatus*

14B *Carpophilus pilosellus*

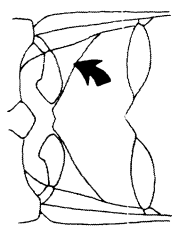
14D *Carpophilus dimidiatus*

15 Axillary space large (15A); pl. 92A----------*Carpophilus marginellus*

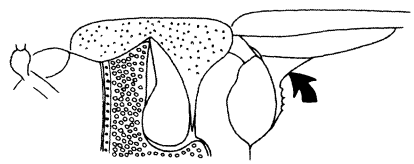
The posterior margin of the axillary space extends posterolaterally from a point near the inner side of the coxa to a point beyond the middle of the metepisternum; dorsal body color light brown to dark mahogany; cuticle shiny and scantily clothed with inconspicuous light hairs. Distribution: subtropical and temperate parts of the Northern Hemisphere; in North America, north to New York and Washington.

Axillary space small (15B)---------- 16

Even when the axillary space appears relatively large, the extremes of its posterior margin extend on the anterior end no farther than the midpoint on the posterior lip of the mesocoxal cavity, and on the posterior end, no farther than the midpoint on the metepisternal suture.



15A *Carpophilus marginellus*

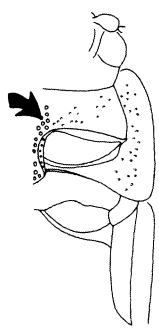


15B *Carpophilus mutilatus*

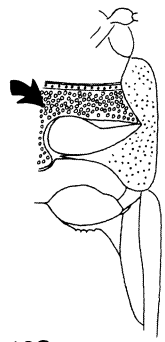
16 Prosternum punctate only on and immediately in front of the prosternal process (16A); each elytron with 2 light areas (an elongate patch along the suture and a basal patch) usually joined together (16B); pl. 91----------*Carpophilus maculatus*

Dorsal body color light brown to very dark brown; cuticle dull, moderately clothed with inconspicuous gold and brown hairs. Distribution: many tropical parts of the world; originally described from Hawaii; not recorded from continental USA.

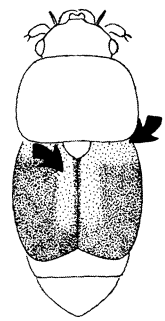
Prosternum entirely or almost entirely punctate (16C); elytral light areas never occurring as an elongate patch near the suture (16D)---------- 17



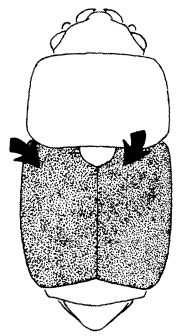
16A *Carpophilus maculatus*



16C *Carpophilus mutilatus*



16B *Carpophilus maculatus*

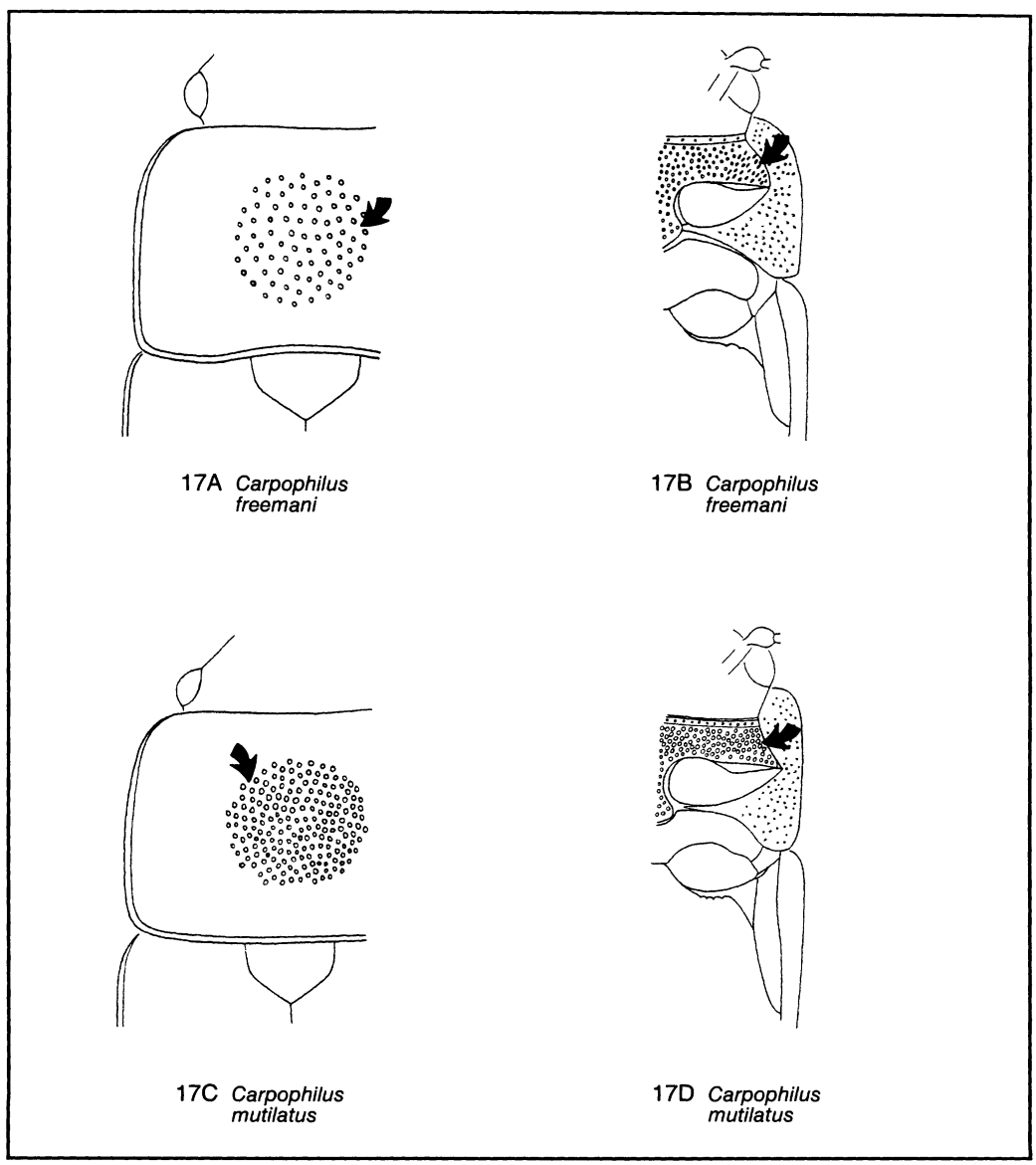


16D *Carpophilus freemani*

17 Pronotal punctures separated from each other by a distance equal to or greater than twice their diameters (17A); lateral extremities of prosternum weakly punctate or granulose (17B); pl. 91----------*Carphophilus freemani*

Dorsal body color red-brown to dark brown; elytra colored a dull yellow except for dark areas next to scutellum, along lateral margin, and at apex; cuticle dull, moderately clothed with inconspicuous yellow and brown hairs. Distribution: cosmopolitan except for arctic and colder temperate regions; in North America, north to New York, North Dakota, and California. See also 9C, 9D.

Pronotal punctures separated by a distance equal to or less than their diameters (17C); lateral extremities of prosternum strongly and densely punctate (17D)---------- 18



17A *Carpophilus freemani*

17B *Carpophilus freemani*

17C *Carpophilus mutilatus*

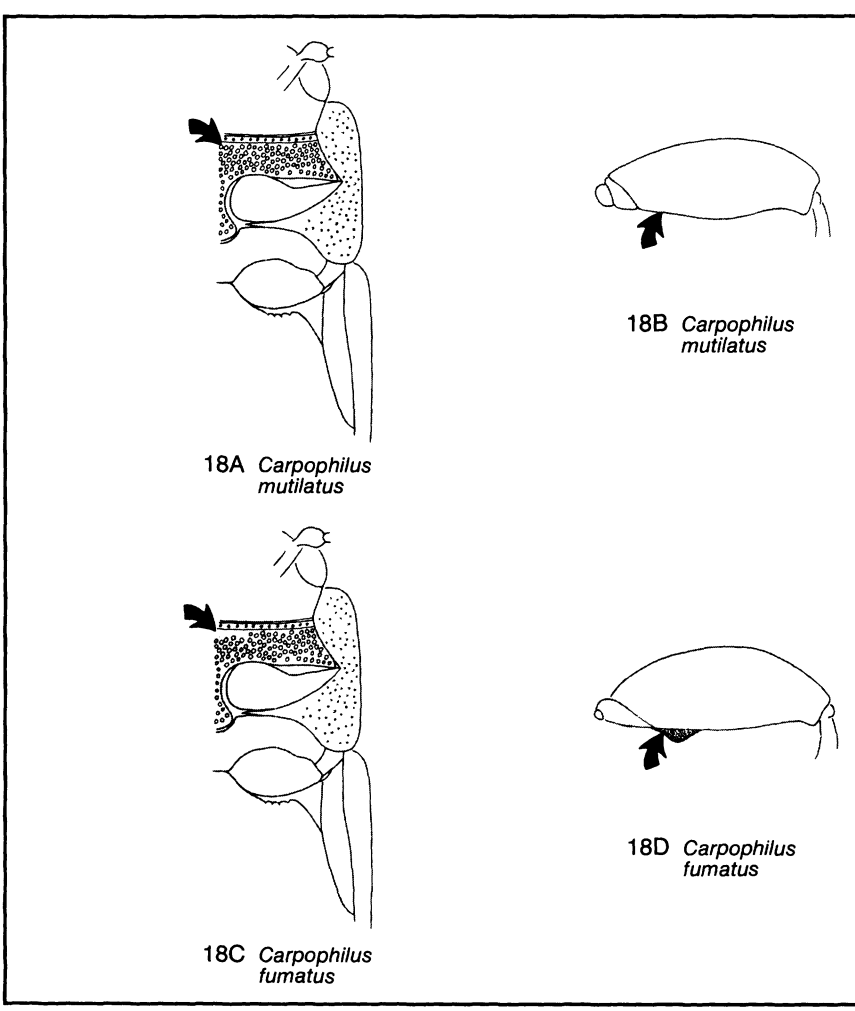
17D *Carpophilus mutilatus*

18 Prosternum entirely punctate (18A); femur III without swelling (18B); pl. 91 ----------*Carpophilus mutilatus*

On the pronotum, a narrow impunctate area extends forward on the midline from the posterior margin; dorsal body color of head, elytra, and abdomen red-brown, of pronotum, yellow to orange-yellow; elytral margin and apex and a large median area of the pronotum often as dark as head; elytral disc sometimes with a cloudy discoloration; cuticle dull, moderately clothed with inconspicuous yellow and brown hairs. Distribution: tropical, subtropical, and milder temperate regions; in North America, north to Virginia and California (Tehama County). See also 17C.

Prosternum punctate except for a small area on the midline just behind the anterior margin (18C); femur III with a small, abrupt swelling on the inner margin near the trochanter (swelling usually larger in males; may be inconspicuous or absent) (18D); pl. 91----------*Carpophilus fumatus*

Color, vestiture, and pronotal punctation similar to *C. mutilatus*. Distribution: tropics and subtropics; known only from Florida in USA.



18A *Carpophilus mutilatus*

18B *Carpophilus mutilatus*

18C *Carpophilus fumatus*

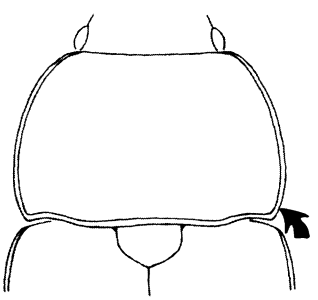
18D *Carpophilus fumatus*

19 Pronotum distinctly narrower anteriorly, with posterior angles obtuse (19A); pronotum moderately convex in lateral view (19B); pl. 92B
---------- **dusky sap beetle,** *Carpophilus lugubris*

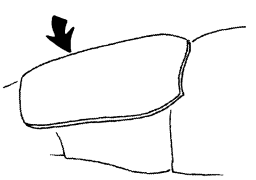
Body color rusty-brown to black (tinged with red); elytron usually with a pale area at shoulder that sometimes extends over base and part of disc; pronotal margins sometimes pale; cuticle dull, moderately clothed with inconspicuous light and dark hairs. Distribution: temperate regions of Western Hemisphere; in North America, from Georgia and Mexico to New Hampshire and Washington. See also 10B.

Pronotum about as wide anteriorly as posteriorly, with a small sinuation before the subacute posterior angles (19C); pronotum slightly depressed (19D); pl. 92C
---------- *Carpophilus ligneus*

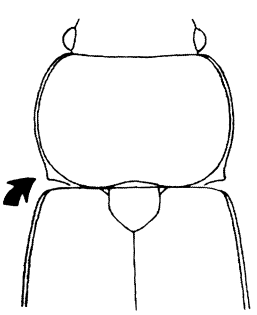
Body color rusty-brown to dark brown (tinged with red); a large, obscurely outlined portion of elytral disc often paler than other dorsal areas; cuticle slightly shining, scantily clothed with inconspicuous light and dark hairs. Distribution: Europe, Central America, North America; in USA, west of Mississippi River and north to Alaska.



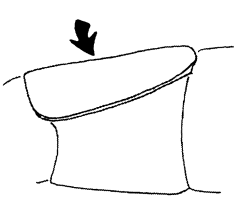
19A *Carpophilus lugubris*



19B *Carpophilus lugubris*



19C *Carpophilus ligneus*

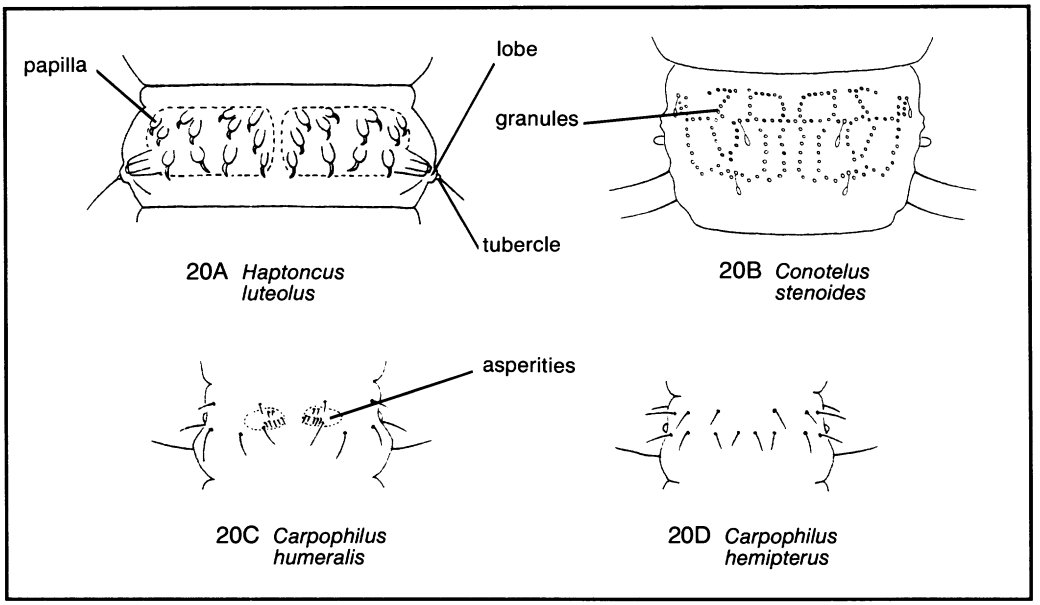


19D *Carpophilus ligneus*

Larvae

20 Abdominal dorsum with sclerites bearing papillae (20A), granules (20B), or asperities (20C) ---------- 21
Abdominal dorsum without ornamentation other than setae (20D) ---------- 24

Although *C. marginellus* does in fact have dorsal asperities, they are so difficult to see that they are considered to be absent for the purposes of this key.
20B redrawn from *1*.

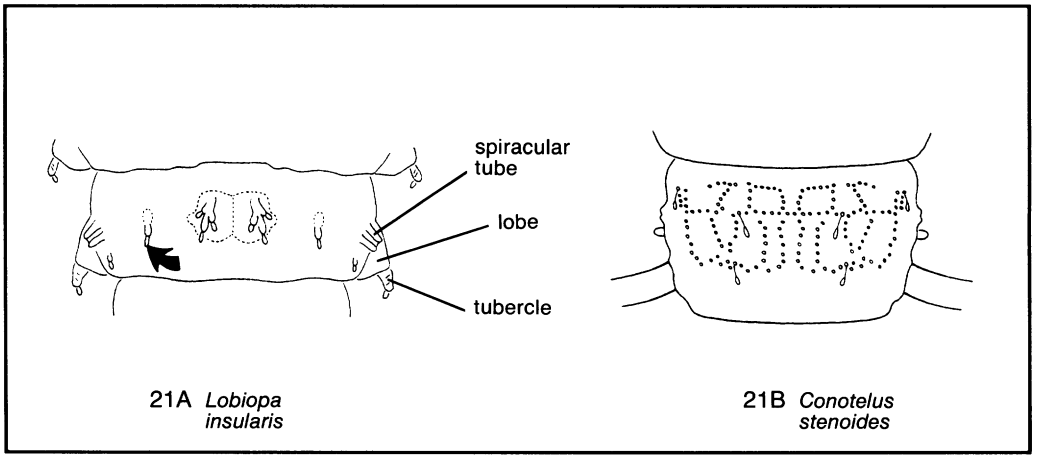


21 Abdomen with lateral tubercles; dorsal papillae prominent, each with an apical spatulate seta (21A) ---------- 22

Two or three ocelli present on each side of head.

Abdomen without lateral tubercles or dorsal papillae (21B) ---------- 23

Two inconspicuous ocelli present on each side of head.
21A&B redrawn from *1*.

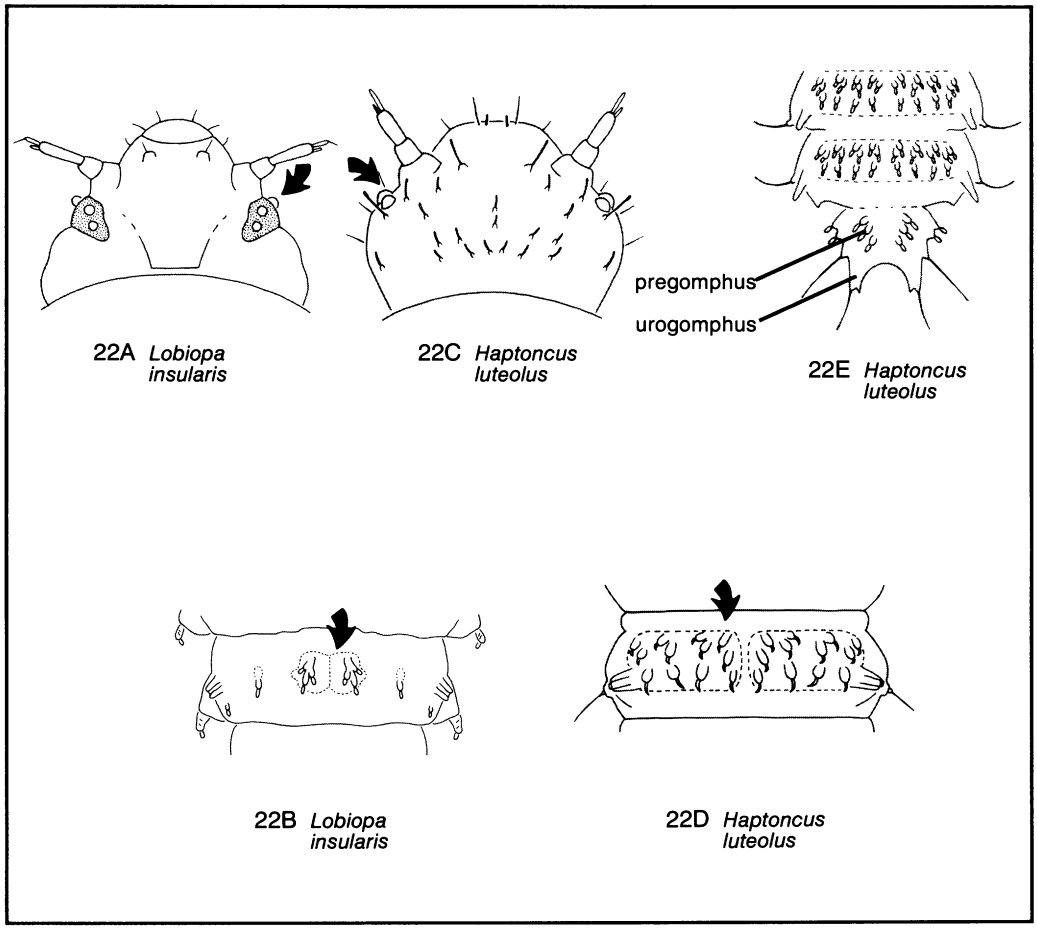


22 Head with 3 large, equal-sized ocelli on each side (22A); each abdominal tergum with a pair of contiguous sclerites (each nearly square in outline) meeting on the midline, with each sclerite bearing 3 papillae, all sharing a common base (22B) ----------*Lobiopa insularis*

Body length ca 8 mm. Each abdominal tergum also has a small papilla-bearing sclerite on each side (22B). Caution: The characters noted in this couplet may be generic and may not distinguish this species from other *Lobiopa*. However, *L. insularis* is the only known food pest species in this genus.
22A&B redrawn from *1*.

Head with 2 small ocelli on each side (22C); each abdominal tergum with 8 short, longitudinal rows of papillae (22D)----------yellowbrown sap beetle, *Haptoncus luteolus*

Body length ca 5.5 mm. Each pregomphus appears to be in the form of 3 papillae arising from a common base (22E). Caution: The characters in this couplet do not distinguish *H. luteolus* from some other members of this genus including *H. californicus* Gillogly (found in California).



22A *Lobiopa insularis*

22C *Haptoncus luteolus*

22E *Haptoncus luteolus*

22B *Lobiopa insularis*

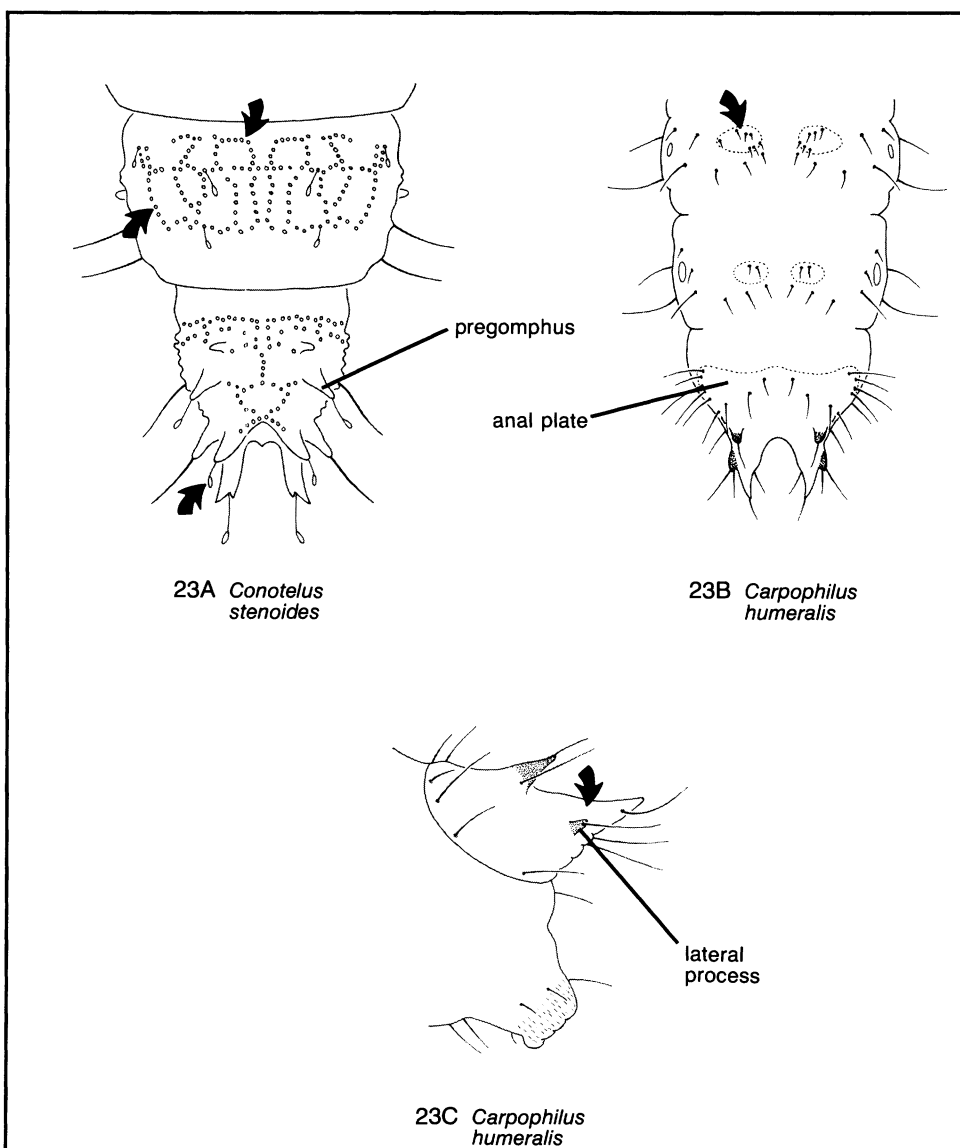
22D *Haptoncus luteolus*

23 Each abdominal tergum with granules arranged in circular and rectangular patterns; urogomphus 2-branched, each branch with a bristle arising at or near the apex (23A)----------*Conotelus stenoides*

Body length ca 5 mm.
23A redrawn from *1*.

Each abdominal tergum with paired sclerites bearing 2 to 12 asperities (23B); urogomphus simple (23C)----------pineapple sap beetle, *Carpophilus humeralis*

Body length ca 7 mm. See also 20C.



23A *Conotelus stenoides*

23B *Carpophilus humeralis*

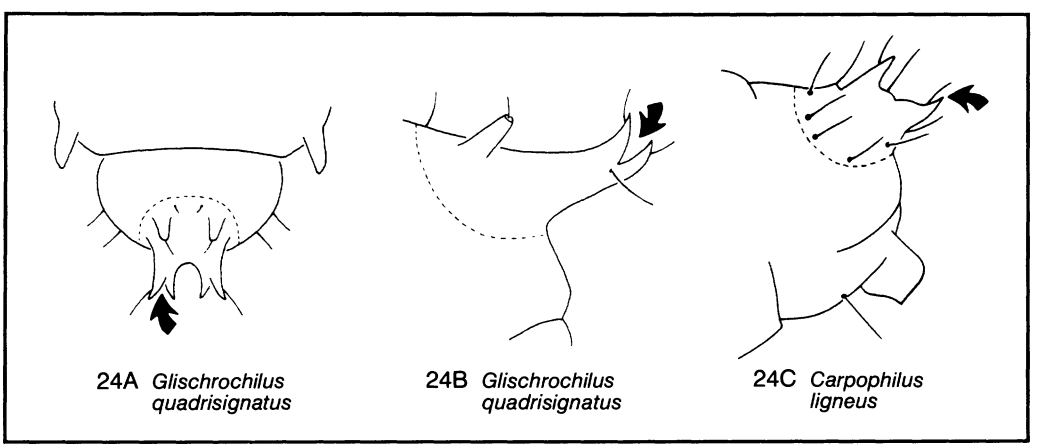
23C *Carpophilus humeralis*

24 Urogomphus branched (24A, 24B)----------*Glischrochilus quadrisignatus*

Body length ca 9 mm. Each urogomphus divided beyond middle into 2 nearly equal, apically pointed branches, the anterior of which is curved upward, the posterior, inward; pregomphus appears as a truncated cone (24A, 24B); spiracular tubes prominent (longest on segment VIII).

Urogomphus unbranched (24C)---------- 25

Each urogomphus may have near its base a small seta-bearing lateral process (note distinction between lateral process, 25C, lateral lobe, 21A, and tubercle, 21A).

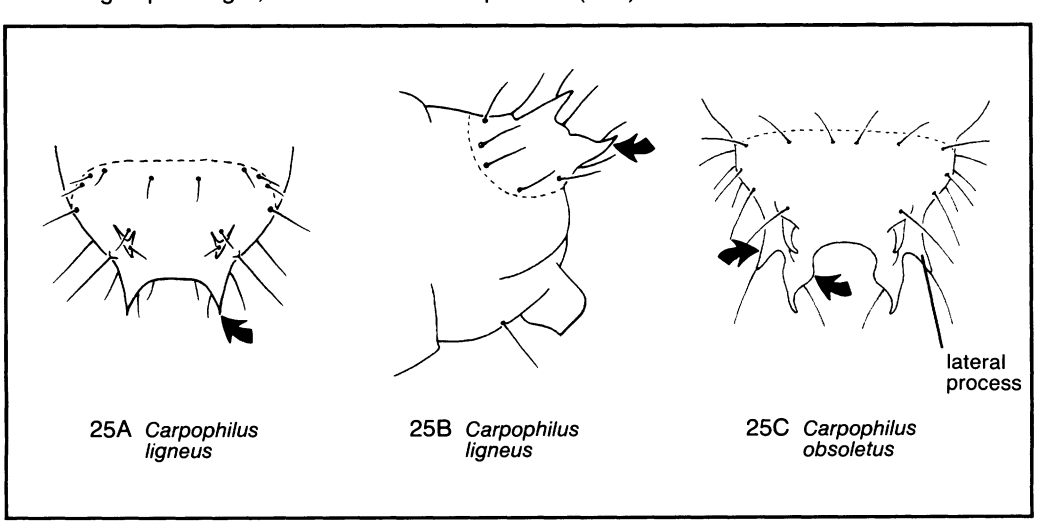


24A *Glischrochilus quadrisignatus* 24B *Glischrochilus quadrisignatus* 24C *Carpophilus ligneus*

25 Urogomphi short, widely separated, and lacking lateral processes (25A, 25B) ---------- *Carpophilus ligneus*

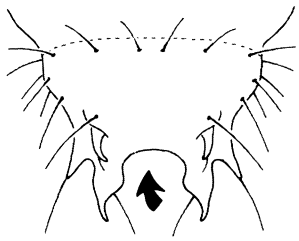
Body length ca 4.5 mm. Pregomphus directed posteriorly but not strongly deflexed (25B). 25A&B based on material provided by Iris Savage; these drawings may not agree entirely with the illustrations in *5*.

Urogomphi longer, each with a lateral process (25C)---------- 26

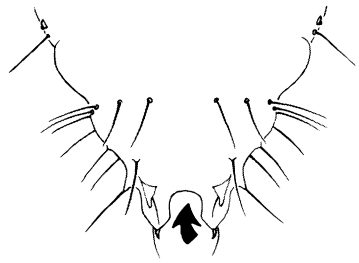


25A *Carpophilus ligneus* 25B *Carpophilus ligneus* 25C *Carpophilus obsoletus*

26 Space between urogomphi wide (26A) ---------- 27
Space between urogomphi narrow (26B) ---------- 30



26A *Carpophilus obsoletus*

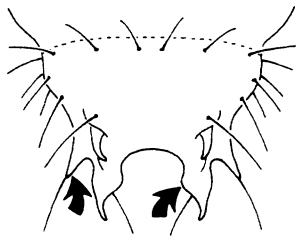


26B *Carpophilus dimidiatus*

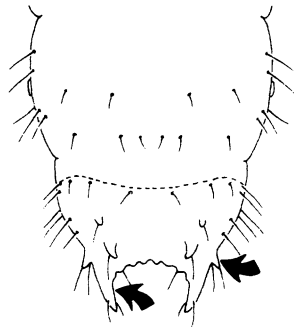
27 Urogomphus dilated on inner surface; lateral process large (27A)--*Carpophilus obsoletus*

Body length ca 6 mm. Pregomphus deflexed and incurved; paired mesonotal and metanotal sclerites weakly developed (may not be visible).

Urogomphus not dilated; lateral process small (27B) ---------- 28



27A *Carpophilus obsoletus*

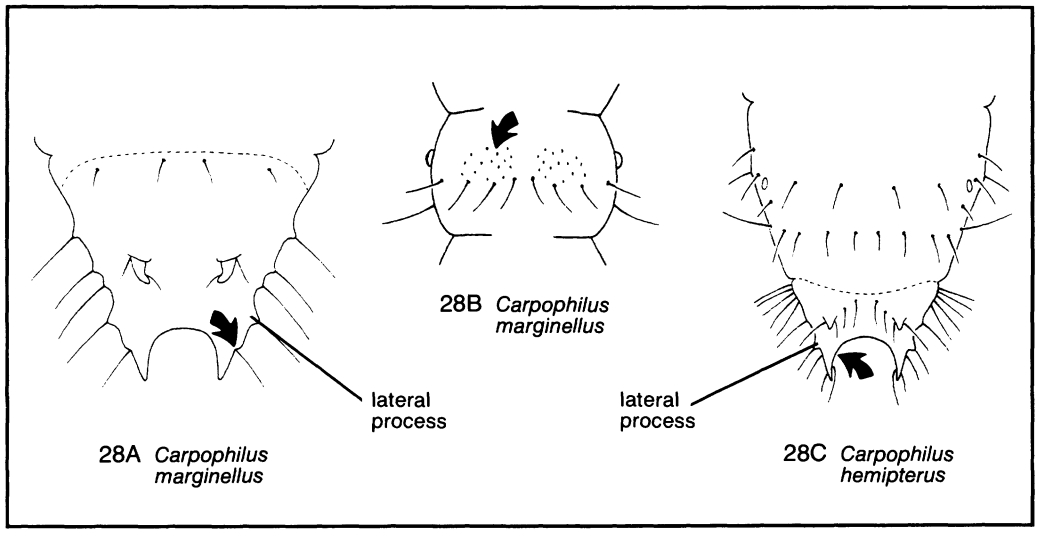


27B *Carpophilus lugubris*

28 Urogomphi abruptly narrowed about midway beyond lateral process, with inner margins subparallel (28A)----------*Carpophilus marginellus*

Body length ca 6 mm. Pregomphus deflexed, incurved, and gradually narrowed to a blunt point; mesonotal and metanotal sclerites moderately developed (usually visible in third instar larvae); each abdominal tergum with 2 transversely oval patches of minute asperities that may or may not be visible (28B; see also couplet 20).

Urogomphi gradually narrowed from lateral process to apex (28C) ---------- 29



28A *Carpophilus marginellus*

28B *Carpophilus marginellus*

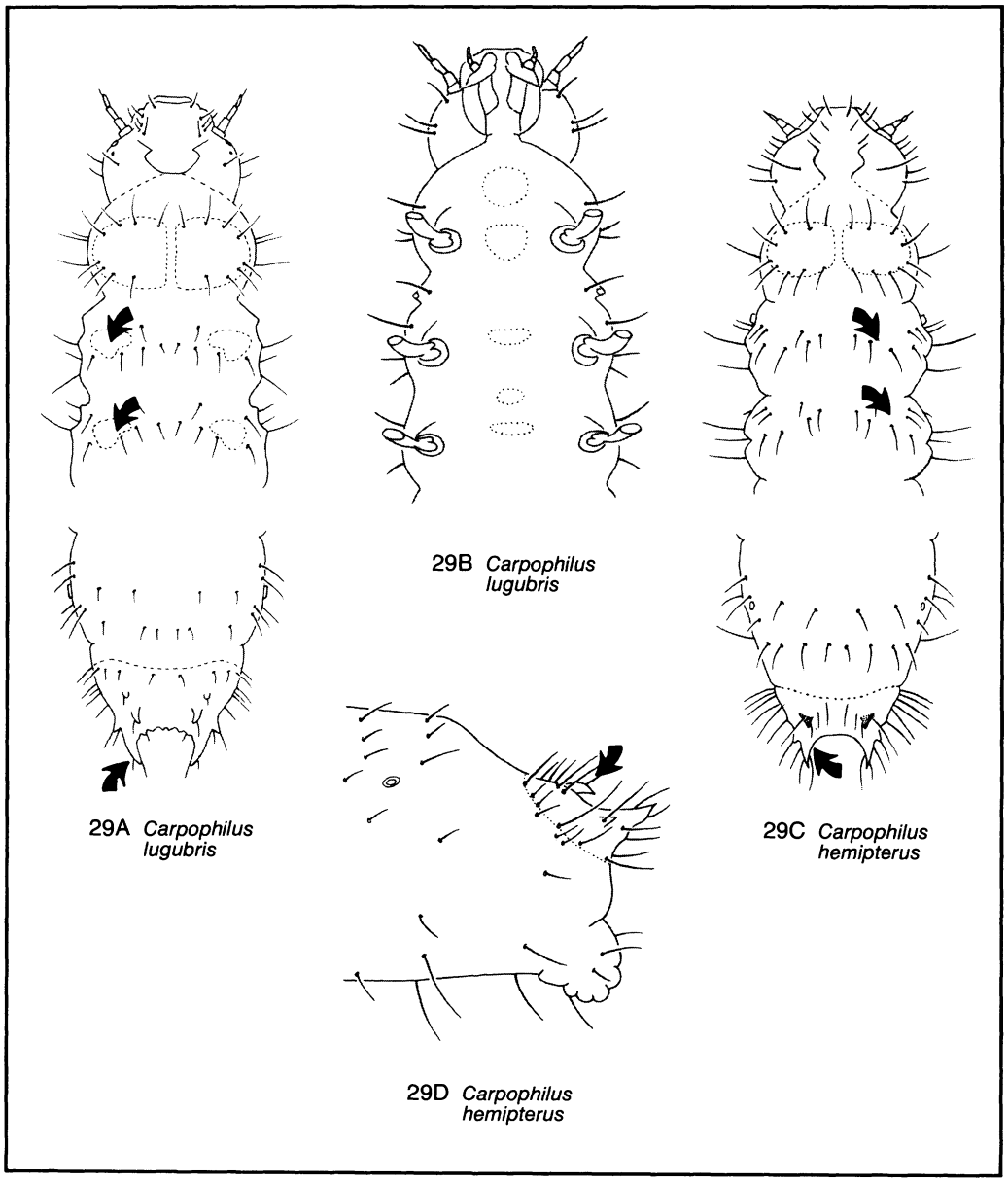
28C *Carpophilus hemipterus*

29 Urogomphus incurved (29A); mesonotal and metanotal sclerites strongly developed (29A)----------**dusky sap beetle,** *Carpophilus lugubris*

Body length ca 7 mm. Thorax with 5 small sclerites along ventral midline (visible in fresh specimens; may be obscured in preserved specimens) (29B).

Urogomphus not incurved, the apex spinelike (29C); mesonotal and metanotal sclerites absent (29C); pl. 90A----------**driedfruit beetle,** *Carpophilus hemipterus*

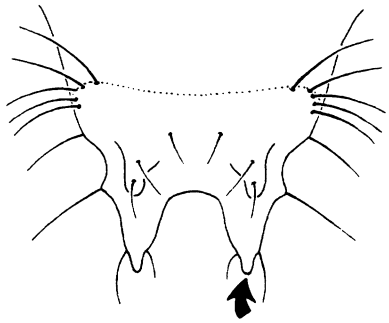
Body length ca 6 mm. Distal half of pregomphus deflexed and parallel with surface of anal plate (29D). See also 20D and 28C.



30 Inner margins of urogomphi divergent from base to apex; urogomphal apex peglike (30A, 30B)----------*Carpophilus mutilatus*
Carpophilus fumatus

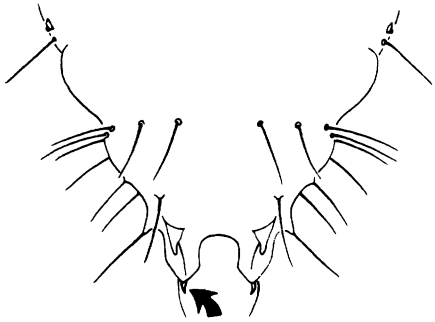
Body length ca 6 mm. Pregomphus abruptly deflexed, the distal half parallel to the surface of the anal plate (30B). Larvae of these 2 species are very similar. No reliable characters for separation are known. In the USA, *C. fumatus* occurs only in Florida.

Inner margins of urogomphi generally parallel for most of their length, or inner margins slightly dilated near apex; each urogomphus broadly rounded and bearing a stout spine (30C, 30D)---------- 31

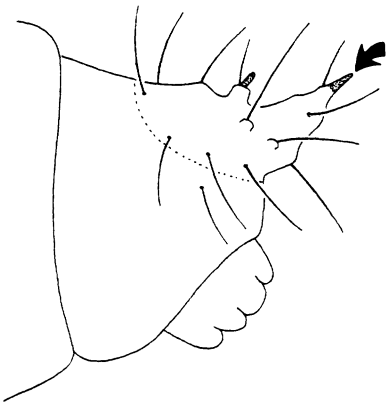


30A *Carpophilus mutilatus*

30B *Carpophilus mutilatus*



30C *Carpophilus dimidiatus*



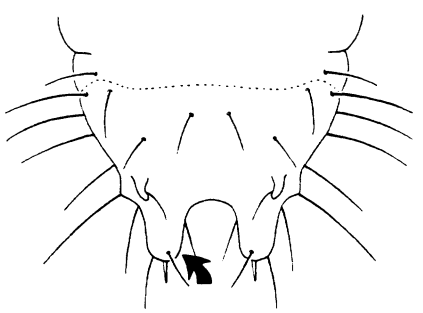
30D *Carpophilus dimidiatus*

31 Urogomphi separated midway along their length by 1.5 times the width of 1 urogomphus; urogomphi never bulging apically (31A)----------*Carpophilus freemani*

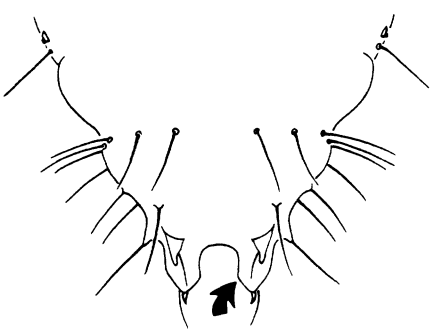
Body length ca 4.5 mm.

Urogomphi separated by less than width of 1 urogomphus; often inner margin of urogomphus appears to have a slight bulge before apex (31B)
----------**corn sap beetle,** *Carpophilus dimidiatus*
Carpophilus pilosellus

Larvae of *C. dimidiatus* and *C. pilosellus* are very similar and difficult to separate. Associated adults are helpful, but mixed infestations occur. Last instar larvae of *C. dimidiatus* tend to be larger (length ca 5.5 mm) than those of *C. pilosellus* (length ca 4.0 mm). See also 30D.



31A *Carpophilus freemani*



31B *Carpophilus dimidiatus*

Acknowledgments

Dr. John M. Kingsolver (Agricultural Research Service's Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington DC) and Mrs. Iris Savage (California Department of Food and Agriculture, Sacramento) critically reviewed the manuscript. Dr. Richard S. Zack, Jr. (Department of Entomology, Washington State University, Pullman) and Mrs. Savage provided distribution records for the West Coast. The author gratefully acknowledges the help given to him by all three of these individuals.

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1962. Anatomical and systematic study of mature larvae of Nitidulidae (Coleoptera). Ent. Meddel. 31:265-299.

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1951. Zur Kenntnis der früheren Entwicklungsstadien von *Carpophilus ligneus* Murray (Col. Nitidulidae). Ann. Ent. Fenn. 17(2)65-72.

9 CRYPTOPHAGID BEETLES (CRYPTOPHAGIDAE, COLEOPTERA)

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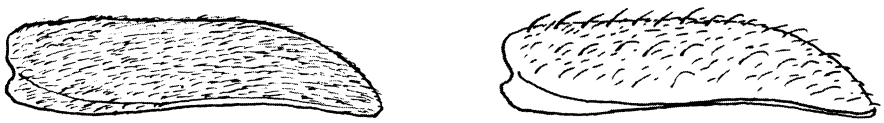
Cryptophagus is the only genus of the family Cryptophagidae associated with stored foods. The species are difficult to identify. Precise identification usually requires removal and observation of the male genitalia. This key to four species is based on the work of Woodroffe and Coombs (*1*), a key to 40 North American species. Members of the genus *Cryptophagus* are associated with molds; their presence in food represents accidental contamination.

KEY TO ADULTS

1 Elytral pubescence of hairs of approximately equal length, entirely decumbent (except, sometimes, laterally) (1A) ---------- 2
Elytral pubescence either of longer, suberect or obliquely-raised hairs or of all hairs obliquely-raised and of uneven length (1B) ---------- 3

Drawings by J.M. Kingsolver.



1A *Cryptophagus acutangulus*

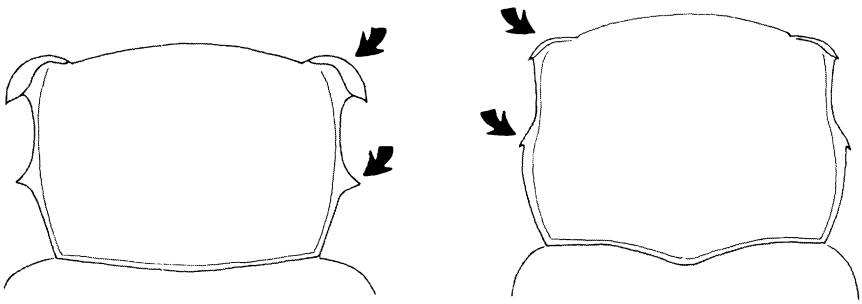
1B *Cryptophagus valens*

2 Width of pronotum greater at level of anterior angles than at level of lateral teeth (2A) ----------**acute-angled fungus beetle,** *Cryptophagus acutangulus*

Distribution: Holarctic; in various habitats, often including moldy grain.

Width of pronotum no greater across anterior angles than across lateral teeth (2B) ----------**sigmoid fungus beetle,** *Cryptophagus varus*

Distribution: Canada, northern United States; in stored products and rodent nests.
Drawings adapted from *1* by C. Feller.



2A *Cryptophagus acutangulus*

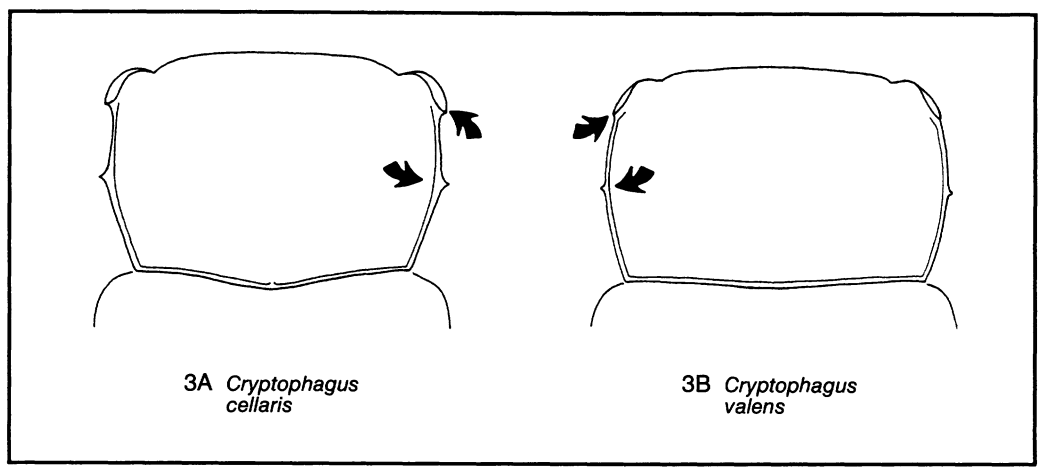
2B *Cryptophagus varus*

3 Margin of pronotum angled at lateral tooth; callosity at anterior angle of pronotum prominent, its posterior corner forming a minute right angle (3A); pl. 93B ----------cellar beetle, *Cryptophagus cellaris*

Distribution: cosmopolitan; in stored products.

Margin of pronotum evenly rounded or slightly sinuate, not angled at lateral tooth; callosity present but not prominent and not right-angled posteriorly (3B) ---------- *Cryptophagus valens*

Distribution: cosmopolitan; in stored products.
Drawings adapted from *1* by C. Feller.



Reference Cited

1 Woodroffe, G.E., and C.W. Coombs.
1961. A revision of the North American *Cryptophagus* Herbst (Coleoptera: Cryptophagidae). Misc. Pub. Ent. Soc. America 2(2)179-211.

10 MINUTE BROWN SCAVENGER BEETLES (LATHRIDIIDAE, COLEOPTERA)

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Lathridiids are mycophagous; their presence in stored foods indicates moldy conditions. Since these beetles do not feed directly on stored foods, their occurrence in such commodities may be considered accidental contamination.

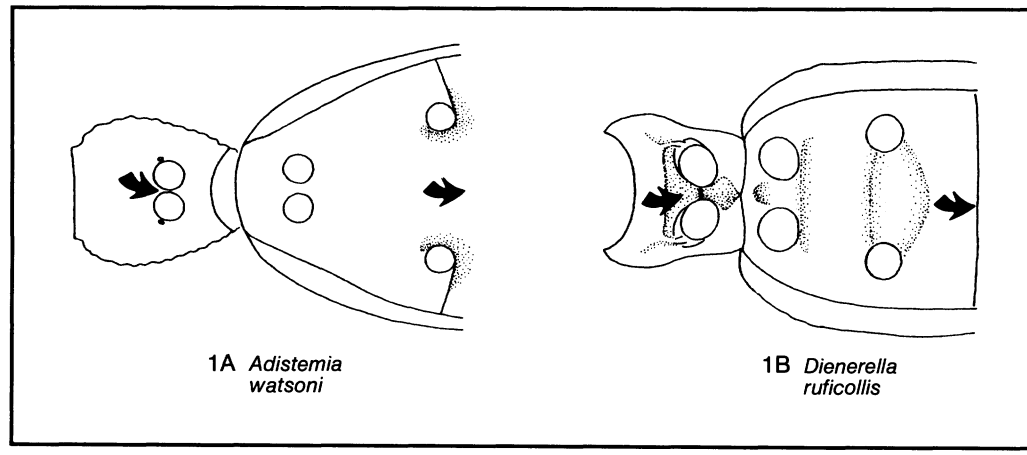
KEY TO ADULTS

Drawings by C. Feller unless otherwise noted.

1 Coxae I and II contiguous; abdominal segment I fused to metasternum between legs III (1A); pl. 94B----------*Adistemia watsoni*

Distribution: Africa, Canary Islands, Europe, Madeira, North America, South America.

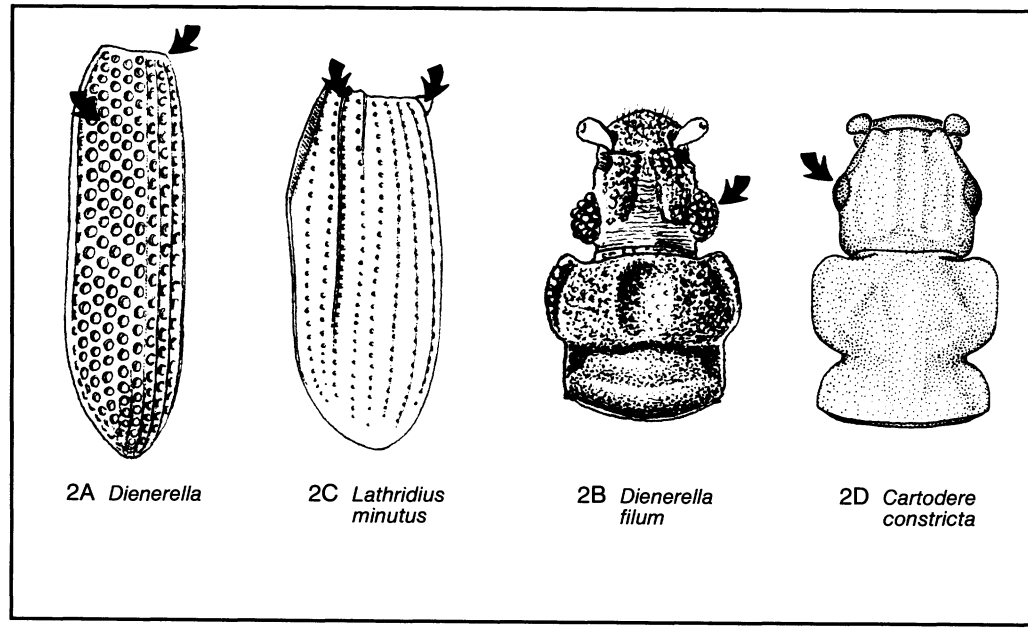
Coxae I and II separated, sometimes narrowly; abdominal segment I separated from metasternum by a suture (1B)---------- 2



2 Seventh interval at elytral shoulder without a prominent carina; scutellum not apparent (2A); eye facets coarse, granular (2B)---------- 3

Seventh interval at elytral shoulder with a sharp, prominent carina; scutellum obvious (2C); eye facets fine (2D)---------- 7

Drawings 2A-C by A.D. Cushman.

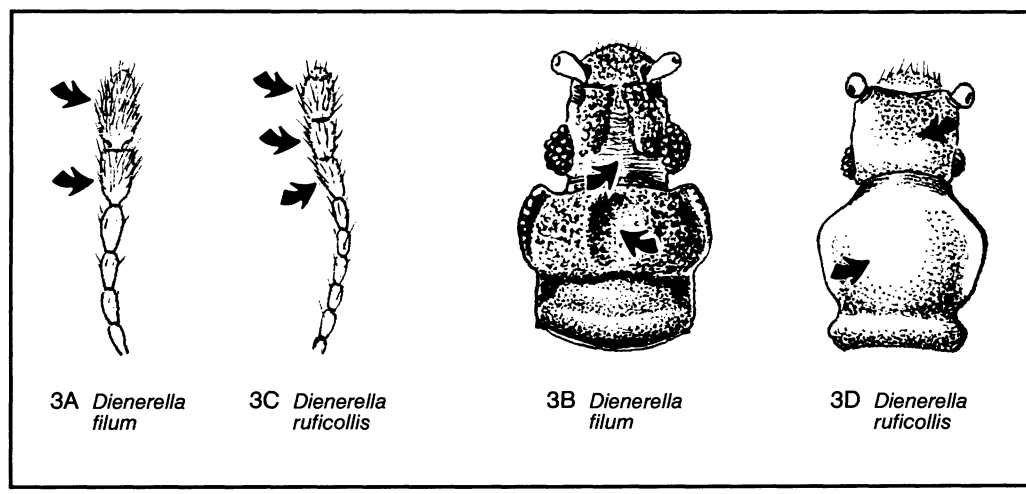


3 Antennal club with 2 segments (3A); anterior half of pronotal disk with broad, moderately deep, oval depression; head with median channel widened posteriorly (3B); pl. 95A----------*Dienerella filum*

Distribution: Europe, North Africa, Western Hemisphere.

Antennal club with 3 segments (3C); anterior half of pronotal disk without depression; head without median channel (3D) ---------- 4

Drawings by A.D. Cushman.

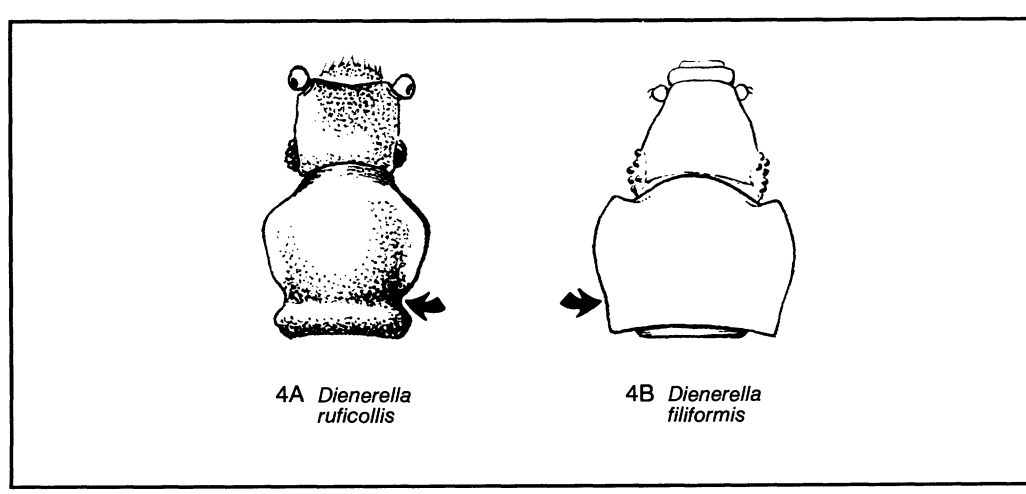


3A *Dienerella filum* 3C *Dienerella ruficollis* 3B *Dienerella filum* 3D *Dienerella ruficollis*

4 Margin of pronotum constricted (4A); pl. 95B----------*Dienerella ruficollis*

Distribution: Central and North America, Europe, New Zealand, North Africa.
Drawing 4A by A.D. Cushman; 4B by J.M. Kingsolver.

Margin of pronotum not constricted (4B) ---------- 5

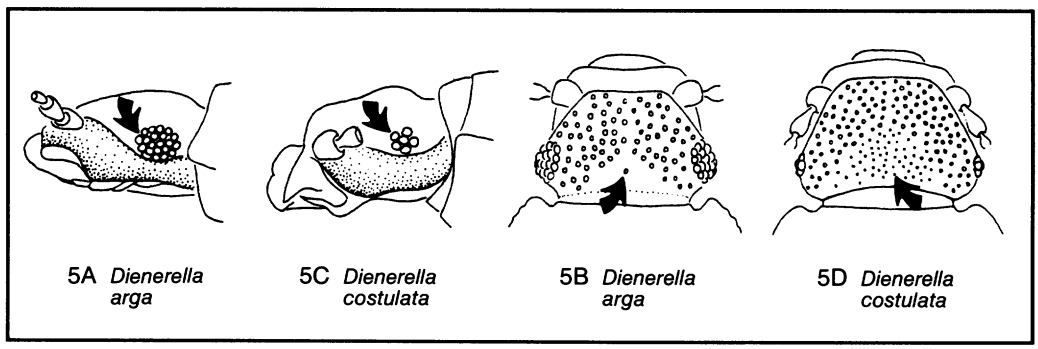


4A *Dienerella ruficollis* 4B *Dienerella filiformis*

5 Eyes normal with 15 to 20 facets (5A); posterodorsal surface of head with triangular depressed area (5B); pl. 95C----------*Dienerella arga*

Distribution: Europe, North Africa, North America.

Eyes reduced with 5 or 6 facets (5C); dorsal surface of head without depressed area (5D)---------- 6



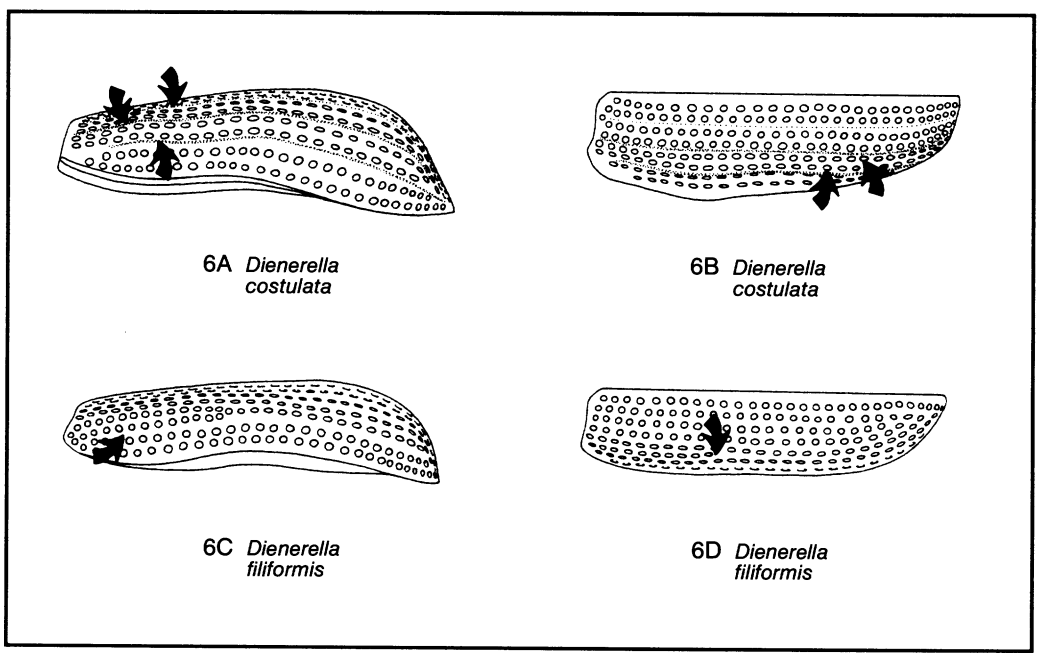
5A *Dienerella arga* 5C *Dienerella costulata* 5B *Dienerella arga* 5D *Dienerella costulata*

6 Elytral intervals 3, 5, and 7 costate (6A); elytral striae 5 and 6 complete, extending from base to apex (6B); pl. 96A----------*Dienerella costulata*

Distribution: Europe, Japan, North America.

Elytral intervals not costate (6C); elytral striae 5 and 6 merge forming a single stria posteriorly (6D); pl. 96B----------*Dienerella filiformis*

Distribution: Europe, Japan, North America, USSR.



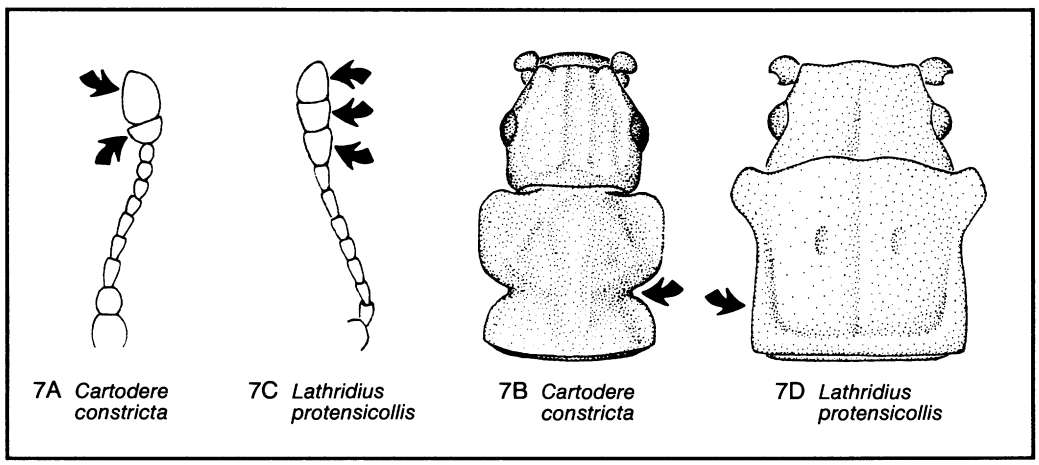
6A *Dienerella costulata* 6B *Dienerella costulata*

6C *Dienerella filiformis* 6D *Dienerella filiformis*

7 Antennal club 2-segmented (7A); pronotum distinctly constricted (7B); pl. 97A
----------**plaster beetle,** *Cartodere constricta*

Distribution: cosmopolitan.

Antennal club 3-segmented (7C); pronotum not distinctly constricted (7D)---------- 8

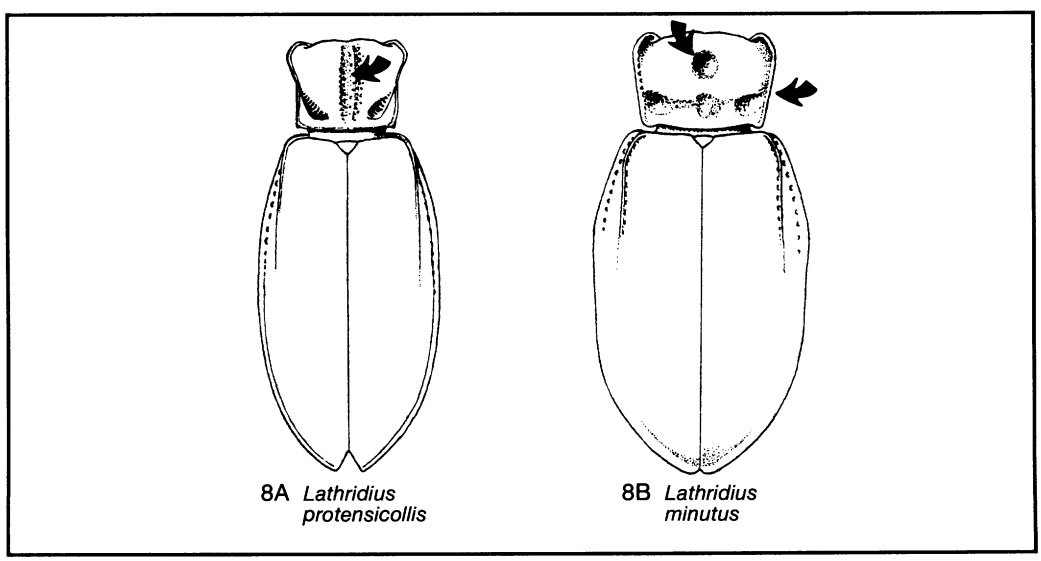


8 Pronotal margin sinuate; median depression of pronotal disk shallow and elongate; elytra slightly produced at apex (8A); pl. 97B----------*Lathridius protensicollis*

Distribution: northwestern USA.

Pronotal margin straight; median depression of pronotal disk round and deep; elytra separately rounded at apex (8B); pl. 97C
---------- **squarenosed fungus beetle,** *Lathridius minutus*

Pronotum narrowed posteriorly. Distribution: cosmopolitan.
Drawings by A.D. Cushman.



11 DARKLING BEETLES (TENEBRIONIDAE, COLEOPTERA)

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The Tenebrionidae, commonly called **darkling beetles** or tenebrionids, is a large family of mostly dark species having a 5-5-4 tarsal formula, the forecoxal cavities closed behind, and simple tarsal claws. These beetles usually live in soil in dry areas or under the bark of dead trees. A few species have adapted to and have become pests in stored dry food products. Many such pests have been transported to all parts of the world.

Tenebrionid pests usually infest grains and cereals. Because most of them cannot gnaw through the hard outer covering of whole grains, they usually attack broken or damaged grains. The exact food preferences of most of these beetles in stored foods have not been determined. It has often been said that grain must be moldy or partially spoiled for some species to develop. Perhaps the adults and larvae subsist mainly on mold. This is not an unreasonable hypothesis because some species live in moldy situations in nature. Their presence in bird and mammal nests, in foods stored by small mammals, in caves, and in insect nests probably predisposes some of them to become pests in foods stored by people. Some tenebrionid pests are also scavengers.

The biologies of only a few species are known; literature on the subject is scattered. *Tenebrio molitor, Tribolium castaneum,* and *T. confusum* are rather well known because of their use in physiological, ecological, and genetic experiments. Literature on *Tribolium* is so vast that a serial journal, *Tribolium Information Bulletin,* is needed to coordinate data; this bulletin is an excellent source for biological information on the genus. General discussions on the biology of pest tenebrionids have seldom been collected under a single cover. Two useful references are Lepesme (*22*) and Cotton (*8*). References to the biologies of individual genera or species are cited at the appropriate place in the determination key that follows.

Identification of adult darkling beetles associated with the food industry is rather simple because the species are scattered in several tribes and various genera. Because their general appearance is often quite distinct, they can usually be easily recognized by the habitus illustrations in Part 3 of this Handbook. Although some adults are quite small, the specific differences can often be seen with only a hand lens. Keys to adult tenebrionids in stored foods have been provided by Lepesme (*22*) and Freeman (*10*). Many generalized keys to species of tenebrionids have been published. Some of the more important are those by Blatchley (*1*) for Indiana, Boddy (*2*) for the Pacific Northwest of North America, Kaszab (*19*) for Central Europe, and Brendell (*3*) for the British Isles.

Larval tenebrionids (pl. 99A, 101A) are called false wireworms because of their resemblance to **wireworms**, the larvae of the Elateridae or **click beetles**. Identification of the larvae is not simple. Some larvae are quite small even when mature, and useful characters, such as setae, are occasionally missing. Some structures of the smaller species, such as legs, must be mounted on microscope slides. The most obvious and easily used character is the apex of the abdomen, segment IX. This can often be seen well enough with a strong hand lens. Unfortunately, larval tenebrionids have been only poorly studied. Not all tenebrionids are known in the larval stage and only a few keys to larvae have been published, two of the more important being Van Emden (*31*) for the British Isles and Hayashi (*17*) for Japan.

The key that follows is the first to deal with the larval tenebrionid pests that infest stored foods. Several species are unknown in the larval stage and therefore do not appear in the key to larvae; these are *Alphitobius viator, Apsena rufipes, Coelopalorus carinatus, C. foveicollis, Lepidocnemeplatia sericea, Palorinus humeralis, Palorus cerylonoides, P. ficicola, P. genalis,* and *P. laesicollis*. Information on distribution, food associations, and bibliographic references for each larval pest species may be found under the species name in the key to adults.

KEY

Drawings by C. Feller unless otherwise noted.

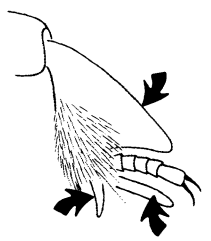
Adults

1 Adult specimens ---------- 2
Larval specimens ---------- 36

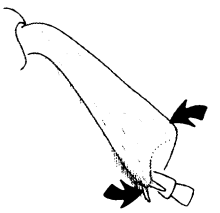
2 Tibia I extremely broad (width at apex almost as great as length); apical spurs of tibia I very long (one spur almost as long as tarsus I) (2A); body completely covered with scales or scalelike setae (so dense as to obscure the epidermis) (pl. 98A) ---------- *Lepidocnemeplatia sericea*

Distribution: western United States; associated with raisins, Mission figs, barley, milo, rice, various grains; also reported from cotton gin trash.

Tibia I narrow or moderately to broadly expanded apically (width at apex no more than ¼ length); spurs of tibia I short, not more than half as long as tarsus I (2B); body not covered with scales (at most covered with setae but epidermis never obscured) (pl. 1F) ---------- 3



2A *Lepidocnemeplatia sericea*



2B *Alphitobius diaperinus*

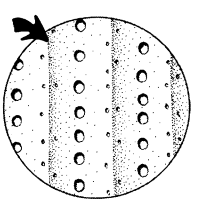
3 Elytra bicolored, yellowish-reddish, with 2 or more broad, transverse bands that are often incomplete (pl. 1F) ---------- **twobanded fungus beetle,** *Alphitophagus bifasciatus*

Distribution: cosmopolitan; associated with barley, beans, chick peas, milo, rice, wheat, mixed feeds, cornmeal (moist), cereals (spoiled), grain products; also reported from fungi, refuse grain, decaying vegetable matter. References: *7, 22*

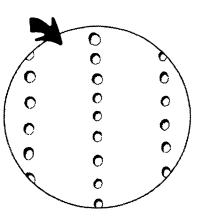
Elytra unicolored (sometimes with setae of different color than epidermis but epidermis of only one color) (pl. 98B) ---------- 4

4 Elytron with a fine (though distinct) longitudinal ridge on each lateral interval (4A) 5
Elytral intervals flat or convex, without ridges (4B), or only interval 7 with a coarse, longitudinal ridge (pl. 104A) ---------- 11

Drawings by A.D. Cushman.



4A *Tribolium audax*



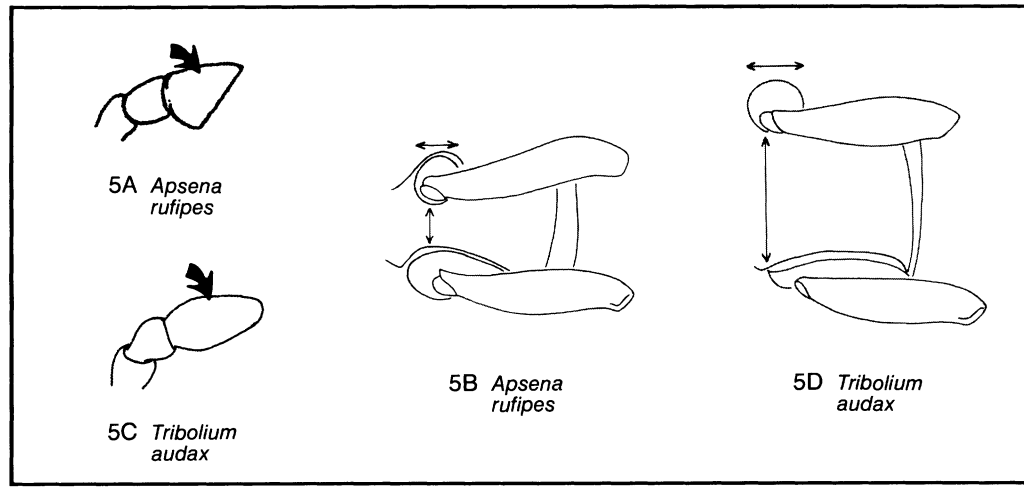
4B *Platydema ruficorne*

5 Maxillary palpus with apical segment broadly triangular (5A); metasternum short (distance between coxa II and coxa III less than diameter of coxa II) (5B); elytra with lateral borders rounded or arcuate (pl. 98B)
---------- fig engraver beetle, *Apsena rufipes*

Distribution: California; associated with raisins, figs (in field and storage).

Maxillary palpus with apical segment parallel-sided or narrowed distally (5C); metasternum long (distance between coxa II and coxa III at least twice diameter of coxa II) (5D); elytra with lateral borders parallel or subparallel (pl. 98C). Genus *Tribolium* 6

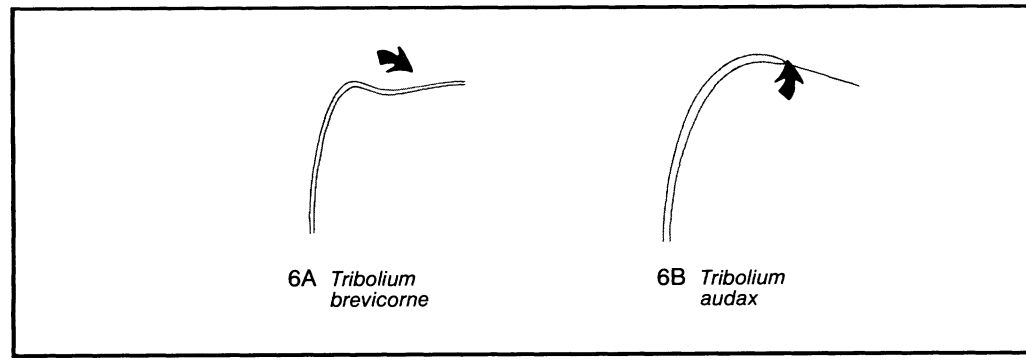
References: *11, 18, 27.*
Drawings by A.D. Cushman and C. Feller.



6 Pronotum with lateral bead continuous with anterior bead (6A); pl. 98C
---------- giant flour beetle, *Tribolium brevicorne*

Distribution: western Canada and western United States; associated with oats, chicken feed, mixed feeds, honey comb; also reported from nest of leaf-cutting bees. References: *26, 29.*
Drawings by A.D. Cushman and C. Feller.

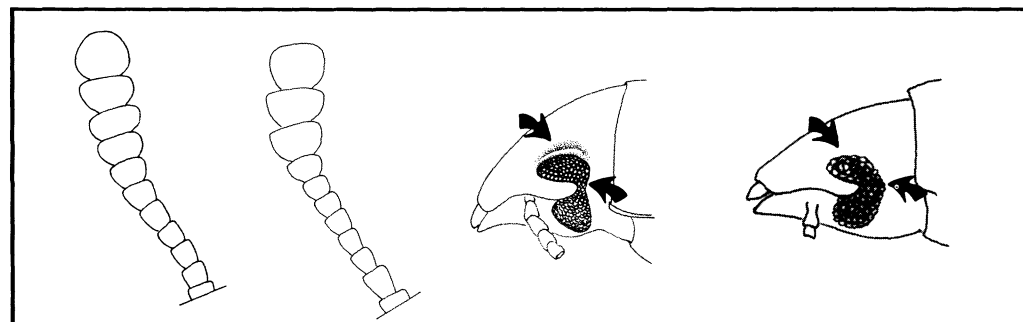
Pronotum with lateral bead reaching only to corner, then seeming to disappear under anterior border (6B)---------- 7



7 Antenna clavate (7A); head with carina over eye; eye divided or deeply constricted (eye at narrowest point without facets or with 1 or 2 facets) (7B)---------- 8

Antenna capitate (7C); head without carina over eye; eye with shallow constriction (eye at narrowest with at least 4 facets) (7D)---------- 9

Drawing 7D by A.D. Cushman.



7A *Tribolium confusum* 7C *Tribolium audax* 7B *Tribolium confusum* 7D *Tribolium audax*

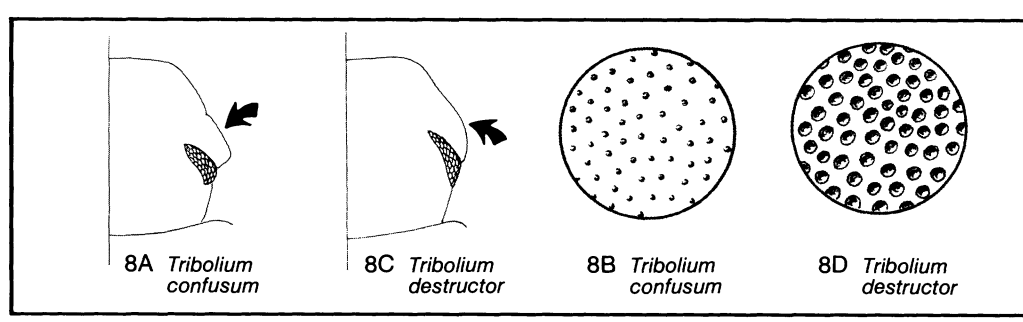
8 Epistoma subangulate at eye (8A); with small punctures centrally on pronotum (8B) and in elytral striae; pronotum widest anterior to half-length (pl. 99B) ---------- **confused flour beetle,** *Tribolium confusum*

Distribution: cosmopolitan (but more common in temperate and northern regions); associated with wheat, wheat bran, cracked wheat, flour, graham flour, corn, cornmeal, corn starch, oats, oatmeal, oat flour, beans, rice, broad beans, barley, rye, safflower meal, breakfast cereals, grains, grain products, peanuts, pecans, cashews, almonds, walnuts, orris root, baking powder, cacao, chocolate, powdered milk, ginger, cayenne pepper, raisins, dried fruit, dried vegetables, beet pulp, biscuit; also reported from cottonseed, cottonseed meal, cottonseed hulls, vetch seed, snuff, dried insects. References: *5, 8, 11, 22, 29.* See also 7A&B.

Epistoma rounded at eye (8C); with large punctures centrally on pronotum (8D) and in elytral striae; pronotum widest at half-length (pl. 98D) ----------false black flour beetle, *Tribolium destructor*

Distribution: Africa, Europe, North America; associated with flour, bran, groats, rolled oats, semolina, alfalfa meal, sunflower seeds, grains, poultry feed, mixed feeds; also reported from cotton, wool, animal products. References: *11, 29.*

Drawings 8A&C by A.D. Cushman and C. Feller; 8B&D by A.D. Cushman.



8A *Tribolium confusum* 8C *Tribolium destructor* 8B *Tribolium confusum* 8D *Tribolium destructor*

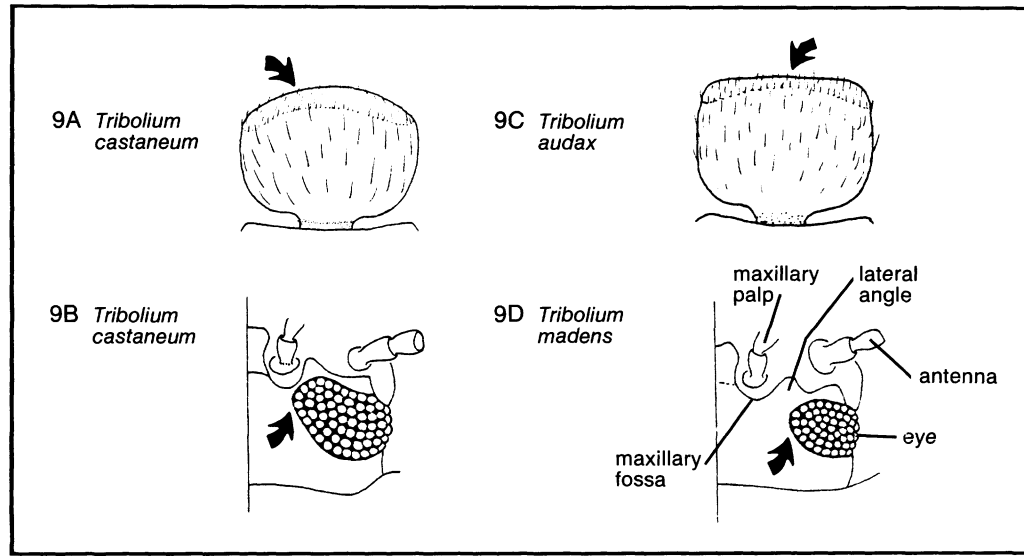
9 Apical antennal segment strongly arcuate (9A); eye large, extending medioventrally nearly to maxillary fossa (9B); pl. 99C ----------**red flour beetle,** *Tribolium castaneum*

Body color: reddish brown. Distribution: cosmopolitan (in North America more common in southern areas); associated with corn, wheat, wheat bran, flour, rye, oats, milo, millet, barley, rice, grains (broken), grain products, mixed feeds, cereals, beans, peas, lentils, butter beans, peanuts, safflower seed, sunflower seed, ginger, mustard, chillies, cinnamon, nutmeg, cacao, copra, copra meal, yams, raisins, sultanas, dried figs, dried fruit, Brazil nuts, walnuts, almonds, cassava chips, orris root, tapioca, dog and cat food; also reported from flax, flax seed, grain spillage, alfalfa seed, snuff, derris root, oilcake, pineapple plants (decayed), cotton gin trash, lac. References: *8, 11, 22, 29.*

Drawings by A.D. Cushman.

Apical antennal segment subtruncate (9C); eye small, extending medioventrally no farther than to region behind lateral angle of maxillary fossa (9D)---------- 10

Body color: black or brownish black.

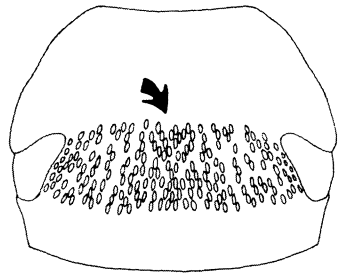


10 Many confluent punctures between eyes (10A); eye not extending medioventrally to region behind lateral angle of maxillary fossa (10B); body slender (pl. 100A) ---------- **American black flour beetle,** *Tribolium audax*

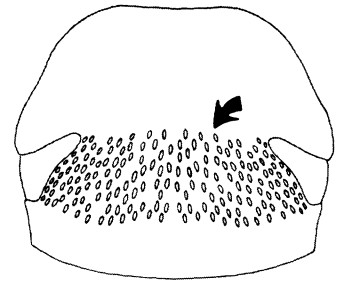
Distribution: North America; associated with wheat, flour, barley, grain, grain products; also reported from bee nests and in logs. References: *11, 15, 29.* See also 4A, 5C&D, 9C.

No confluent punctures between eyes (10C); eye extending medioventrally to region behind lateral angle of maxillary fossa (10D); body robust (pl. 100B) ---------- black flour beetle, *Tribolium madens*

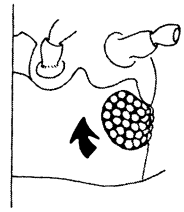
Distribution: Europe, North Africa; recently reported from Canada, USA; associated with flour, cornmeal, grains, seeds. References: *11, 29.*



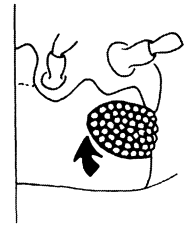
10A *Tribolium audax*



10C *Tribolium madens*



10B *Tribolium audax*



10D *Tribolium madens*

11 Length 10 to 25 mm ---------- 12
Length 3 to 7 mm ---------- 14

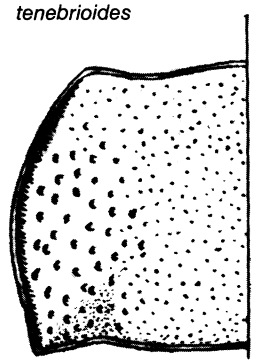
12 Pronotum with very large punctures laterally and small punctures overall (12A); pl. 100C ---------- *Neatus tenebrioides*

Distribution: North America; associated with grain, barley, cereals, cereal products; also reported from under bark of dead trees, squirrel nests, bumblebee nest.

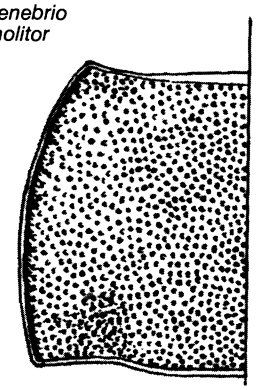
Drawings by A.D. Cushman.

Pronotum with large and small punctures overall (12B) ---------- 13

12A *Neatus tenebrioides*



12B *Tenebrio molitor*



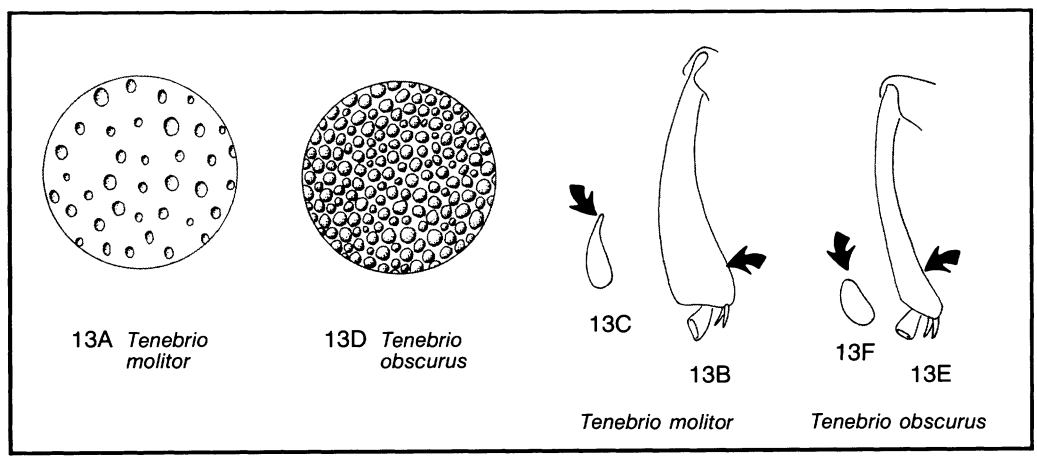
13 Pronotal punctures not contiguous (13A); tibia I moderately expanded apically (13B), with a sharp edge dorsally on apical half (13C); integument weakly shining; pl. 101C ---------- **yellow mealworm,** *Tenebrio molitor*

The exarate pupa of *T. molitor* is shown in pl. 101B. Distribution: cosmopolitan; associated with corn, cornmeal, oats, wheat bran, grain, mixed feeds, cereal products, bread, crackers, potatoes, dried fruits, meat; also reported from corn cobs, mill sweepings, tobacco, feathers, cotton gin trash. References: *8, 9, 22.* See also 12B.

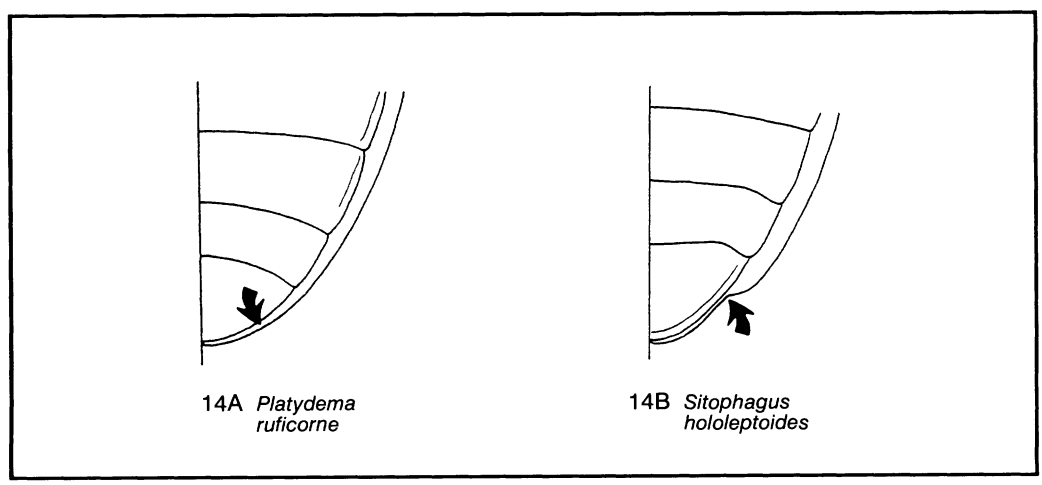
Many pronotal punctures contiguous (13D); tibia I weakly expanded apically (13E), with blunt or rounded edge dorsally on apical half (13F); integument dull ("matte finish"); pl. 101D ---------- **dark mealworm,** *Tenebrio obscurus*

Distribution: cosmopolitan; associated with corn, flour, barley, grain, black pepper, mixed feeds, beet pulp; also reported from cottonseed, cottonseed meal, cotton gin trash, soda ash, phosphate fertilizers. References: *8, 9, 22.*

Drawings 13A&D by A.D. Cushman; 13B&C&E&F by A.D. Cushman and C. Feller.



14 Elytron with pseudopleuron gradually narrowed, sometimes reaching apex (14A) - 15
Elytron with pseudopleuron abruptly abbreviated before apex (14B) ---------- 30

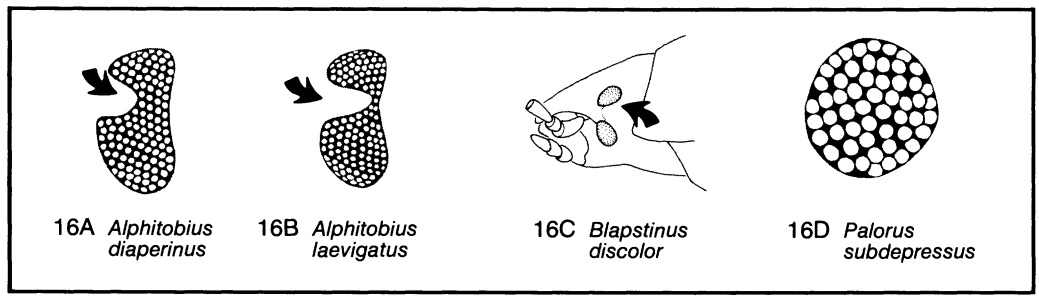


15 Body broad and oval (lateral borders strongly curved); dorsal surface satiny black and hairless (pl. 100D) ----------redhorned grain beetle, *Platydema ruficorne*

Distribution: eastern North America; associated with corn, shelled corn, corn shorts, grain (damp, moldy). See also 4B, 14A.

Body elongate (lateral borders almost parallel-sided); dorsal surface shiny, weakly shiny, or hairy (pl. 103A) ---------- 16

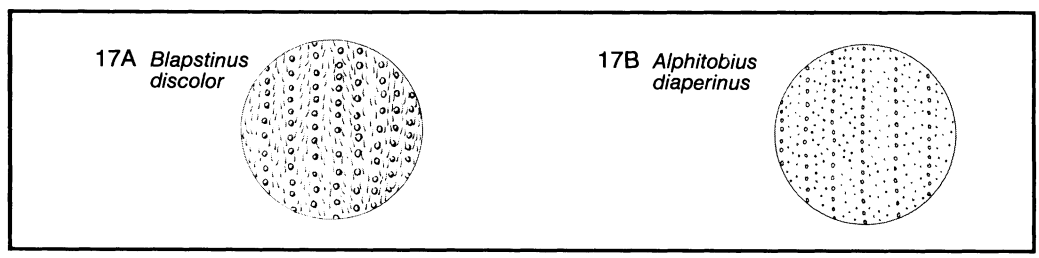
16 Length 5 to 7 mm; eye emarginate (16A, 16B) or divided (16C) ---------- 17
Length 3 to 3.5 mm; eye entire (16D) ---------- 22



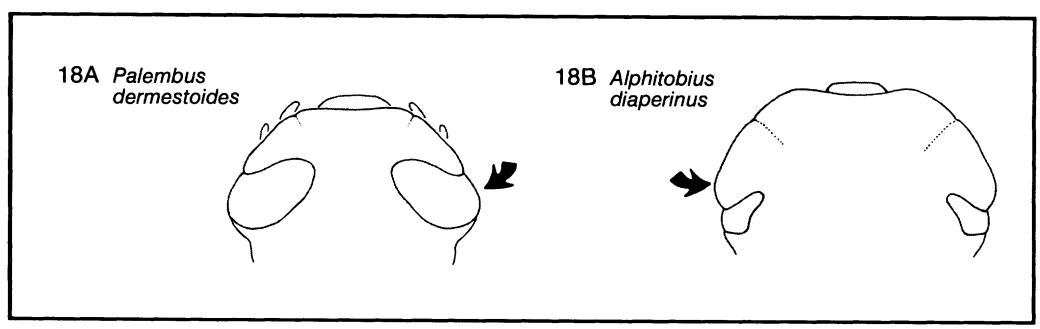
17 Dorsum with dense recumbent setae (17A); pl. 102A
---------- fig darkling beetle, *Blapstinus discolor*

Distribution: western Canada (British Columbia) and USA (California, Idaho, Nevada, Oregon, Utah, Washington); associated with figs, grapes, raisins, peaches, persimmons, strawberries, dried fruits, tomatoes, sugar beets, peppers, beans. See also 16C.

Dorsum without setae (17B) ---------- 18



18 Head widest at eyes; eyes large, separated by distance subequal to width of eye (18A) 19
Head widest anterior to eyes; eyes small, separated by distance greater than 3 times width of eye (18B) ---------- 20

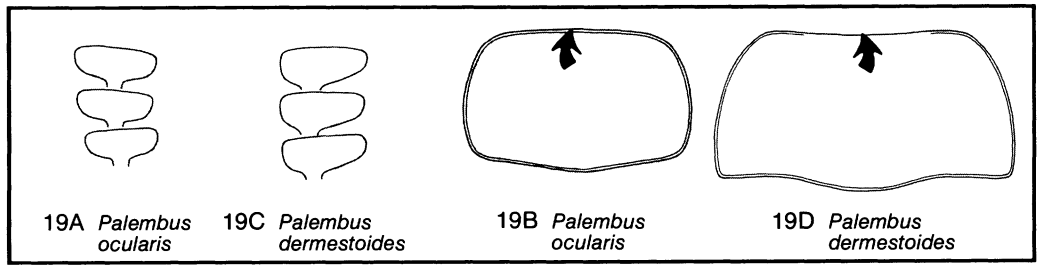


19 Antenna with broad segments symmetrical (19A); pronotum with anteromedial bead (19B); pl. 102B ----------*Palembus ocularis*

Distribution: pantropical, USA (Florida); associated with corn, oats, wheat, fish meal, yeast; also reported from seed pods of *Tamarindus indicus* and *Cassia* spp., on fruits of wild banana and okra. Reference: *16*.

Antenna with broad segments moderately asymmetrical (19C); pronotum without anteromedial bead (19D); pl. 102C ----------*Palembus dermestoides*

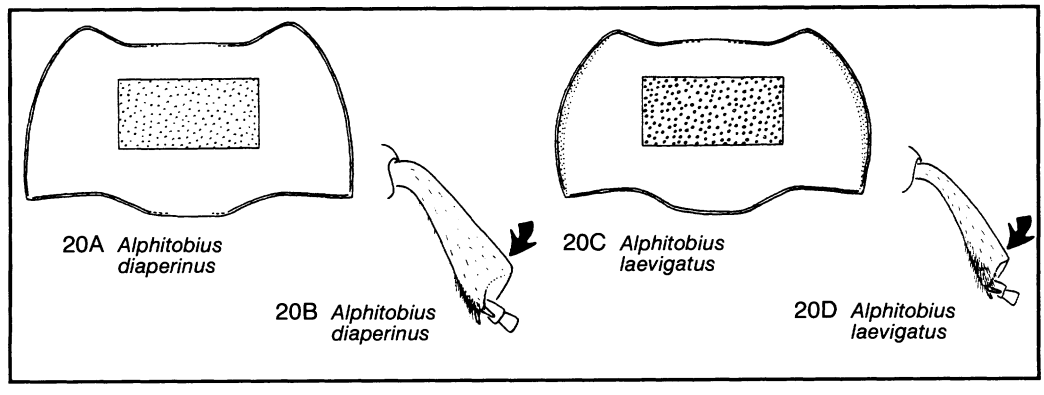
Distribution: pantropical; associated with corn, cornmeal, wheat flour, oats, rice bran, peanuts, nuts, dried yeast, yeast extract, sucrose, pollen, royal jelly, bread, apples; also reported from lotus and jujube fruits; reared as oriental medicine on herbs. References: *16, 30*. See also 18A.



20 Body shiny; pronotum with small punctures separated by a distance much greater than diameter of one puncture (20A); tibia I broadly expanded apically (20B); pl. 103A----------**lesser mealworm,** *Alphitobius diaperinus*

Distribution: cosmopolitan; associated with wheat, broken wheat, flour, barley, oatmeal, rice, grain (damp and moldy), cereals, cereal products, mixed feeds, peanuts, soy beans, black gram (urd), cowpeas, copra, cacao, chocolate, sweet potatoes, biscuits, cassava chips, manioc roots; also reported from flax seed, linseed, cottonseed, oilseed products, gum dammar, drugs, tobacco, silkworm cocoons, skins, bones, poultry litter, bat caves. References: *21, 22*. See also 16A, 17B, 18B.

Body dull; pronotum with large punctures usually separated by a distance no greater than diameter of one puncture (20C); tibia I moderately (20D) or weakly expanded apically---------- 21

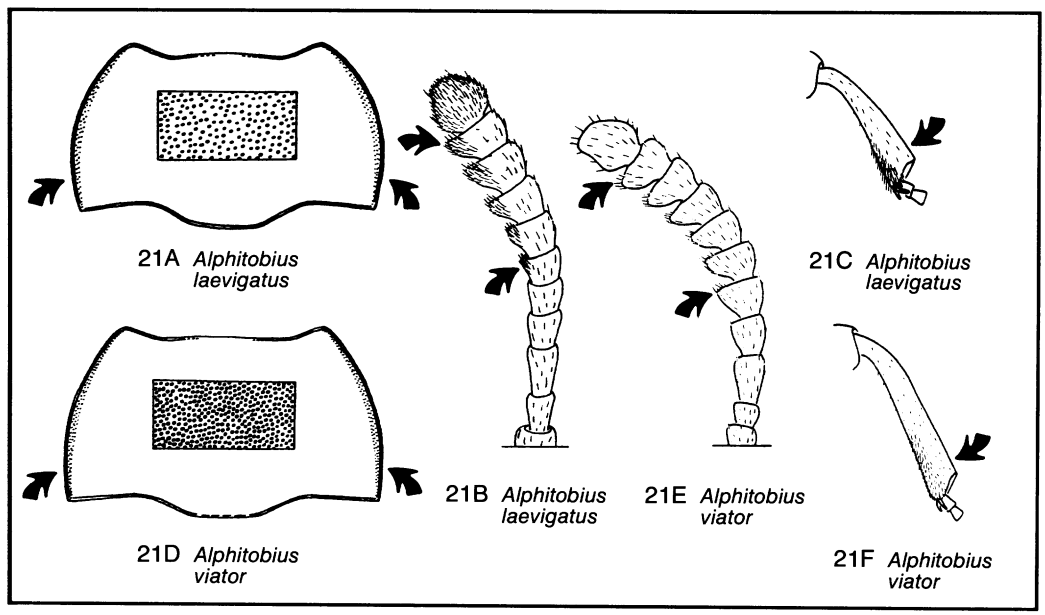


21 Pronotum with lateral borders distinctly narrowed toward posterior angles; pronotal punctures less dense (21A); antenna with segments VI to X asymmetrically expanded apically (21B); tibia I moderately expanded apically (21C); pl. 103B
---------- **black fungus beetle,** *Alphitobius laevigatus*

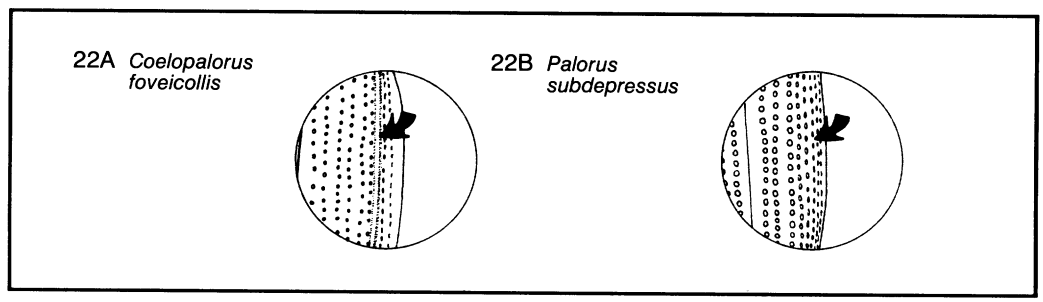
Distribution: cosmopolitan; associated with wheat bran, grain, damp and moldy grain, cereals, cereal products, nuts, dried fruits, legumes, spices, peanuts, mixed feeds, copra, cacao, sugar beets, illupe nuts; also reported from cottonseed, poultry litter, bat caves, animal products, oilseeds and products. Reference: *22*. See also 16B.

Pronotum with lateral borders subparallel toward posterior angles; pronotal punctures more dense (21D); antenna with segments V to X asymmetrically expanded toward apex (21E); tibia I weakly expanded apically (21F); pl. 103C
---------- *Alphitobius viator*

Distribution: tropical Africa; associated with ginger roots, chili peppers, corn; also reported from bones. Reference: *12*.
20A and 21A&D redrawn from *12*.



22 Elytron with interval 7 carinate (22A; pl. 104A&B) ---------- 23
Elytron with interval 7 rounded or flat (22B; pl. 105A-C) ---------- 24

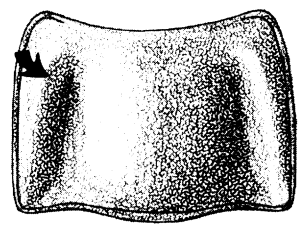


23 Pronotum with deep lateral depressions (23A); pl. 104A----------*Coelopalorus foveicollis*

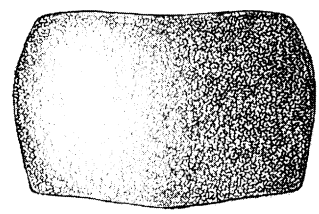
Distribution: Oriental Region; imported into East Africa, Trinidad, USA (Alabama, Hawaii); associated with corn, wheat shorts, copra, grain products, cowpeas, illupe nuts, sago flour, peanut cake, cassava chips; also reported from cattle feed, spillage in rice stores, beetle burrows in logs. References: *13, 14.* See also 22A.

Pronotum without lateral depressions (23B); pl. 104B----------*Coelopalorus carinatus*

Distribution: Oriental Region; associated with betel nuts, illupe nuts, rice. Reference: *13.*



23A *Coelopalorus foveicollis*

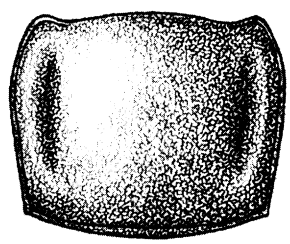


23B *Coelopalorus carinatus*

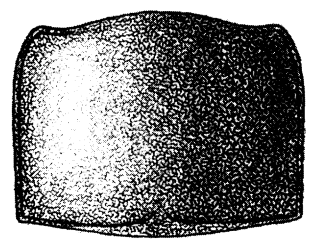
24 Pronotum with deep lateral depressions (24A); pl. 105B----------*Palorus laesicollis*

Distribution: Africa; associated with corn (broken kernels), oats; also reported from corn cobs, under bark. References: *13, 14.*

Pronotum without lateral depressions (24B)---------- 25



24A *Palorus laesicollis*

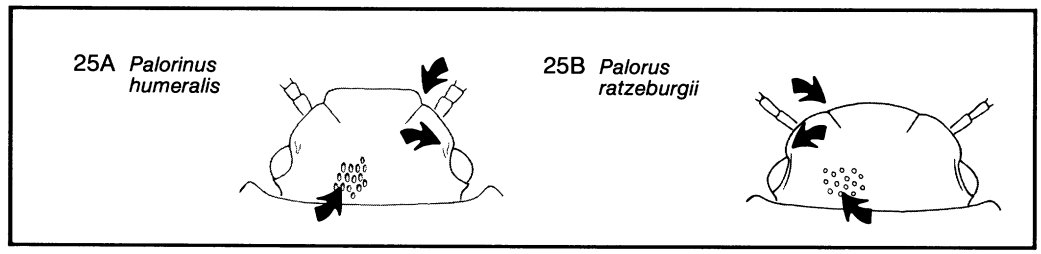


24B *Palorus subdepressus*

25 Head without fine carina (though sometimes with wrinkles) adjacent to top of eye; clypeogenal suture ending posterior to lateral borders; punctures between eyes dense, deep, usually oval (25A)----------*Palorinus humeralis*

Distribution: Oriental Region; associated with nutmeg, sago flour. Reference: *13.*

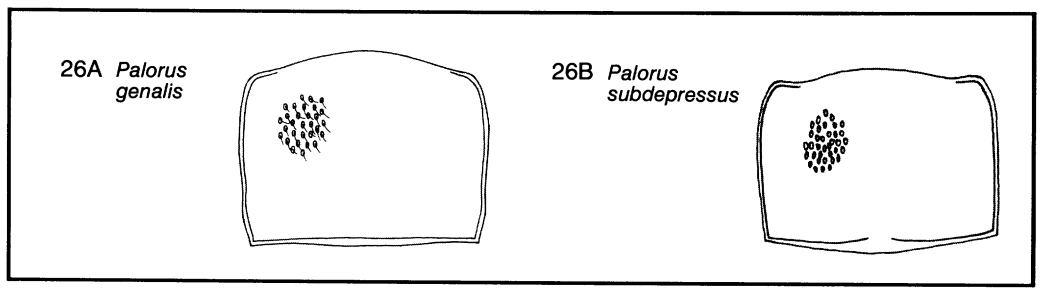
Head with fine carina adjacent to top of eye; clypeogenal suture ending within anterior border or at junction of anterior and lateral borders; punctures between eyes, when dense, are round and not deep (25B) ---------- 26



26 Pronotal punctures with setae (26A) ---------- *Palorus genalis*

Setae often abraded from medial pronotal punctures. Distribution: Oriental Region; imported into Africa, Central America, West Indies; associated with rice, nutmeg, cassava, illupe nuts, sago flour, tapioca, peanut cake, ginger, beans (cattle feed). Reference: *13*.

Pronotal punctures without setae (26B) ---------- 27

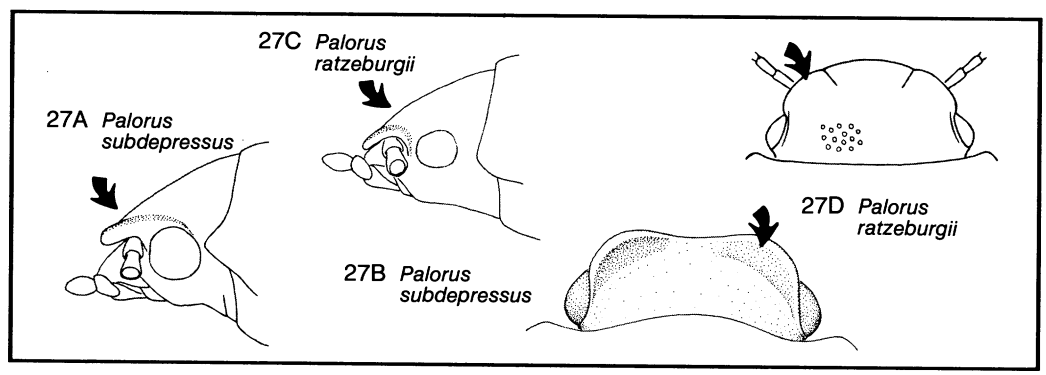


27 Clypeus with borders strongly raised laterally and dorsally to antennal insertions, causing a distinct depression posterior to border (27A, 27B); pl. 105A ---------- **depressed flour beetle,** *Palorus subdepressus*

Distribution: cosmopolitan; associated with wheat, rice, sorghum, corn, pollards, sago flour, grain, mixed feeds, peanuts, beans (cattle feed), betel nuts, illupe nuts, ginger, pepper, copra, cacao; also reported from flax seed, under bark of logs. References: *13, 22*. See also 16D, 22B, 26B.

27B redrawn from *13*.

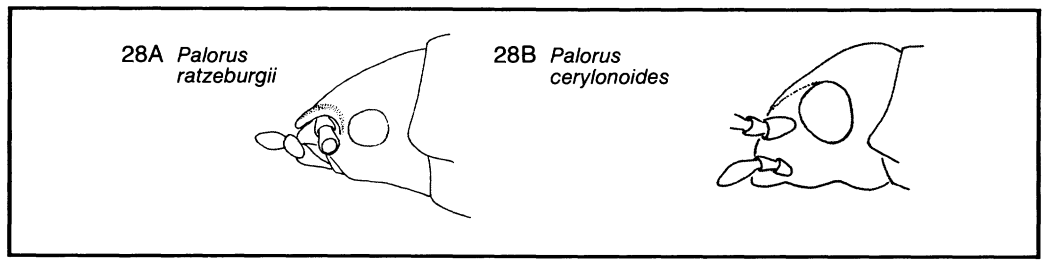
Clypeus with border at most slightly thickened (not strongly raised) laterally and dorsally to antennal insertions, with depression posterior to border vague or shallow (27C, 27D) ---------- 28



28 Eye small (28A); pl. 105C----------**smalleyed flour beetle,** *Palorus ratzeburgii*

Distribution: cosmopolitan; associated with flour, corn, barley, rice, cereals, cereal products, grain, grain products, bread, peanuts, cassava meal, caraway seeds, macaroni, semolina, rolled oats, split peas, lentils, sago, tapioca, dried milk, almonds, dried apricots, powdered ginger; also reported from linseed seeds and cakes. References: *4, 13, 14, 22.* See also 27D.

Eye large (28B) ---------- 29

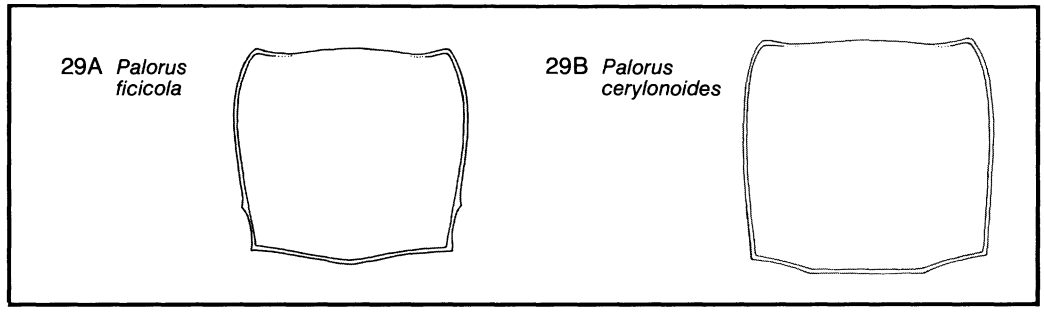


29 Pronotum with lateral borders moderately to strongly convergent to base (29A) ---------- *Palorus ficicola*

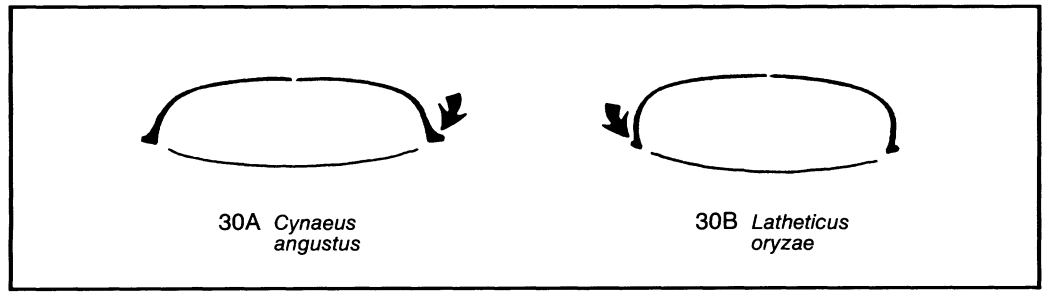
Distribution: Africa; associated with wheat, peanuts, sorghum; also reported from rice store spillage. Reference: *13.*

Pronotum with lateral borders subparallel to weakly convergent to base (29B) ----------*Palorus cerylonoides*

Distribution: Africa, Oriental Region; associated with illupe nuts, rice, flour mills; also reported from under bark of trees. Reference: *13.* See also 28B.
29A&B redrawn from *13.*



30 Length at least 6.5 mm; ridge of pseudopleuron easily visible in dorsal view (30A) 31
Length less than 4 mm; ridge of pseudopleuron hidden in dorsal view (30B)-------- 32



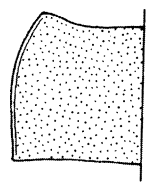
31 Pronotum covered with fine punctures (31A); apex of antenna surpassing base of pronotum by length (or more) of last segment (pl. 106A)-------*Sitophagus hololeptoides*

Surface shiny; males only with epistoma curved dorsally into 2 broad horns (pl. 106A) (epistoma simple in females). Distribution: Central America, Madeira, Mexico, Panama, South America, USA (Arizona, California, Florida, Texas), West Indies; associated with corn, cereals, nutmeg, cacao, copra, avocados, limes, tomatoes, peanuts, yams; also reported from gumbo-limbo and *Pinus ponderosa*. Reference: *22.*. See also 14B.

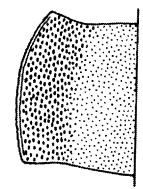
Pronotum with coarse punctures laterally and fine punctures medially (31B); apex of antenna falling short of pronotal base by the length (or more) of last 2 segments (pl. 103D)----------**larger black flour beetle,** *Cynaeus angustus*

Both sexes with simple, unarmed epistoma (pl. 103D). Distribution: North America; associated with wheat, flour, corn, oats, rolled oats, barley, sorghum, grain, cereal products, flaked soybeans, dried figs; also reported from corn cobs. Reference: *20*. See also 30A.

31A *Sitophagus hololeptoides*



31B *Cynaeus angustus*



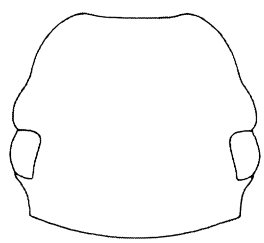
32 Length of head before eyes much greater than ½ distance between eyes (32A); antenna short (length less than distance between eyes) (pl. 104C) ----------**longheaded flour beetle,** *Latheticus oryzae*

Mandibles unarmed. Distribution: cosmopolitan; associated with wheat, flour, corn, rye, barley, rolled barley, milo, rice, grain products, cereals, mixed feeds, beans, raisins, cassava chips, oatmeal, bran, tea. References: *6, 22, 24*. See also 30B.

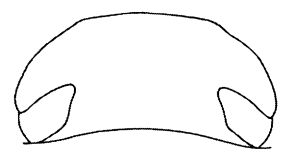
Length of head before eyes not greater than ½ distance between eyes (32B); antenna long (length more than 1.5 times distance between eyes) (pl. 106B). Genus *Gnatocerus*---------- 33

Mandibles armed only in males (see 34A&B). Reference: *27*.

32A *Latheticus oryzae*



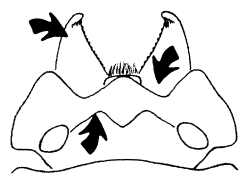
32B *Gnatocerus cornutus*



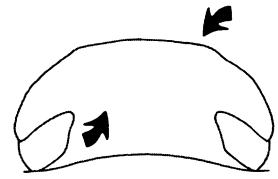
33 Males; mandibles with horns; head with 2 or 4 tubercles between eyes; epistoma incised anteriorly (accommodating dorsally projected mandibular horns) (33A; pl. 106B&C)---------- 34

Females; mandibles without horns; head without tubercles between eyes; epistoma not incised (33B)---------- 35

33A *Gnatocerus cornutus* ♂



33B *Gnatocerus cornutus* ♀



34 Mandibular horns broad and finely serrate (34A); pl. 106B
----------**broadhorned flour beetle,** *Gnatocerus cornutus*

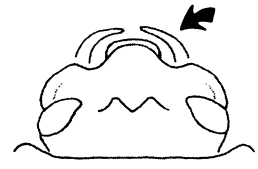
Distribution: cosmopolitan; associated with flour, bran, corn, cornmeal, farina, semolina, pancake flour, oatmeal, rolled barley, milo, rice, flaked rice, cereal, cereal products, mixed feeds, cacao, ginger, spices, army biscuit, bread, dog biscuit, yeast cakes; also reported from beet seed, cottonseed meal cake, pyrethrum flowers, rotenone powder, bone meal, animal products, cotton gin trash. References: *22, 23, 25, 28.*

Mandibular horns slender and simple (34B); pl. 106C
----------**slenderhorned flour beetle,** *Gnatocerus maxillosus*

Distribution: cosmopolitan; associated with wheat, corn, cornmeal, rice, mixed feeds, peanuts, nutmeg; also reported from tamarind pods, pumpkin seeds. Reference: *22.*

34A *Gnatocerus cornutus* ♂

34B *Gnatocerus maxillosus* ♂

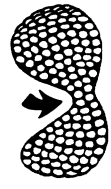


35 Eye deeply incised (composed of only 1 or 2 facets at narrowest) (35A)
----------**broadhorned flour beetle,** *Gnatocerus cornutus*

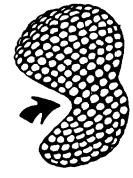
Eye moderately incised (composed of more than 2 facets at narrowest) (35B)
----------**slenderhorned flour beetle,** *Gnatocerus maxillosus*

Drawings by A.D. Cushman.

35A *Gnatocerus cornutus* ♀

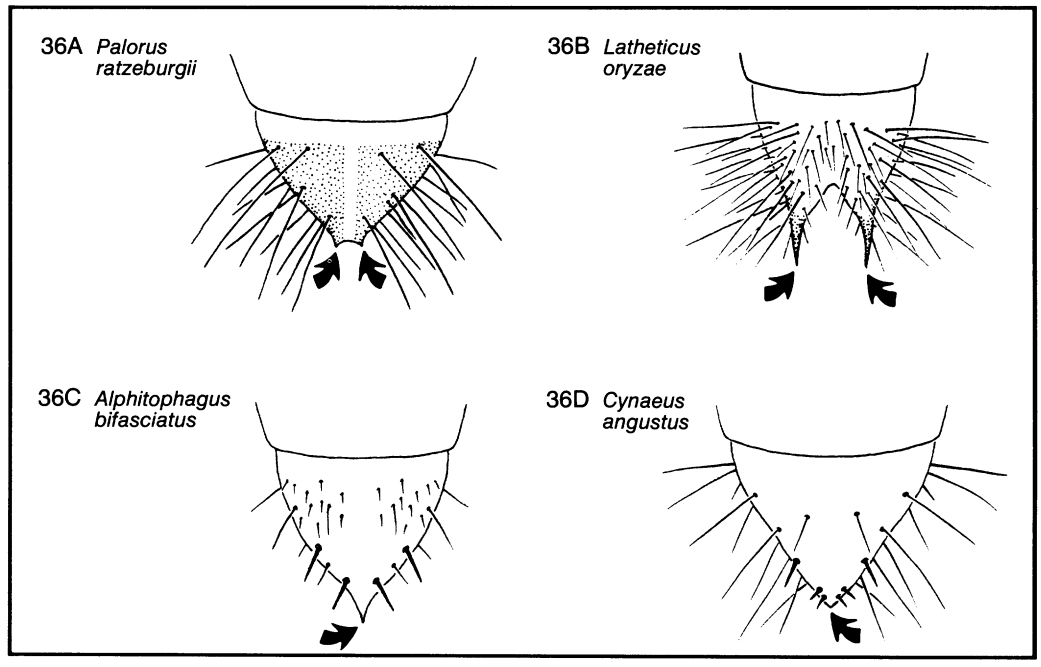


35B *Gnatocerus maxillous* ♀

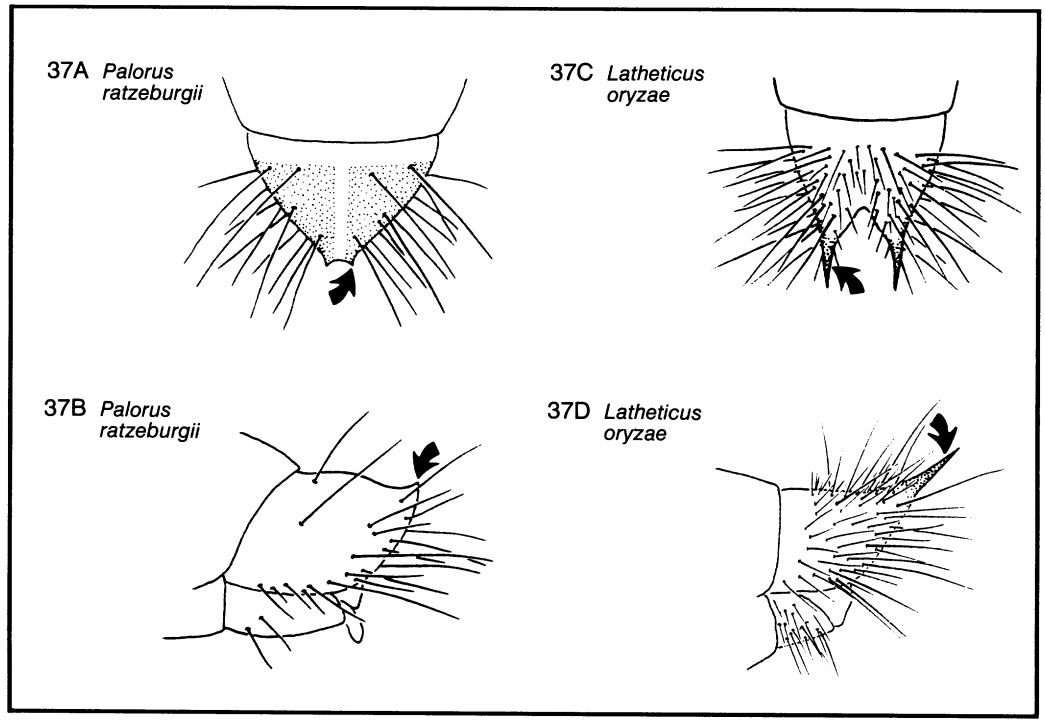


Larvae

36 Last abdominal tergum with 2 acute processes (urogomphi) (36A, 36B)---------- 37
Last abdominal tergum narrowed to a single acute or blunt process (36C, 36D)--- 47



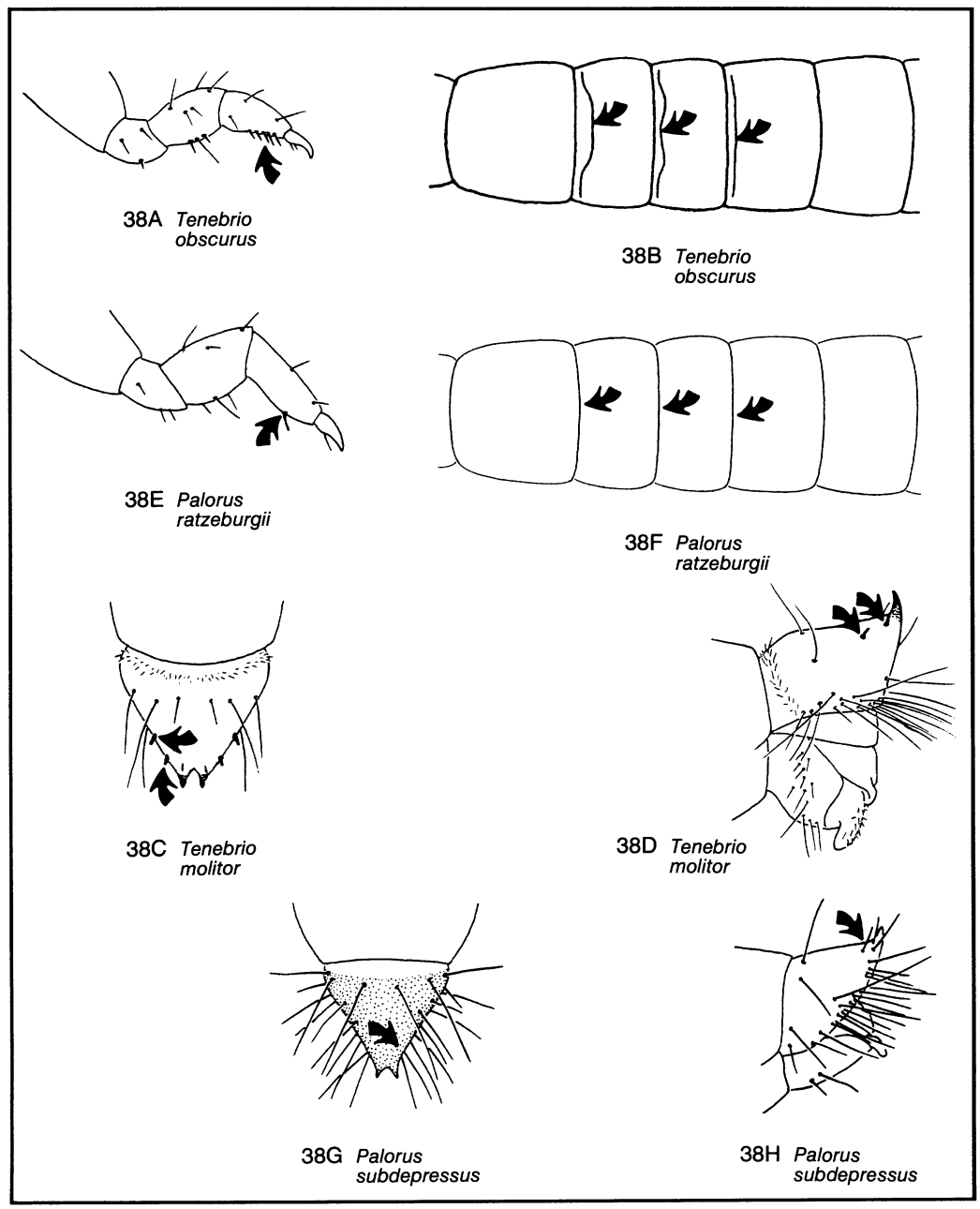
37 Urogomphus short (length approximately 1/5 or less length of last tergum including urogomphi) (37A, 37B)---------- 38
Urogomphus long (length 1/3 to 2/3 length of last tergum including urogomphi) (37C, 37D)---------- 41



38 Tibiotarsus I with 4 or 5 ventral setae (38A); thoracic terga II and III and abdominal tergum I each with distinct anterior transverse carina or raised line (38B); last abdominal tergum with 2 short stout setae on each side near base of urogomphi (38C, 38D)---------- 39

Drawing 38B by A.D. Cushman.

Tibiotarsus I with 1 ventral seta (38E); thoracic terga II and III and abdominal tergum I without anterior transverse carina or raised line (38F); last abdominal tergum without short stout setae on each side (38G, 38H)---------- 40

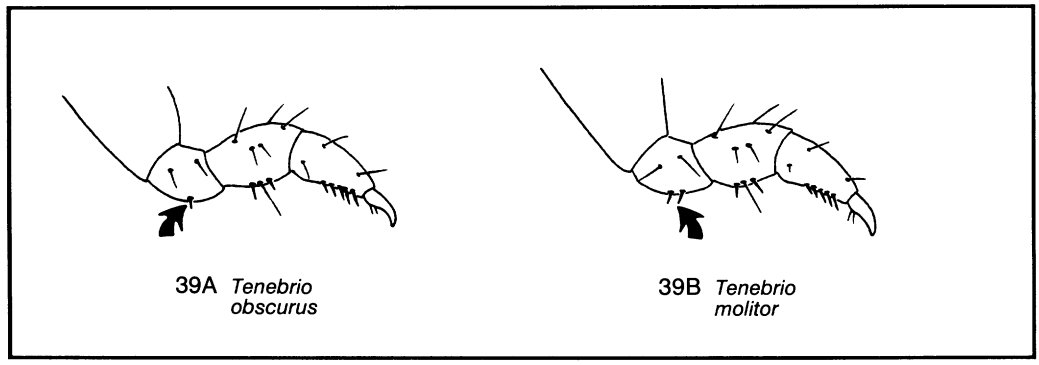


39 Trochanter I with 1 short stout ventral seta (39A)-----**dark mealworm,** *Tenebrio obscurus*

See also 38B.

Trochanter I with 2 short stout ventral setae (39B); pl. 101A
----------**yellow mealworm,** *Tenebrio molitor*

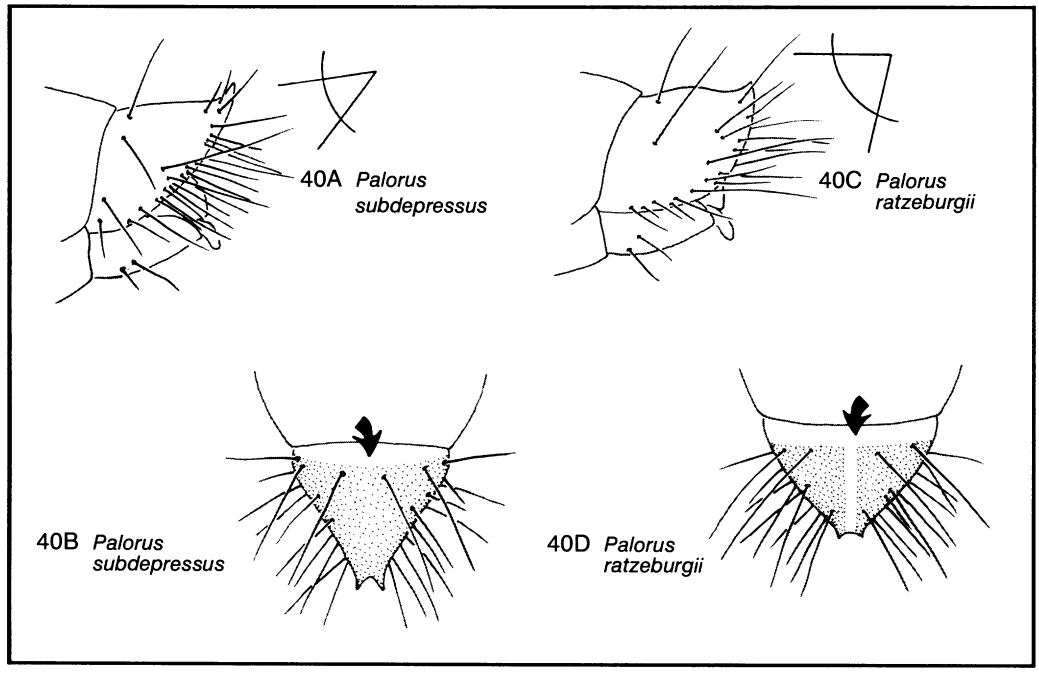
See also 38C&D.



40 Last abdominal tergum with area ventral to urogomphus inclined approximately 45° from horizontal (40A), with lateral borders moderately converging posteriorly (40B), and without a colorless longitudinal medial line (40B)
----------**depressed flour beetle,** *Palorus subdepressus*

Last abdominal tergum with area ventral to urogomphus inclined approximately 70° from horizontal (40C), with lateral borders strongly converging posteriorly (40D), and with a colorless longitudinal medial line (40D)
----------**smalleyed flour beetle,** *Palorus ratzeburgii*

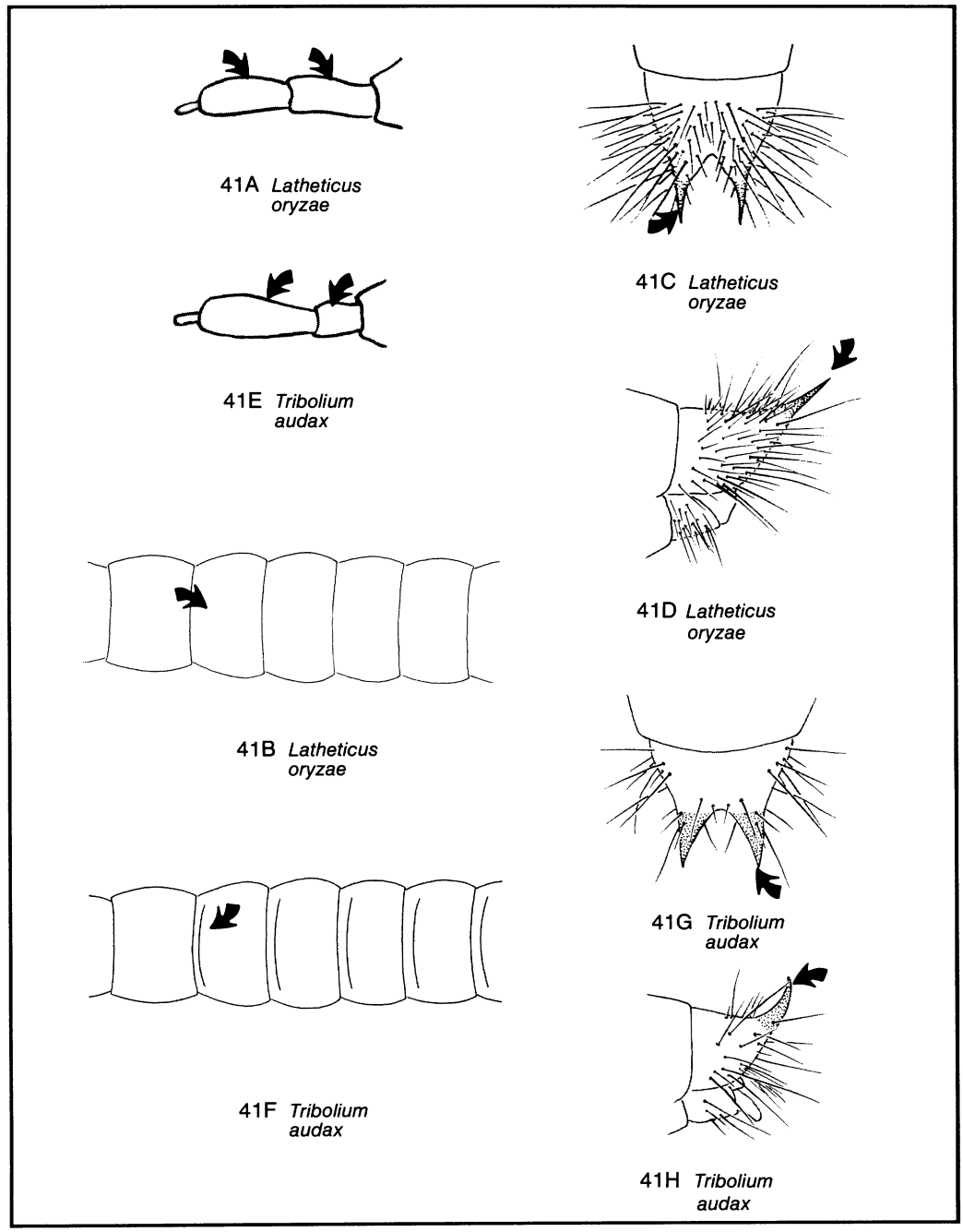
See also 37A, 38E&F.



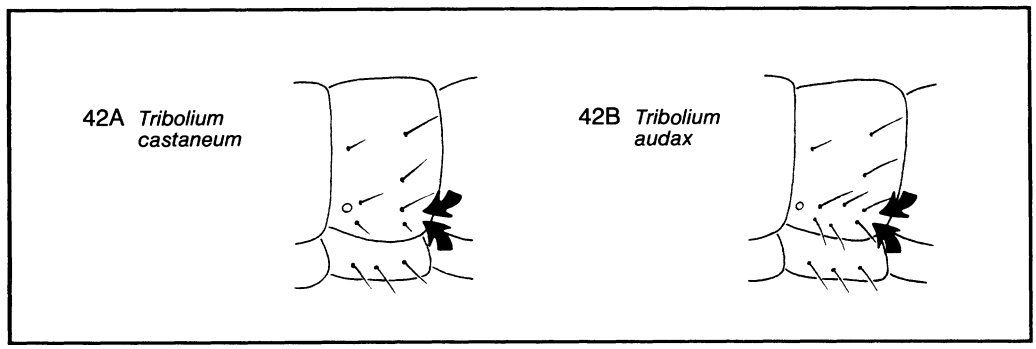
41 Antennal segments I and II subequal in length (41A); thoracic and abdominal terga lacking a distinct anterior transverse carina or raised line (41B); urogomphus light or white basally, dark apically (41C, 41D)---------**longheaded flour beetle,** *Latheticus oryzae*

Drawings 41A&E by A.D. Cushman.

Antennal segment I approximately 1/2 as long as II (41E); thoracic tergum II through abdominal tergum VII each with a distinct anterior transverse carina or raised line (41F); urogomphus uniformly colored (41G, 41H)---------- 42

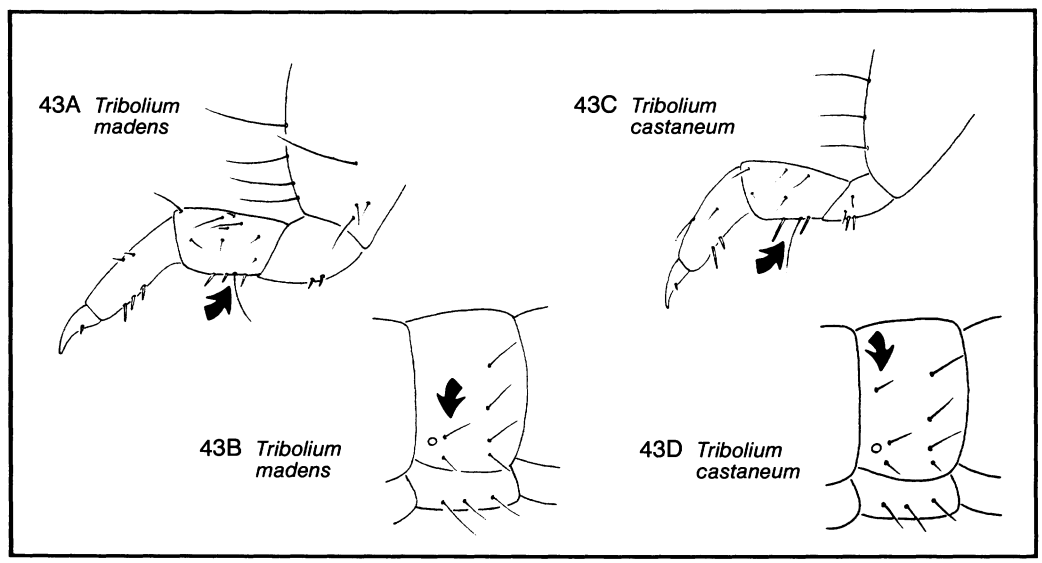


42 Abdominal segments I to IV each with 2 setae above and 2 below an imaginary line drawn posteriorly from spiracle (42A)---------- 43
Abdominal segments I to IV each with 3 setae above and 3 below line drawn posteriorly from spiracle (42B)---------- 44

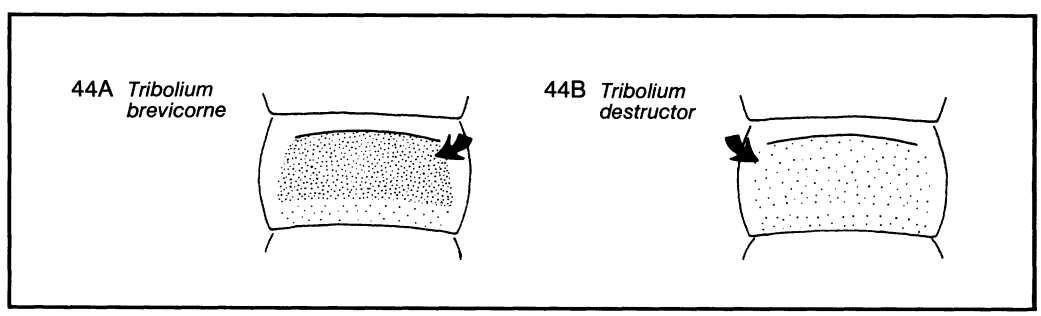


43 Femur I with 4 ventral setae (43A); abdominal terga I to IV with 2 long setae on each side in anterior row of setae (43B)----------black flour beetle, *Tribolium madens*

Femur I with 3 ventral setae (43C); abdominal terga I to IV with 3 long setae on each side in anterior row of setae (43D)----------**red flour beetle,** *Tribolium castaneum*



44 Abdominal terga I to IV with sclerotized areas dark brown (44A)---------- 45
Abdominal terga I to IV with sclerotized areas yellowish (44B)---------- 46

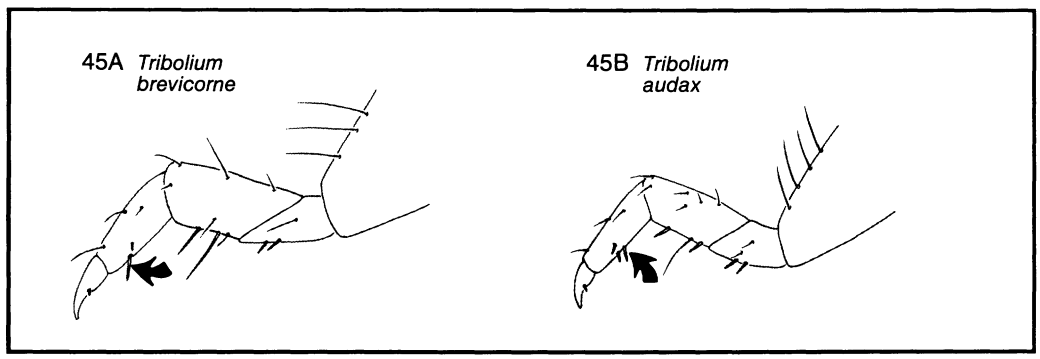


45 Tibiotarsus I with 1 ventral seta (45A)----------giant flour beetle, *Tribolium brevicorne*

See also 44A.

Tibiotarsus I with 2 ventral setae (45B)-----**American black flour beetle,** *Tribolium audax*

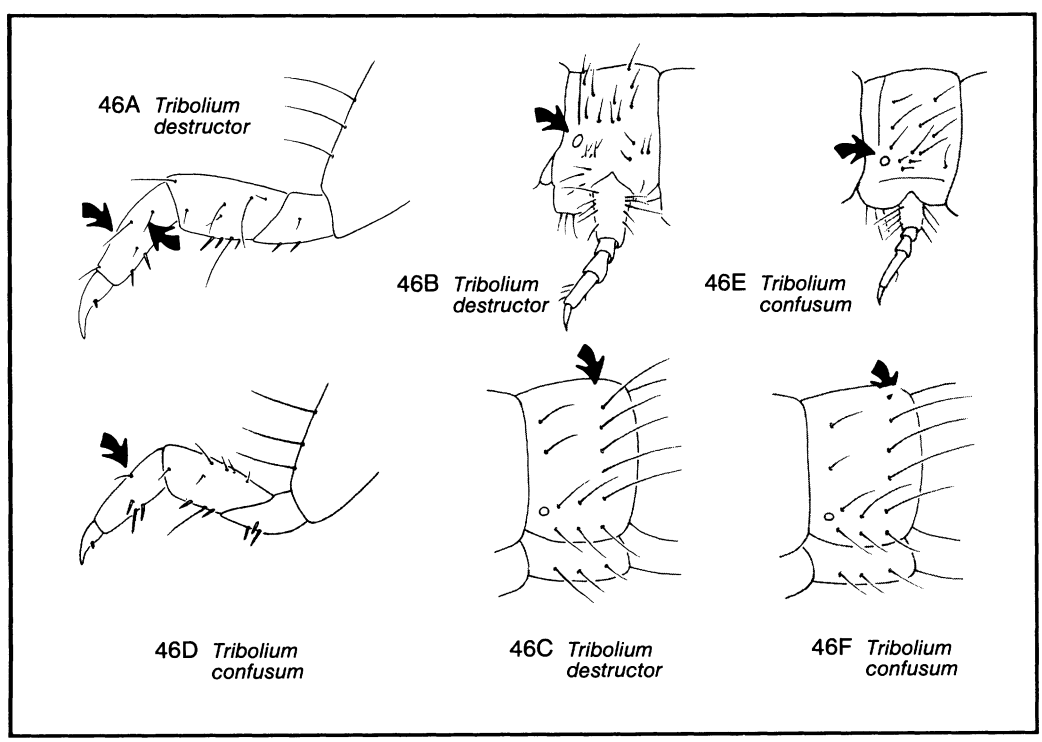
See also 41E-H, 42B.



46 Tibiotarsus I with 2 posterodorsal setae (46A); mesothoracic spiracle oval (46B); abdominal terga I to IV with 6 or 7 long setae on each side in posterior row of setae (46C)----------false black flour beetle, *Tribolium destructor*

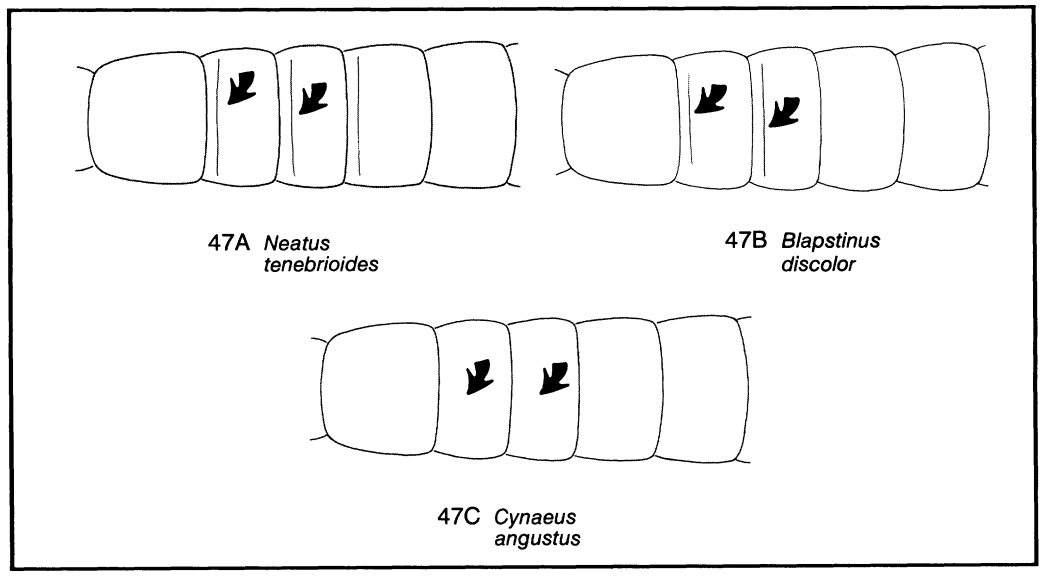
See also 44B.

Tibiotarsus I with 1 posterodorsal seta (46D); mesothoracic spiracle round (46E); abdominal terga I to IV with 4 or 5 long setae on each side in posterior row of setae (46F); pl. 99A----------**confused flour beetle,** *Tribolium confusum*



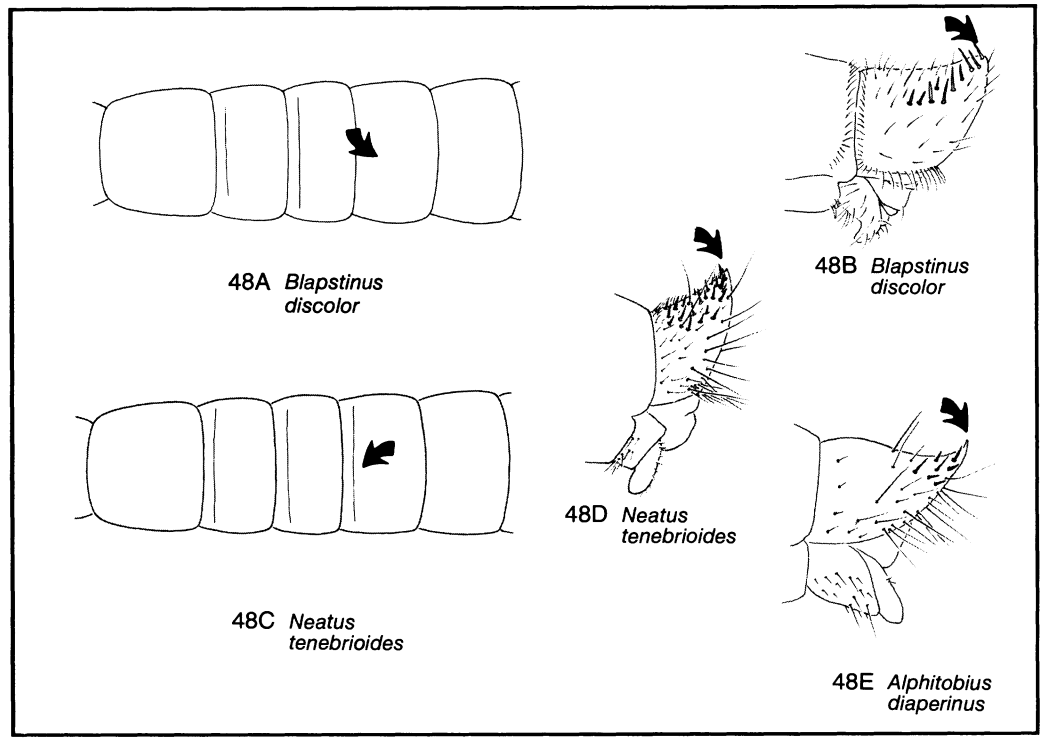
47 Thoracic terga II and III with distinct anterior transverse carina or raised line (47A, 47B)---------- 48

Thoracic terga II and III without anterior transverse carina or raised line (47C)----- 51



48 Abdominal tergum I without anterior transverse carina or raised line (48A); tergum of last abdominal segment with blunt apex (48B) ----------fig darkling beetle, *Blapstinus discolor*

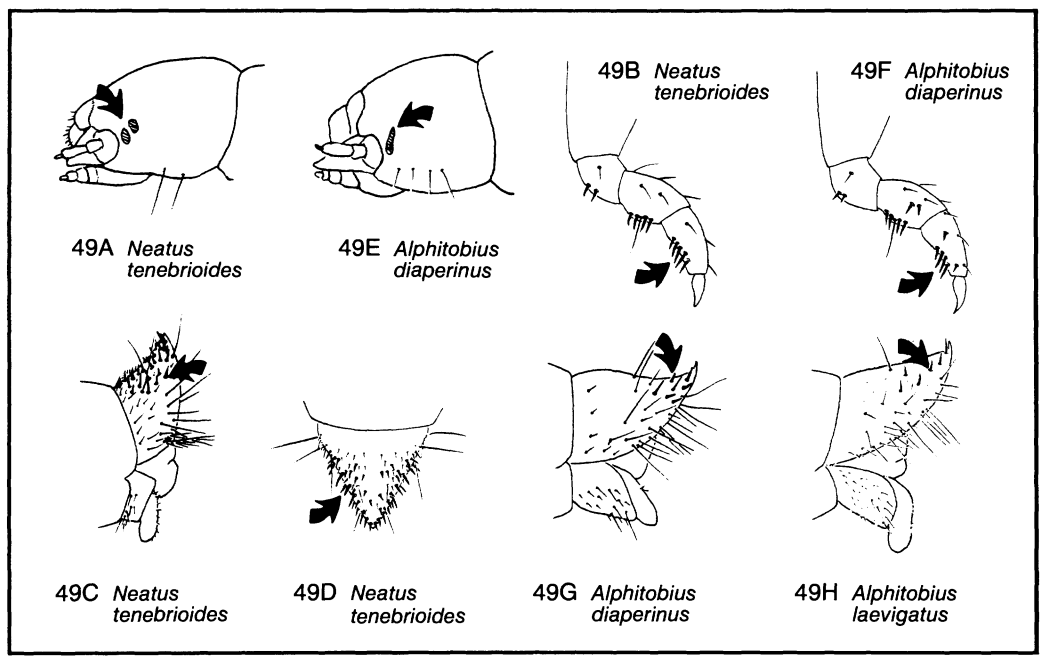
Abdominal tergum I with a distinct anterior transverse carina or raised line (48C); tergum of last abdominal segment with acute apex (48D, 48E)---------- 49



49 Head with 2 eye spots on each side (49A); tibiotarsus I with 5 or more coarse setae ventrally and only long slender setae posteriorly (49B); last abdominal tergum with numerous short setae (approximately 15) on each side (49C, 49D)
----------*Neatus tenebrioides*

See also 48B&C.
Drawings 49A&E by A.D. Cushman.

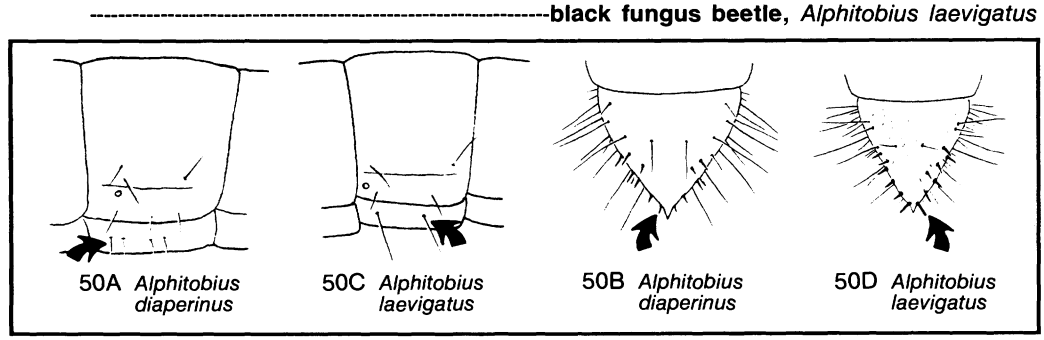
Head with 1 eye spot on each side (49E); tibiotarsus I with 4 or fewer coarse setae ventrally and at least 1 short thick seta in addition to long slender setae posteriorly (49F); last abdominal tergum with longer and fewer setae (approximately 6) on each side (49G, 49H)---------- 50



50 Abdominal sterna II to VII with 3 or more setae laterally (50A); last abdominal tergum with seta adjacent to apex not extending to apex (50B; see also 49G)
----------**lesser mealworm,** *Alphitobius diaperinus*

See also 49E&F.
Drawings 50A&C by A.D. Cushman.

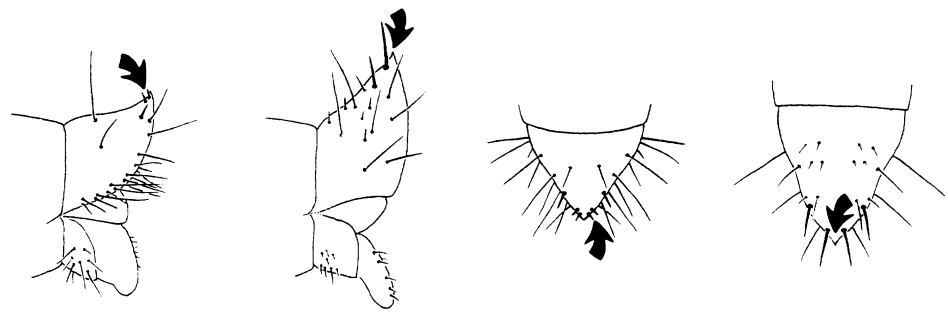
Abdominal sterna II to VII with 2 setae laterally (50C); last abdominal tergum with seta adjacent to apex or beyond (50D; see also 49H)
----------**black fungus beetle,** *Alphitobius laevigatus*



51 Last abdominal tergum with a pair of short setae on each side near apex (51A, 51B) ----------**larger black flour beetle,** *Cynaeus angustus*

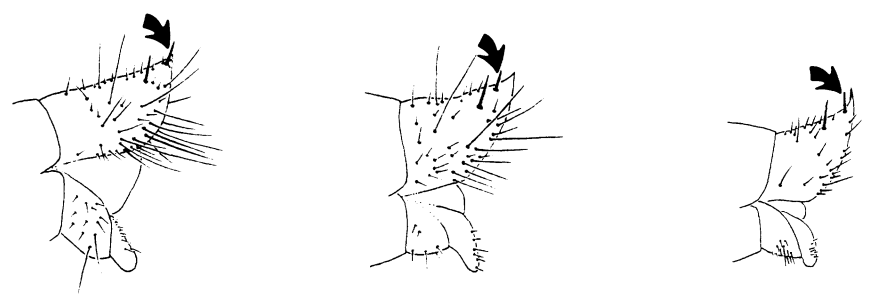
See also 47C.

Last abdominal tergum without a pair of short setae on each side near apex (51C, 51D)---------- 52



51A *Cynaeus angustus* 51C *Platydema ruficorne* 51B *Cynaeus angustus* 51D *Platydema ruficorne*

52 Last abdominal tergum with posterolateral seta far surpassing apex (52A, 52B)--- 53
Last abdominal tergum with posterolateral seta not surpassing apex (52C, 52D, 52E)---------- 54



52A *Sitophagus hololeptoides* 52C *Gnatocerus maxillosus* 52D *Alphitophagus bifasciatus*

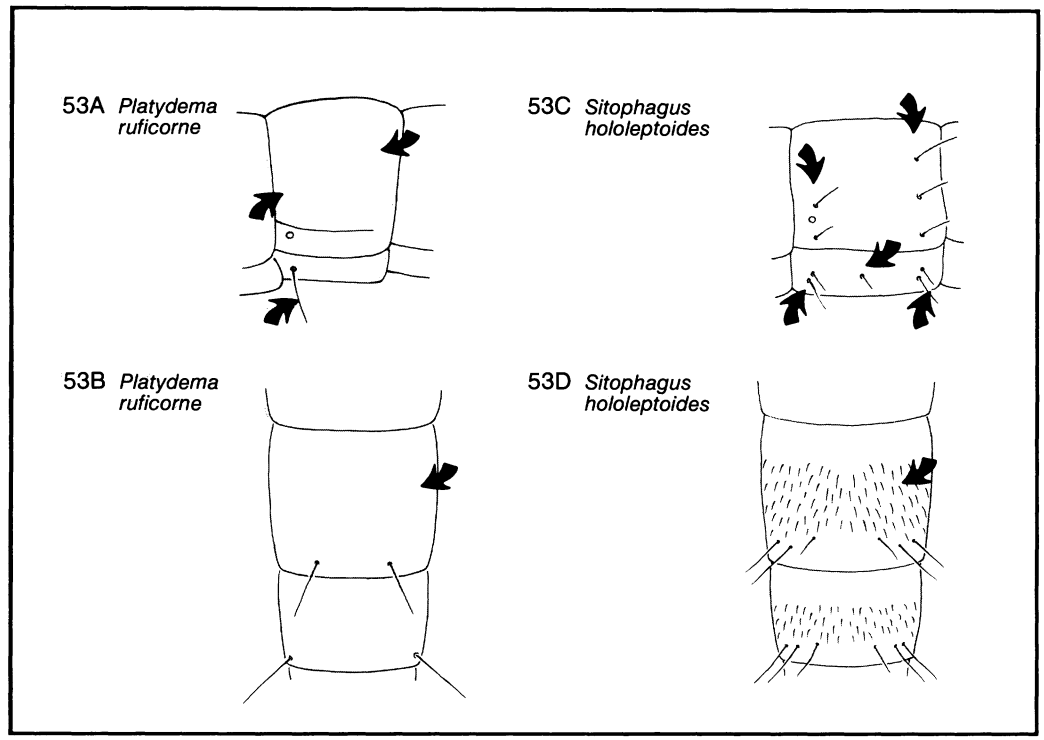
52B *Sitophagus hololeptoides* 52E *Gnatocerus maxillosus*

53 Abdominal sterna II to IV with 1 long seta in anterior corner (53A); abdominal terga II to IV without setae (53A) and VII and VIII without short setae (53B) ----------redhorned grain beetle, *Platydema ruficorne*

See also 51C&D.

Abdominal sterna II to IV with 2 long setae in anterior corner, 2 in posterior corner, and 1 between the corners (53C); abdominal terga II to IV with 2 setae in anterior row and 3 setae in posterior row (53C), and VII and VIII with numerous short setae (53D)----------*Sitophagus hololeptoides*

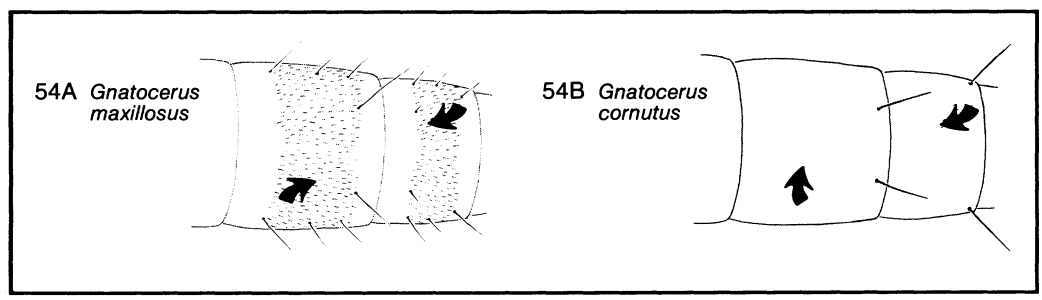
See also 52A&B.



54 Abdominal terga VII and VIII with numerous short setae (54A) ----------**slenderhorned flour beetle,** *Gnatocerus maxillosus*

See also 52C&E.

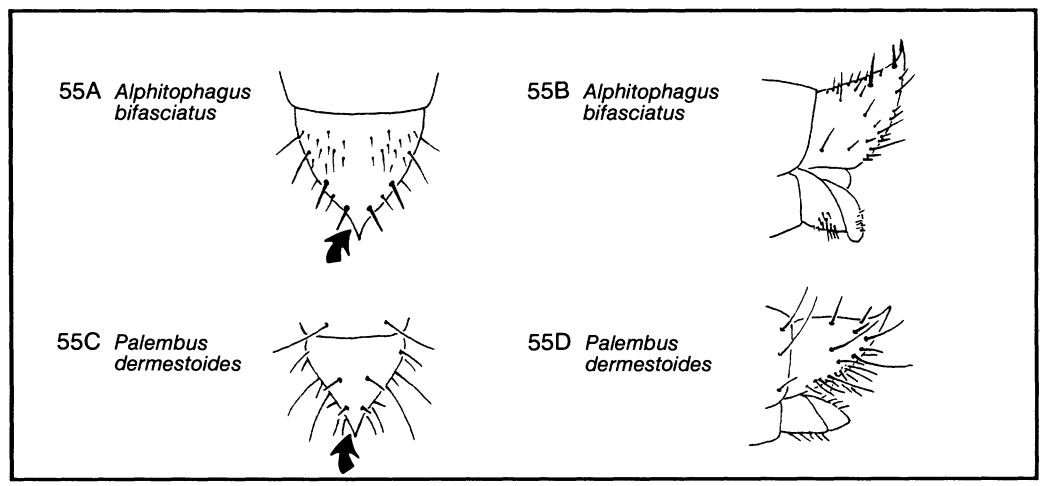
Abdominal terga VII and VIII without short setae (54B)---------- 55



55 Last abdominal tergum with apex suddenly narrowed (55A, 55B)
----------**twobanded fungus beetle,** *Alphitophagus bifasciatus*

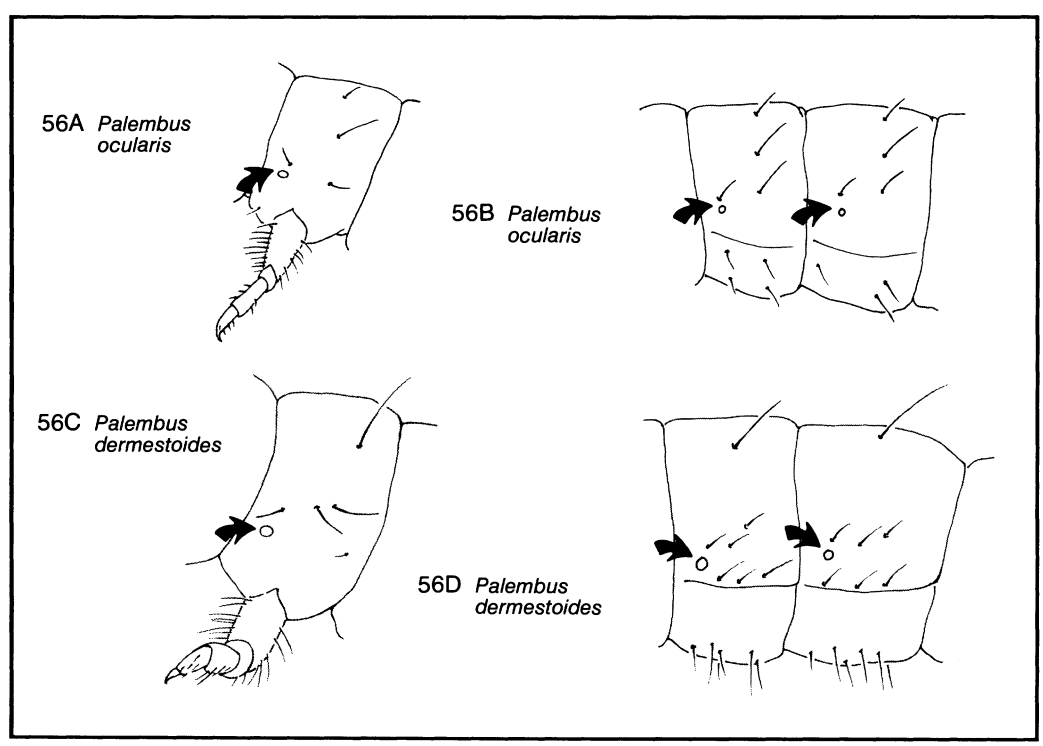
See also 36C, 52D.

Last abdominal tergum with apex gradually narrowed (55C, 55D)---------- 56



56 Mesothoracic spiracle oval (56A); spiracle of abdominal segment I subequal in size to spiracle of segment II (56B); abdominal terga VII and VIII obviously darker than terga II to VI----------*Palembus ocularis*

Mesothoracic spiracle round (56C); spiracle of abdominal segment I obviously larger than spiracle of segment II (56D); abdominal terga I to VIII light colored---------- 57

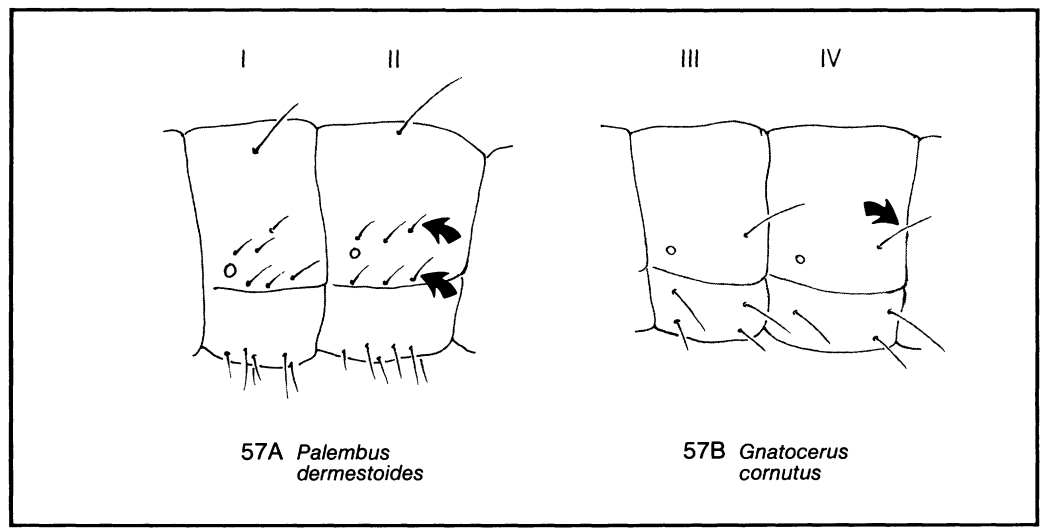


57 Abdominal terga II to IV with 3 setae above and 3 setae below an imaginary line drawn posteriorly from spiracle (57A)----------*Palembus dermestoides*

See also 55C&D, 56C.

Abdominal terga II to IV with 1 seta above and no setae below an imaginary line drawn posteriorly from spiracle (57B)----------**broadhorned flour beetle,** *Gnatocerus cornutus*

See also 54B.



57A *Palembus dermestoides*

57B *Gnatocerus cornutus*

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12 SEED BEETLES (BRUCHIDAE, COLEOPTERA)

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Seeds of many food plants, especially those in the bean family (Fabaceae), are often infested by bruchids. Since the larvae feed internally, an infestation may not become apparent until the adults emerge. Adults are easily recognized to species, but the larvae are difficult to determine to genus or species, even with reference specimens available for comparison. Some species are not separable in the larval stage. The larvae are plump, white or yellowish grubs with legs reduced (pl. 108A, 109A) or absent (pl. 107A). The most important taxonomic feature of larvae is the shieldlike labial plate (sclerome) on which the labial palpi are reduced to a pair of setae (see couplet illustration 29A, adapted from *2,* in chapter 4). The mandibles of the larvae are rounded apically and lack teeth (*2*).

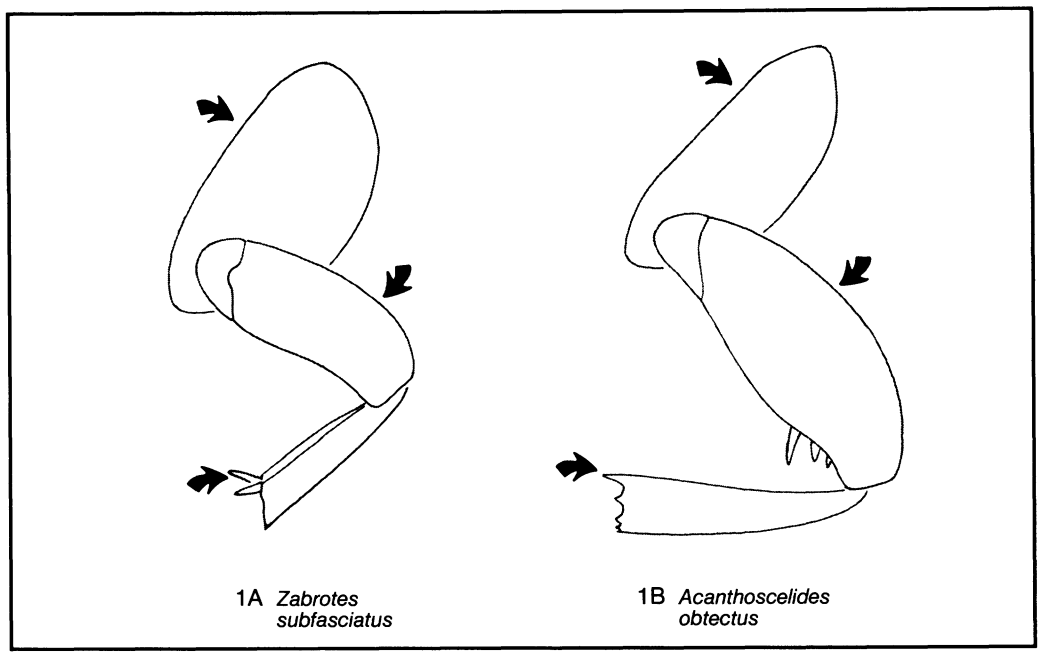
KEY TO ADULTS

Drawings by C. Feller unless otherwise noted.

1 Apex of tibia III with 2 movable spurs; coxa III much wider than femur III (1A); pl. 107B&C ----------**Mexican bean weevil,** *Zabrotes subfasciatus*

Distribution: Africa, India, tropical America; in common bean varieties.

Apex of tibia III without movable spurs (fixed spines may be present); coxa III ranges in width from narrower to scarcely wider than femur III (1B) ---------- 2



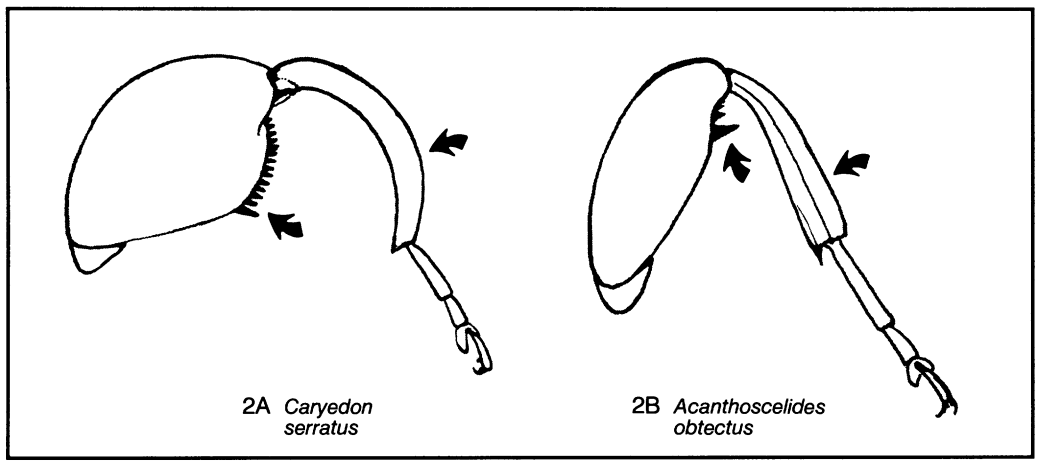
1A *Zabrotes subfasciatus*

1B *Acanthoscelides obtectus*

2 Femur III greatly enlarged, with 1 large tooth and 11 or 12 smaller teeth on ventral margin; tibia III curved, matching curvature of femur III (2A); pl. 108B ----------groundnut bruchid, *Caryedon serratus*

Distribution: Old World tropics; introduced to New World tropics; in seeds of tamarind (*Tamarindus indica*) in India, Mexico, and Caribbean islands, acacia (*Acacia* spp.), *Cassia* spp., peanuts (*Arachis hypogaea*) in Africa, and other legumes (Fabaceae) (*1*).
Drawings 2A&B by A.D. Cushman.

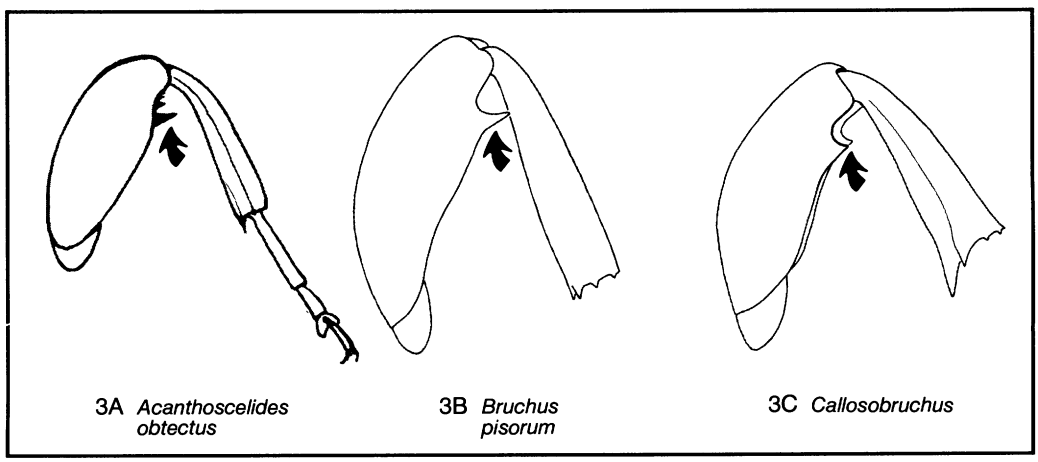
Femur III not greatly enlarged; no more than 4 teeth on ventral margin of femur III; tibia III nearly straight (2B) ---------- 3



3 With leg III in closed position, ventral margin of femur III with 3 or 4 teeth inside tibia III and no teeth outside tibia III (3A); pl. 108C------**bean weevil,** *Acanthoscelides obtectus*

Distribution: cosmopolitan; in seeds of beans (*Phaseolus* spp.).
Drawing 3A by A.D. Cushman.

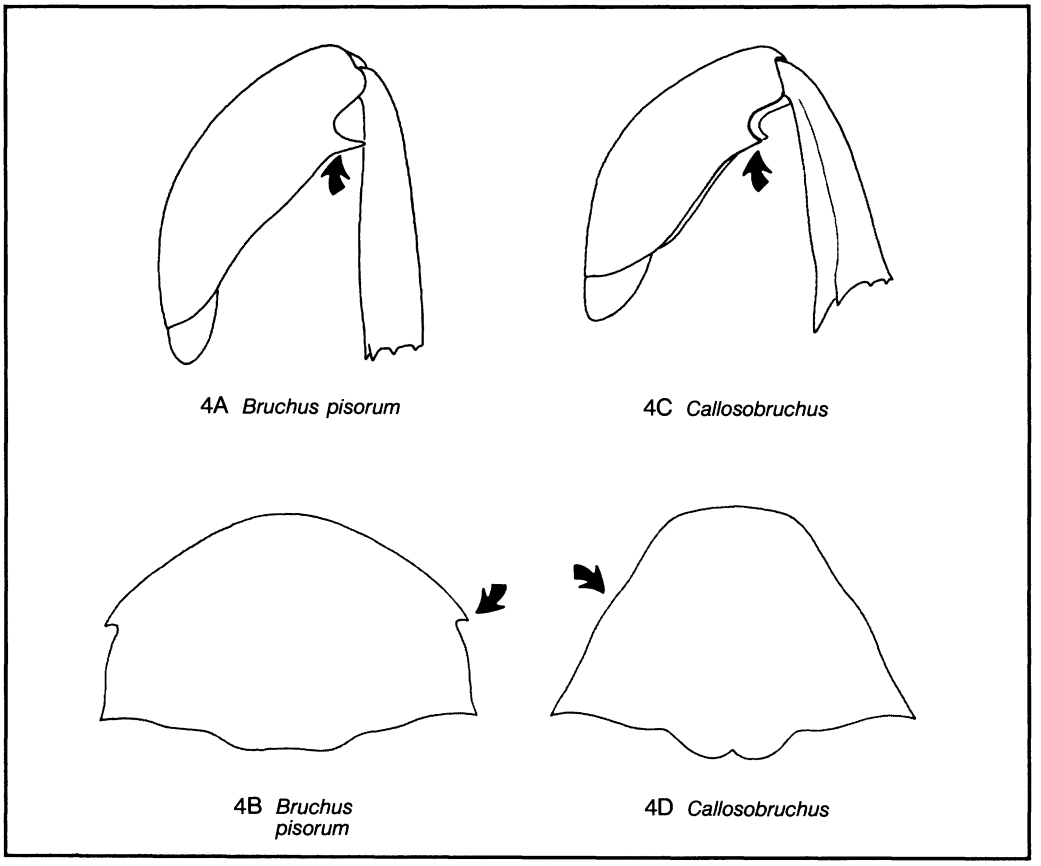
With leg III in closed position, ventral margin of femur III with 1 or no internal teeth and 1 external tooth (3B, 3C) ---------- 4



4 Femur III with external tooth only (4A); pronotal margin with 1 tooth (4B); pl. 109B
----------**pea weevil,** *Bruchus pisorum*

Distribution: cosmopolitan; in seeds of garden pea (*Pisum sativum*).

Femur III with 1 external tooth and 1 internal tooth (4C); pronotal margin with no teeth (4D) 5

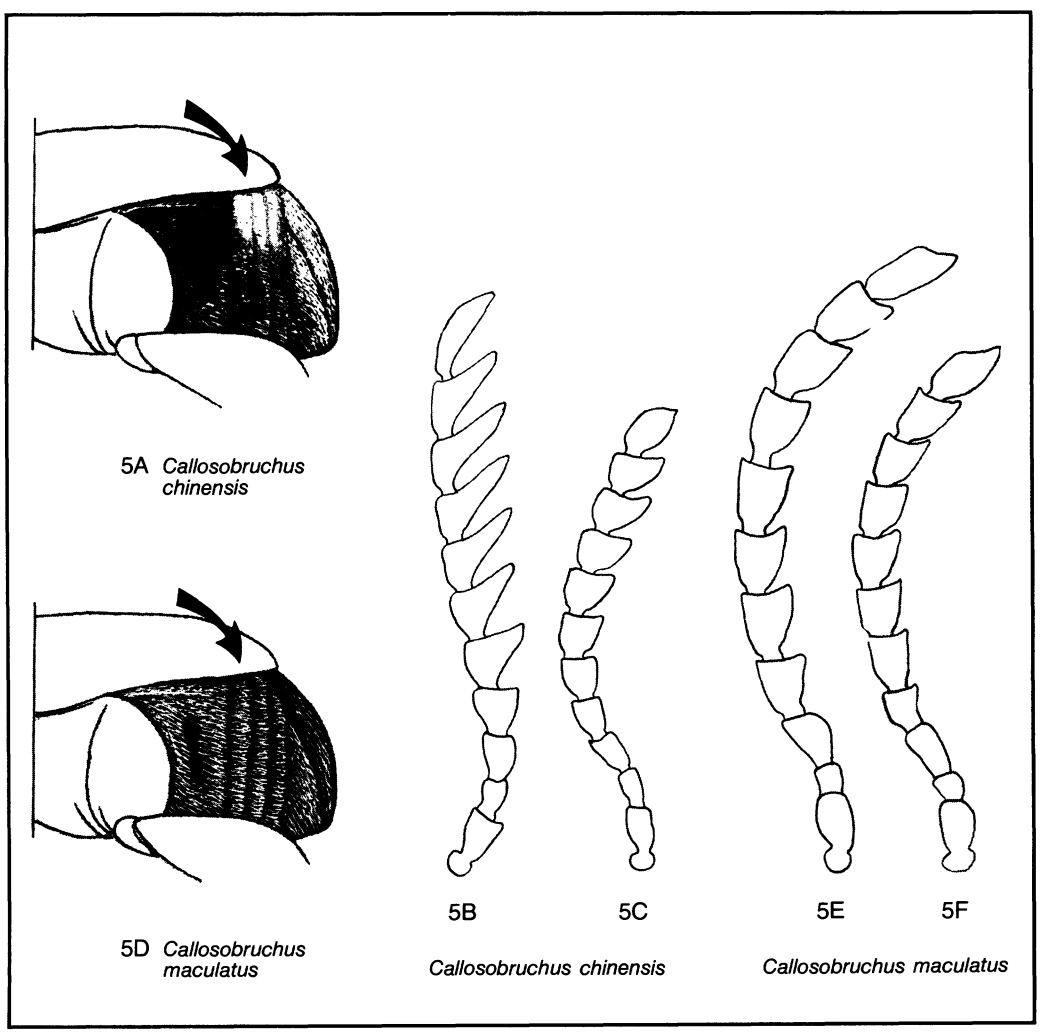


5 Dorsal margin of abdominal segments II to V with a dense, continuous patch of white hair (5A); antenna pectinate (5B, male) or serrate (5C, female); pl. 1K
---------- Chinese pea weevil, *Callosobruchus chinensis*

Distribution: cosmopolitan; in various legumes, including pigeon pea (*Cajanus cajan*), hyacinth bean (*Dolichos lablab*), garden bean (*Phaseolus vulgaris*), broadbean (*Vicia faba*), adzuki bean (*Vigna angularis*), mung bean (*V. r. radiata*), cowpea (*V. u. unguiculata*). Other common names: southern cowpea weevil, adzuki bean weevil, mung bean weevil.

Dorsal margin of abdominal segments II to V with diffuse yellowish or whitish hair not in a dense patch (5D); antenna serrate (5E, 5F); pl. 1J
---------- **cowpea weevil,** *Callosobruchus maculatus*

Distribution: cosmopolitan; in seeds of hyacinth bean, cowpea, mung bean, garden bean, and other legumes.
Drawings 5A&D by A.D. Cushman; 5B&C&E&F by J.M. Kingsolver.



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Notes and Sketches

13 WEEVILS (CURCULIONIDAE, COLEOPTERA)

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The few kinds of weevils customarily considered as stored product pests are among those keyed and illustrated in this chapter. These are the weevils most likely to cause losses in storage or to be pantry pests. Their foods are subject to postharvest attack and injury.

Most other weevils that are food pests develop along with their hosts and are likely to have left the crop by harvest time or to be nearly ready to do so. Some species leave before pupation; in this case adults are unlikely to be encountered. In other species, pupation occurs in the host, and adults may be found in the market place. A few species, notably the **sweet potato weevil,** may even increase in numbers during storage.

The **cowpea curculio** and the **pecan weevil** are keyed and illustrated as examples of preharvest food pests. The following survey of additional, primarily preharvest, pests lists only some highlights. The emphasis is on North American pests and some possible future immigrants, especially those from tropical America and Eurasia.

Root and Stem Crops

Beets, sugar beets. *Bothynoderes punctiventris* (Germar) is a major pest in central Europe. Other potential immigrants from Eurasia are *Chromoderus fasciatus* (Müller) and *Conorrhynchus mendicus* (Gyllenhal).

Carrots. The **carrot weevil,** *Listronotus oregonensis* (LeConte), is indigenous. *Liparus coronatus* (Goeze) and *Mecaspis alternans* (Herbst) are potential immigrants from Eurasia.

Horseradish. *Baris lepidii* Germar is a destructive, recent immigrant from Eurasia.

Onions. At least four species of *Brachycerus* are potential immigrants from Mediterranean Europe.

Potatoes. The Andean genus *Premnotrypes* includes 12 species, most of which are known pests but of unknown immigration potential.

Sugarcane. In the American tropics, at least two species of *Metamasius* are pests, particularly of injured or overripe sugarcane.

Sweet potatoes. The **sweet potato weevil,** *Cylas formicarius elegantulus* (Summers), is a major pest throughout warm parts of the world except in Africa where sweet potatoes are eaten by several other species of *Cylas*. Several other kinds of weevils infest sweet potato tubers, including two West Indian species, *Euscepes postfasciatus* (Fairmaire), which has spread to Pacific islands, and *Palaeopus costicollis* Marshall, which also infests yams.

Yams. Two potential immigrants are *Palaeopus costicollis* from the West Indies and *Elytroteinus subtruncatus* (Fairmaire) from the Pacific region.

Fruit Crops

Cucurbits. The melon weevil, *Acythopeus curvirostris* (Boheman), is a potential immigrant from Eurasia.

Legumes. Peas and beans are eaten in the field by various species, native and exotic, of *Apion* and *Chalcodermus*.

Nuts. North American nuts are attacked by various indigenous species of *Conotrachelus* and *Curculio*. Other species of *Curculio* from Eurasia are potential immigrants.

Orchard fruits. Fruits of apple, cherry, peach, pear, and plum are eaten by various species of *Coccotorus, Conotrachelus,* and *Tachypterellus* in North America and *Furcipus* in Eurasia.

Peppers. The **pepper weevil,** *Anthonomus eugenii* Cano, is an immigrant from Mexico.

Small fruits. Most berry weevils attack buds rather than fruits, but at least one indigenous species of *Anthonomus* feeds on cranberry fruits. The **grape curculio,** *Craponius inaequalis,* is indigenous.

Tropical fruits. Avocado fruits in tropical America are attacked by various species of *Conotrachelus* and *Heilipus*. Other species of *Conotrachelus* eat guava fruits in tropical America. Pests of cola nuts from Africa include *Balanogastris kolae* and several species of *Sophrorhinus*. Two species of the Oriental genus *Sternochetus* develop in mango seeds, and at least one other develops in fruits; the seed weevil, *S. mangiferae* (Fabricius), has spread to Hawaii and the West Indies.

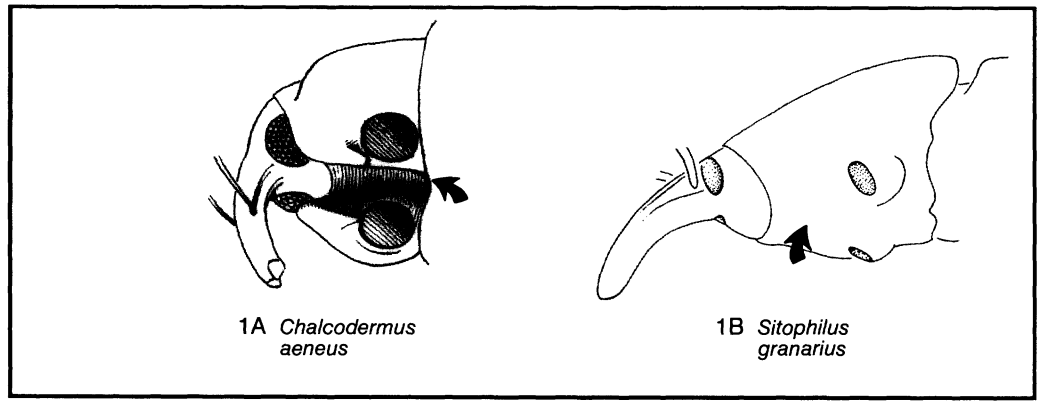
KEY TO ADULTS
Drawings by C. Feller unless otherwise noted.

1 Prosternum with deep groove which receives snout (1A); tarsal claws fused basally; pl. 110B ----------**cowpea curculio,** *Chalcodermus aeneus*

Body black, deeply punctured dorsally. Distribution: Caribbean region, southeastern USA; in cowpeas and related legumes. Adults oviposit on the developing fruits; at maturity, the larvae emerge from the pods, drop to the ground, and pupate in the soil.
Drawing 1A by A.D. Cushman.

Prosternal groove absent (1B); tarsal claws free basally---------- 2

Body brown, variously sculptured.



1A *Chalcodermus aeneus*

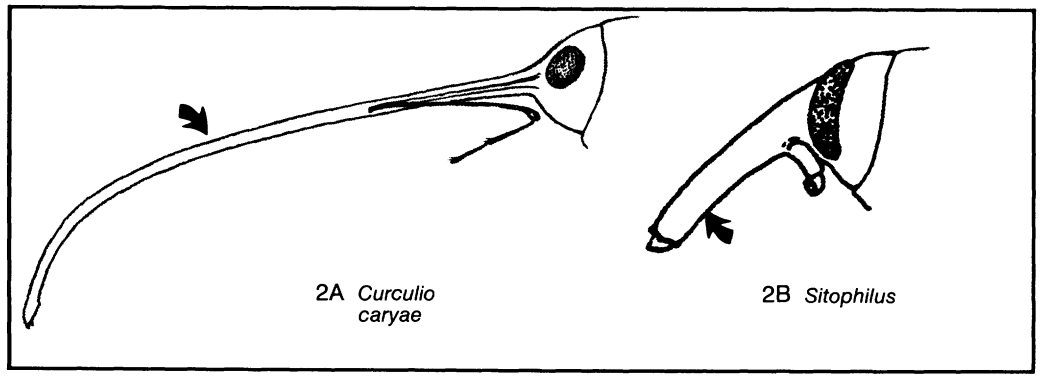
1B *Sitophilus granarius*

2 Snout long (about as long as or longer than body) and very slender (2A); tarsal claws toothed; pl. 111B ----------**pecan weevil,** *Curculio caryae*

Body yellowish brown, finely punctate and densely squamose dorsally. Distribution: eastern USA; in hickory nuts and pecans. This is one of 27 species of *Curculio* found in America north of Mexico (*1*). Most of the species develop in acorns, but several develop in various commercial nuts. The larvae develop in the growing fruit, drop with the fruit, emerge, burrow into the ground, and pupate. Larvae may be found in harvested nuts.

Snout relatively short (much shorter than body) and stout (2B); tarsal claws not toothed 3

Body color and sculpture various.
Drawings by A.D. Cushman.



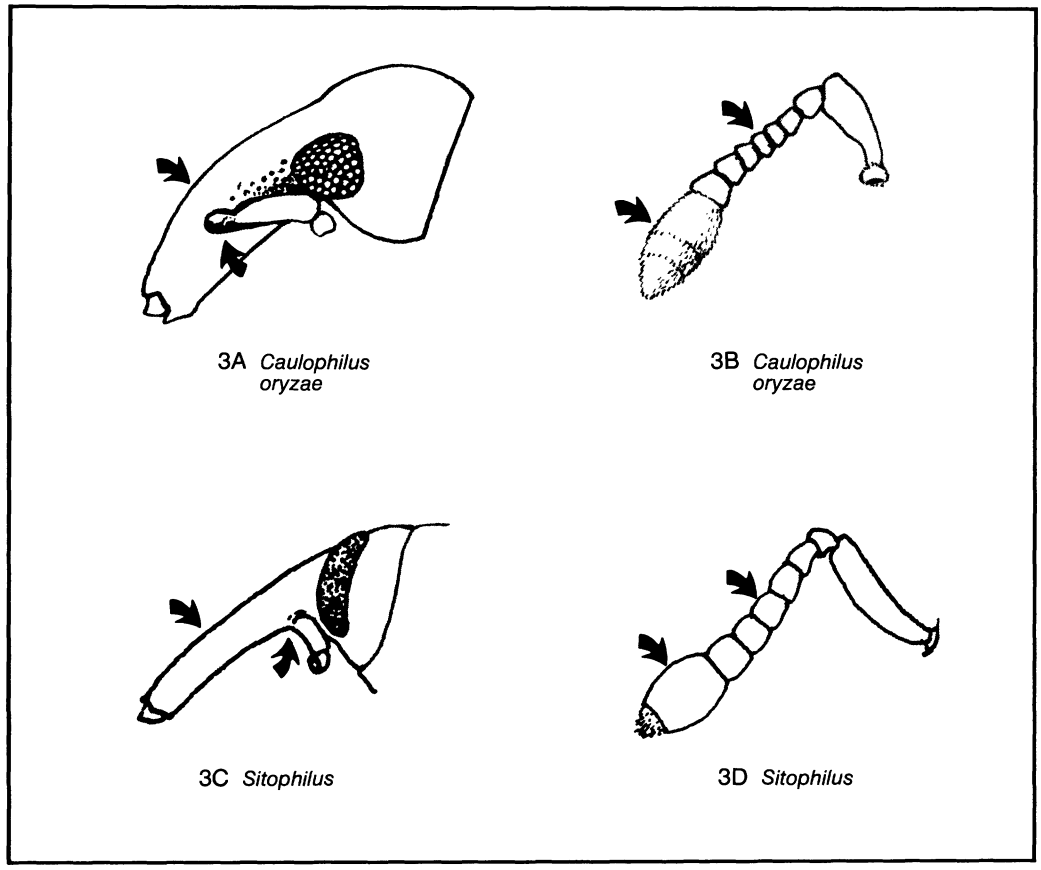
2A *Curculio caryae*

2B *Sitophilus*

3 Snout short and stout, with dorsal margin curved; antenna inserted near middle of snout, far in front of eye (3A); antennal funicle with 7 segments; antennal club with basal segment not shiny (3B); pygidium not exposed; pl. 112B
----------**broadnosed grain weevil,** *Caulophilus oryzae*

Distribution: Caribbean region, southeastern USA; occasionally intercepted and perhaps established elsewhere. It appears to be a pest principally of ripening or freshly harvested corn, but specimens may be found in stored seeds or damaged grain. This species also develops in certain fruits, notably in avocado seeds, and in root products (ginger, yams). For further information on the hosts of *C. oryzae,* called *C. latinasus* in the older literature, see *2.*
Drawings by A.D. Cushman.

Snout cylindrical, with dorsal margin straight; antenna inserted near base of snout, just in front of eye (3C); funicle with 6 segments; club with basal segment shiny (3D); pygidium largely exposed. Genus *Sitophilus*---------- 4

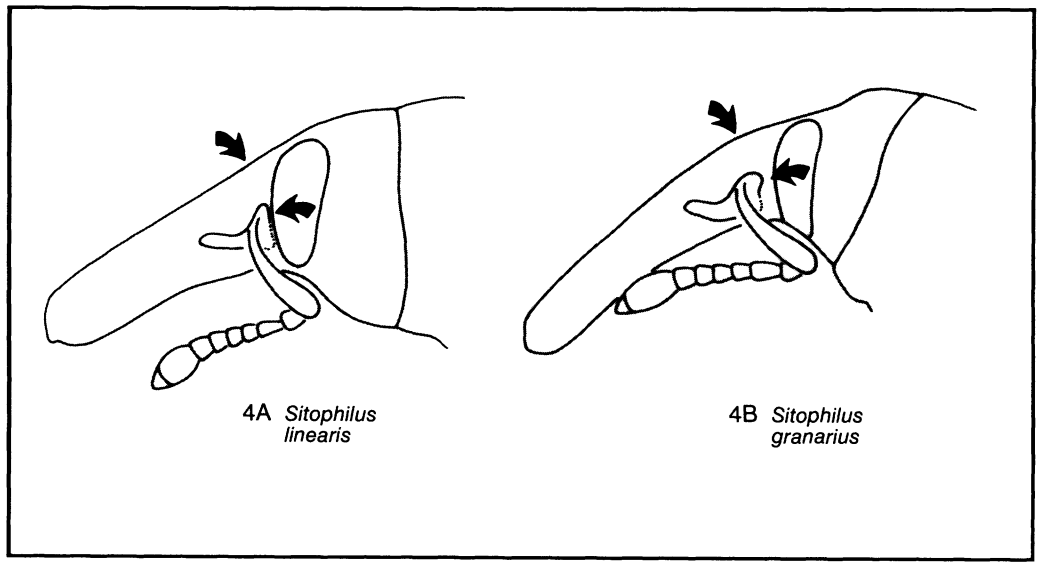


4 Snout (in profile) not arched over antennal insertion, its dorsal margin on same plane as frons; antennal insertion nearly contiguous with front of eye (posterior margin of scrobe adjacent to eye) (4A); pl. 113A----------**tamarind weevil,** *Sitophilus linearis*

Pronotal punctures small, nearly circular, not interconnected longitudinally; erect setae of elytral intervals 1, 3, 5, 7, and 9 minute, shorter than width of strial punctures; elytral intervals equally raised; alternate intervals not more strongly raised basally than even intervals. Distribution: pantropical. This species develops in fruits of tamarind trees. It is often intercepted at United States ports of entry, but otherwise it is not a stored food pest.

Snout arched over antennal insertion, its dorsal margin not on same plane as frons; antennal insertion separated from eye by a distance subequal to width of scape (posterior margin of scrobe distinct from front margin of eye) (4B) ---------- 5

Other characters various, not in same combination.



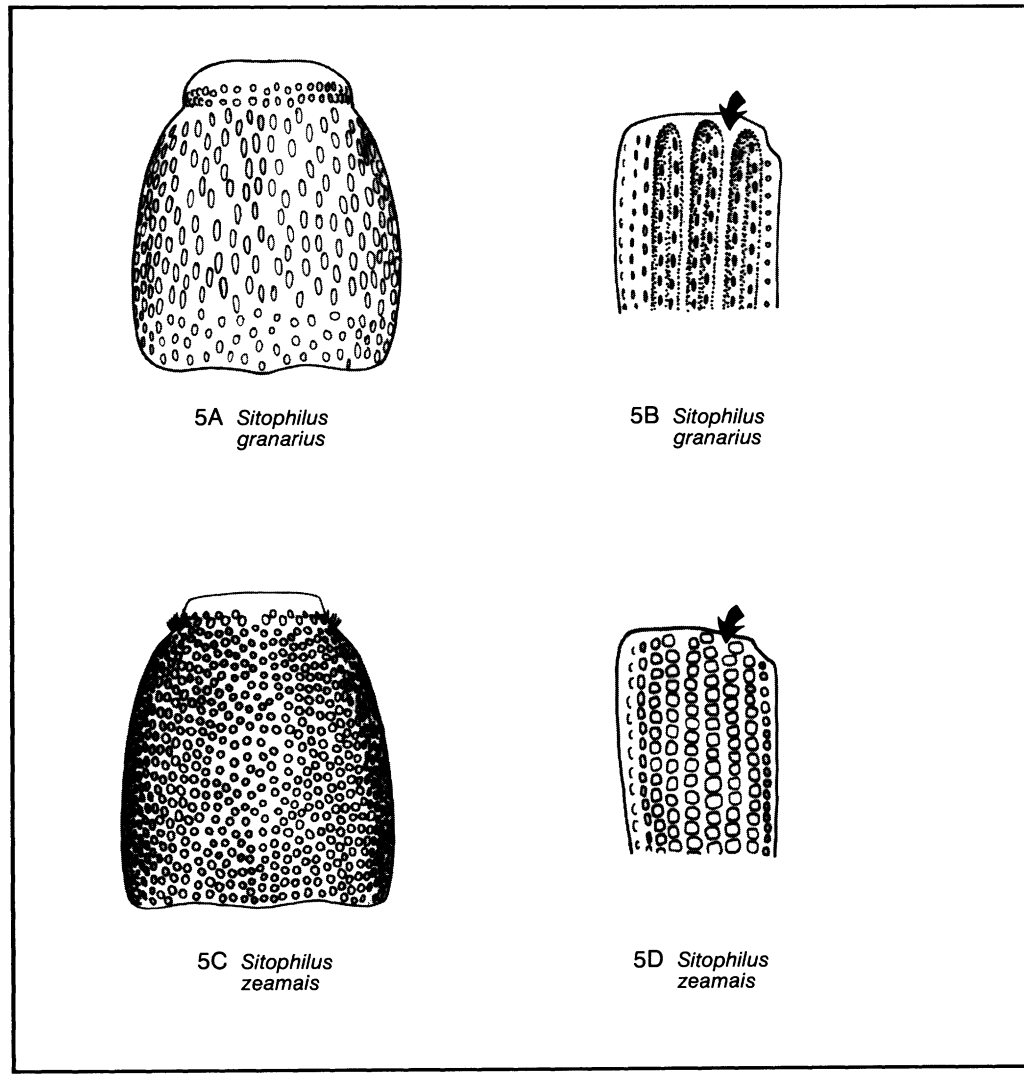
4A *Sitophilus linearis*

4B *Sitophilus granarius*

5 Pronotal punctures widely separated, large, elongate (about twice as long as wide), with spaces between punctures generally flat, wide, not forming longitudinal rugae (5A); elytral intervals about as wide as or wider than striae; intervals 3, 5, and 7 strongly raised basally (5B); strial punctures small, not quadrangular, not strongly encroaching upon intervals, not separated from one another by narrow transverse ridges (5B); pl. 113C----------**granary weevil,** *Sitophilus granarius*

Distribution: cosmopolitan; in whole grain; a major stored food pest.

Pronotal punctures closely spaced, small, nearly circular (much less than twice as long as wide), with spaces between punctures generally narrow (5C); elytral intervals much narrower than striae; intervals 3, 5, and 7 not strongly raised basally (5D); strial punctures large, quadrangular, strongly encroaching upon intervals, separated from one another by narrow transverse ridges (5D)---------- 6



5A *Sitophilus granarius*

5B *Sitophilus granarius*

5C *Sitophilus zeamais*

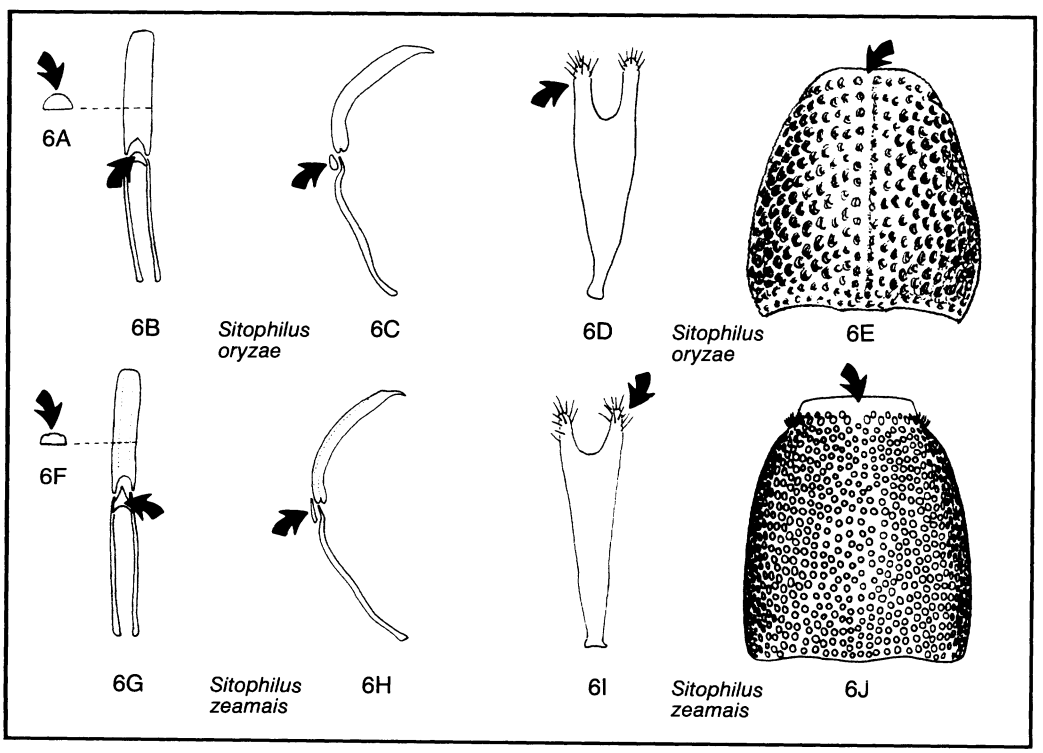
5D *Sitophilus zeamais*

6 Upper surface of median lobe of aedeagus evenly convex (6A); free sclerite at base of median lobe of aedeagus small, with apex rounded (6B, 6C); Y-shaped sternite VIII (spiculum ventrale) of female with lateral lobes parallel-sided and rounded apically (6D); midline of pronotum usually puncture-free (6E); pl. 114A ---------- **rice weevil,** *Sitophilus oryzae*

Punctures on pronotal disc mostly longitudinally elliptical; pronotal and elytral surfaces relatively dull, with moderately strong microsculpture. Distribution: cosmopolitan; in whole grains; a major stored food pest. Of all the characters given in this key, only those of the male genitalia are completely reliable for distinguishing *S. oryzae* from *S. zeamais*. However, when these 2 species occur in mixed infestations, most individuals can be distinguished by the other characters given and by the fact that individuals of *S. oryzae* are often smaller and paler than those of *S. zeamais*. Both species, in addition to infesting stored grains, may infest grain in the field; they also infest other kinds of seeds.

Upper surface of median lobe of aedeagus flattened, with a distinct longitudinal impression on each side of midline (6F); free sclerite of aedeagus large, with apex acute (6G, 6H); lobes of sternite VIII of female gradually and evenly tapered and vaguely acute apically (6I); punctures usually present along midline of pronotum (6J); pl. 114B ---------- **maize weevil,** *Sitophilus zeamais*

Punctures on pronotal disc mostly circular; pronotal and elytral surfaces relatively shiny, with weak microsculpture. Distribution: cosmopolitan; in whole grain; a major stored food pest.
Drawing 6E by A.D. Cushman.



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1969. Monograph of the genus *Curculio* in the New World (Coleoptera: Curculionidae). Part 1. United States and Canada. Misc. Pub. Ent. Soc. America 6(5)239-285.

2 Whitehead, D.R.
1982. Foods of *Caulophilus* spp., particularly the broadnosed grain weevil, *C. oryzae* (Gyllenhal), based on interception records (Coleoptera: Curculionidae: Cosoninae). Proc. Ent. Soc. Washington 84(1)81-84.

14 ADULT MOTHS (LEPIDOPTERA)

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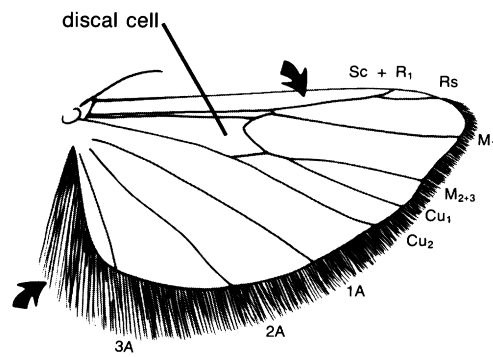
KEY
Drawings by C. Feller unless otherwise noted.

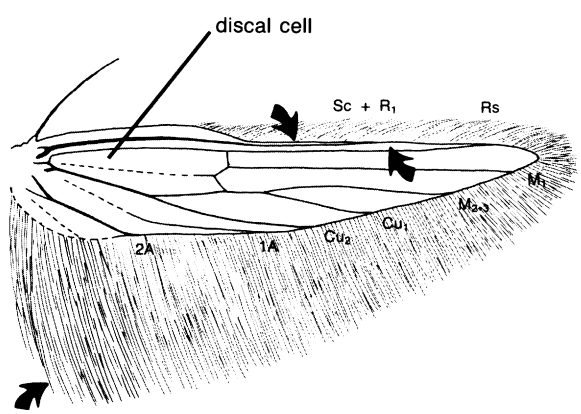
1 Hind wing with a short fringe (fringe hairs less than half as long as the breadth of the wing); Sc and Rs either closely parallel or fused to a point beyond discal cell (1A). Pyralidae (**pyralid moths**) ---------- 2

Caution: fringe hair length in *Corcyra cephalonica* and *Ephestiodes gilvescentella* may approach wing breadth/2.

Hind wing with a long fringe (fringe hairs at least as long as wing breadth/2); Sc and Rs clearly separate or divergent before and beyond end of discal cell (1B)------- 19



1A *Ephestia elutella*



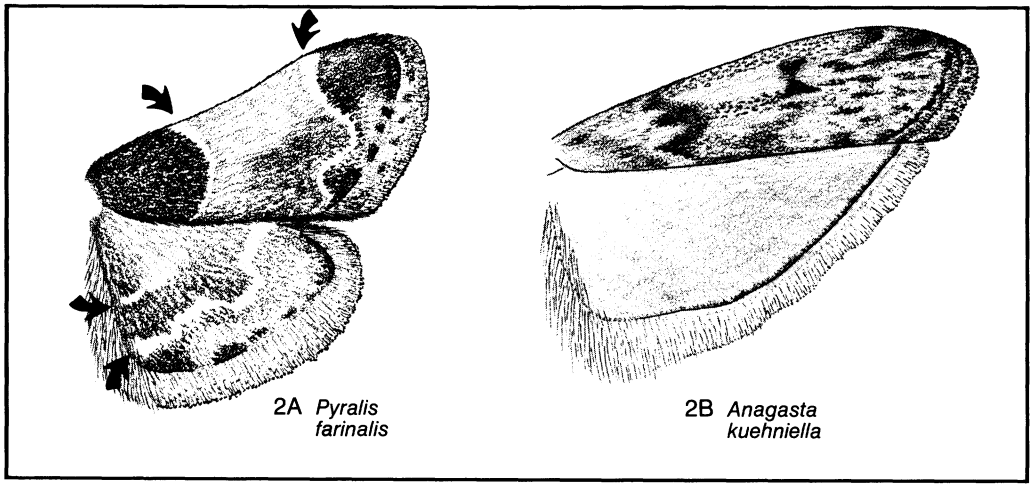
1B *Endrosis sarcitrella*

2 Both front and hind wings crossed by 2 narrow, wavy white lines (2A); pl. 2-O ----------**meal moth,** *Pyralis farinalis*

The white lines, called the transverse anterior (=antemedial) and transverse posterior (=postmedial) lines, on the forewing bracket a pale brown area and separate it from basal and apical areas that are much darker (chocolate- or purplish-brown); forewing length usually more than 10 mm.

Wavy white lines absent, or present on forewing only (2B) ---------- 3

Hind wing color is a dull gray or white, either without a pattern or with a narrow dark border or diffuse marginal shading; forewing length 6 to 15 mm.

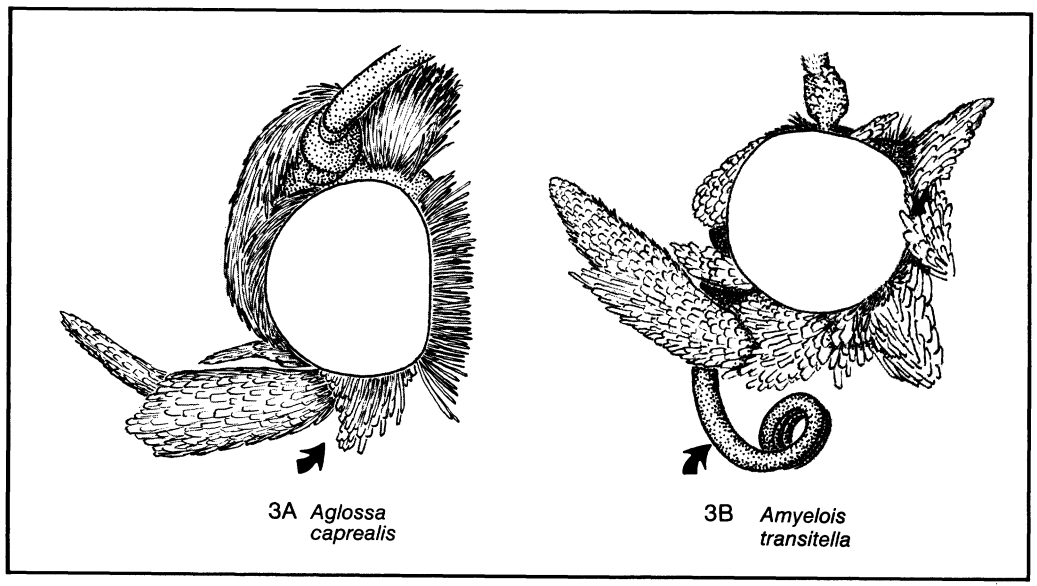


2A *Pyralis farinalis*

2B *Anagasta kuehniella*

3 Tongue absent (3A) or rudimentary (if present, then shorter than twice the diameter of the eye)---------- 4

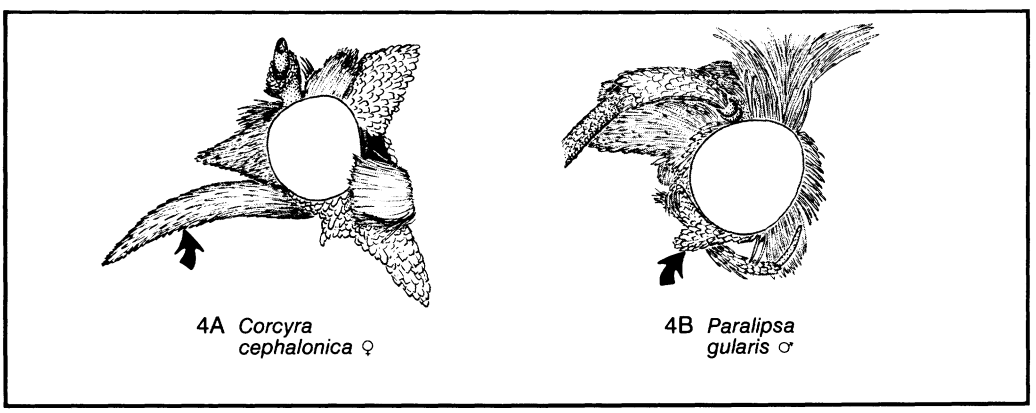
Tongue present and well developed (longer than twice the diameter of the eye) (3B) 11



3A *Aglossa caprealis*

3B *Amyelois transitella*

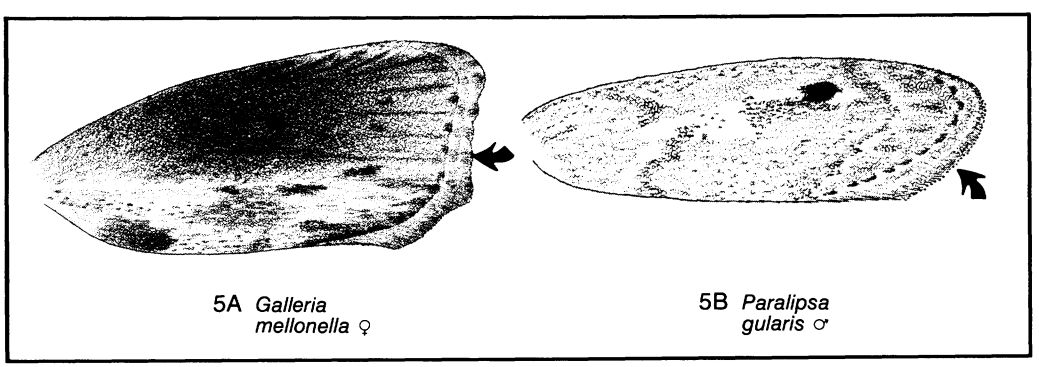
4 Labial palp long (about as long as longest leg spur) and protruding (4A)---------- 5
Labial palp either distinctly shorter than longest leg spur or if nearly as long, then folded transversely against face (not protruding forward) (4B)---------- 8



4A *Corcyra cephalonica* ♀ 4B *Paralipsa gularis* ♂

5 Outer margin (termen) of forewing concave (5A); pl. 2M
----------female, **greater wax moth,** *Galleria mellonella*

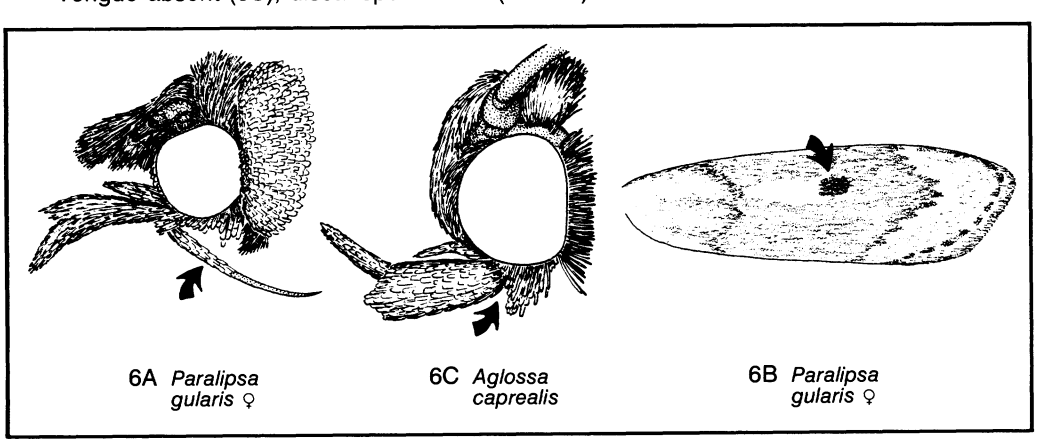
Outer margin of forewing convex (5B)---------- 6



5A *Galleria mellonella* ♀ 5B *Paralipsa gularis* ♂

6 Tongue present but reduced (about equal in length to labial palp) (6A); forewing with conspicuous black discal spot (6B); pl. 2L
----------female, **stored nut moth,** *Paralipsa gularis*

Tongue absent (6C); discal spot absent (see 7B)---------- 7



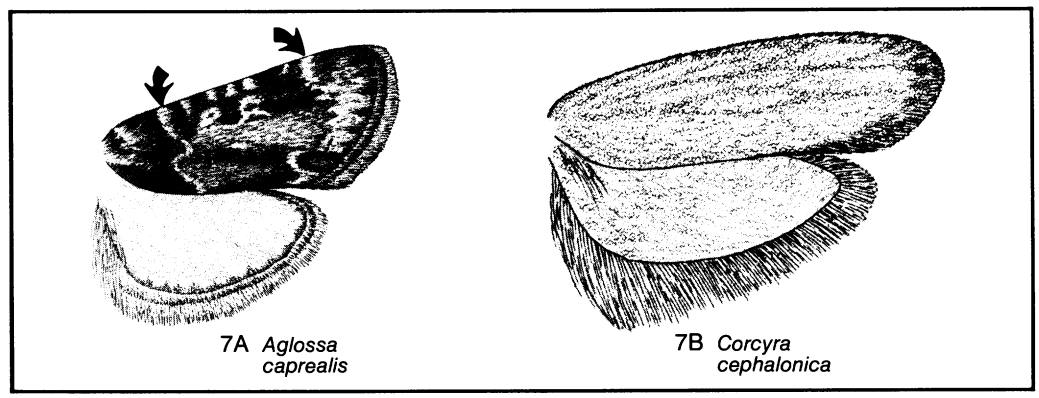
6A *Paralipsa gularis* ♀ 6C *Aglossa caprealis* 6B *Paralipsa gularis* ♀

7 Breadth of forewing greater than 4 mm; forewing with pale antemedial and postmedial lines on a variegated, darker brown background (7A) ---------- murky meal moth, *Aglossa caprealis*

See also 6C.

Breadth of forewing less than 4 mm; forewing light gray-brown, almost without pattern (7B); pl. 2H----------female, **rice moth**, *Corcyra cephalonica*

See also 4A.

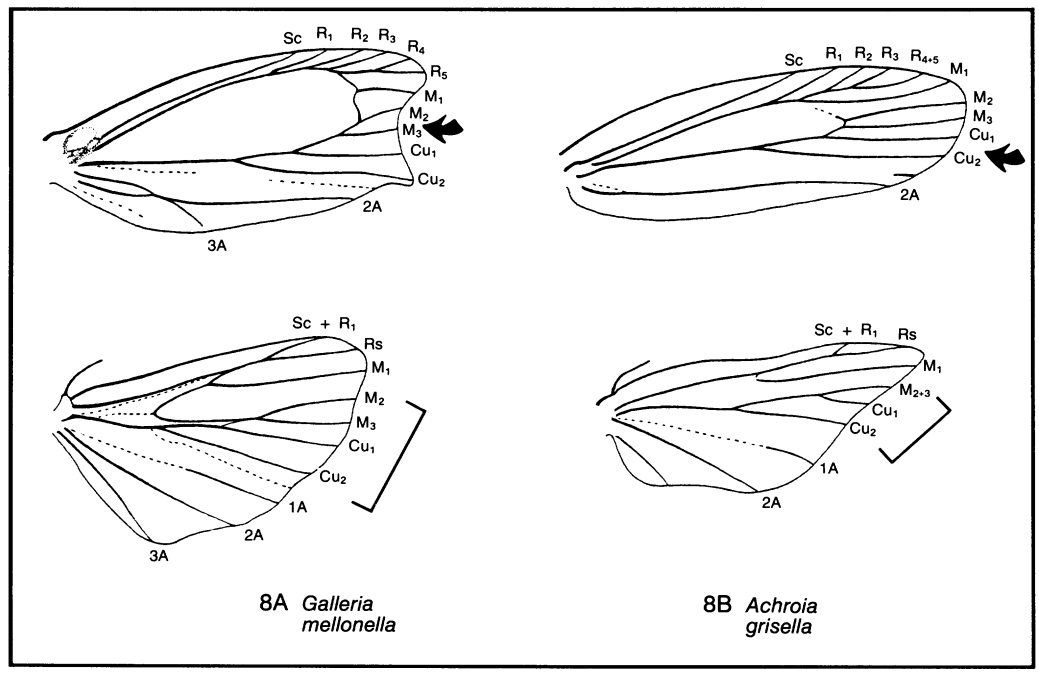


7A *Aglossa caprealis* 7B *Corcyra cephalonica*

8 Forewing breadth 5 to 7 mm; termen of forewing concave; Cu of hind wing apparently 4-branched (8A); pl. 2M---------- male, **greater wax moth,** *Galleria mellonella*

See also 5A.

Forewing breadth less than 5 mm; termen of forewing convex; Cu of hind wing apparently 3-branched (8B)---------- 9



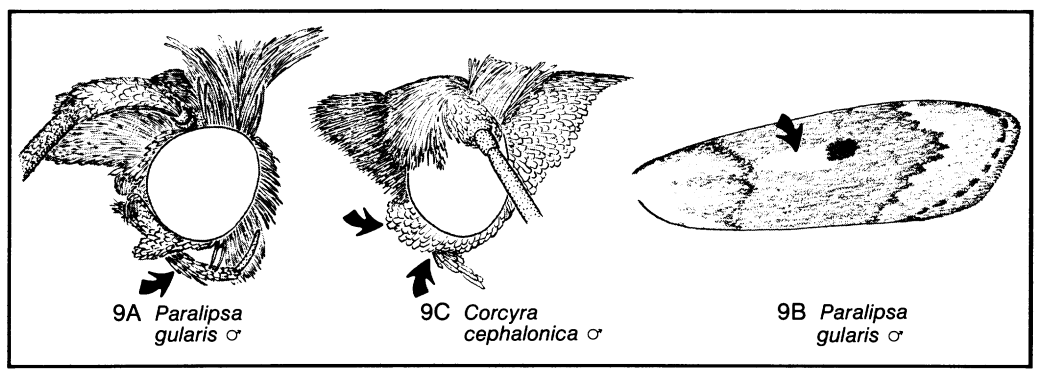
8A *Galleria mellonella* 8B *Achroia grisella*

9 Tongue present but very short (9A); forewing with yellowish patch near middle (9B); pl. 2L----------male, **stored nut moth,** *Paralipsa gularis*

Labial palps of male inconspicuous; forewing grayish-brown, with (9B) or without discal spot.

Tongue absent (9C); forewing almost without markings (see 7B) ---------- 10

Forewing grayish-brown.

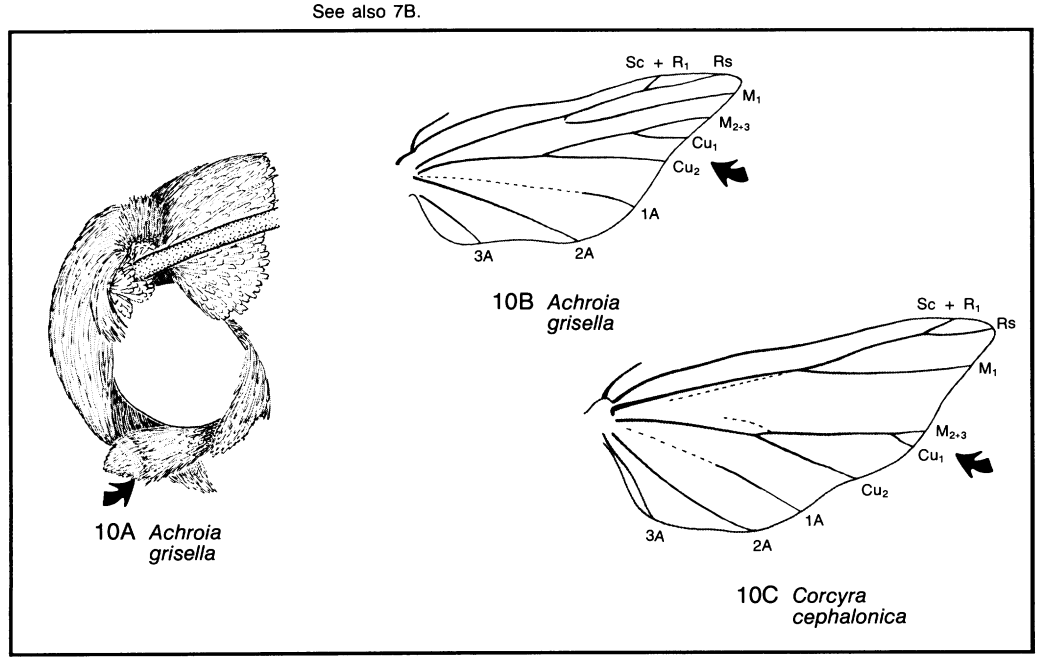


10 Labial palp conspicuous though short (length not exceeding diameter of eye) (10A); labial palps of male transversely incurved, pincerlike; hind wing of male with concave termen (10B); pl. 2C---------- **lesser wax moth,** *Achroia grisella*

See also 8B.

Labial palp inconspicuous, very short, upcurved and closely appressed to front of head (tip often concealed in frontal scale tuft) (see 9C); hind wing with convex termen (10C); pl. 2H----------male, **rice moth**, *Corcyra cephalonica*

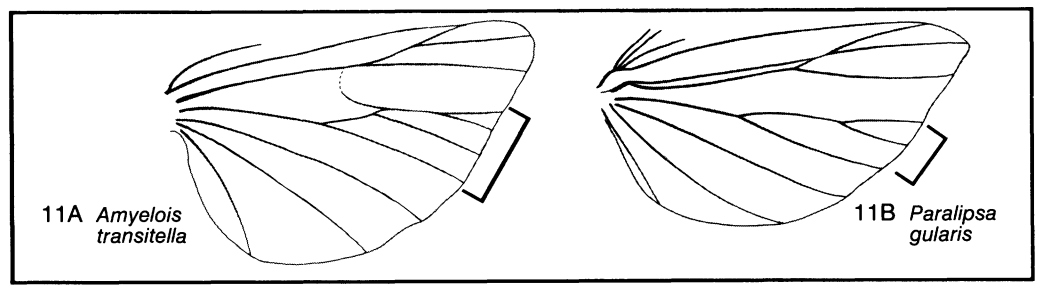
See also 7B.



11 Cu of hind wing apparently 4-branched (11A)-----**navel orangeworm,** *Amyelois transitella*

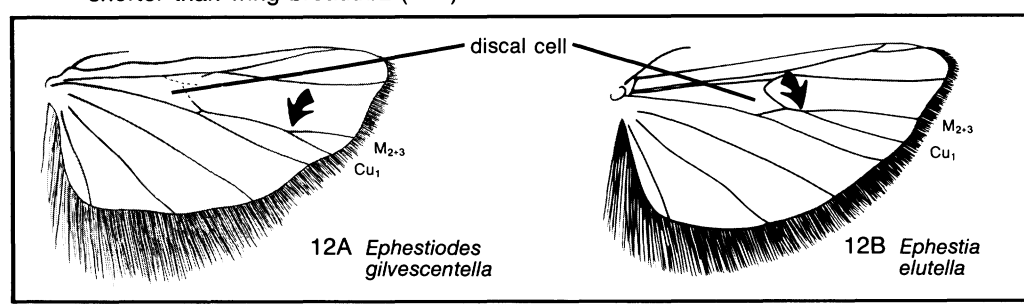
See also 3B.

Cu of hind wing apparently 3-branched (11B)---------- 12



12 M_{2+3} and Cu_1 of hind wing branching nearer to termen than to discal cell; longest fringe hair of hind wing almost equal to wing breadth/2 (12A) ----------dusky raisin moth, *Ephestiodes gilvescentella*

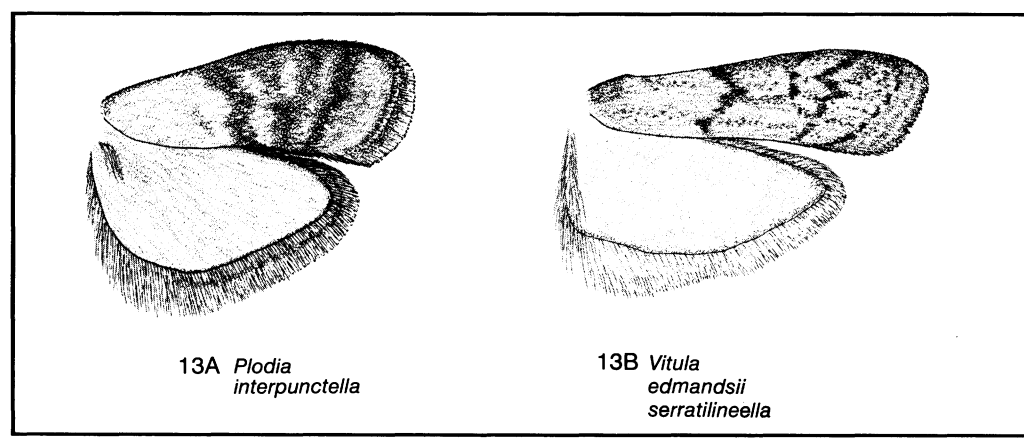
M_{2+3} and Cu_1 branching closer to discal cell than to termen; longest fringe hair much shorter than wing breadth/2 (12B)---------- 13



13 Forewing distinctly bicolored (basal one-third light colored, distal two-thirds dark colored) (13A); pl. 2F, 2G---------- **Indianmeal moth,** *Plodia interpunctella*

The best diagnostic character for this species pertains to the wing scales: Among the stored-food moths, only *Plodia interpunctella* has deep pink or coppery-red scales on the forewing.

Forewing without contrasting basal and distal colors (13B) ---------- 14

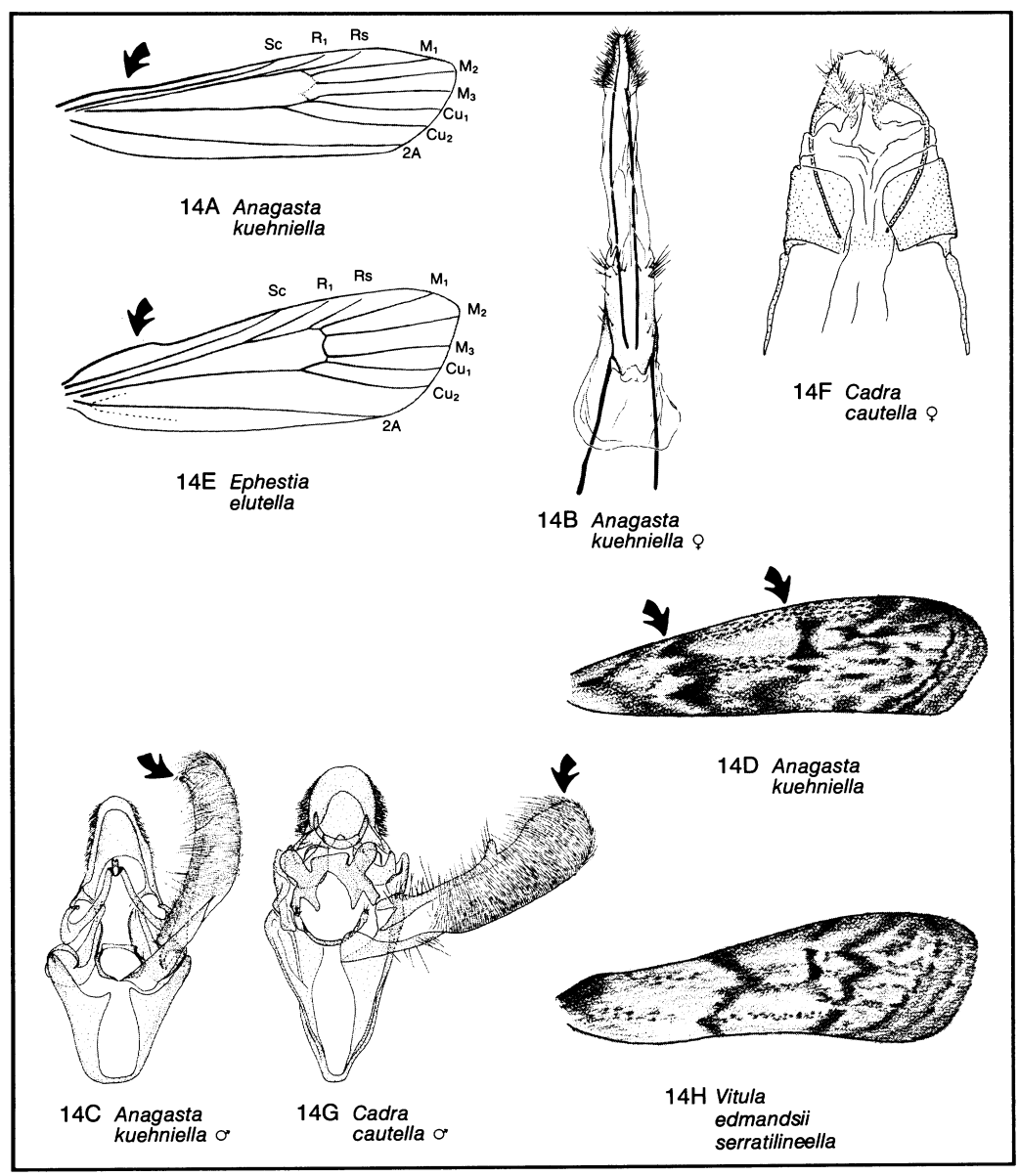


14 Forewing of male without costal fold (14A); ovipositor much elongated or extensile (14B); costa of valve with only a short terminal process (14C); pl. 2-I
----------**Mediterranean flour moth,** *Anagasta kuehniella*

Forewing usually with an obvious pattern of transverse lines and a discal spot (14D). See also 2B.
Drawing 14A by D.C. Ferguson.

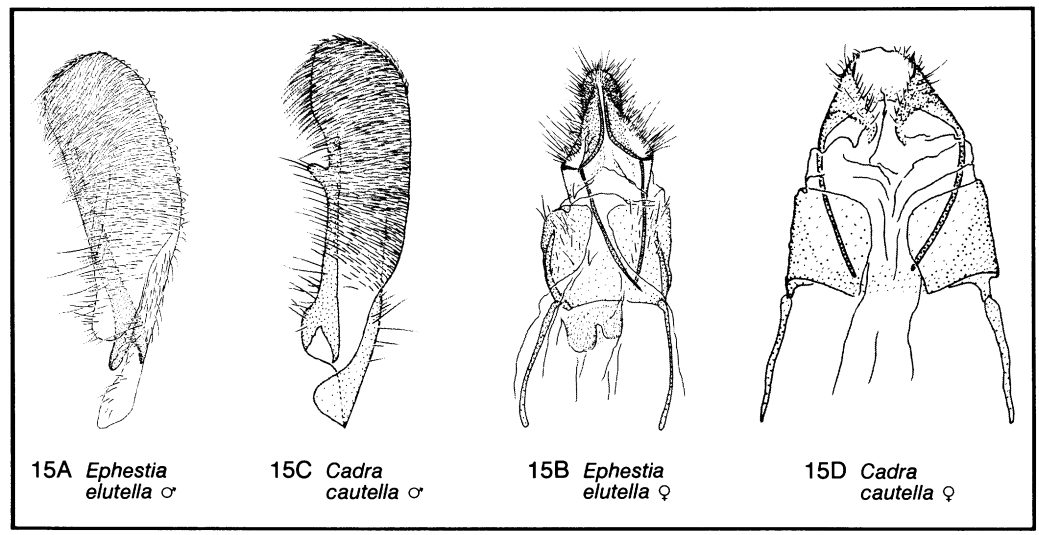
Forewing of male with costal fold (usually folded under and appressed against lower wing surface) (14E); ovipositor short (14F); valve either without a terminal costal process (14G; see also 15A, 15C, 17C) or, if a terminal process is present, there is also a prominent process located near the midpoint of the costal margin (see 17A) 15

Forewing with (14H) or without an obvious pattern.



15 Valve lacking a costal process (15A); ovipositor bluntly attenuated (15B)---------- 16

Valve with a costal process (15C); ovipositor broadly rounded or obtuse (15D). Genus *Cadra*---------- 17



15A *Ephestia elutella* ♂ 15C *Cadra cautella* ♂ 15B *Ephestia elutella* ♀ 15D *Cadra cautella* ♀

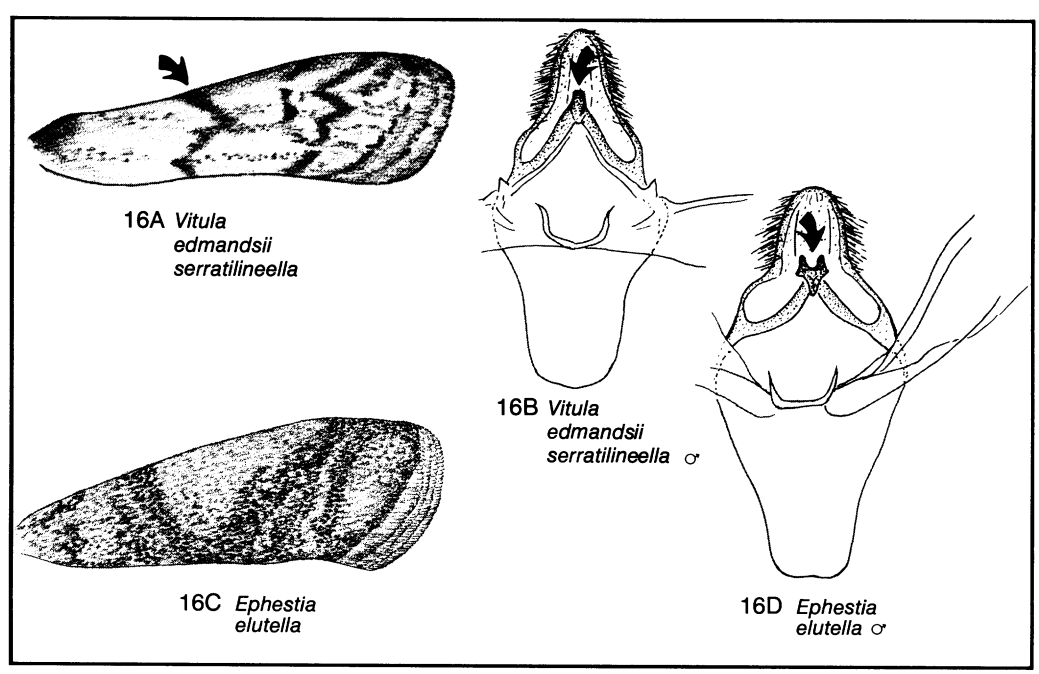
16 Forewing nearly always more than 9 mm long, with dentate transverse lines (16A); gnathos not bifurcate apically (16B) ----------**driedfruit moth,** *Vitula edmandsii serratilineella*

See also 13B.

Forewing less than 9 mm long, with simple (not dentate) lines (16C); gnathos apically bifurcate (16D); pl. 2J----------**tobacco moth,** *Ephestia elutella*

See also 1A, 14E, 15A.

Drawings 16B&D by D.C. Ferguson.



16A *Vitula edmandsii serratilineella*

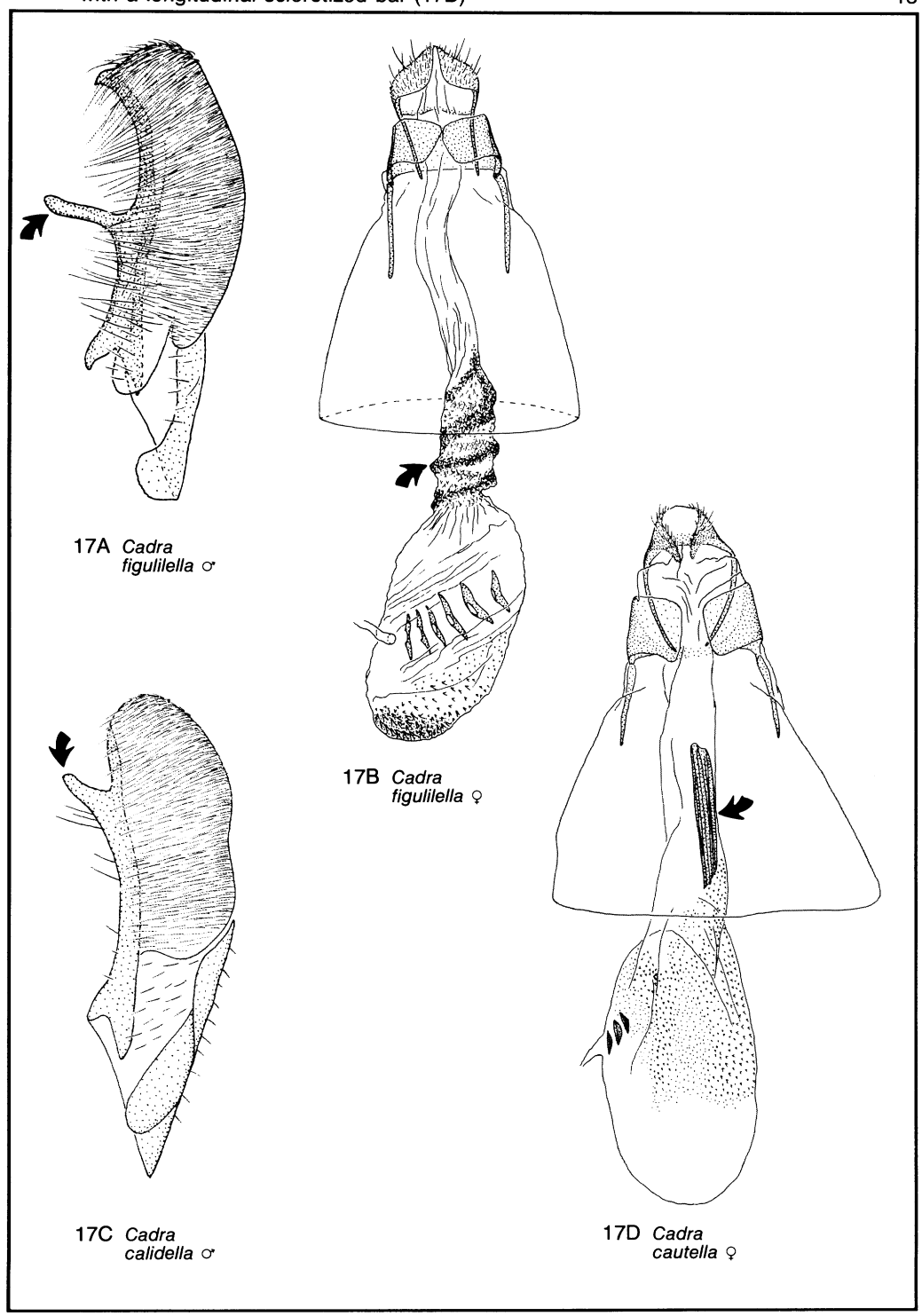
16B *Vitula edmandsii serratilineella* ♂

16C *Ephestia elutella*

16D *Ephestia elutella* ♂

17 Length of costal process of valve subequal to width of valve (17A); ductus bursae with spiral rings of sclerotin (17B)---------- **raisin moth,** *Cadra figulilella*

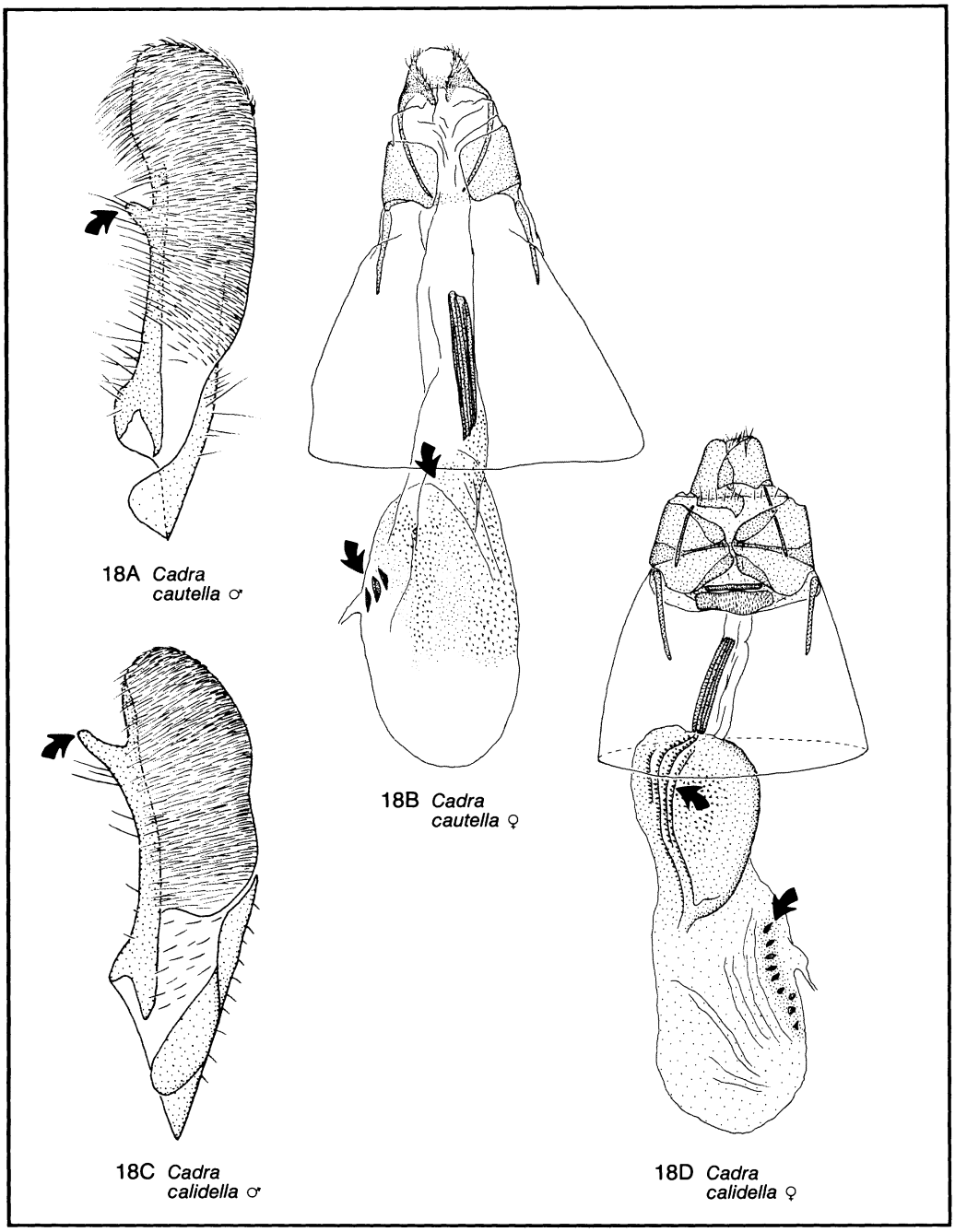
Length of costal process of valve much less than width of valve (17C); ductus bursae with a longitudinal sclerotized bar (17D) ---------- 18



18 Costal process of valve located near middle of costal margin (18A); sclerite of ductus bursae not continuing on to bursa copulatrix; bursa with 2 to 4 (rarely 1 or 5) signa (lamina dentata) (18B)----------**almond moth,** *Cadra cautella*

See also 14G.

Costal process of valve located beyond middle of costal margin (18C); sclerotized bands extending from sclerite of ductus bursae onto bursa copulatrix; bursa usually with no less than 5 signa (18D)---------- carob moth, *Cadra calidella*



19 Labial palp long, sickle-shaped, sharp-pointed, projecting upward; head smooth-scaled (19A) ---------- 20

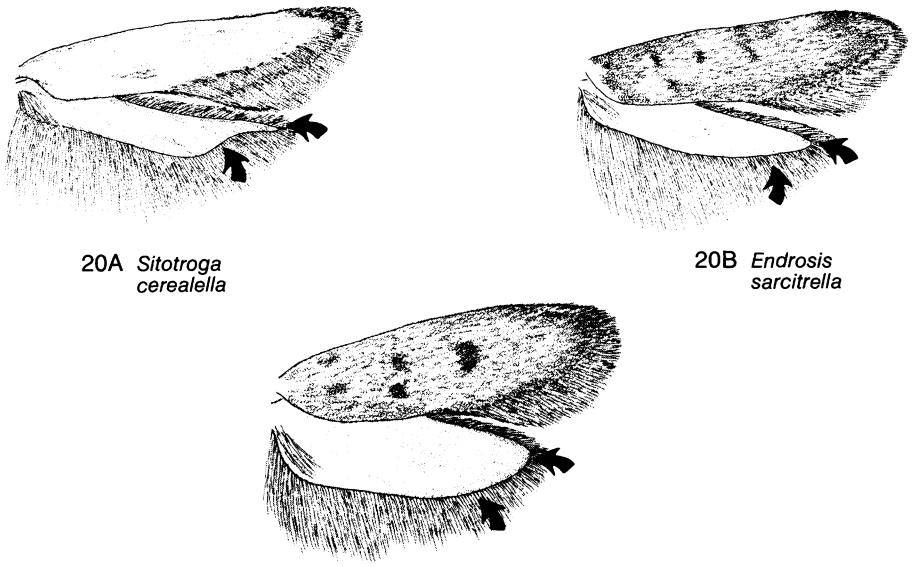
Labial palp short, nearly straight, blunt-pointed, and projecting anteriorly (horizontal or declivent); head rough-haired (19B). Tineidae (tineid moths)---------- 22

19A *Endrosis sarcitrella*

19B *Monopis crocicapitella*

20 Hind wing abruptly attenuated, with sharply-pointed apex; termen concave (20A); forewing pale ochreous brown, often unmarked, but sometimes with a diffuse black spot near distal end of discal cell and (or) another on the apex (pl. 2E). Gelechiidae (**gelechiid moths**)---------- **Angoumois grain moth,** *Sitotroga cerealella*

Hind wing regularly tapered, with apex rounded or bluntly pointed (20B, 20C); forewing buff to dark buff-brown, usually with 2 or more dark spots. Oecophoridae (**oecophorid moths**)---------- 21



20A *Sitotroga cerealella*

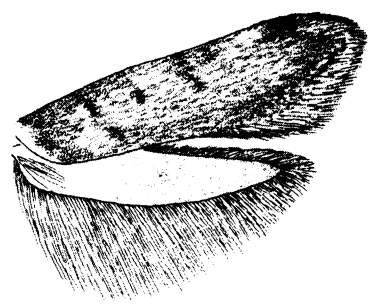
20B *Endrosis sarcitrella*

20C *Hofmannophila pseudospretella*

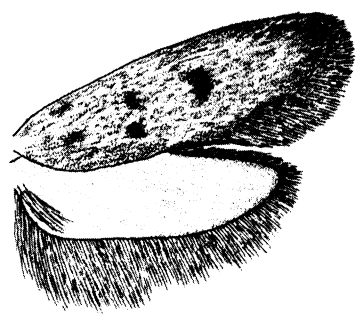
21 Head and pronotum conspicuously white (pl. 2N); labial palp mostly white, with black tip; forewing a shining buff, speckled with dark brown, and usually with 2 or 3 blackish spots (21A); hind wing with 7 veins ---------- **whiteshouldered house moth,** *Endrosis sarcitrella*

See also 1B, 19A.

Head, thorax, and labial palp brown; forewing buff-brown to dark buff-brown (pl. 2B); forewing with 3 diffuse or distinct dark brown spots (21B); hind wing with 8 veins ---------- **brown house moth,** *Hofmannophila pseudospretella*



21A *Endrosis sarcitrella*

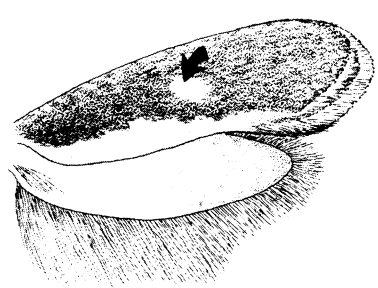


21B *Hofmannophila pseudospretella*

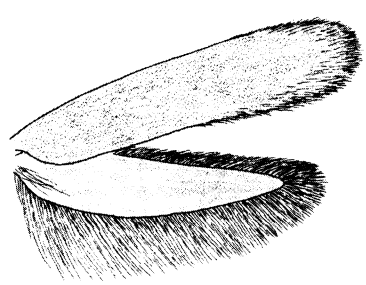
22 Forewing dark brown, with a broad cream-colored inner margin and central spot (22A); pl. 2D----------*Monopis crocicapitella*

See also 19B.

Forewing neither mostly dark brown nor with a definite spot (22B) ---------- 23



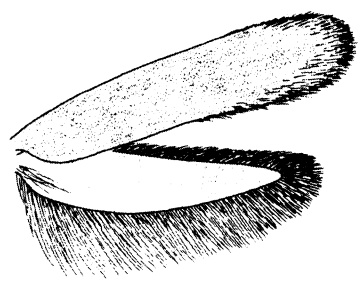
22A *Monopis crocicapitella*



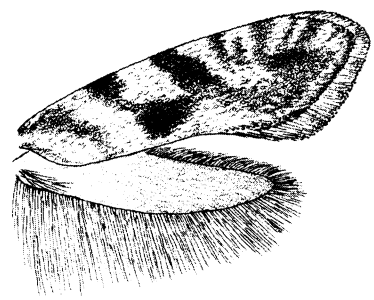
22B *Tineola bisselliella*

23 Forewing a pale ochreous buff, entirely unmarked (23A); pl. 2A
---------- **webbing clothes moth,** *Tineola bisselliella*

Forewing buff with dark dusting and irregular brown markings and with about 6 dark reddish-brown or chocolate-brown spots (23B); pl. 2K
---------- **European grain moth,** *Nemapogon granella*



23A *Tineola bisselliella*



23B *Nemapogon granella*

15 LARVAL MOTHS (LEPIDOPTERA)

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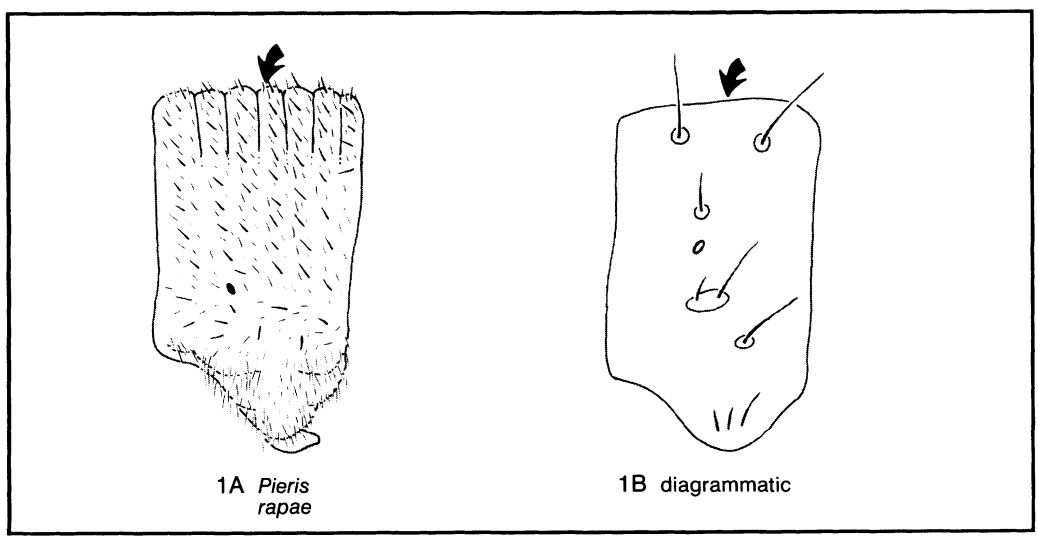
KEY
Drawings by C. Feller unless otherwise noted.

1 Body and head with numerous short secondary setae; abdominal segments divided (at least dorsally) into several annulets (1A); pl. 115A. Pieridae (**whites, sulfur butterflies**)----------**imported cabbageworm,** *Pieris rapae*

A green larva with a yellowish middorsal stripe and a yellowish broken lateral stripe through the spiracles. Distribution: Europe, North America (imported); hosts: Brassicaceae. This is the only butterfly species included in the key. References: *5, 26, 29.*

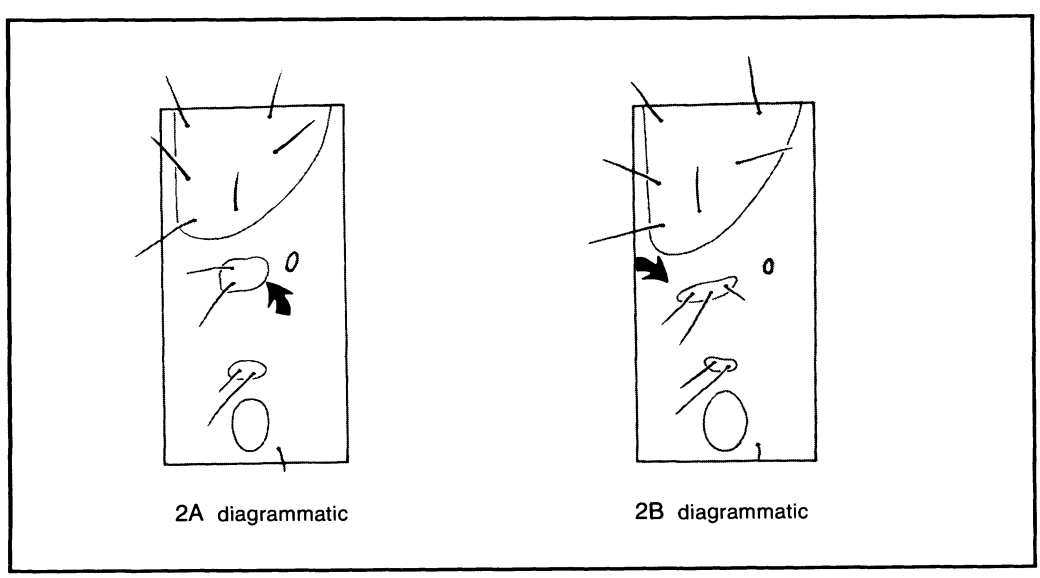
Body and head with primary setae only; abdominal segments not divided into several annulets (1B). Other Lepidoptera ---------- 2

References: *5, 10, 11, 14, 15, 17, 18, 20, 21, 24, 26, 29, 31.*



1A *Pieris rapae* 1B diagrammatic

2 Two setae in prespiracular group of prothorax (2A)---------- 2
Three setae in prespiracular group of prothorax (2B)---------- 26



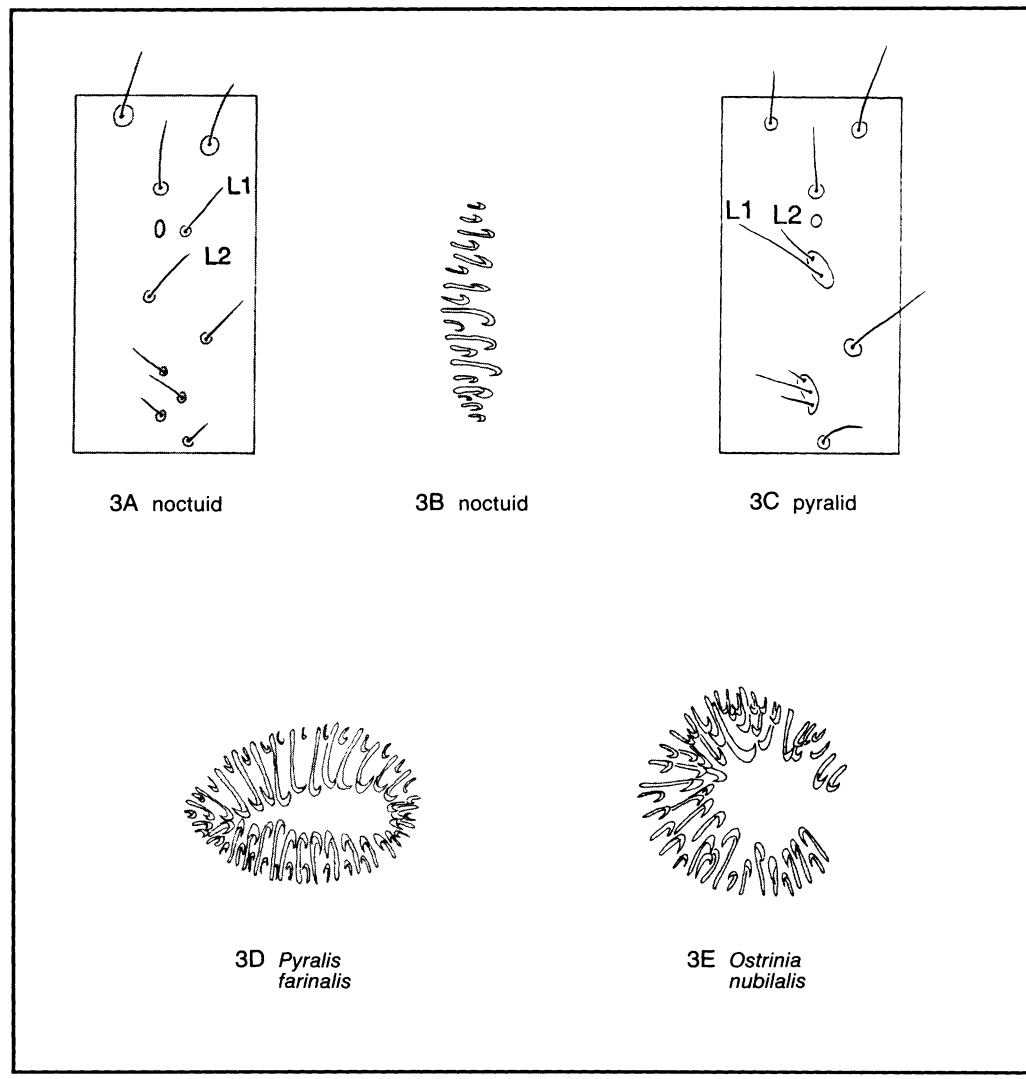
2A diagrammatic 2B diagrammatic

3 Abdominal segments I to VIII with seta L1 behind and L2 below spiracle (3A); crochets in a mesoseries (3B). Noctuidae (**owlet moths** and **underwings**)---------- 4

References: *3, 7.*

Abdominal segments I to VIII with setae L1 and L2 close together below spiracle (3C); crochets in a complete circle (3D) or a penellipse (3E). Pyralidae (**pyralid moths**) 7

References: *4, 12.*



3A noctuid

3B noctuid

3C pyralid

3D *Pyralis farinalis*

3E *Ostrinia nubilalis*

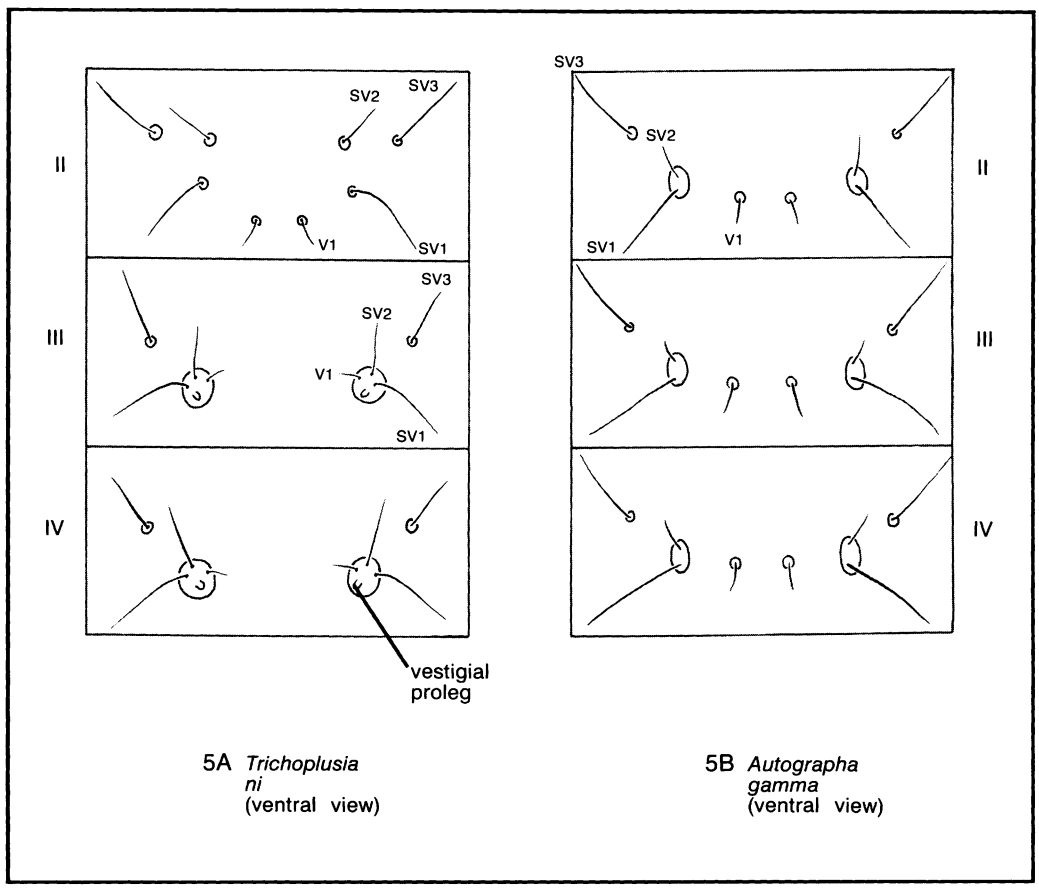
4 Normal prolegs present on abdominal segments V and VI (absent or vestigial on segments III and IV) (pl. 115B)---------- 5
Normal prolegs present on abdominal segments III and VI (pl. 115C)---------- 6

5 Vestigial prolegs present on abdominal segments III and IV; setae SV1, SV2 and V1 grouped closely about proleg on segments III and IV; pinacula of setae SV1 and SV2 well separated on segment II (5A)
----------**cabbage looper,** *Trichoplusia ni*

Distribution: the Americas, West Indies; on cabbage and other crucifers. References: *8, 9.*

Vestigial prolegs absent on abdominal segments III and IV; pinacula of SV1 and SV2 fused on segments II tc IV; seta V1 separated from SV1 and SV2 on all segments (5B); pl. 115B----------silver Y moth, *Autographa gamma*

Distribution: Asia, Europe, North Africa; general feeder.



5A *Trichoplusia ni* (ventral view)

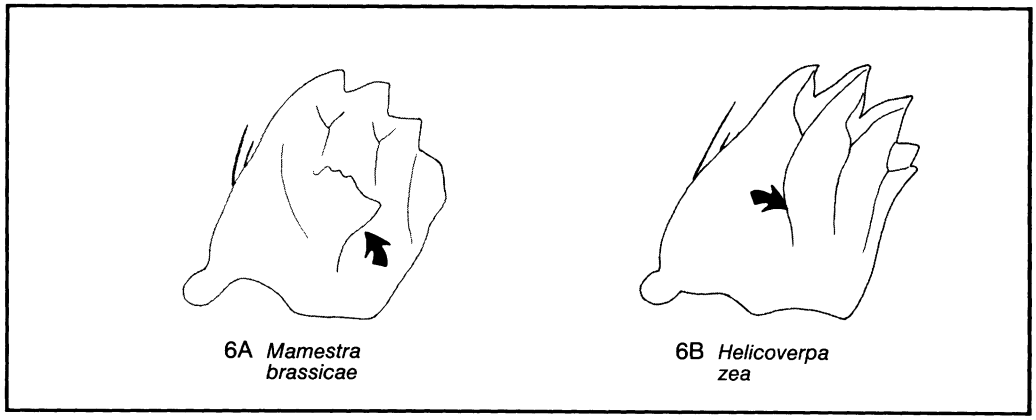
5B *Autographa gamma* (ventral view)

6 Mandible with broad plate on oral surface (6A); integument smooth; pl. 115C ---------- cabbage moth, *Mamestra brassicae*

Distribution: Asia, Europe; on crucifers and other leafy vegetables.

Mandible without broad plate on oral surface (6B); integument with short sharp spines; pl. 116A ---------- **corn earworm, tomato fruitworm,** *Helicoverpa zea*

Distribution: the Americas, West Indies; on beans, corn, cotton, tomatoes, and many other plants. Reference: *6.*



6A *Mamestra brassicae*

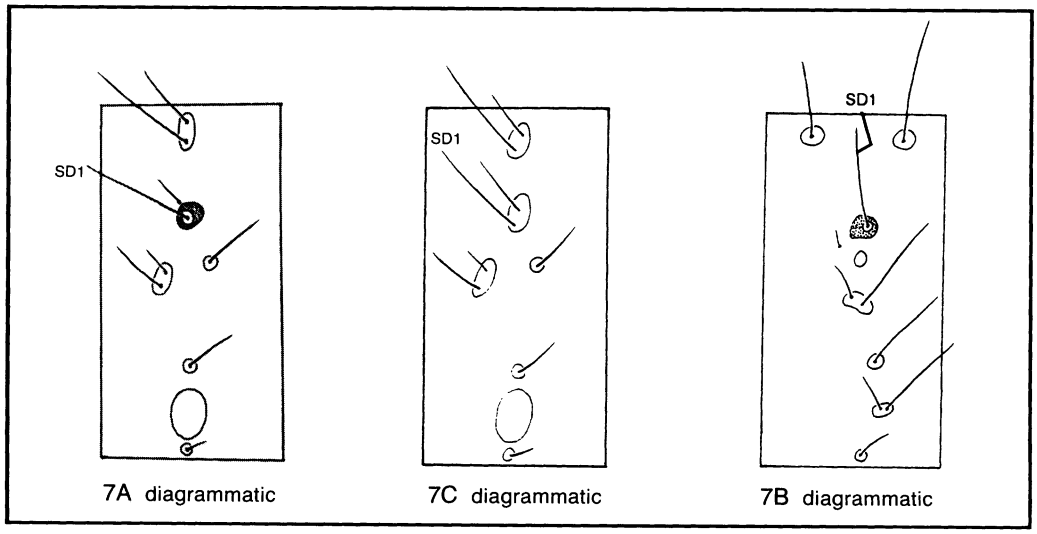
6B *Helicoverpa zea*

7 With sclerotized ring around seta SD1 of mesothorax (7A) Phycitinae (phycitine moths) ---------- 8

Seta SD1 of abdominal segment VIII also surrounded by a sclerotized ring (7B). References: *1, 23, 27.*

Without sclerotized ring around seta SD1 of mesothorax (7C) ---------- 18

Sclerotized ring sometimes present around SD1 on segment VIII.

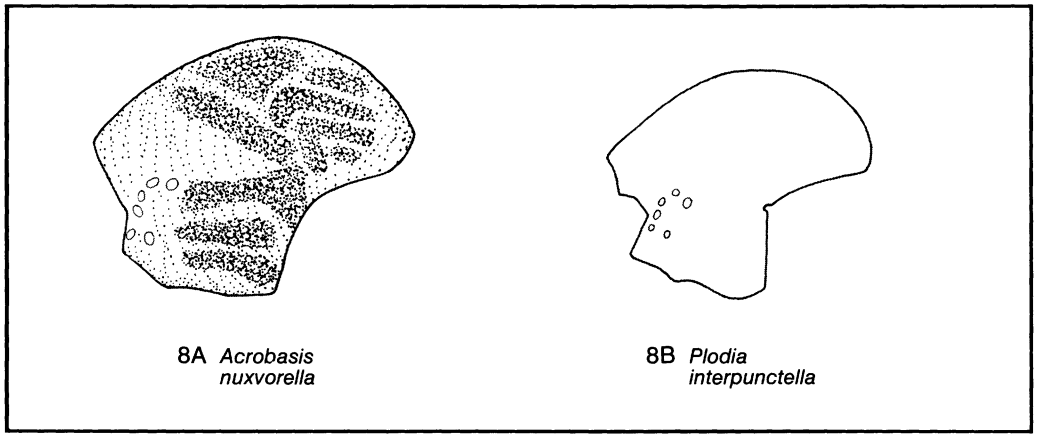


7A diagrammatic

7C diagrammatic

7B diagrammatic

8 Head rugulose, yellow or yellowish-brown, with darker pattern of coalesced spots (8A) 9
Head smooth, uniformly yellow to brown, without darker pattern (8B) ---------- 10



8A *Acrobasis nuxvorella*

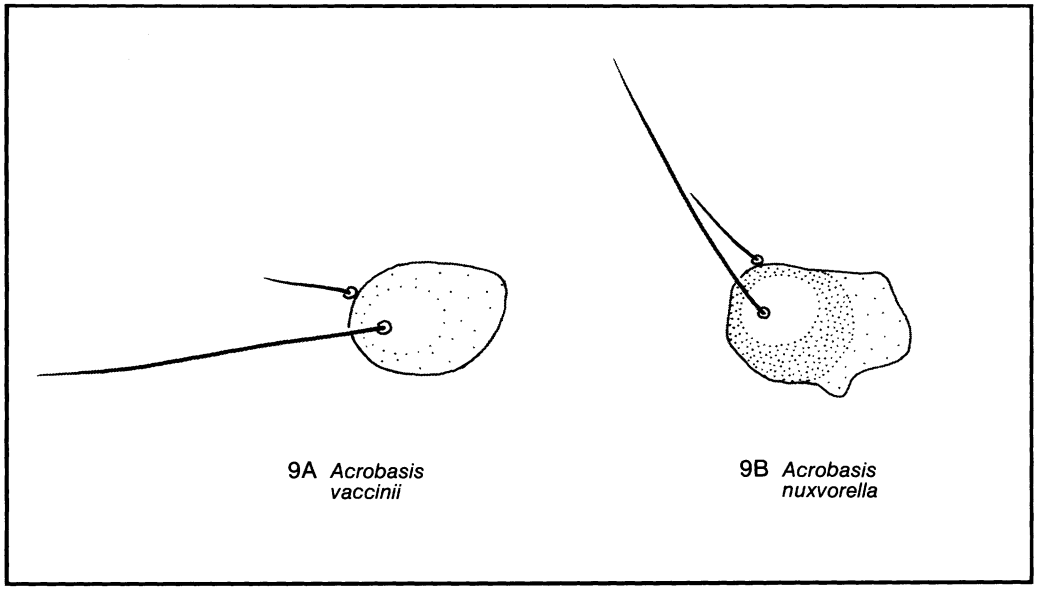
8B *Plodia interpunctella*

9 Head pale yellow with pale brownish pattern; sclerotized ring on mesothorax pale yellow (9A) ---------- **cranberry fruitworm,** *Acrobasis vaccinii*

Distribution: eastern Canada, eastern USA; on blueberries, cranberries. Reference: *22.*

Head yellowish-brown with brown to dark brown pattern; sclerotized ring on mesothorax dark with pale posterior margin (9B)
---------- **pecan nut casebearer,** *Acrobasis nuxvorella*

Distribution: eastern USA; on pecans. Reference: *22.*



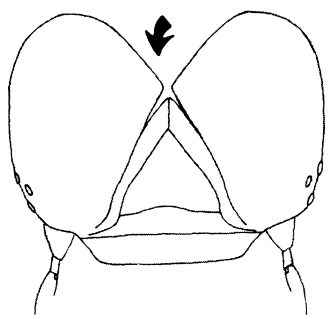
9A *Acrobasis vaccinii*

9B *Acrobasis nuxvorella*

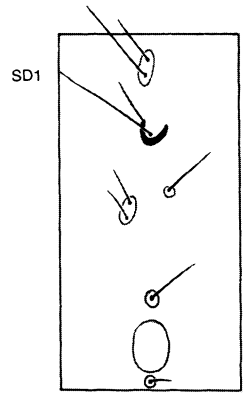
10 Coronal suture absent (10A); sclerotized rings around seta SD1 on mesothorax (10B) and on abdominal segment VIII incomplete ---------- **navel orangeworm,** *Amyelois transitella*

Distribution: the Americas, West Indies; on oranges, walnuts, and other fruits and pods.

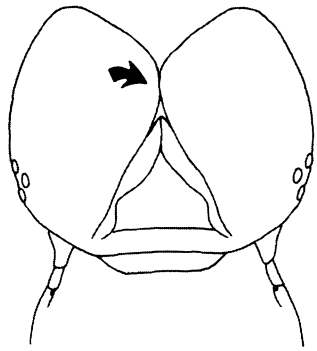
Coronal suture present (10C); sclerotized rings around seta SD1 on mesothorax (10D) and on abdominal segment VIII complete ---------- 11



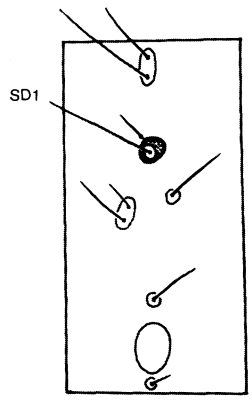
10A *Amyelois transitella*



10B *Ameylois transitella*

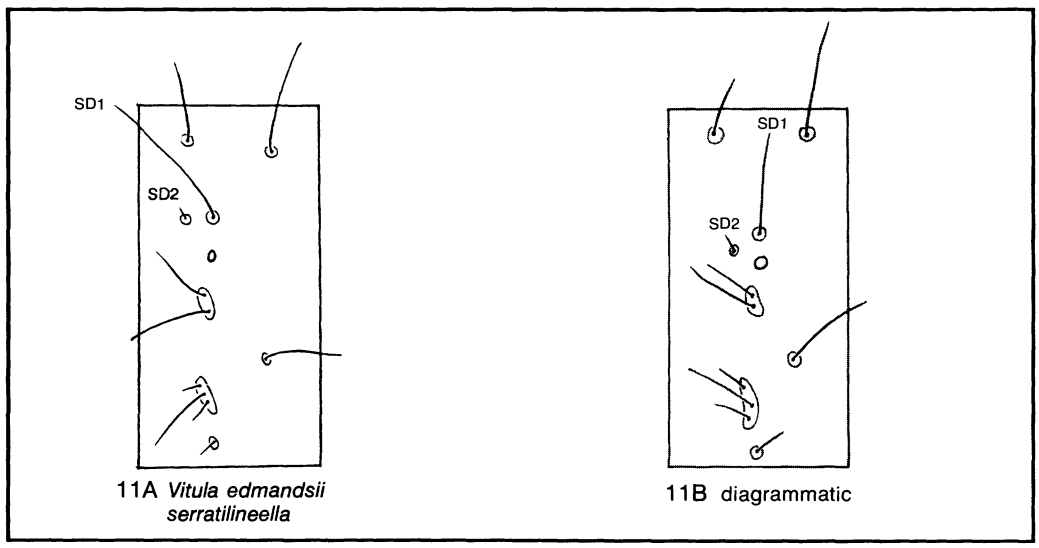


10C *Cadra cautella*



10D diagrammatic

11 Seta SD2 level with seta SD1 on most of abdominal segments I to VII (11A) ------- 12
Seta SD2 below seta SD1 on most of abdominal segments I to VII (11B)---------- 13



11A *Vitula edmandsii serratilineella*

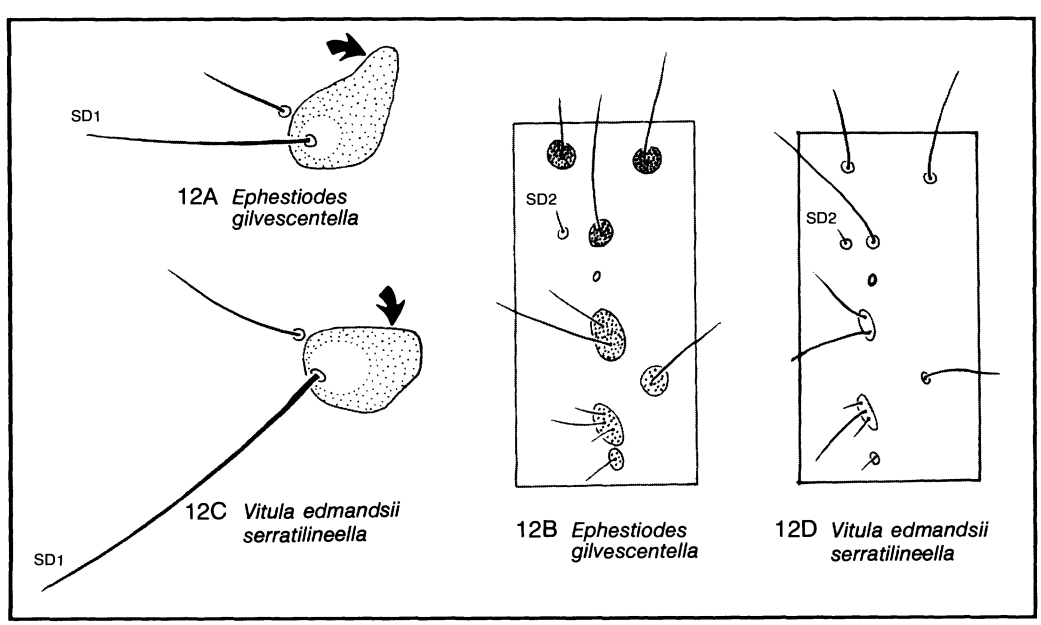
11B diagrammatic

12 Sclerotized ring around seta SD1 on mesothorax elongated dorsoposteriorly (12A); pinacula on abdominal segments I to VIII large and brown (12B)
----------dusky raisin moth, *Ephestiodes gilvescentella*

Distribution: Hawaii, western North America; in raisins and stored almonds.

Sclerotized ring around seta SD1 on mesothorax irregularly rounded (12C); pinacula on segments I to VIII small (may or may not be pigmented) (12D)
----------**driedfruit moth,** *Vitula edmandsii serratilineella*

Distribution: western Canada, western USA; on dried fruit, honey, and pollen. See also 11A. Reference: *25*.



12A *Ephestiodes gilvescentella*

12C *Vitula edmandsii serratilineella*

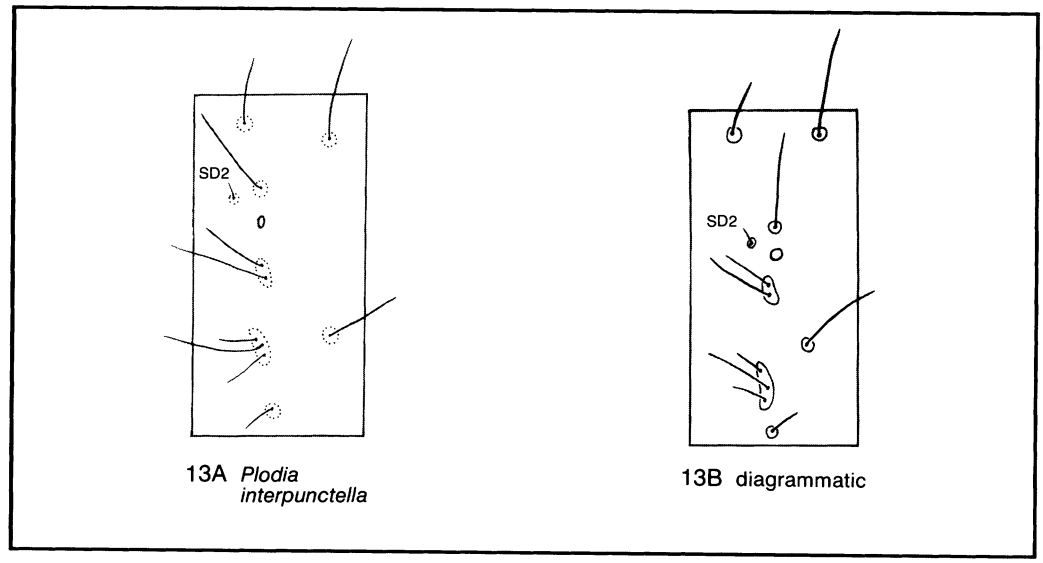
12B *Ephestiodes gilvescentella*

12D *Vitula edmandsii serratilineella*

13 Abdominal segments I to VIII apparently without pinacula (concolorous with body and not evident) (13A); pl. 116B ----------**Indianmeal moth,** *Plodia interpunctella*

Distribution: cosmopolitan; in stored grain and vegetable and fruit products. See also 8B. Reference: *14*.

Abdominal segments I to VIII with small pigmented pinacula (13B). Genera *Cadra* and *Anagasta*---------- 14

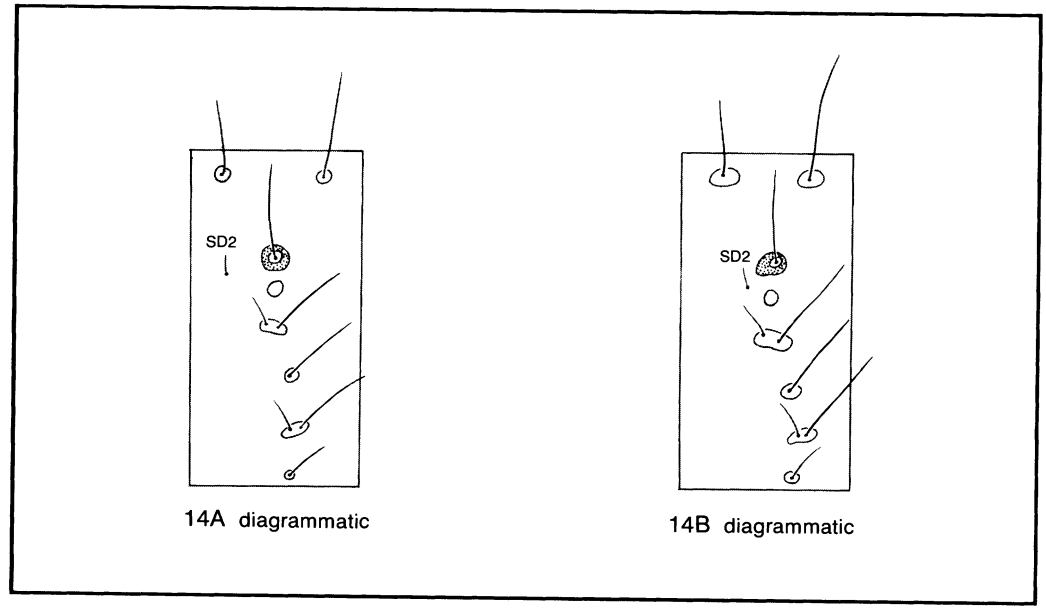


13A *Plodia interpunctella*

13B diagrammatic

14 Abdominal segment VIII with seta SD2 separated from spiracle by 2 to 3 times the horizontal diameter of the spiracle (14A)---------- 15

Abdominal segment VIII with seta SD2 separated from spiracle by a distance equal to the horizontal diameter of the spiracle (14B)---------- 16



14A diagrammatic

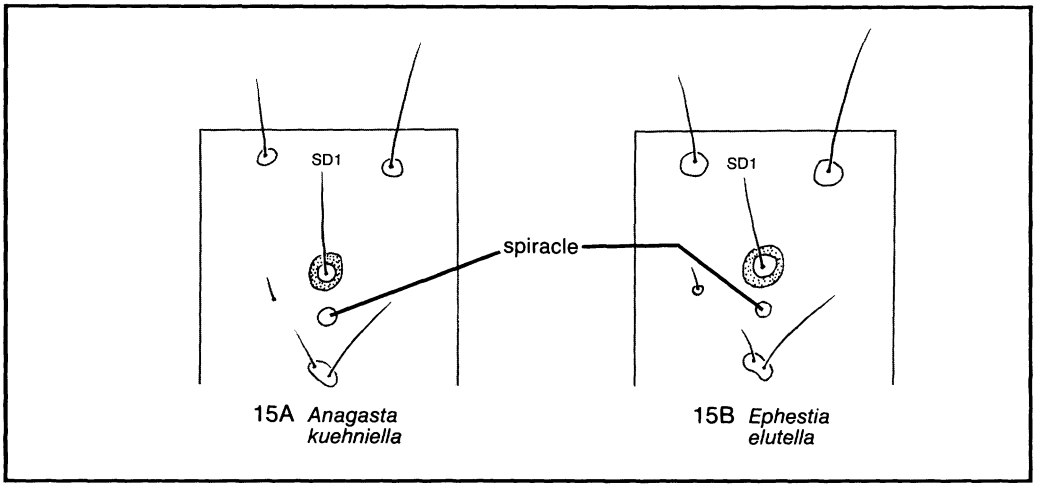
14B diagrammatic

15 Spiracle of abdominal segment VIII as large as the area enclosed by the sclerotized ring around seta SD1 (15A) ---------- **Mediterranean flour moth,** *Anagasta kuehniella*

Distribution: nearly cosmopolitan; in grain and other stored and dried vegetable products.

Spiracle of abdominal segment VIII 2/3 or less as broad as the area enclosed by the sclerotized ring around seta SD1 (15B) ---------- **tobacco moth,** *Ephestia elutella*

Distribution: nearly cosmopolitan; in stored and dried vegetable products.



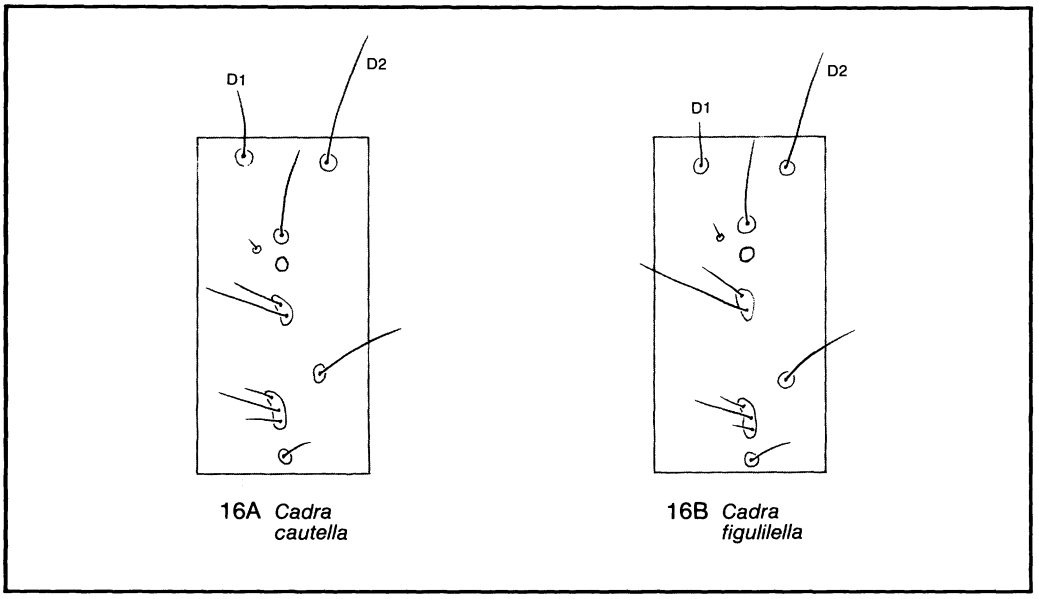
15A *Anagasta kuehniella*

15B *Ephestia elutella*

16 Seta D2 of abdominal segments I to VIII 2 to 2.5 times the length of seta D1 (16A); pl. 116C ---------- **almond moth,** *Cadra cautella*

Distribution: cosmopolitan; in stored and dried vegetable products. See also 10C.

Seta D2 of abdominal segments I to VIII 3 to 5 times the length of seta D1 (16B) 17



16A *Cadra cautella*

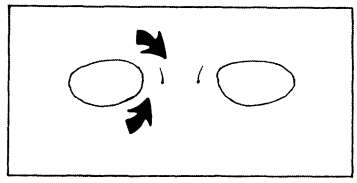
16B *Cadra figulilella*

17 Distance between setae V1 on mesothorax twice or less than the distance between seta V1 and coxa III (17A)----------**raisin moth,** *Cadra figulilella*

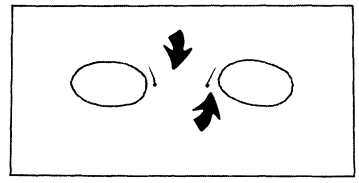
Distribution: nearly cosmopolitan; in dried fruits, nuts, seeds, and beans. See also 16B.

Distance between setae V1 on mesothorax 3 to 5 times the distance between seta V1 and coxa III (17B)----------carob moth, *Cadra calidella*

Distribution: Mediterranean region; in carobs, dried fruits, nuts.



17A *Cadra figulilella*



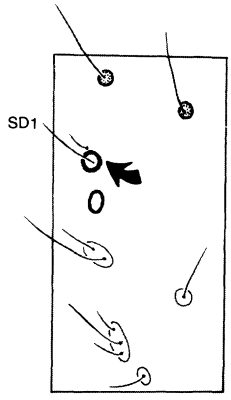
17B *Cadra calidella*

18 Abdominal segment I with sclerotized ring around seta SD1 (18A). Galleriinae (galleriine moths)---------- 19

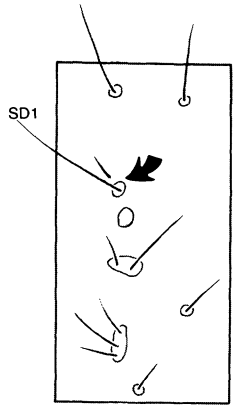
Seta SD1 of abdominal segment VIII also has a sclerotized ring (18B).

Abdominal segment I without sclerotized ring around seta SD1 (18C)---------- 22

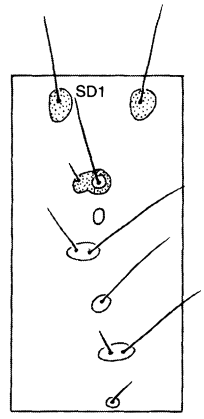
Seta SD1 of abdominal segment VIII may or may not have a sclerotized ring.



18A *Paralipsa gularis*

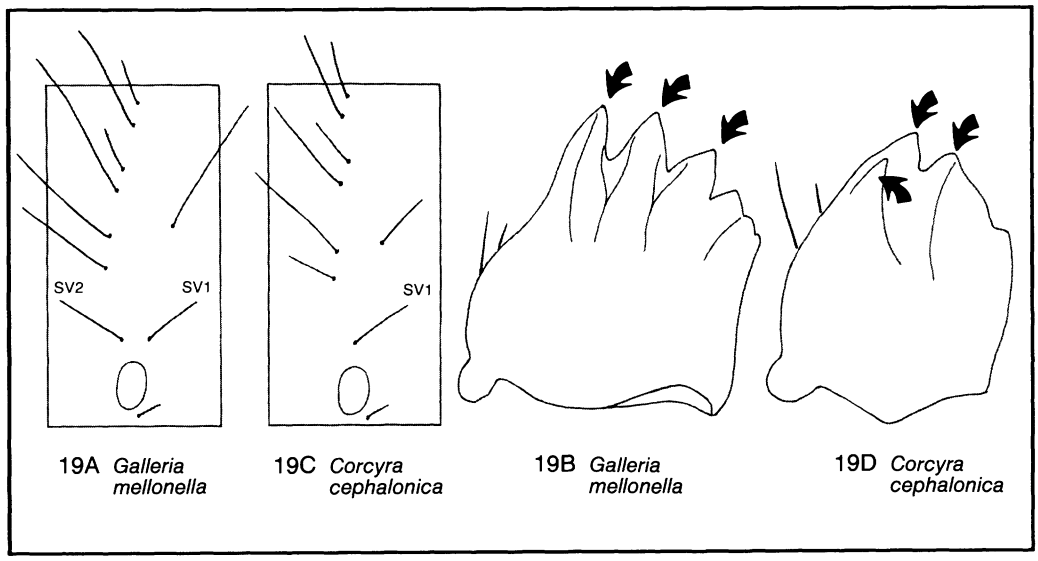


18C diagrammatic



18B *Paralipsa gularis*

19 Subventral group bisetose on meso- and metathorax (19A); mandible with 3 apical teeth and no ventral subapical tooth (19B)---------- 20
Subventral group unisetose on meso- and metathorax (19C); mandible with 2 apical teeth and 1 ventral subapical tooth (19D) ---------- 21

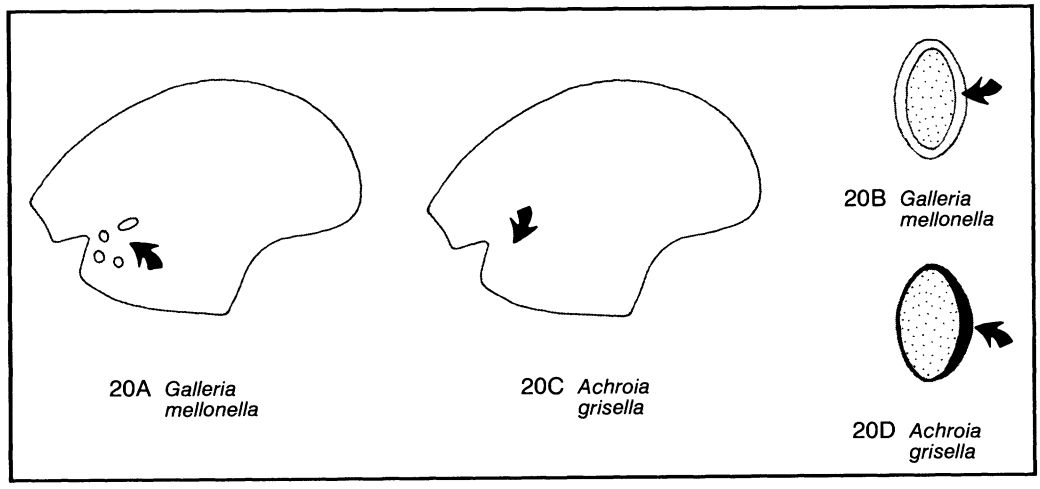


20 Head with 4 stemmata on each side (20A); spiracle with yellowish peritreme of uniform thickness (20B); pl. 117A----------**greater wax moth,** *Galleria mellonella*

Stemmata I and II are fused; stemma IV is missing. Distribution: cosmopolitan; in honeycombs. See also 19A&B.

Stemmata absent (20C); spiracle with black peritreme, thicker on caudal margin (20D)----------**lesser wax moth,** *Achroia grisella*

Distribution: nearly cosmopolitan; in honeycombs and dried fruits.

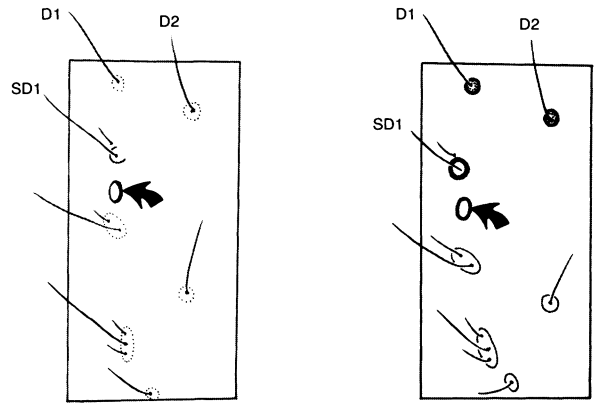


21 Sclerotized ring around seta SD1 on abdominal segments I and VIII not complete; spiracular peritremes thicker on caudal margin; pinacula of setae D1 and D2 on abdominal segments not pigmented (21A); pl. 117B ---------- **rice moth**, *Corcyra cephalonica*

Distribution: cosmopolitan; in dried vegetable products.
See also 19C&D.

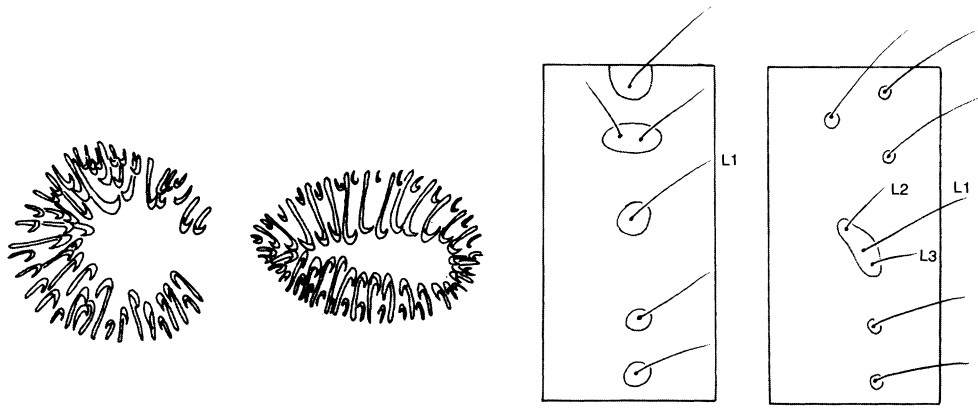
Sclerotized ring around seta SD1 on abdominal segments I and VIII complete; spiracular peritreme of uniform thickness; pinacula of setae D1 and D2 on abdominal segments pigmented (21B)----------**stored nut moth,** *Paralipsa gularis*

Distribution: nearly cosmopolitan; in stored vegetable products. See also 18B.



21A *Corcyra cephalonica* 21B *Paralipsa gularis*

22 Ventral prolegs with crochets in a penellipse (22A); abdominal segment IX with 1 seta in lateral group (22B). Pyraustinae (pyraustine moths) ---------- 23
Ventral prolegs with crochets in a complete circle (22C); abdominal segment IX with 3 setae in lateral group (22D). Pyralinae (pyraline moths)---------- 25

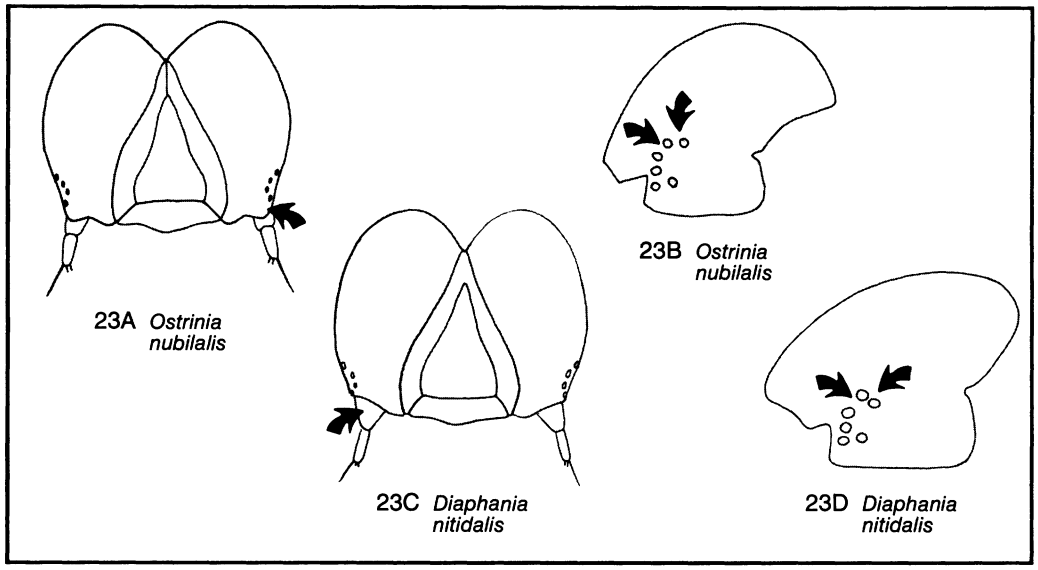


22A *Ostrinia nubilalis* 22C *Pyralis farinalis* 22B diagrammatic 22D diagrammatic

23 Head capsule with a shieldlike extension over base of antenna (23A); stemma II equidistant from stemmata I and III (23B); pl. 117C ----------**European corn borer**, *Ostrinia nubilalis*

Distribution: Europe, USA; in beans, corn, peas, and many other plants. See also 3E.

Head capsule without shieldlike extension over base of antenna (23C); stemma II closer to stemma I than to stemma III (23D)---------- 24

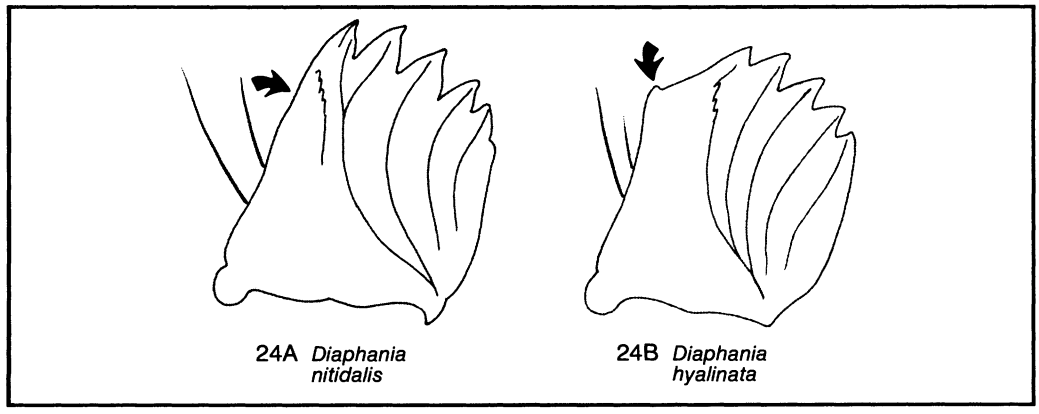


24 Head with a pigmented triangular spot at genal angle; mandible without a projection on lateral margin (24A); pl. 118A----------**pickleworm**, *Diaphania nitidalis*

Pinacula dark in early instars, pale in late instars. Distribution: the Americas, West Indies; in cantaloupes, cucumbers, gourds, squash. See also 23C, 23D.

Head without a pigmented triangular spot at genal angle; mandible with a projection on the lateral margin (24B) ----------**melonworm**, *Diaphania hyalinata*

Pinacula pale in all instars. Distribution: eastern USA, Central America, northern South America, West Indies; in cantaloupe, cucumbers, gourds, pumpkins, squash.

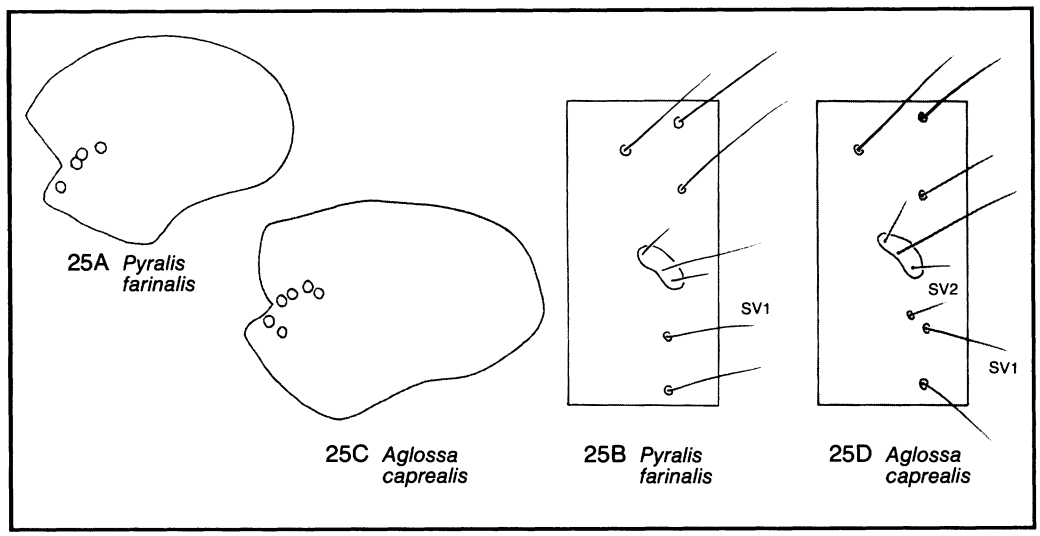


25 Head with 4 pairs of stemmata (25A); abdominal segment IX with 1 subventral seta (25B); pl. 118B----------**meal moth,** *Pyralis farinalis*

Stemmata I and II fused; stemma VI usually missing.
Distribution: cosmopolitan; in dried vegetable products.
See also 3D.

Head with 6 pairs of stemmata (25C); abdominal segment IX with 2 subventral setae (25D); pl. 118C----------murky meal moth, *Aglossa caprealis*

Distribution: nearly cosmopolitan; in damp grain and rotting vegetable matter.

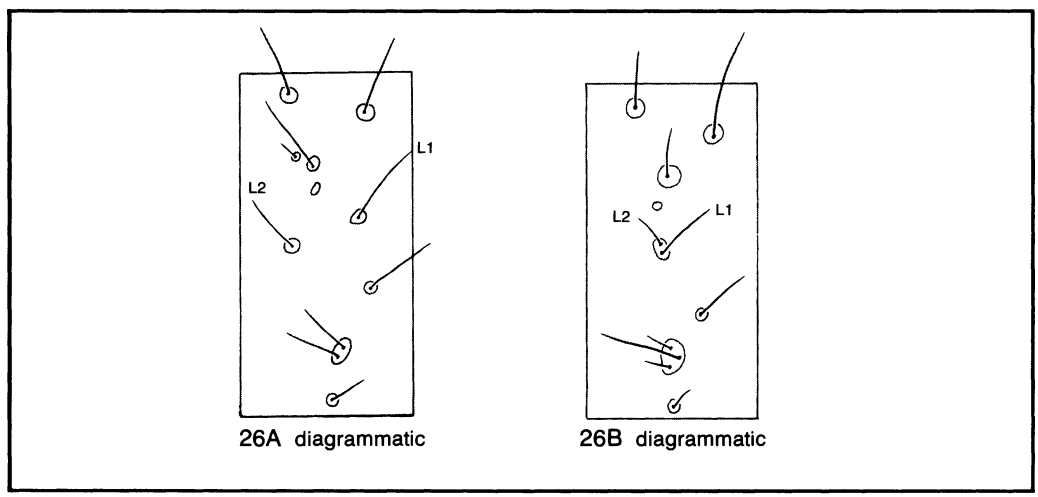


25A *Pyralis farinalis*
25C *Aglossa caprealis*
25B *Pyralis farinalis*
25D *Aglossa caprealis*

26 Setae L1 and L 2 on abdominal segments I to VIII distant from each other below spiracle (26A). Tineidae (**clothes moths**)---------- 27

L1 may be well above L 2 behind the spiracle.
References: *16, 30.*

Setae L1 and L 2 on segments I to VIII close together below spiracle (26B)-------- 29

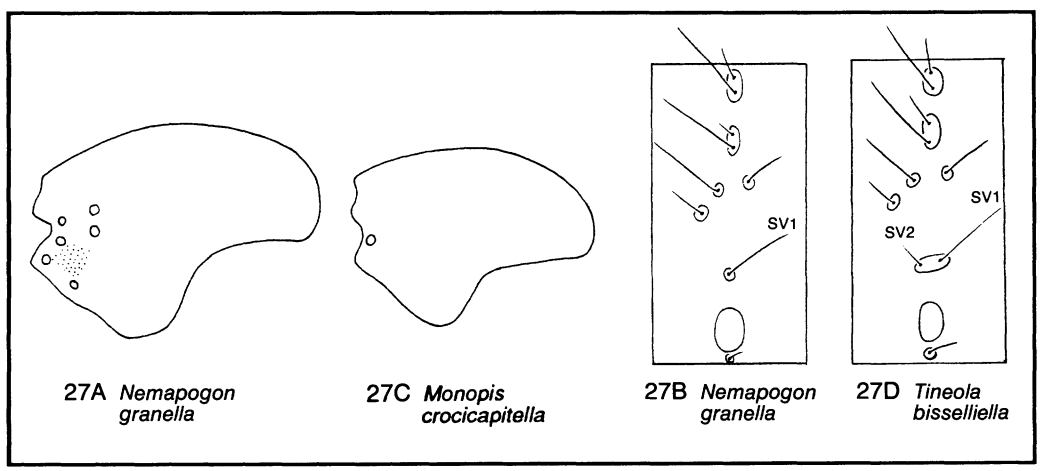


26A diagrammatic
26B diagrammatic

27 Head with 6 pairs of stemmata (27A); meso- and metathorax each with 1 subventral seta (27B)----------**European grain moth**, *Nemapogon granella*

Distribution: nearly cosmopolitan; in mushrooms, stored grain, and dried fruits.

Head with 1 pair of stemmata (27C) or stemmata absent; meso- and metathorax each with 2 subventral setae (27D)---------- 28



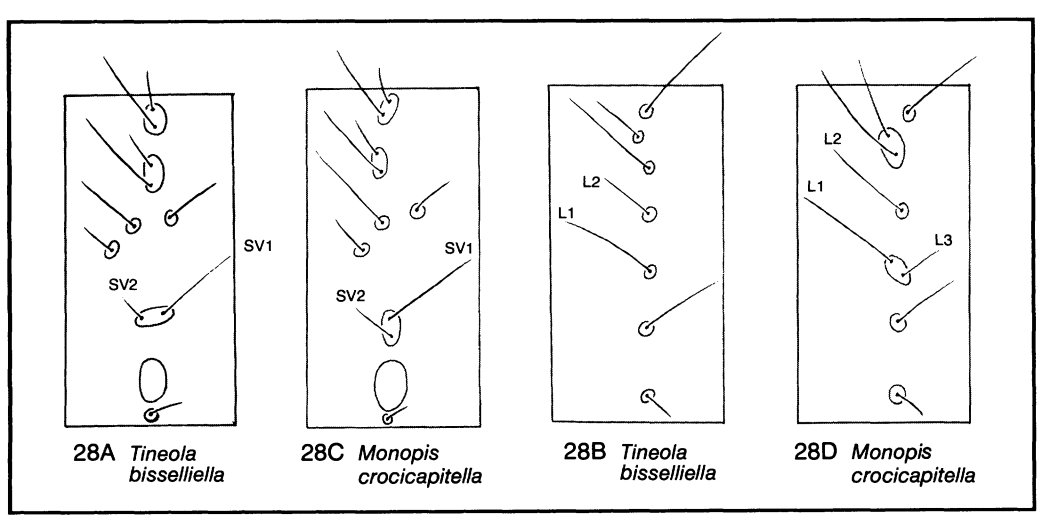
27A *Nemapogon granella* 27C *Monopis crocicapitella* 27B *Nemapogon granella* 27D *Tineola bisselliella*

28 Subventral setae in a nearly horizontal line on meso- and metathorax (28A); abdominal segment IX with 2 lateral setae (28B); stemmata absent; pl. 119A ----------**webbing clothes moth,** *Tineola bisselliella*

Distribution: cosmopolitan; in wool, hair, feathers, and other animal products and occasionally stored cereals.

Subventral setae in nearly a vertical line on meso- and metathorax (28C); abdominal segment IX with 3 lateral setae (28D); head with 1 pair of stemmata ----------*Monopis crocicapitella*

Distribution: Asia, Europe, North Africa, eastern USA; in textiles and dried vegetable matter. See also 27C.

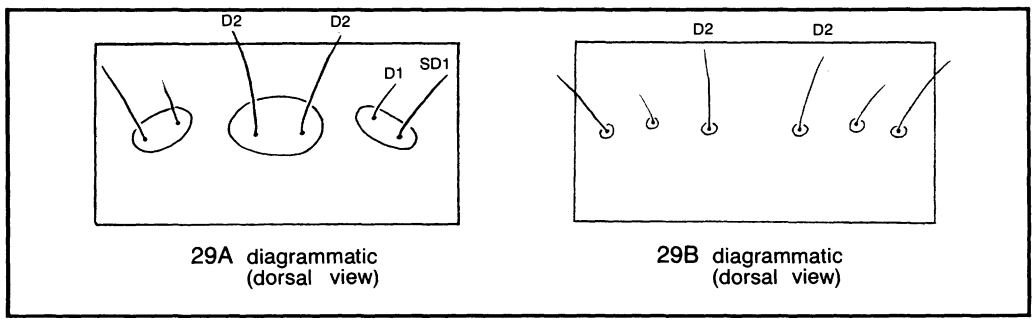


28A *Tineola bisselliella* 28C *Monopis crocicapitella* 28B *Tineola bisselliella* 28D *Monopis crocicapitella*

29 Paired setae D2 of abdominal segment IX on a single pinaculum (29A). Tortricidae (**leafroller moths**) ---------- 30

References: *19, 28.*

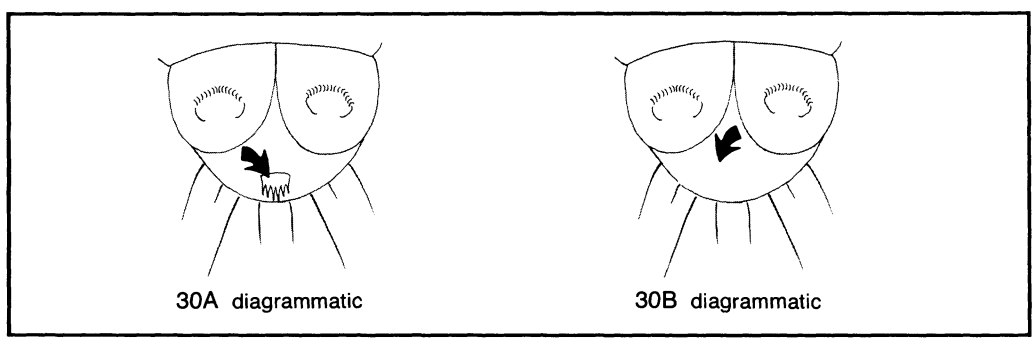
Paired setae D2 of abdominal segment IX not on a single pinaculum (29B) -------- 36



29A diagrammatic (dorsal view)

29B diagrammatic (dorsal view)

30 Anal fork present (30A)---------- 31
Anal fork absent (30B)---------- 33



30A diagrammatic

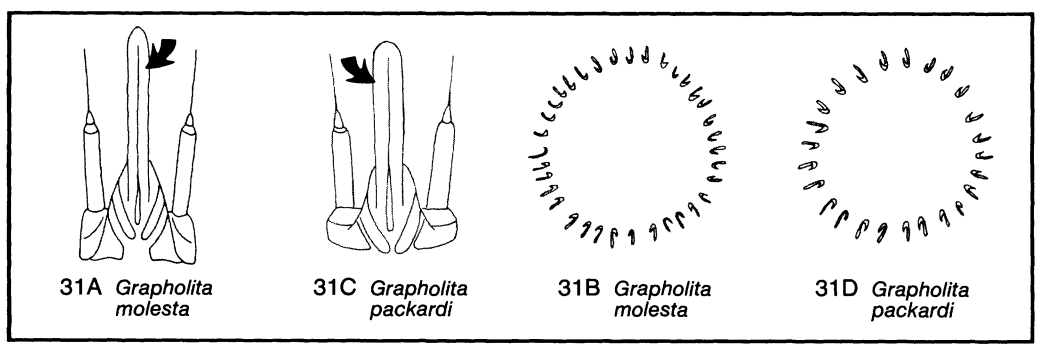
30B diagrammatic

31 Spinneret 7 to 8.5 times as long as wide (31A); 30 to 40 crochets on ventral prolegs (31B)----------**oriental fruit moth,** *Grapholita molesta*

Body length 10 to 12 mm. Distribution: widespread in temperate regions; in apples, apricots, cherries, nectarines, peaches, pears, plums, quinces. Reference: *2.*

Spinneret 5 to 6 times as long as wide (31C); 25 to 30 crochets on ventral prolegs (31D) 32

Body length 8 to 10 mm.



31A *Grapholita molesta*

31C *Grapholita packardi*

31B *Grapholita molesta*

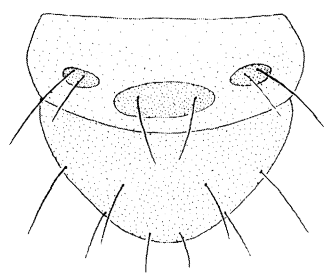
31D *Grapholita packardi*

32 Anal shield brown; pinacula of posterior segments brownish, never suffused with reddish pigment (32A)----------**cherry fruitworm,** *Grapholita packardi*

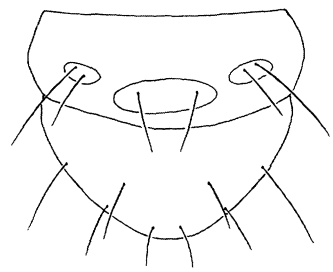
Distribution: eastern Canada and eastern USA; in apples and cherries and in fruits of hawthorn and rose. See also 31C&D.

Anal shield yellowish or pale brown; pinacula of posterior segments never brownish, usually suffused with reddish pigment (32B)---**lesser appleworm,** *Grapholita prunivora*

Distribution: Canada, Europe (introduced), USA; in apples, cherries, pears, and plums.



32A *Grapholita packardi*

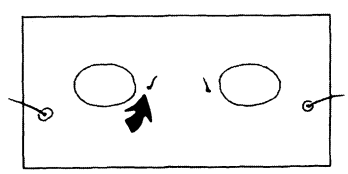


32B *Grapholita prunivora*

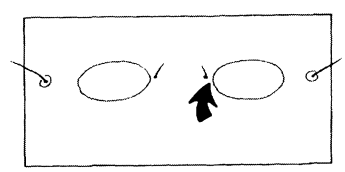
33 Coxae III separated by a distance equal to about 1.5 times their greatest diameter; seta V1 well separated from coxa (33A)----------**filbertworm,** *Cydia latiferreana*

Distribution: Canada, Mexico, USA; in acorns and chestnuts.

Coxae III about their own diameter apart; seta V1 very close to coxa (33B) --------- 34



33A *Cydia latiferreana* (ventral view)

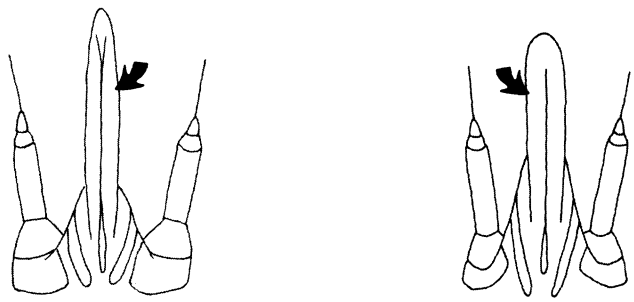


33B *Cydia* (ventral view)

34 Spinneret 6 to 6.5 times as long as wide (34A); head yellowish-brown overlaid with darker pattern; pl. 119B---------- **codling moth,** *Cydia pomonella*

Distribution: nearly cosmopolitan; in apples, chestnuts, pears, quinces, and walnuts.

Spinneret 5 times as long as wide (34B); head yellow-brown without darker pattern 35



34A *Cydia pomonella*

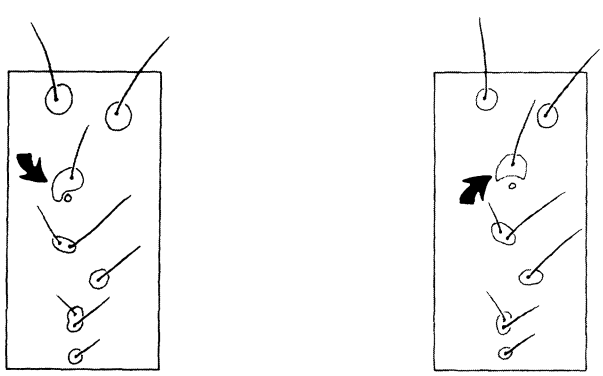
34B *Cydia caryana*

35 Pinaculum of seta SD1 on abdominal segments I to VII usually elongated anterior to spiracle (35A)---------- **pea moth,** *Cydia nigricana*

Distribution: Asia Minor, Canada, Europe, USA; in pea pods.

Pinaculum of seta SD1 on abdominal segments I to VII not elongated anterior to spiracle (35B)---------- **hickory shuckworm,** *Cydia caryana*

Distribution: eastern Canada, eastern USA; in pecans and hickory nuts. See also 34B.



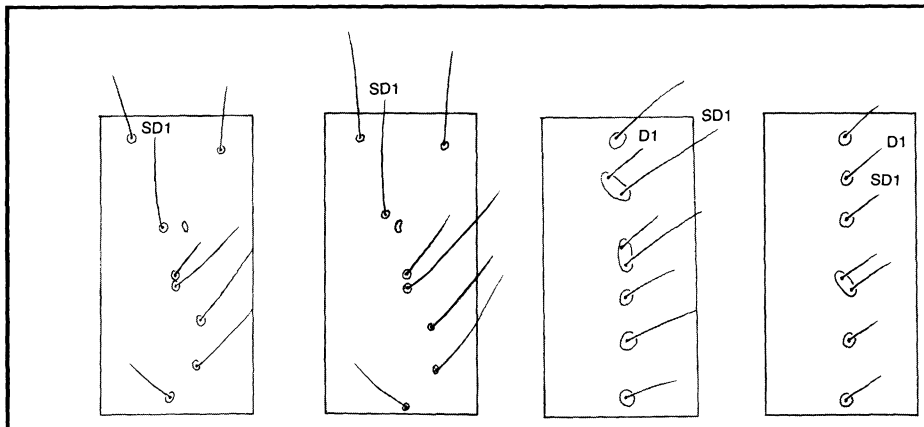
35A *Cydia nigricana*

35B *Cydia caryana*

36 Seta SD1 of abdominal segment VIII directly in front of spiracle (36A); seta SD1 of abdominal segment IX on same pinaculum with D1 (36B); pl. 119C. Cosmopterigidae (cosmopterigid moths)
----------**pink scavenger caterpillar,** *Pyroderces rileyi*

Distribution: Mexico, USA, West Indies; in corn, cotton, and many rotten or dried fruits.

Seta SD1 of abdominal segment VIII above and in front of spiracle (36C); seta SD1 of abdominal segment IX not on same pinaculum with D1 (36D)---------- 37

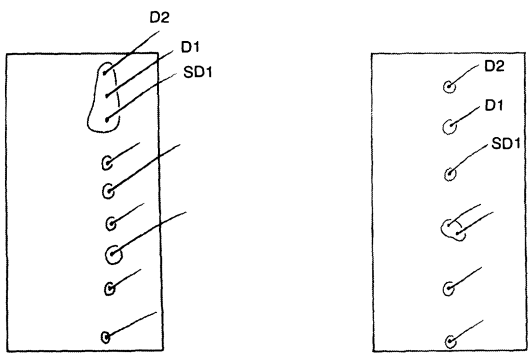


36A *Pyroderces rileyi* 36C diagrammatic 36B *Pyroderces rileyi* 36D diagrammatic

37 Setae D1, D2, and SD1 of abdominal segment IX on a single pinaculum (37A); pl. 120A. Argyresthiidae (argyresthiid moths)-------**apple fruit moth,** *Argyresthia conjugella*

Distribution: Europe, Canada (British Columbia), USA (California, Oregon); in apples and *Sorbus* berries.

Setae D1, D2, and SD1 of abdominal segment IX not on a single pinaculum (37B) 38

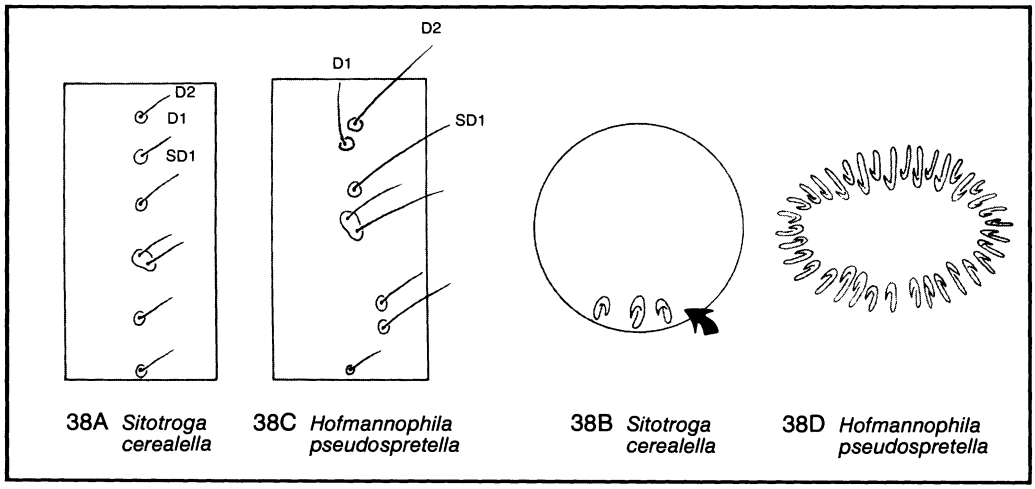


37A *Argyresthia conjugella* 37B *Sitotroga cerealella*

38 Seta D1 equidistant from setae D2 and SD1 on abdominal segment IX (38A); ventral prolegs short, narrow, often indistinct, with only 2 to 4 crochets (38B); pl. 120B. Gelechiidae (**gelechiid moths**)----------**Angoumois grain moth,** *Sitotroga cerealella*

Distribution: nearly cosmpolitan; larvae live inside kernels of stored grain.

Seta D1 closely associated with and anterior to D2 on abdominal segment IX (38C); prolegs distinct, well developed, with many crochets (38D). Oecophoridae (**oecophorid moths**)---------- 39



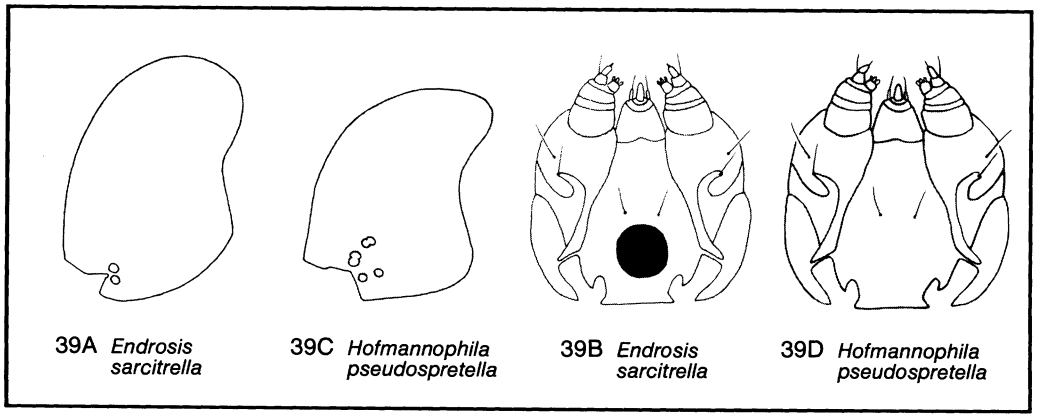
38A *Sitotroga cerealella* 38C *Hofmannophila pseudospretella* 38B *Sitotroga cerealella* 38D *Hofmannophila pseudospretella*

39 Head with 2 pairs of stemmata (39A); submentum with large oval pit (39B) ----------**whiteshouldered moth,** *Endrosis sarcitrella*

Distribution: nearly cosmopolitan; in bulbs and decaying fruit.

Head with 4 pairs of stemmata (39C); submentum without large oval pit (39D); pl. 120C ----------**brown house moth**, *Hofmannophila pseudospretella*

Stemmata I and II fused and stemmata III and IV fused, giving the appearance of 4 stemmata. Distribution: nearly cosmopolitan; in bulbs, stored vegetable products, and many other substrates. See also 38C.



39A *Endrosis sarcitrella* 39C *Hofmannophila pseudospretella* 39B *Endrosis sarcitrella* 39D *Hofmannophila pseudospretella*

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Notes and Sketches

16 FLIES (DIPTERA)

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Many kinds of flies are attracted to perishable foods on which they feed and deposit their eggs or larvae (maggots). Feeding by the larvae often hastens further decay by fostering growth of secondary decomposers such as bacteria and fungi. Larvae may develop rapidly in some media. For example, blow fly larvae (Calliphoridae) may reach full growth in three days under optimal conditions. Some larvae feed inside plant tissues and therefore often go unnoticed when the plants are bought for food or prepared for storage.

The keys given here to some common flies or groups of flies often associated with food are designed to separate taxa at least to family level and in some cases to generic or specific level. Most of the structures referred to in the keys are visible to the unaided eye or require no more than a hand lens; others require the use of a dissecting microscope. The key characters and the descriptive notes used to separate larvae pertain to full-grown larvae.

This key is compiled from several sources (*1, 2, 4, 5*). More complete, technical keys to family and generic levels for adult flies (and, in many cases, larvae) may be found in McAlpine *et al.* (*3*).

KEY

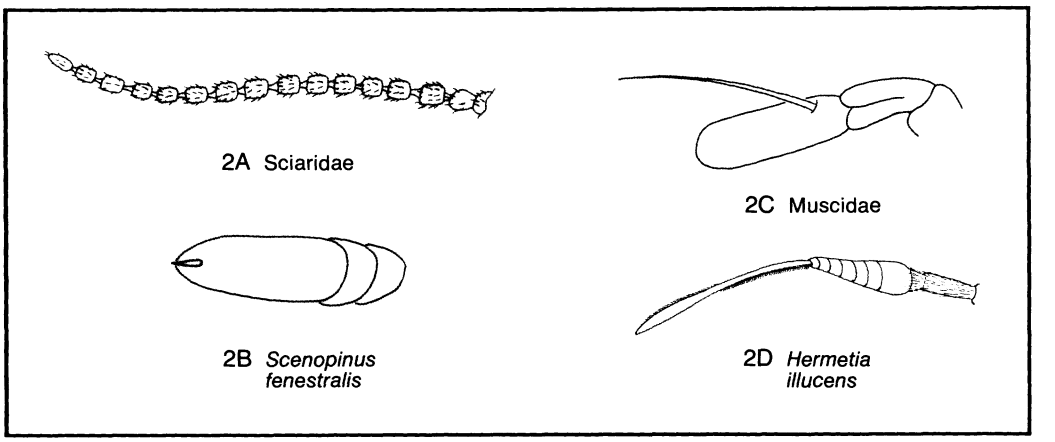
Drawings by C. Feller unless otherwise noted.

Adults

1 Adult specimen ---------- 2
Larval specimen ---------- 32

2 Antenna with 7 to 16 segments, each segment discrete, more or less similar, and freely articulated (2A) ---------- 3
Antenna with 3, often dissimilar, segments (2B, 2C) ---------- 5

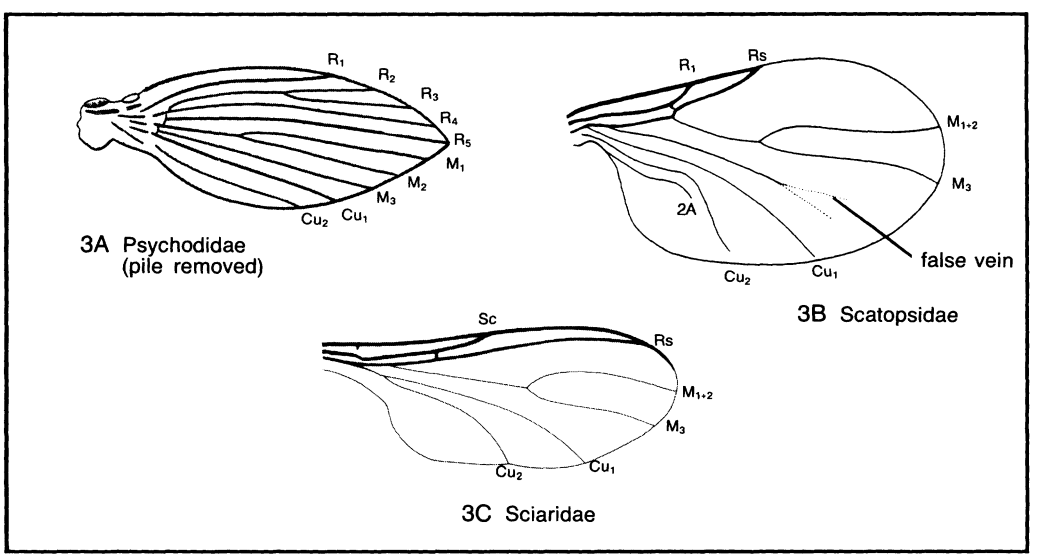
The third segment may be annulate (2D) or aristate (2B, 2C).



3 Mothlike; body and wings densely haired, with wings held rooflike over body (pl. 121C); wing veins evenly distributed, not stronger anteriorly than elsewhere (3A) ---------- **moth flies,** Psychodidae

Drawing 3A from 2.

Not mothlike; much of the body smooth and shining; wings held flat or erect over body (see 4A, 4B); wing veins stronger and concentrated in anterior part of wing (3B, 3C) ---------- 4

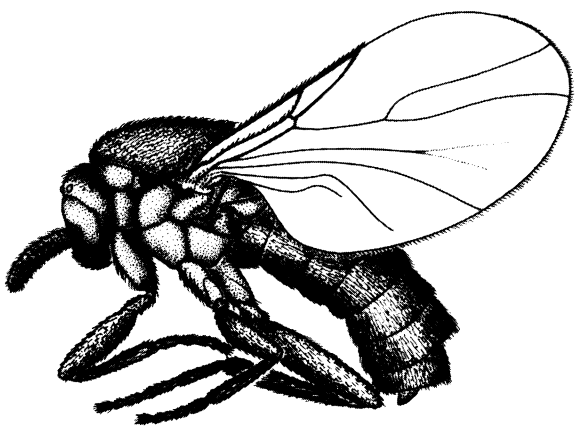


4 Antenna clublike, with 7 to 12 segments; antennal length much shorter than thorax (4A) ---------- minute black scavenger flies, Scatopsidae

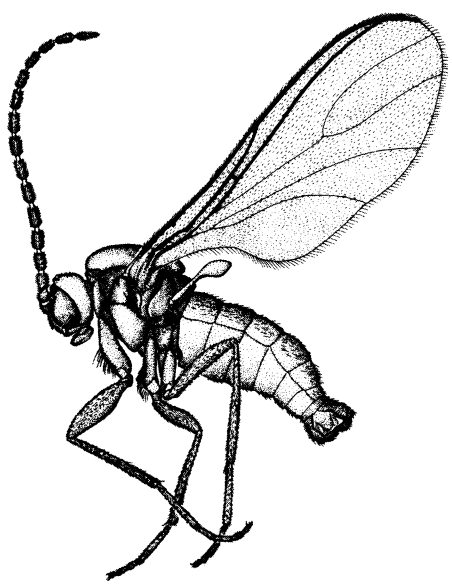
Species of the cecidomyiid genera *Heteropeza, Henria,* and *Mycophila* infesting cultivated mushrooms would also key out at this point (the adults of these genera have 10 or fewer antennal segments). In Sciaridae, the costal vein ends just beyond the last branch of R; in Cecidomyiidae, the costal vein continues beyond the wing tip. It would be unusual to find the adults of these mushroom pests anywhere but in mushroom houses. Even there cecids would be associated with the edible portions of mushrooms only as accidental contaminants. See also 3B.

Antenna elongate and flexible, with 16 segments; antennal length longer than thorax (4B) ---------- **darkwinged fungus gnats,** Sciaridae

See also 2A, 3C.



4A Scatopsidae

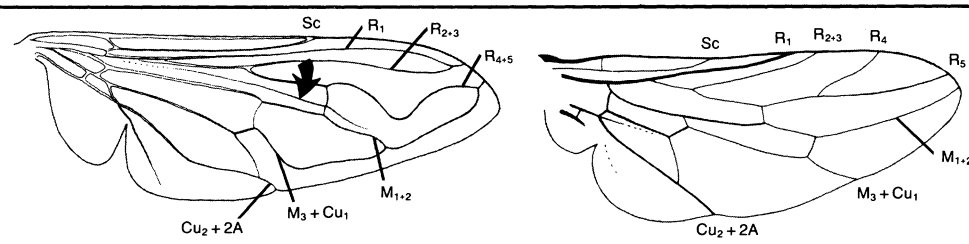


4B Sciaridae

5 Wing with spurious vein (5A); body beelike; pl. 122A. Syrphidae (**flower flies**) ---------- **drone fly,** *Eristalis tenax*

This is one of several similar species likely to be found.

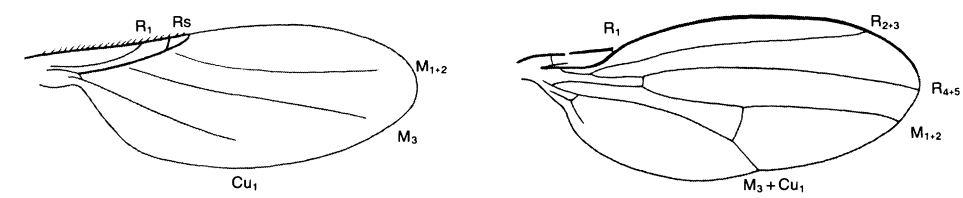
Wing without spurious vein (5B); body not beelike ---------- 6



5A *Eristalis tenax* 5B *Scenopinus*

6 Wing with strong veins anteriorly and weak, oblique veins posteriorly (6A); pl. 123C&D ---------- **humpbacked flies,** Phoridae

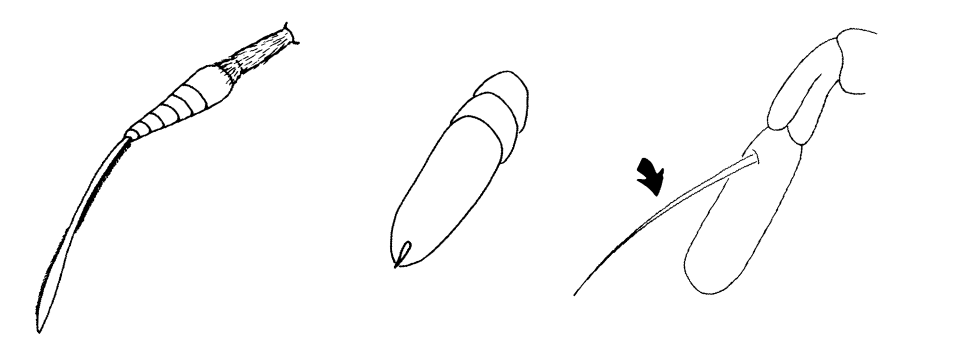
Wing veins not appreciably stronger anteriorly than elsewhere (6B) ---------- 7



6A *Megaselia* 6B *Drosophila*

7 Antenna without a long, dorsal arista (7A, 7B) ---------- 8

Antenna with a long, dorsal arista (7C) ---------- 9



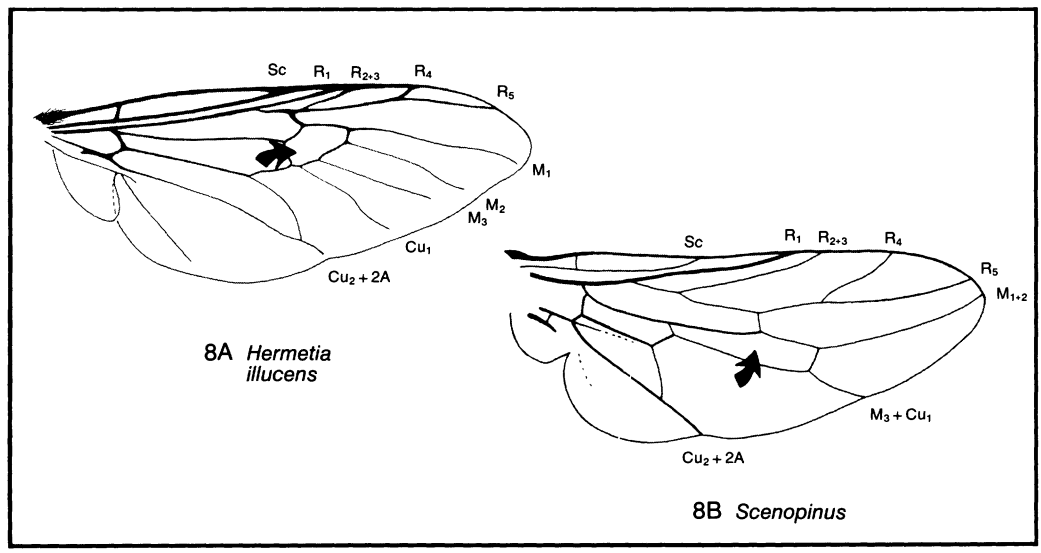
7A *Hermetia illucens* 7B *Scenopinus fenestralis* 7C Muscidae

8 Discal (central) cell rounded with several veins issuing from it (8A); pl. 124B&C. Stratiomyidae (**soldier flies**) ----------**black soldier fly,** *Hermetia illucens*

This is one of several similar species likely to be found.
See also 7A.

Discal cell long, with only 2 veins issuing from it (8B); pl. 125A. Scenopinidae (window flies) ----------*Scenopinus* spp.

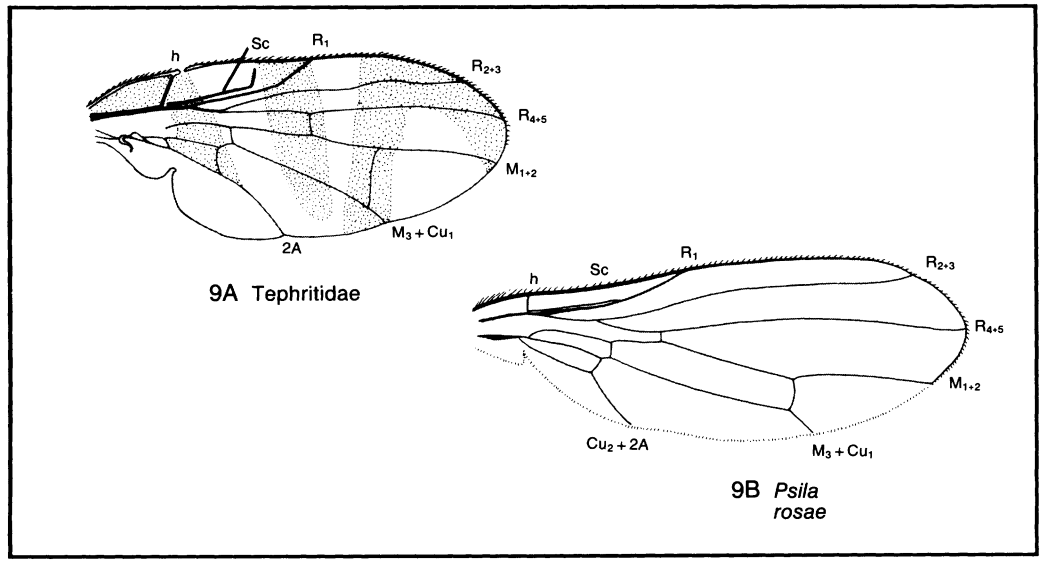
See also 7B.



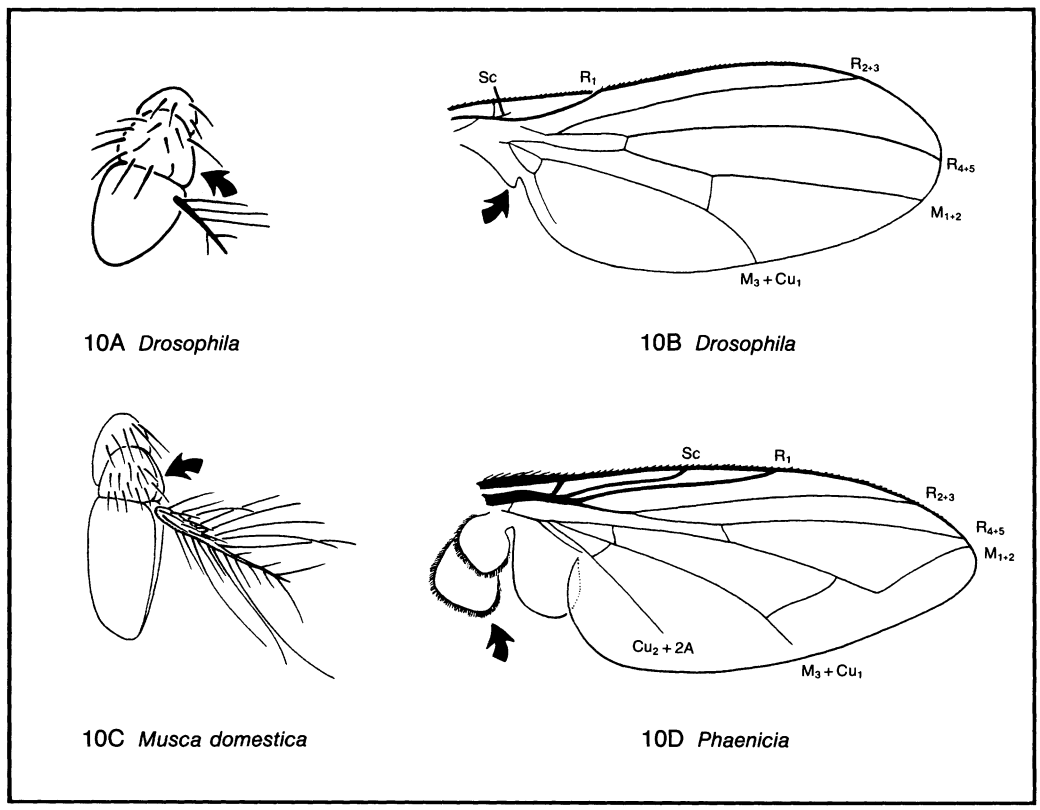
9 Thorax, abdomen, and wing (9A) patterned ----------**fruit flies,** Tephritidae

Tephritids likely to occur in fruit products include *Anastrepha* spp., *Rhagoletis* spp., and *Ceratitis capitata.*

Thorax and abdomen usually brown to black; wing not patterned (9B) (may be a spot near apex of R_{2+3}) ---------- 10



10 Antennal segment II without longitudinal suture (10A); calypteres of wing absent or inconspicuous (10B) ---------- 11
Antennal segment II with longitudinal suture (10C); wing with large calypteres (10D) 15



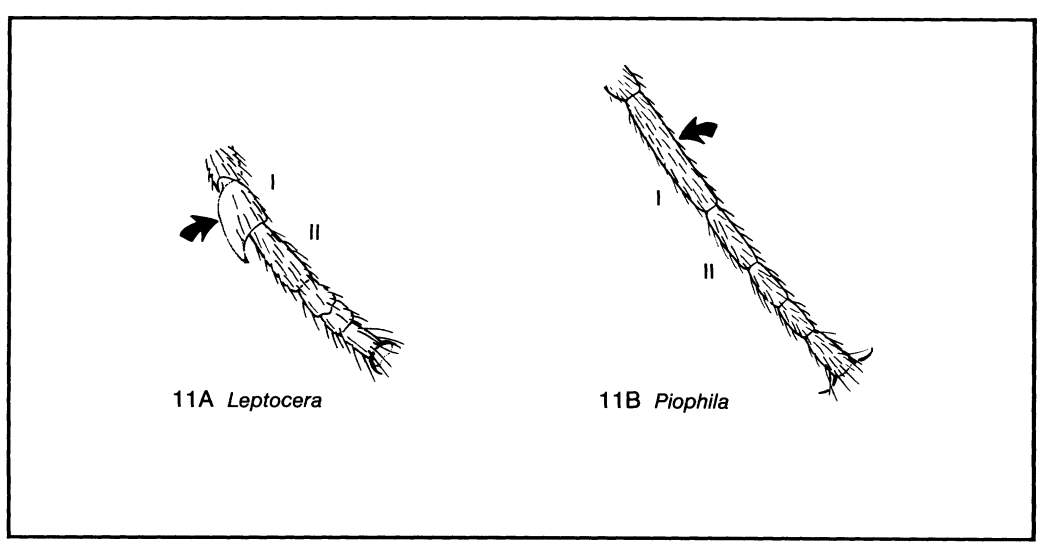
10A *Drosophila*

10B *Drosophila*

10C *Musca domestica*

10D *Phaenicia*

11 First segment of tarsus III wider and shorter than segment II (11A); pl. 125B. Sphaeroceridae (small dung flies) ---------- *Leptocera* spp.
First segment of tarsus III longer but not wider than segment II (11B) ---------- 12



11A *Leptocera*

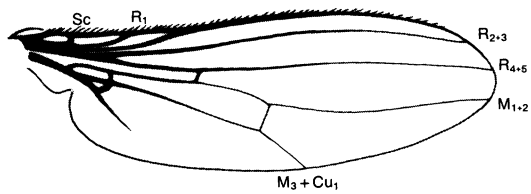
11B *Piophila*

12 Arista plumose (12A) ---------- 13
Arista simple or with inconspicuous hairs (12B) ---------- 14

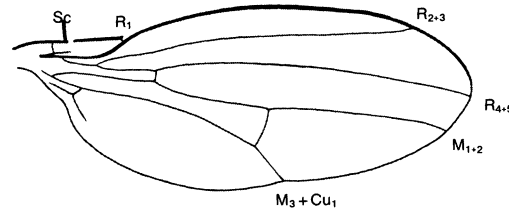
12A *Drosophila* 12B *Piophila casei*

13 Abdomen conspicuously narrowed at base (pl. 126A&B); subcostal vein complete (13A) ---------- black scavenger flies, Sepsidae
Abdomen not conspicuously narrowed at base (pl. 126C); subcostal vein incomplete (13B). Drosophilidae **(small fruit flies)**----------*Drosophila*

See also 10A, 12A.



13A *Sepsis*



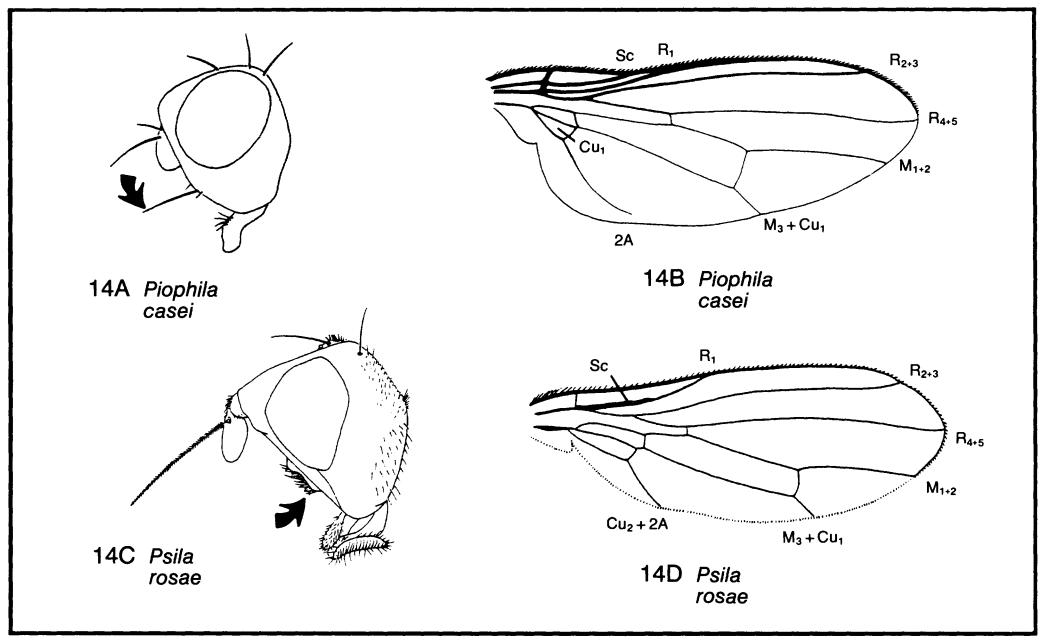
13B *Drosophila*

14 Strong oral bristle present (14A); subcostal vein ending in costa (14B); pl. 127A.
Piophilidae **(skipper flies)**----------**cheese skipper,** *Piophila casei*

See also 11B.

Strong oral bristle absent (14C); subcostal vein ending in radius (14D); pl. 127B.
Psilidae **(rust flies)**----------**carrot rust fly,** *Psila rosae*

This is one of several similar species likely to be found.



14A *Piophila casei*

14B *Piophila casei*

14C *Psila rosae*

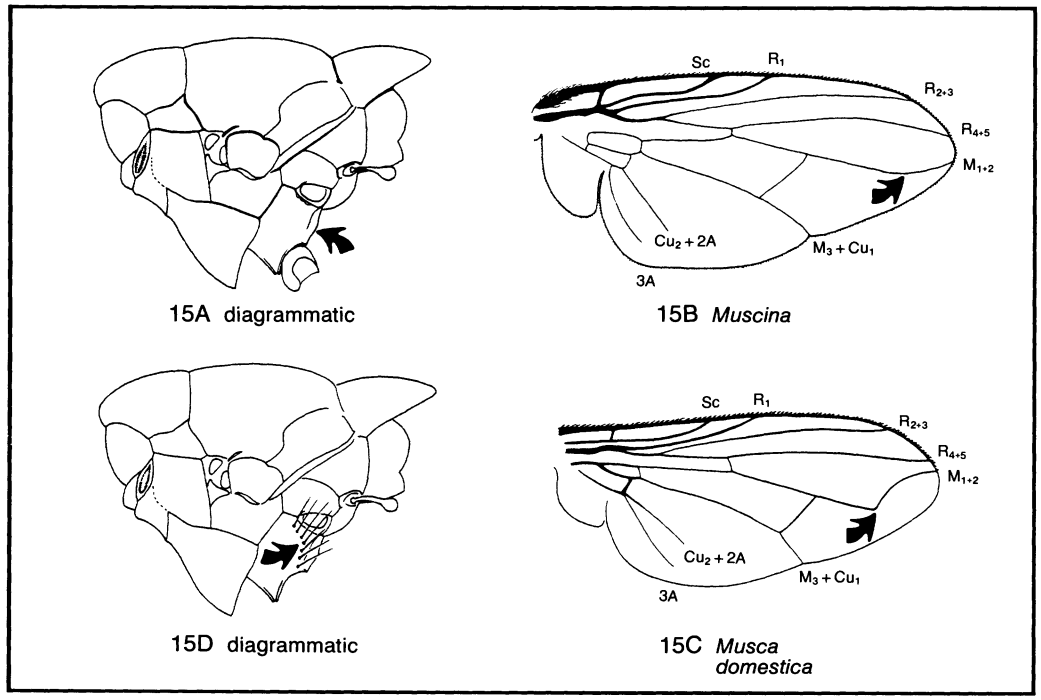
14D *Psila rosae*

15 Hypopleuron bare (15A). Muscidae (muscid flies) ---------- 16

Median vein (M_{1+2}) straight or gently curved forward (15B), except in *Musca* spp. (15C).

Hypopleuron with a row of strong setae (15D) ---------- 21

Median vein (M_{1+2}) strongly bent forward near apex (as in 15C).



15A diagrammatic

15B *Muscina*

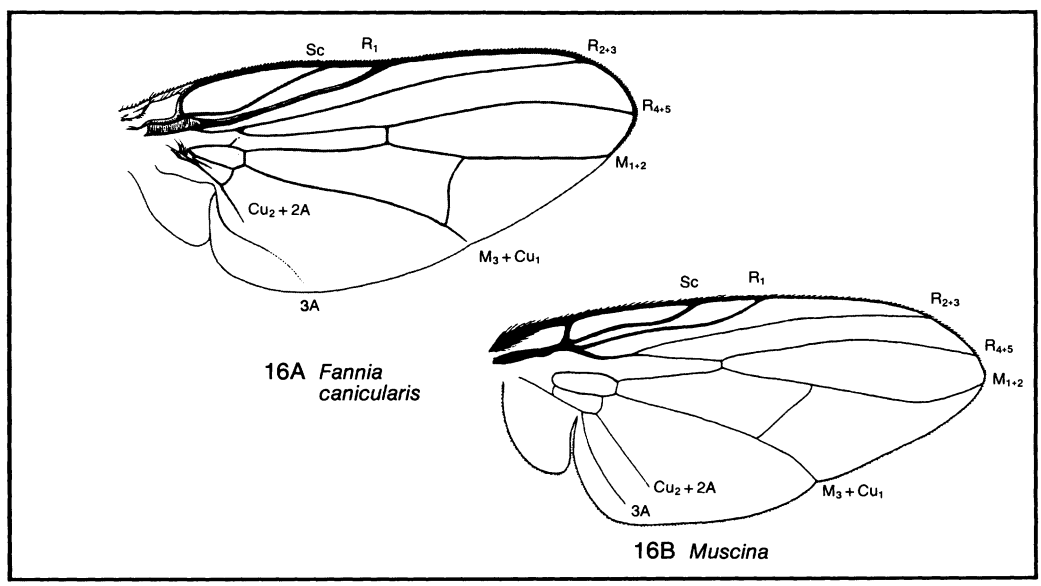
15D diagrammatic

15C *Musca domestica*

16 Vein 3A so strongly curved forward that it would intersect with a hypothetical extension of $Cu_2 + 2A$ well before wing margin (16A); pl. 128B ---------- **little house fly,** *Fannia canicularis*

This is one of several species likely to be found.

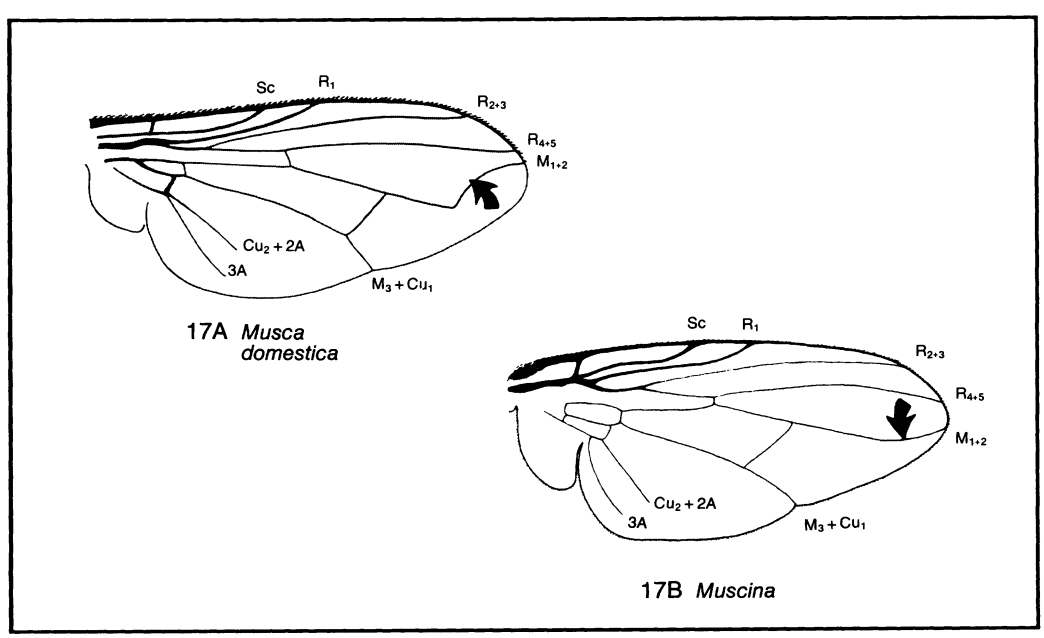
Vein 3A straight or only weakly curved (16B) ---------- 17



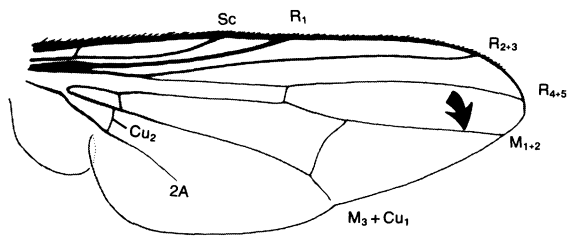
17 Vein M_{1+2} strongly bent forward apically (17A); pl. 129B ------ **house fly,** *Musca domestica*

See also 10C.

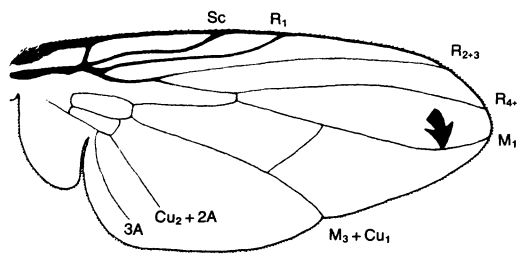
Vein M_{1+2} straight or weakly curved apically (17B) ---------- 18



18 Median vein straight (18A); body shining, black. Genus *Ophyra* ---------- 19
Median vein curved apically (18B); body dull, grayish-black, with tip of scutellum reddish. Genus *Muscina* ---------- 20



18A *Ophyra*



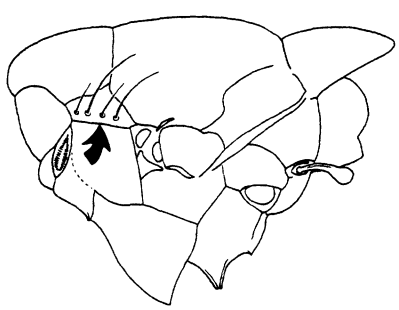
18B *Muscina*

19 Palpus yellow; pl. 130A ---------- bronze dump fly, *Ophyra aenescens*
Palpus black ---------- dump fly, *Ophyra leucostoma*

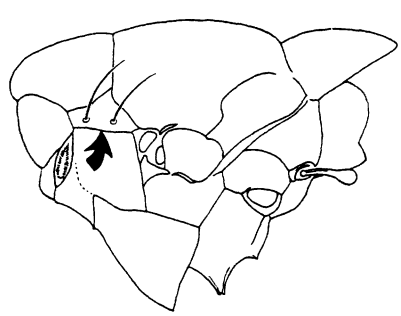
20 Legs predominantly red; pl. 130B ---------- **false stable fly,** *Muscina stabulans*
Legs black ---------- *Muscina assimilis*

21 Notopleuron with 3 or 4 setae (21A); body dull colored, the abdomen with checkered pattern; pl. 131B. Sarcophagidae (**flesh flies**) ---------- *Sarcophaga* spp.

Notopleuron with 2 setae (21B); body shining green, bronze, or blue. Calliphoridae (**blow flies**) ---------- 22

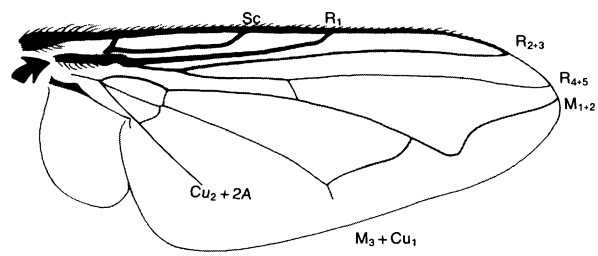


21A diagrammatic

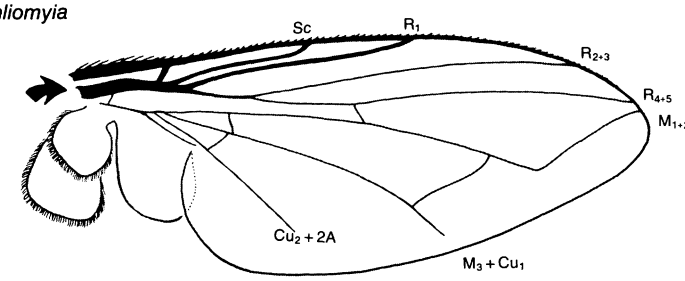


21B diagrammatic

22 Base of stem vein (R) ciliate (22A) ---------- 23
Base of stem vein (R) bare (22B) ---------- 26

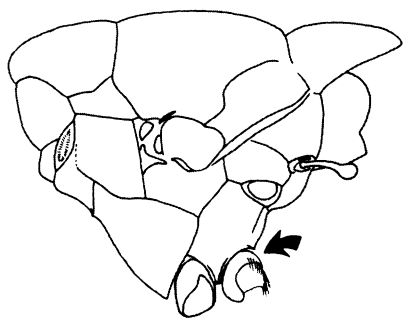


22A *Cochliomyia*

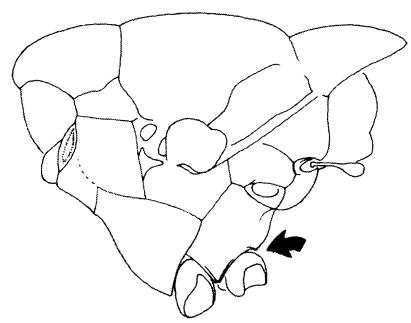


22B *Phaenicia*

23 Coxa III pilose posteriorly (23A) ---------- 24
Coxa III bare posteriorly (23B) ---------- 25



23A diagrammatic



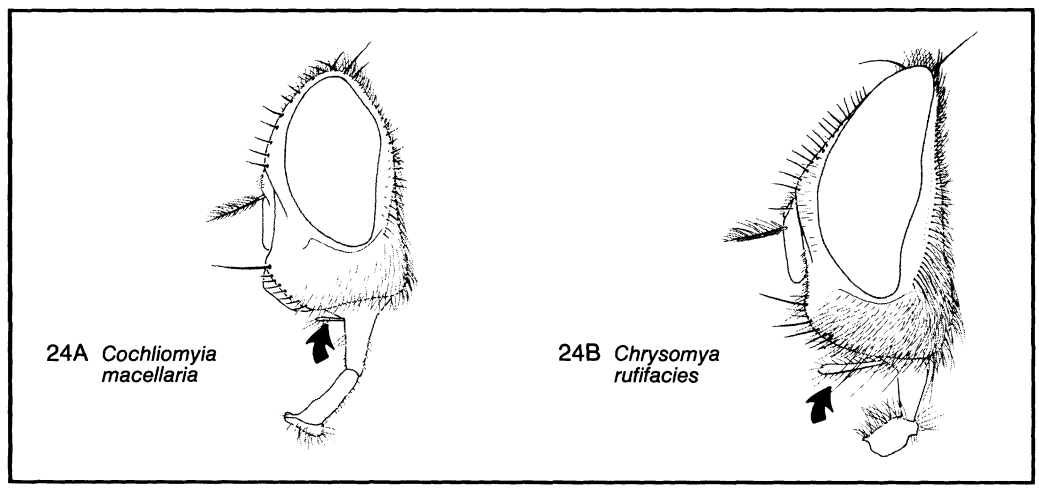
23B diagrammatic

24 Palpus short, filiform (24A); pl. 132B------**secondary screwworm,** *Cochliomyia macellaria*

See also 22A.

Palpus long, clavate (24B); pl. 133E&F--------Old World screwworm flies, *Chrysomya* spp.

Body length: 8-12 mm. Members of the genus *Chrysomya,* widely distributed in the Old World, commonly lay eggs on meat and fish (*2*). Four species are now established in the New World. The **hairy maggot blow fly,** *C. rufifacies,* appeared in Costa Rica shortly before 1978 and has since spread through Mexico to Texas and Oklahoma. *C. albiceps, C. megacephala,* and *C. chloropyga* have been collected in South America (Brazil, Peru) since 1975.

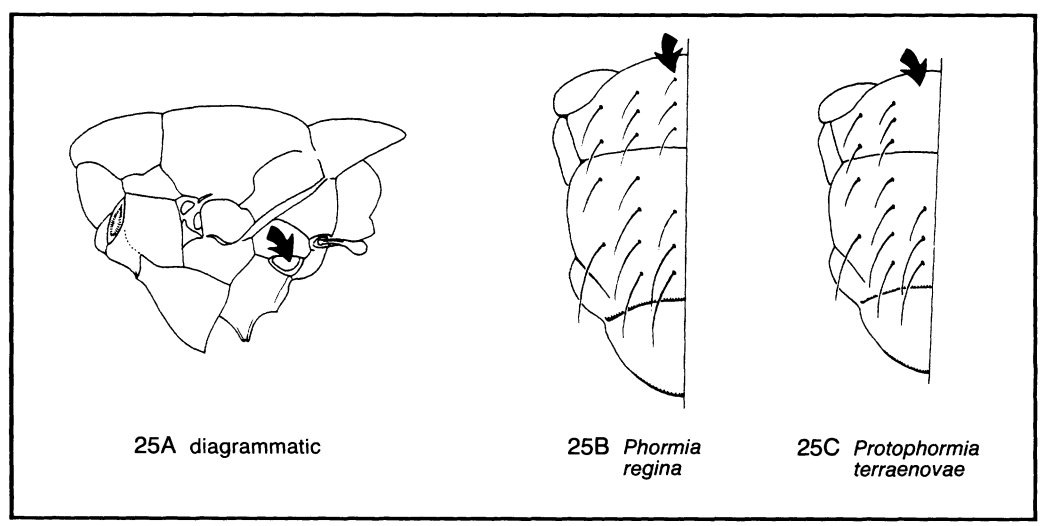


24A *Cochliomyia macellaria*

24B *Chrysomya rufifacies*

25 Mesothoracic spiracle (25A) with orange hair; presutural acrostical bristles well developed (25B)----------**black blow fly,** *Phormia regina*

Mesothoracic spiracle (25A) with black hair; presutural acrostical bristles vestigial, not differentiated from surrounding hairs (25C)
---------- Holarctic blow fly, *Protophormia terraenovae*



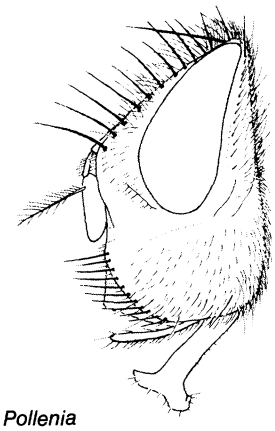
25A diagrammatic

25B *Phormia regina*

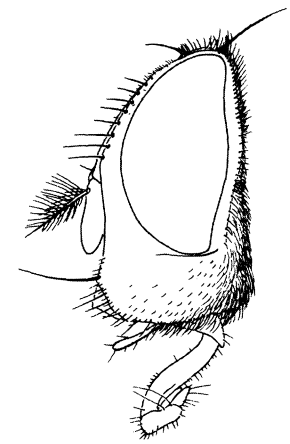
25C *Protophormia terraenovae*

26 Eye comparatively small in relation to head (26A); thorax with crinkly yellow hair among the bristles ----------**cluster fly,** *Pollenia rudis*

Eye comparatively large in relation to head (26B); thorax without crinkly hair------- 27



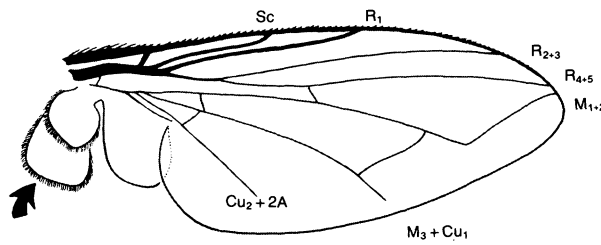
26A *Pollenia rudis*



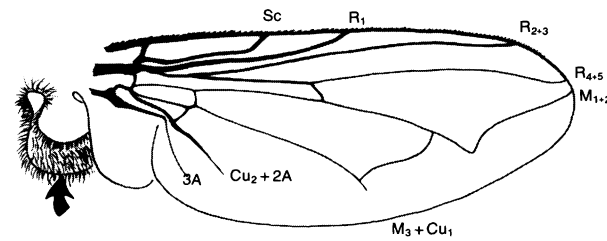
26B *Phaenicia sericata*

27 Lower (proximal) calypter bare (27A). Genus *Phaenicia*---------- 28

Lower calypter with long, dark pile (27B)---------- 29



27A *Phaenicia*



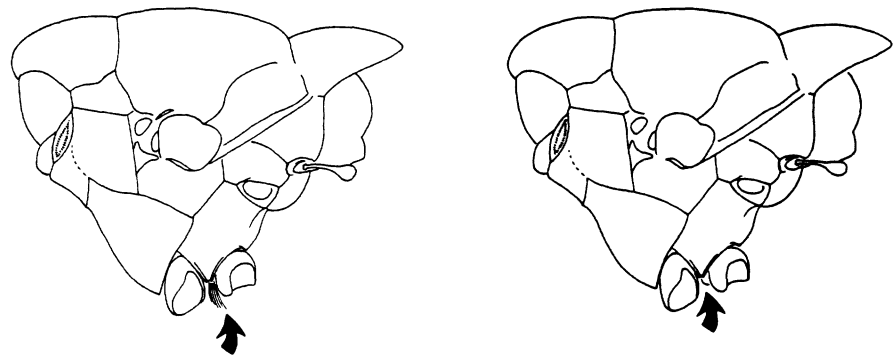
27B *Calliphora*

28 Metasternum setose (28A)----------green bottle fly, *Phaenicia sericata*

Body length: 6-9.5 mm. See also 26B.

Metasternum bare (28B)----------bronze bottle fly, *Phaenicia cuprina*

Body length: 5-8.5 mm.



28A *Phaenicia sericata*

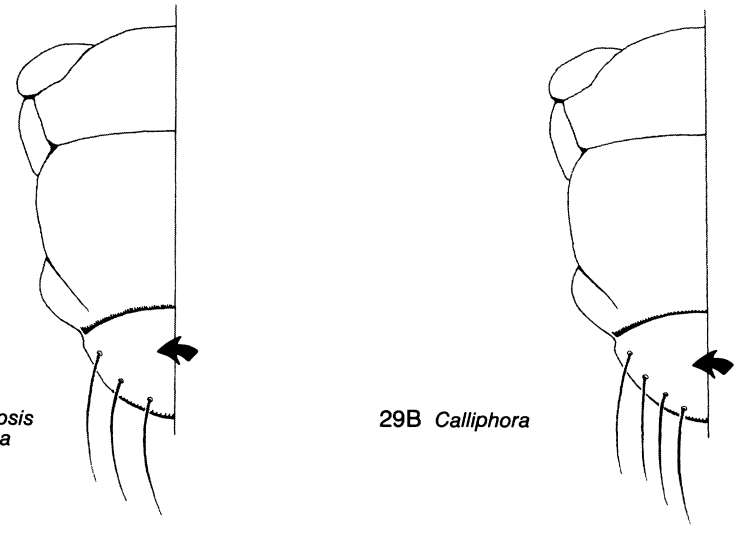
28B *Phaenicia cuprina*

29 Scutellum with 3 strong lateral bristles on each side (29A)
----------blue bottle fly, *Cynomyopsis cadaverina*

Body length: 9-14 mm.

Scutellum with 4 strong lateral bristles on each side (29B). Genus *Calliphora*------- 30

See also 27B.



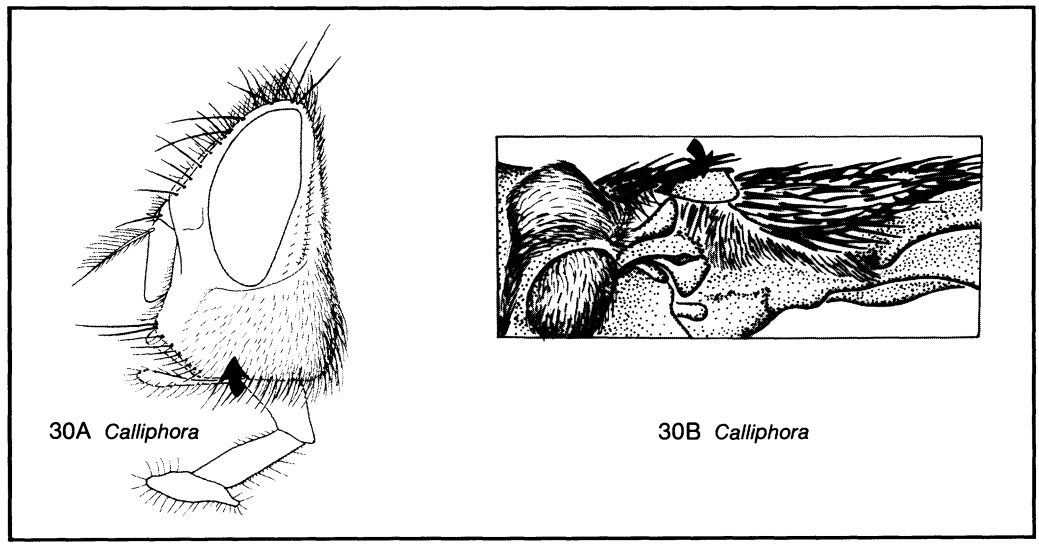
29A *Cynomyopsis cadaverina*

29B *Calliphora*

30 Integument of bucca (30A) reddish on anterior half; basicosta (30B) yellow to orange
---------- cosmopolitan blue bottle fly, *Calliphora vicina*

Body length: 6-12 mm.

Buccal integument (30A) black; basicosta (30B) black---------- 31

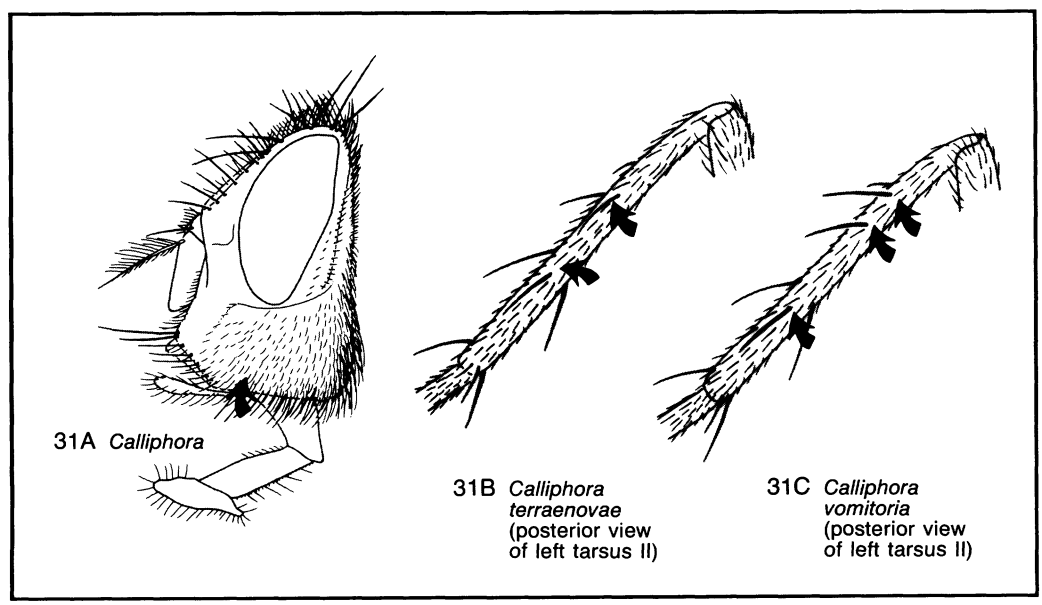


31 Buccal hairs (31A) mostly black; tibia II with 2 posterior bristles (31B)
---------- Nearctic blow fly, *Calliphora terraenovae*

Body length: 9-13 mm.

Buccal hairs (31A) mostly reddish orange; tibia II with 3 posterior bristles (31C)
---------- Holarctic blue bottle fly, *Calliphora vomitoria*

Body length: 10-14 mm.

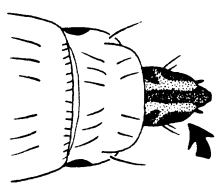


Larvae

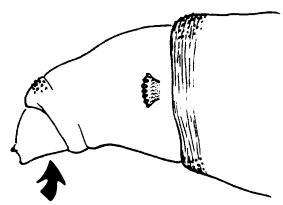
32 Larva with a definite, sclerotized head capsule (32A) ---------- 33

Cecid larvae (Cecidomyiidae) would key out at this point. These larvae are less than 5 mm long and have a tiny, lightly-sclerotized head capsule. The most distinctive character is the sternal spatula, a clove-shaped "breast bone" located ventrally on the prothorax. Most of the mushroom-infesting species have minute, whitish larvae that are inconspicuous against the white color of their hosts, but if members of the genus *Mycophila* are present, their bright orange color renders the mushrooms unmarketable.

Larva without a definite, sclerotized head capsule (mouth hooks may or may not be visible) (32B) ---------- 37



32A *Hermetia illucens*



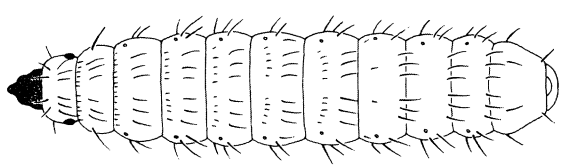
32B *Musca domestica*

33 Large larva (15 to 20 mm) with long, conspicuous setae on all body segments (33A). Stratiomyidae (**soldier flies**); pl. 124A ----------**black soldier fly,** *Hermetia illucens*

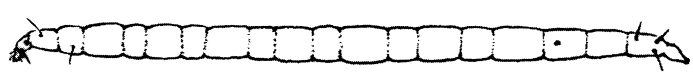
This is one of several similar species likely to be found. See also 32A.

Small larva (less than 8 mm), either mostly glabrous or pubescent (31B) ---------- 34

Drawing 33B by A.D. Cushman.



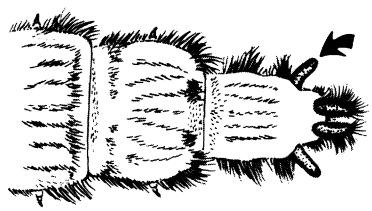
33A *Hermetia illucens*



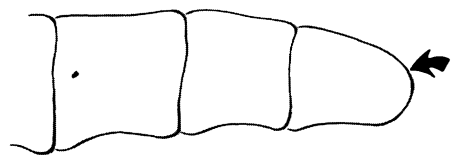
33B *Scenopinus*

34 Body fuzzy; posterior spiracles at tips of long, membranous processes (34A) or at tip of a sclerotized tube (34B) ---------- 35
Body smooth; posterior spiracles flush with body wall (34C) ---------- 36

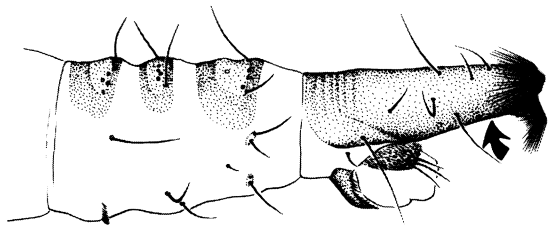
Larval chironomid midges (Chironomidae [Tendipedidae]) would key out at this point. Midge larvae have a complete head capsule, usually have prominent anterior and posterior prolegs, and have no functional spiracles. Midge larvae occasionally appear in foods that have been washed with unfiltered water from storage tanks or ponds.



34A Scatopsidae



34C Sciaridae



34B Psychodidae

35 Posterior spiracles at ends of long, dorsolateral tubes (35A)
---------- minute black scavenger flies, Scatopsidae

Body length: 3-5 mm.

Posterior spiracles at end of long median tube (see 34B); pl. 121A&B
---------- **moth flies,** Psychodidae

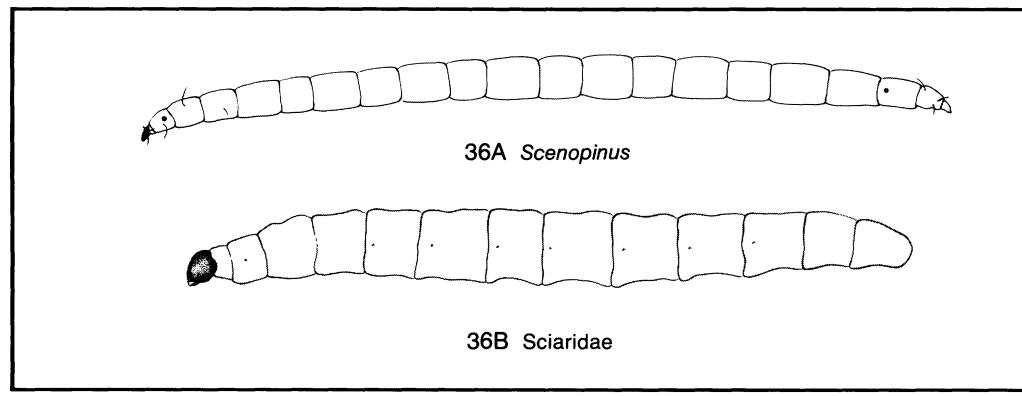
35A Scatopsidae

36 Larva eellike, with diminutive, conelike, brown head capsule (36A); short but conspicuous setae present on first 3 segments and on last segment. Scenopinidae (window flies) ---------- *Scenopinus* spp.

Body length: about 22 mm.

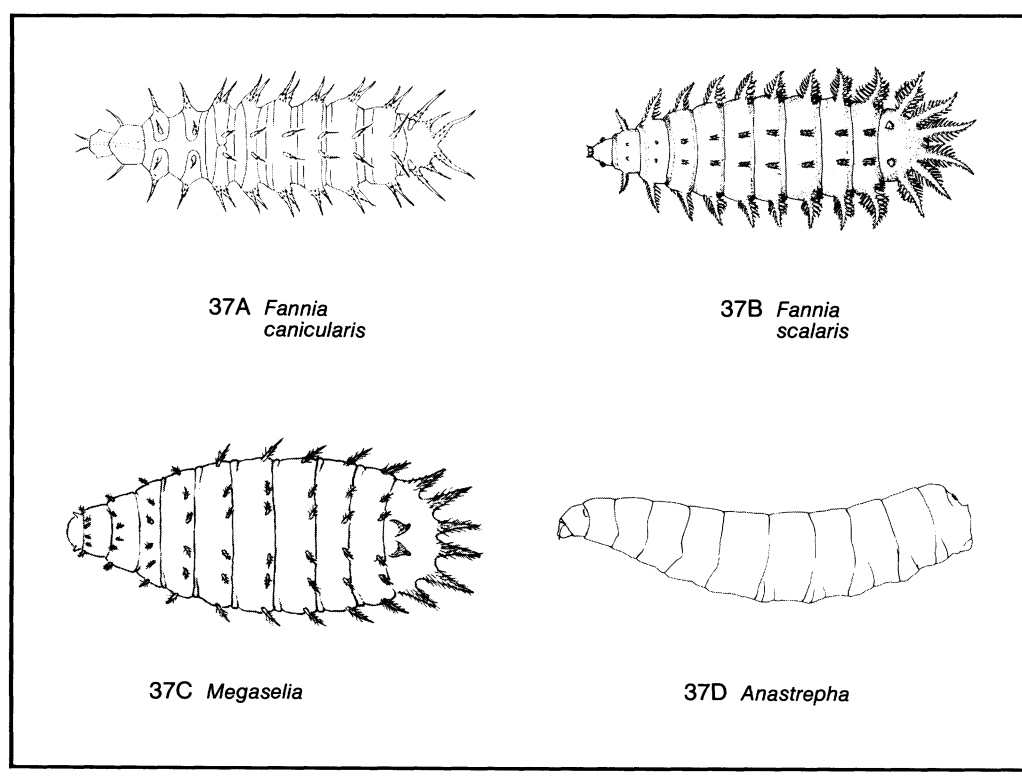
Larva more robust, with a large black head capsule (36B); conspicuous setae absent ---------- **darkwinged fungus gnats,** Sciaridae

Body length: 6-11 mm.



37 Body more or less depressed, with long, often feathery lobes on most segments (37A, 37B, 37C) ---------- 38
Body cylindrical, without conspicuous lobes on each segment (37D) ---------- 39

Drawing 37B from 2; 37C by A.D. Cushman.

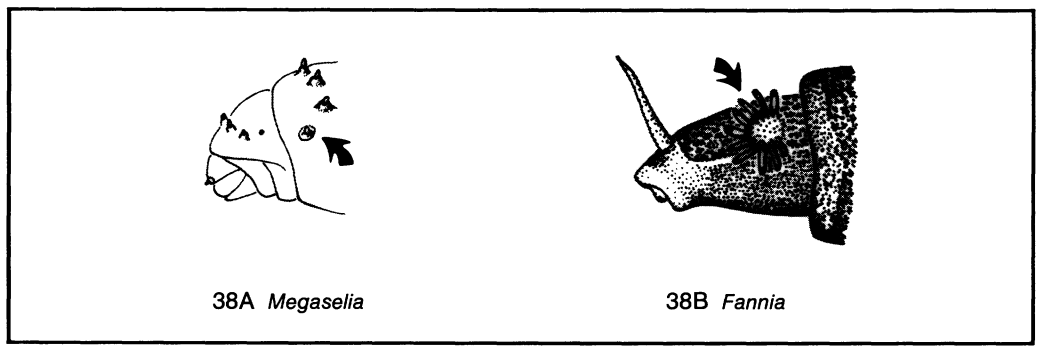


38 Body about 5 mm long; anterior spiracle simple (38A); pl. 123A&B ---------- **humpbacked flies,** Phoridae (in part)

See also 37C, 45A.

Body about 10 mm long; anterior spiracle branched (38B); pl. 128A. Muscidae (muscid flies) (in part) ---------- *Fannia* spp.

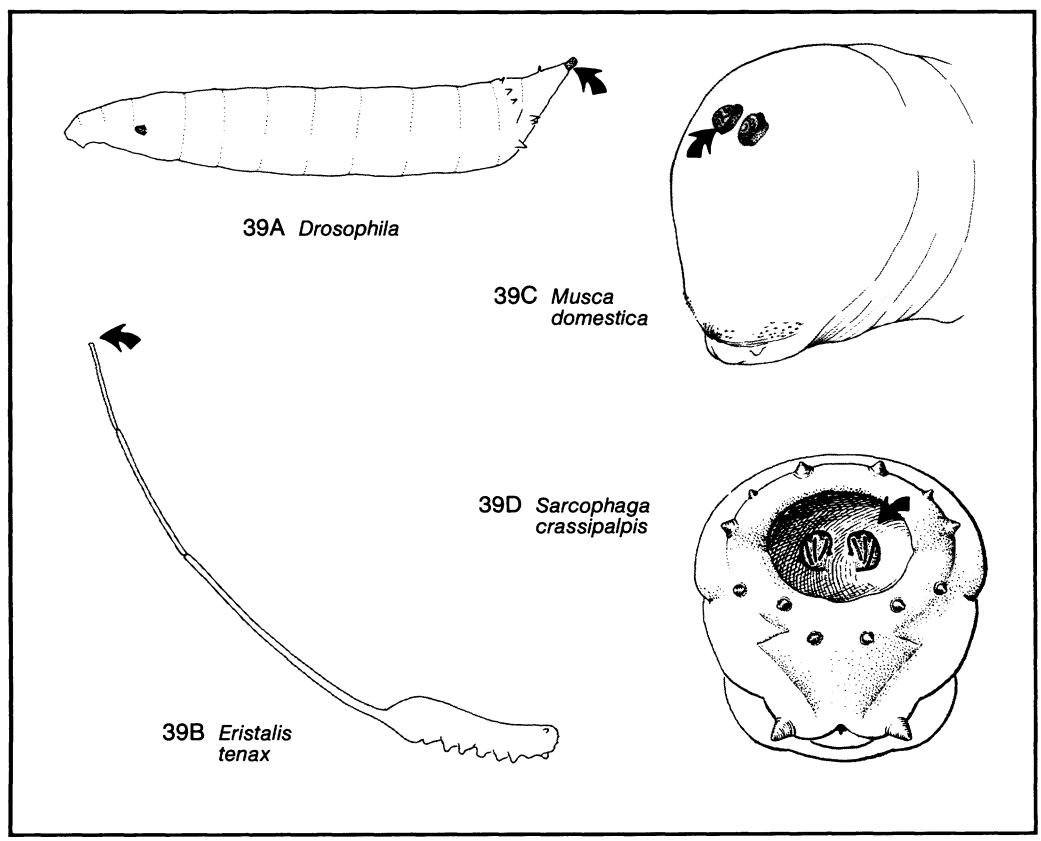
See also 37A&B.



38A *Megaselia* 38B *Fannia*

39 Posterior spiracles small, located either on peglike tubercles or cones (39A) or at the end of a long tail (39B) ---------- 40
Posterior spiracles large, more or less flush with body surface (39C, 39D) ---------- 46

Drawing 39D by A.D. Cushman.



39A *Drosophila*

39C *Musca domestica*

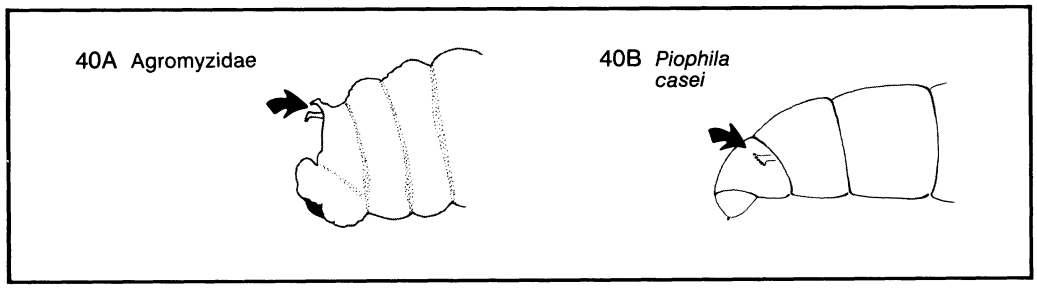
39D *Sarcophaga crassipalpis*

39B *Eristalis tenax*

40 Anterior spiracles located on dorsal surface of body (40A) -**leafminer flies,** Agromyzidae

Body length: 5 mm.

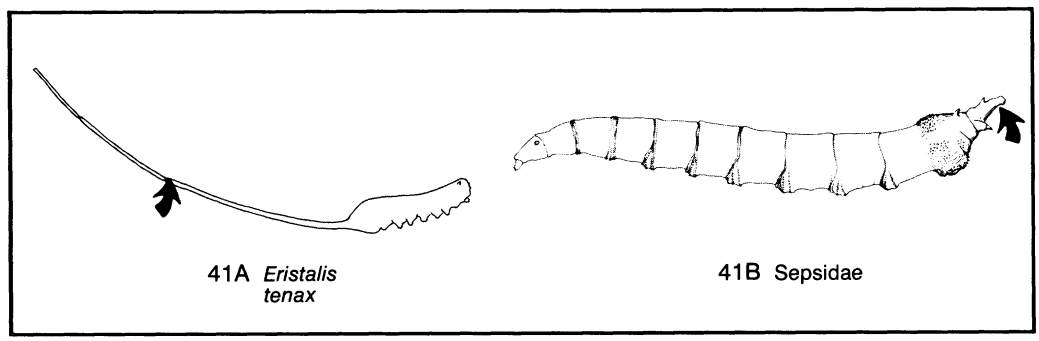
Anterior spiracles located on sides of body (40B)---------- 41



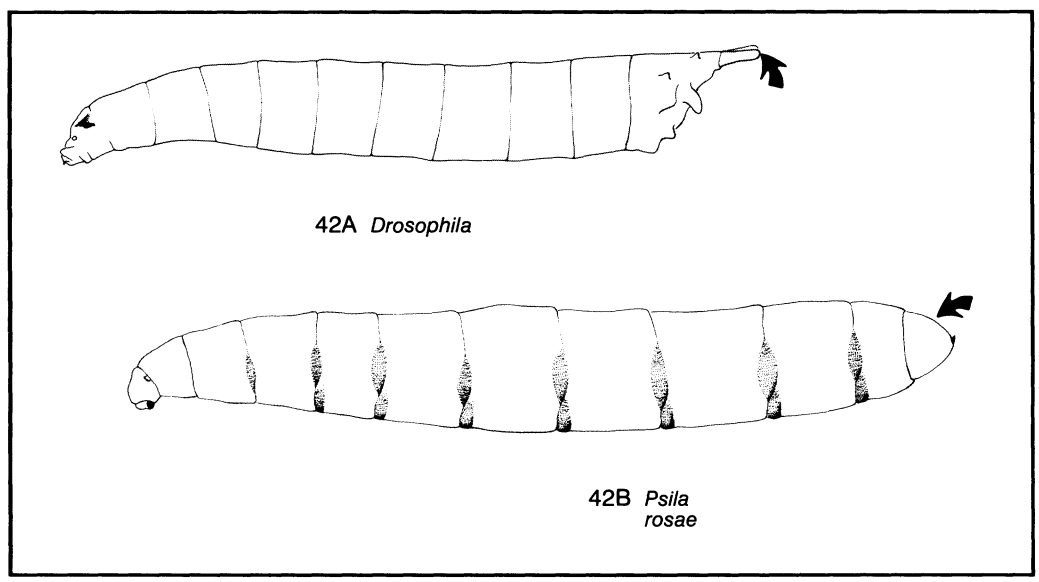
41 Posterior end of body extended as a long, telescoping tail (41A); pl. 122B. Syrphidae **(flower flies)**----------**drone fly,** *Eristalis tenax*

This is one of several similar species likely to be found.

Posterior end of body never more than slightly extended (41B) ---------- 42



42 Posterior spiracles located at apex of long tubercles (42A) ---------- 43
Posterior spiracles located at apex of short cones (42B)---------- 44



43 Anterior spiracle a tube with many retractable branches protruding from tip (43A) ---------- **small fruit flies**, Drosophilidae

Body length: 5 mm. See also 42A.

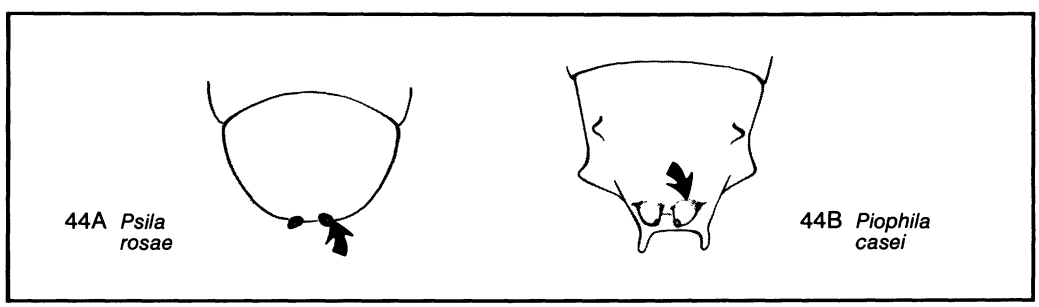
Anterior spiracle branched from base (43B)----------black scavenger flies, Sepsidae

Body length: 5-6 mm. See also 41B.

44 Posterior spiracles located on sclerotized, pigmented cones; last abdominal segment without lobes (44A). Psilidae (rust flies)---------- **carrot rust fly,** *Psila rosae*

Body length: 8 mm. This is one of several similar species likely to be found. See also 42B.

Posterior spiracles located on membranous cones; last abdominal segment with lobes (44B) ---------- 45

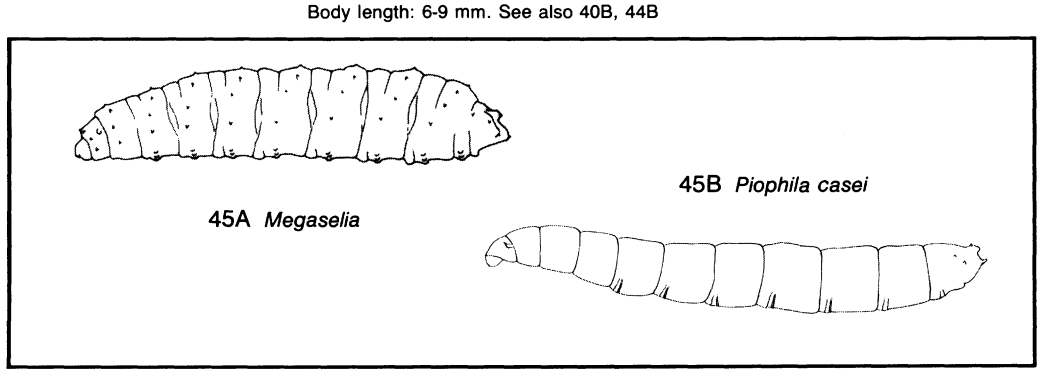


45 Larva with lobes on most segments (45A); pl. 123A&B ---------- **humpbacked flies,** Phoridae (in part)

See also 37C, 38A.

Larva with lobes only on last segment (45B). Piophilidae (**skipper flies**) ---------- **cheese skipper,** *Piophila casei*

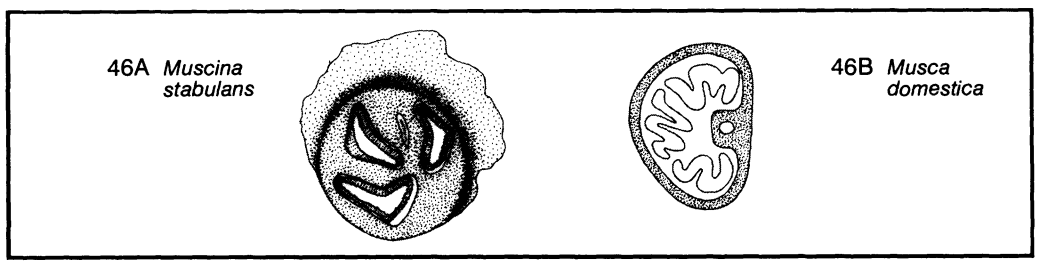
Body length: 6-9 mm. See also 40B, 44B



46 Posterior spiracular plate completely pigmented (except for openings and button, when present) (46A). Muscidae (muscid flies) (in part) ----------*Muscina* spp.

Body length: 10-12 mm.

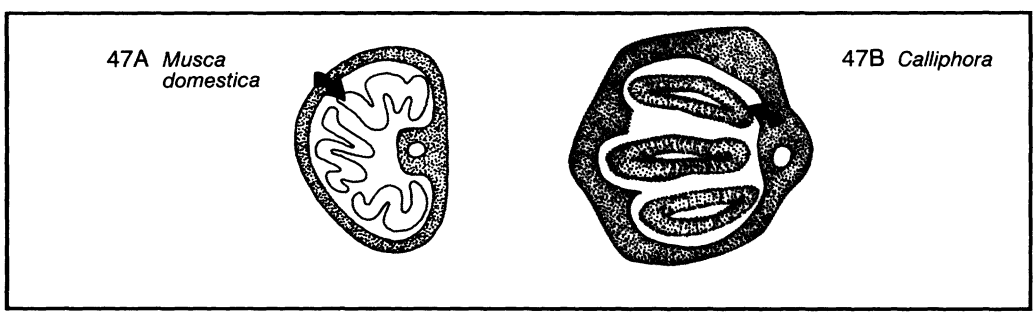
Posterior spiracular plate unpigmented (except for peritreme, if present) (46B)----- 47



47 Posterior spiracles with sinuous slits (47A); pl. 129A. Muscidae (muscid flies) (in part) ----------**house fly,** *Musca domestica*

See also 32B, 39C.

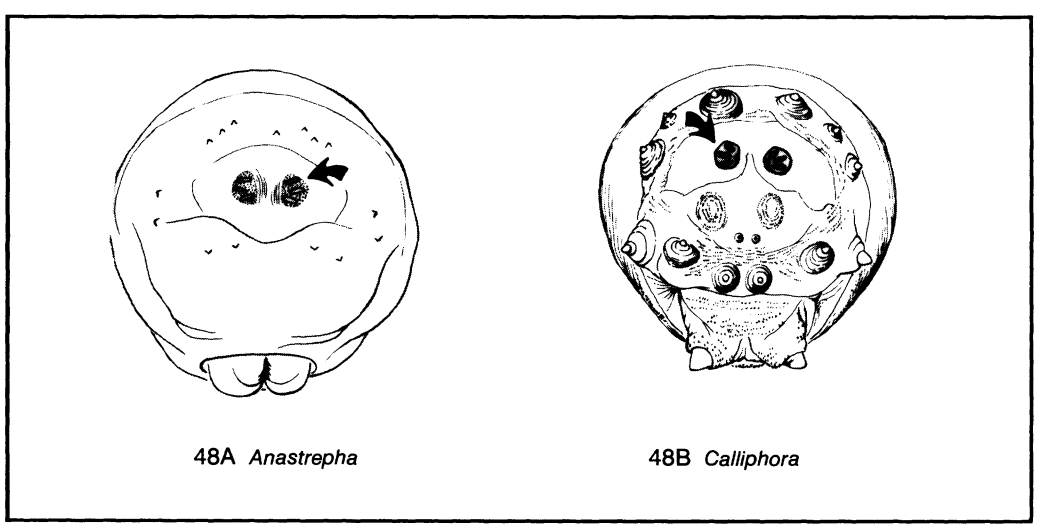
Posterior spiracles with straight slits (47B) ---------- 48



48 Peritreme absent from posterior spiracular plate (48A)----------**fruit flies,** Tephritidae

Body length: 9-10 mm. See also 37D.

Peritreme present around posterior spiracular plate (48B)---------- 49

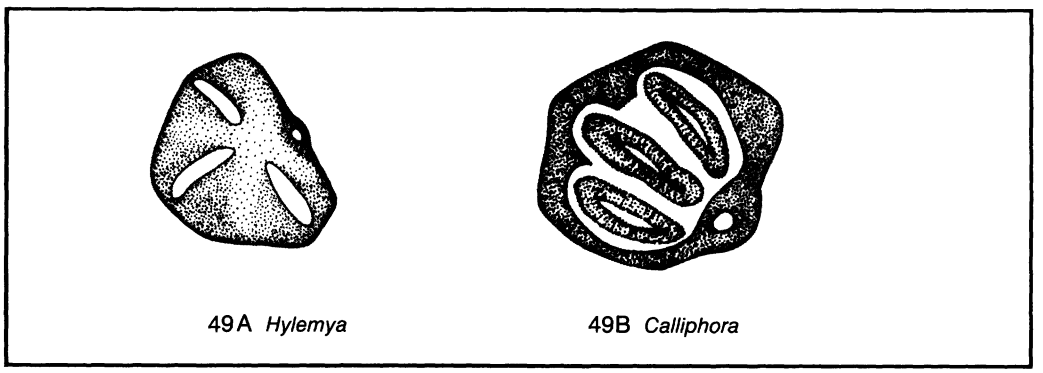


49 Posterior spiracles with 3 short slits positioned almost perpendicular to one another (49A); pl. 134E. Anthomyiidae **(anthomyiid flies)**----------*Hylemya* spp.

Spiracular button, if present, located near the upper medial margin of spiracular plate.

Posterior spiracles with slits approximately parallel (49B)---------- 50

Spiracular button located near the medial or lower medial edge of spiracular plate.



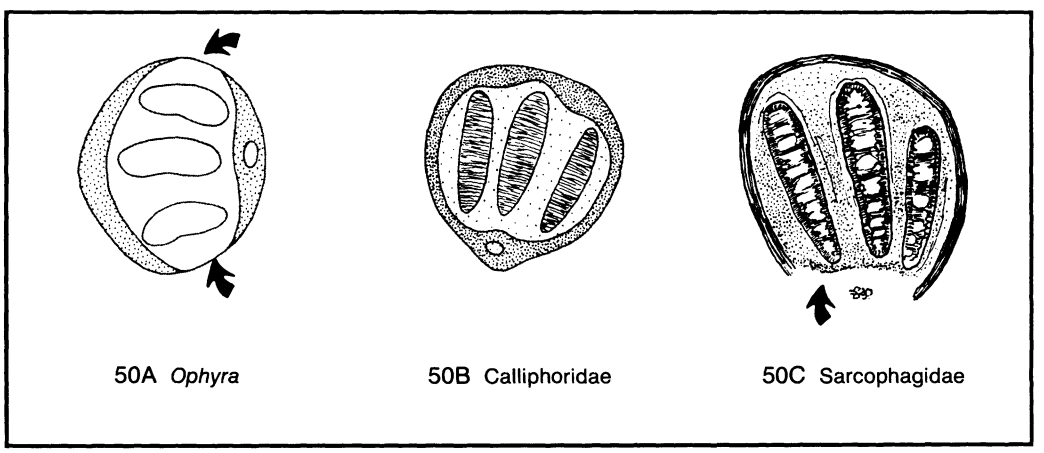
49A *Hylemya* 49B *Calliphora*

50 Peritreme of posterior spiracle with 2 unsclerotized areas (50A). Muscidae (muscid flies) (in part)----------*Ophyra* spp.

Body length: 9-10 mm.

Peritreme of posterior spiracle complete (50B) or with only 1 weakly sclerotized area (50C)---------- 51

Drawing 50C from 2.

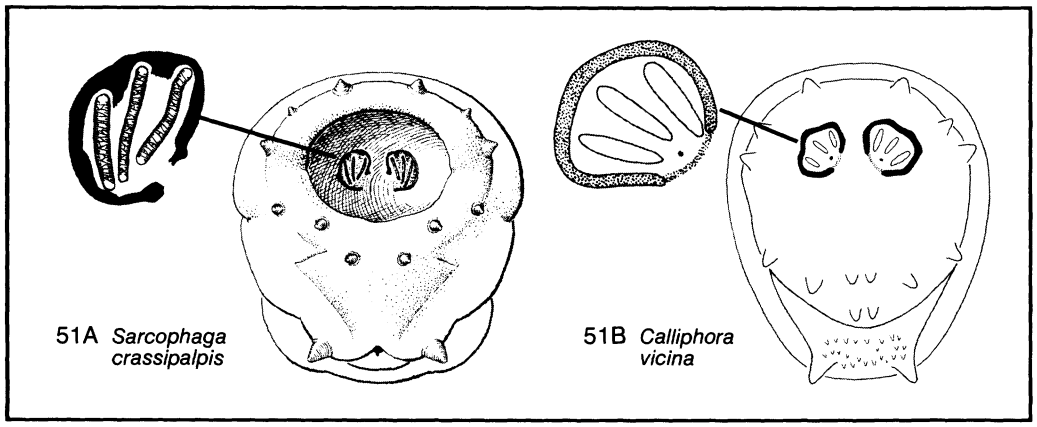


50A *Ophyra* 50B Calliphoridae 50C Sarcophagidae

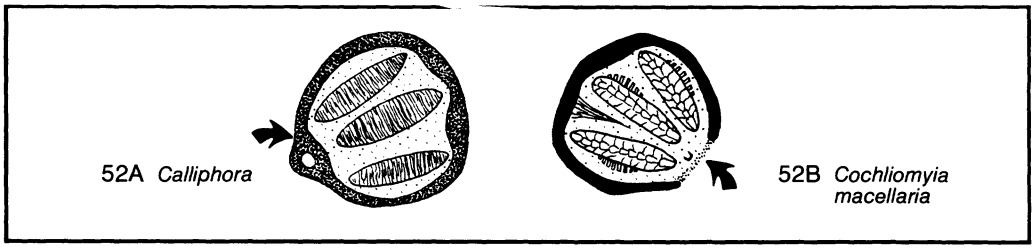
51 Posterior spiracular plates set in a cavity; spiracular slits essentially vertical in orientation (51A); pl. 131A----------**flesh flies,** Sarcophagidae

See also 50C.
Drawing 51A from 2.

Posterior spiracles not set in a cavity; spiracular slits directed towards midventral line (51B). Calliphoridae (**blow flies**)---------- 52



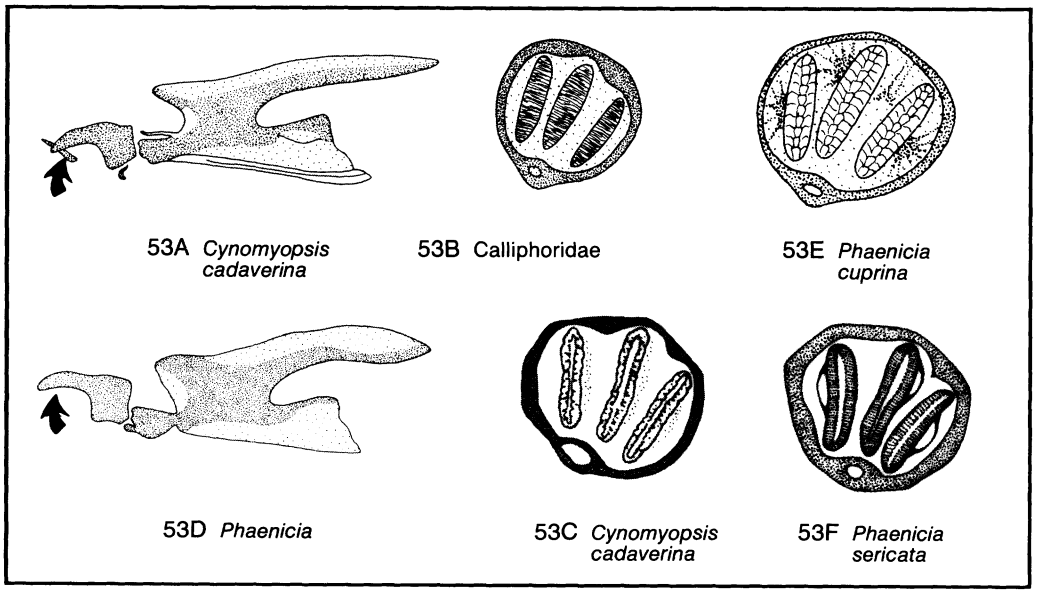
52 Posterior spiracles with complete peritreme (52A) ---------- 53
Posterior spiracles with incomplete peritreme (52B) ---------- 54



53 Accessory sclerite of cephalopharyngeal skeleton present (53A); peritreme of posterior spiracles strongly sclerotized (53B, 53C) ----------*Calliphora* spp.
---------- blue bottle fly, *Cynomyopsis cadaverina*

Body length of *Calliphora* spp.: 6.8-18 mm.; of *C. cadaverina*: 18-22 mm. See also 47B, 48B, 51B.

Accessory sclerite absent (53D); peritreme less strongly sclerotized (53E, 53F); pl. 134A-D----------*Phaenicia* spp.

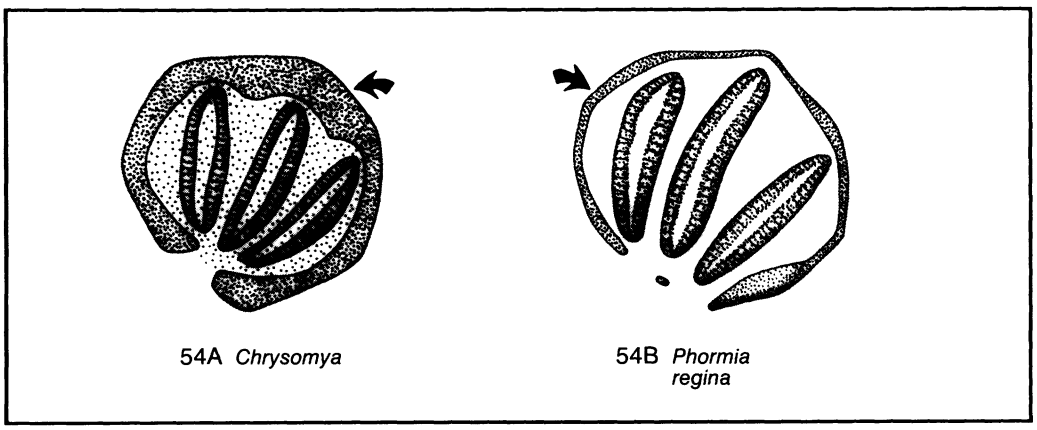


54 Peritreme of posterior spiracle very thick (54A); pl. 133A-D
----------Old World screwworm flies, *Chrysomya* spp.

Body length: 12-18 mm. Body segments sometimes with dorsal lobes.

Peritreme of posterior spiracle only moderately thick (54B)---------- 55

Body segments without dorsal lobes.

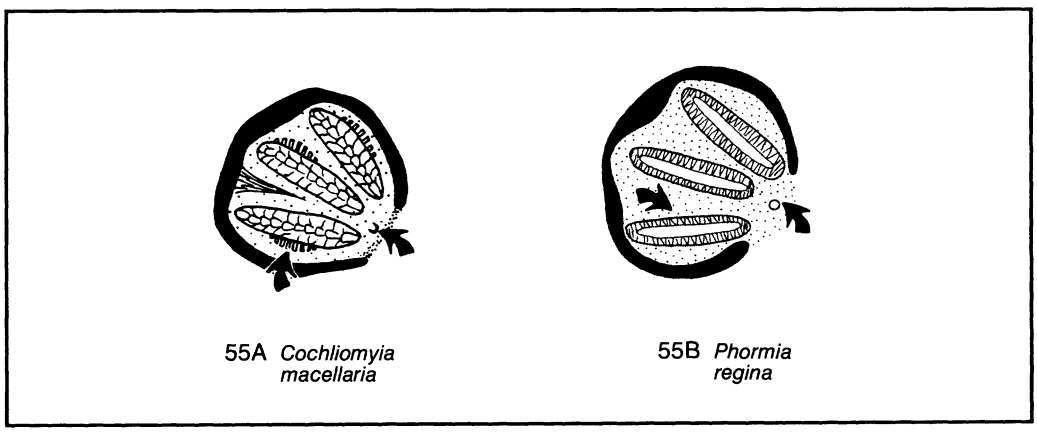


54A *Chrysomya*

54B *Phormia regina*

55 Button absent or indistinct on posterior spiracles; walls of posterior spiracular slits with lateral swellings (55A); pl. 132A---**secondary screwworm,** *Cochliomyia macellaria*

Button distinct on posterior spiracles; spiracular slits without lateral swellings (55B)
----------**black blow fly,** *Phormia regina*



55A *Cochliomyia macellaria*

55B *Phormia regina*

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Notes and Sketches

17 ANTS (FORMICIDAE, HYMENOPTERA)

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Ants are recognized by the constriction at the base of the abdomen and by the presence of one or two nodes in the constricted area that are distinctly differentiated from the rest of the abdomen. Also, the antennae are elbowed, with the first segment (scape) unusually long. Three castes are usually present: workers, females (queens), and males; these are described below.

Workers (fig. 17.1, pl. 135-150). Wings and wing scars absent; ocelli lacking or very small. Those species with workers all about the same size are termed monomorphic; in polymorphic species there is a considerable size range in the worker caste. The largest forms are called soldiers, the smaller forms, minors or minor workers. When soldiers are present they are commonly structurally different from the minors. Workers are most commonly encountered, and they are the most abundant of the three castes. They construct the nest, defend the colony, take care of the colony, and forage for food. It is the worker caste that may be observed foraging for food in food storage areas.

Females (fig. 17.2). Morphologically similar to workers but usually larger, with the thorax enlarged by the wing musculature; with wings or wing scars and with three distinct ocelli.

About 580 species and/or subspecies of Formicidae occur in North America north of Mexico (*1, 2*). About 50 of these have a reputation for being household or food-industry pests (*3*). Ants may nest in or near buildings, in wood or soil, or under objects. They often forage for food in food storage areas. Some ants prefer sweet substances, but many are general feeders taking whatever they find during foraging trips.

The key given here is limited to the subfamilies and to some of the more common genera and species of household pests occurring in North America. Illustrations of these as well as some of the less common taxa (all from *3*) are given in chapter 27. Additional taxonomic and biological information may be found in the references at the end of this key (see also ch. 28).

Males (fig. 17.3). Wings present; head usually reduced in size and bearing disproportionately large eyes and large ocelli; mouthparts reduced; antennae elbowed but scape sometimes rather short; genital appendages usually protruding. The sexual castes (males and females) may be very abundant at the time of swarming (they are normally seen outside the nest only at swarming time). They are often attracted to lights in buildings, but they do not forage for food as do the workers.

Larvae (fig. 17.4). Thoracic legs lacking; without horny projection at apex of abdomen; commonly gourd-shaped, with a slender neck and small head capsule; hairs of various sizes and shapes usually abundant on body. Larvae of some species spin cocoons in which the pupal stage is passed; others do not. Ant larvae are not easily differentiated from those of other Hymenoptera.

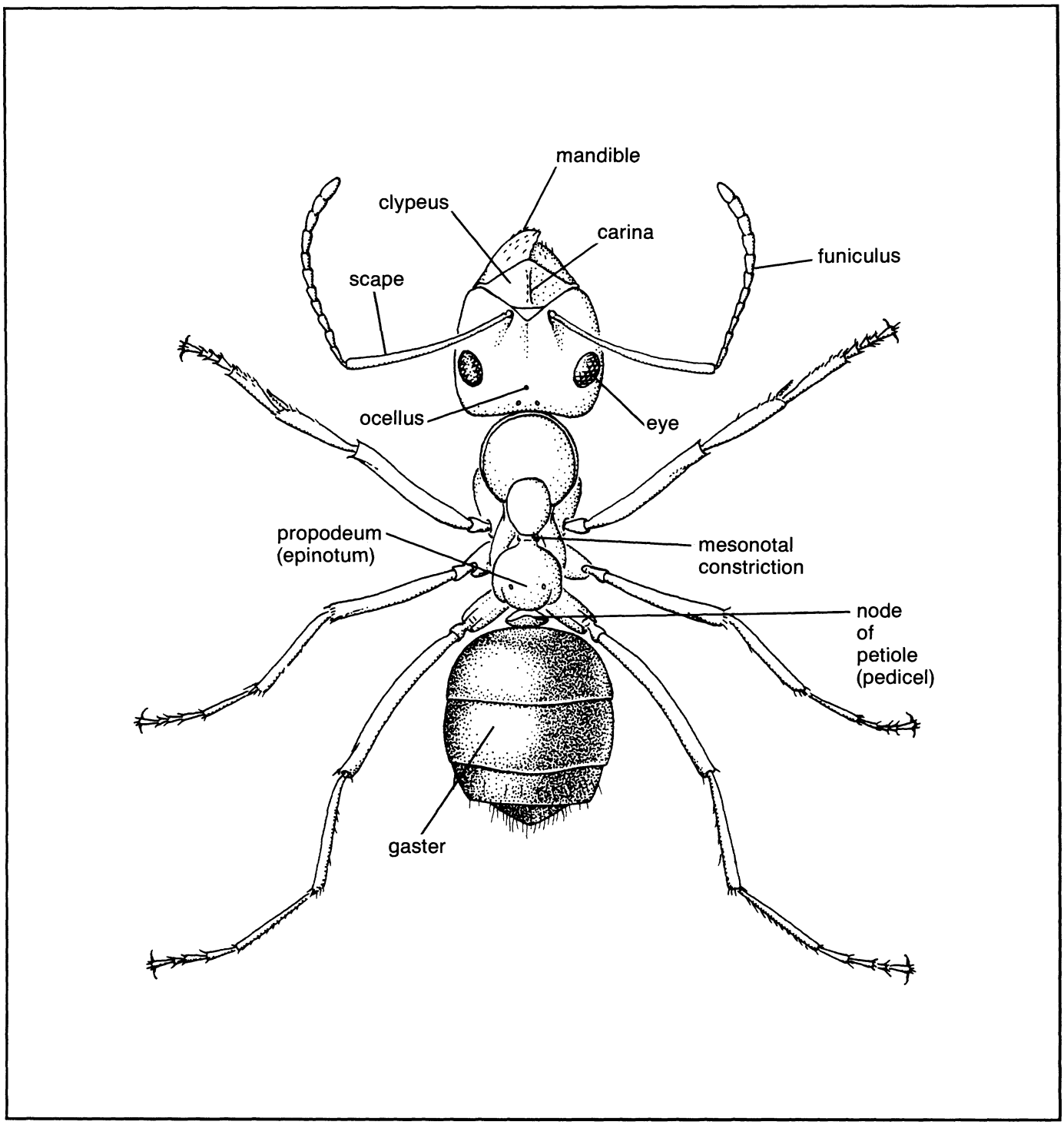


Figure 17.1. Worker, **Allegheny mound ant,** *Formica exsectoides* Forel, dorsal view. (Redrawn from 3 by C. Feller.)

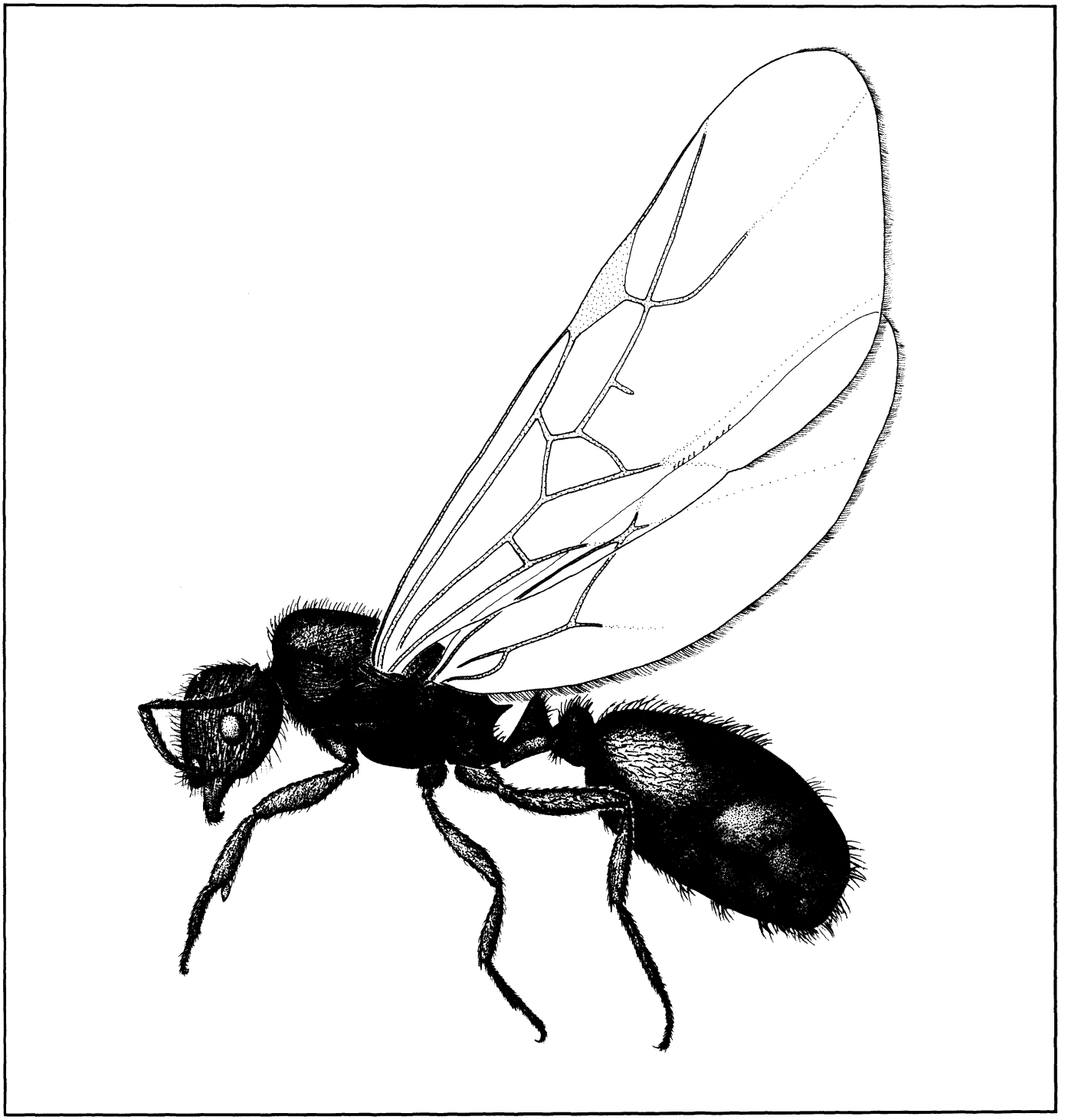


Figure 17.2. Female, **pavement ant,** *Tetramorium caespitum,* lateral view. (Drawing by C. Feller.)

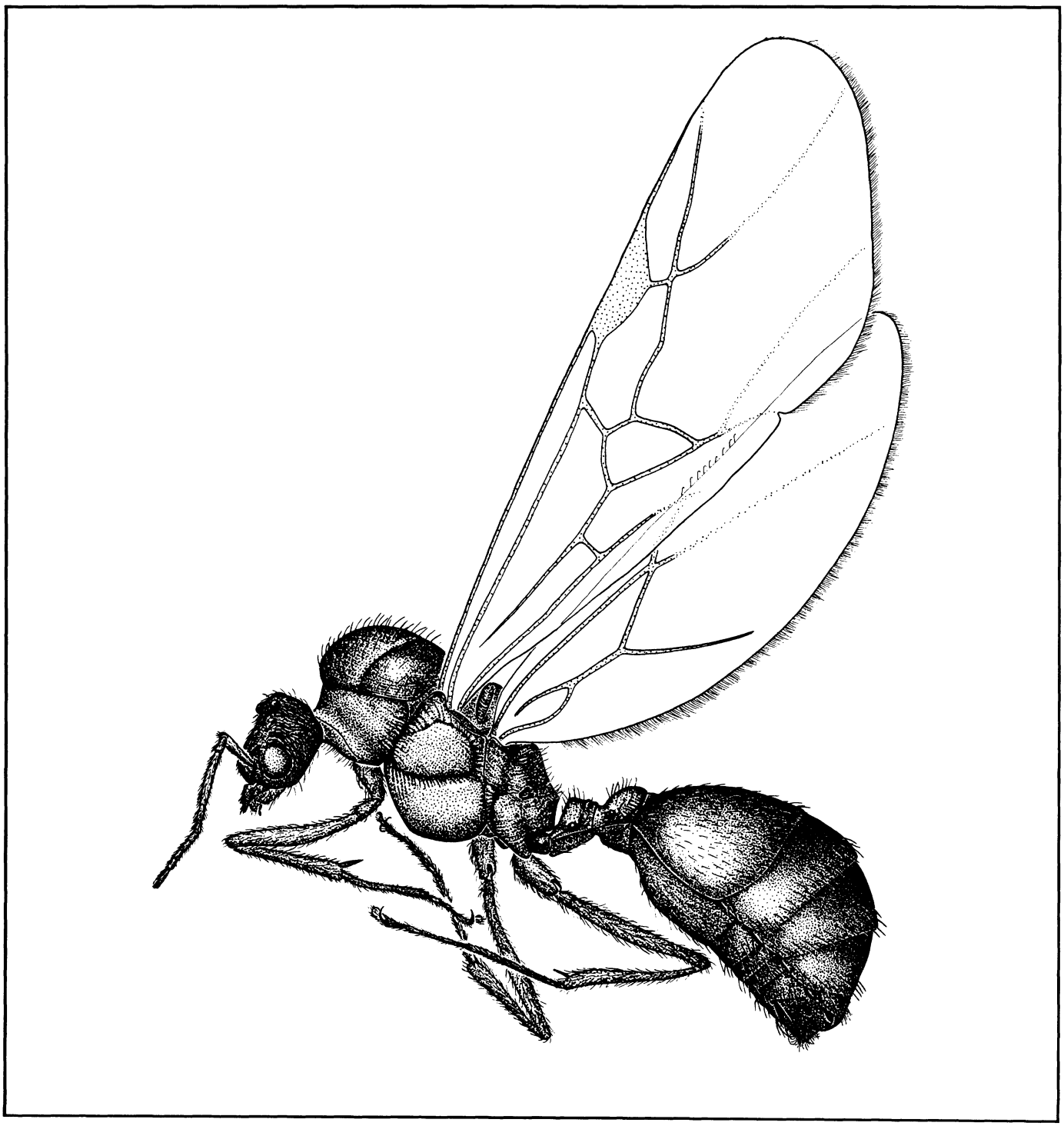


Figure 17.3. Male, **pavement ant,** *Tetramorium caespitum,* lateral view. (Drawing by C. Feller.)

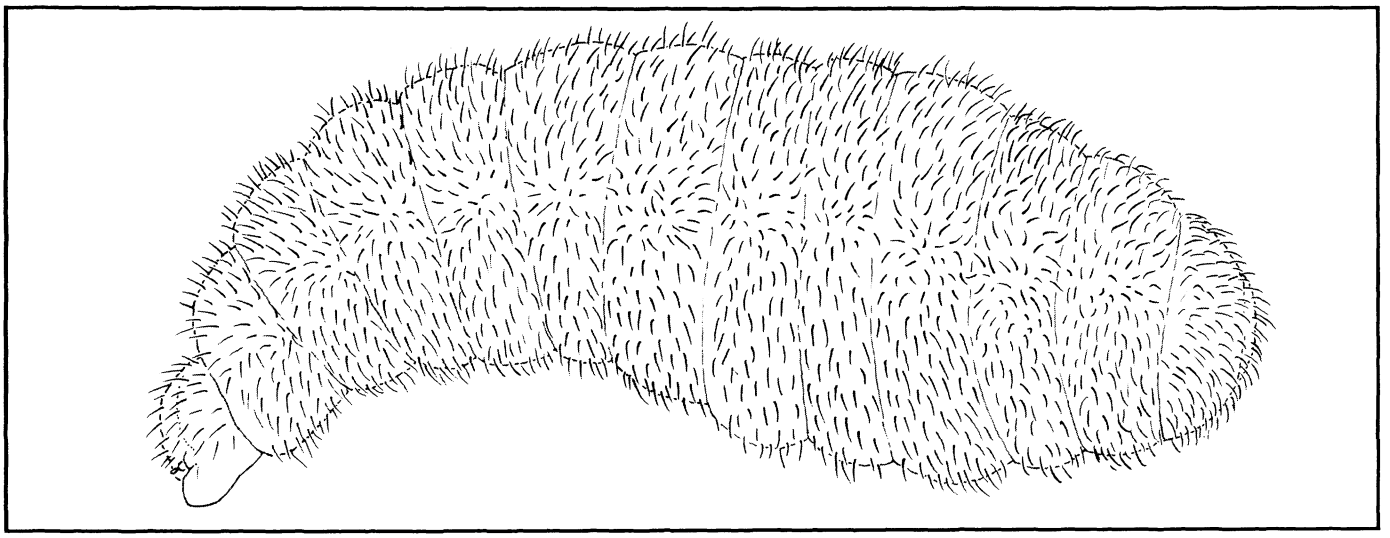
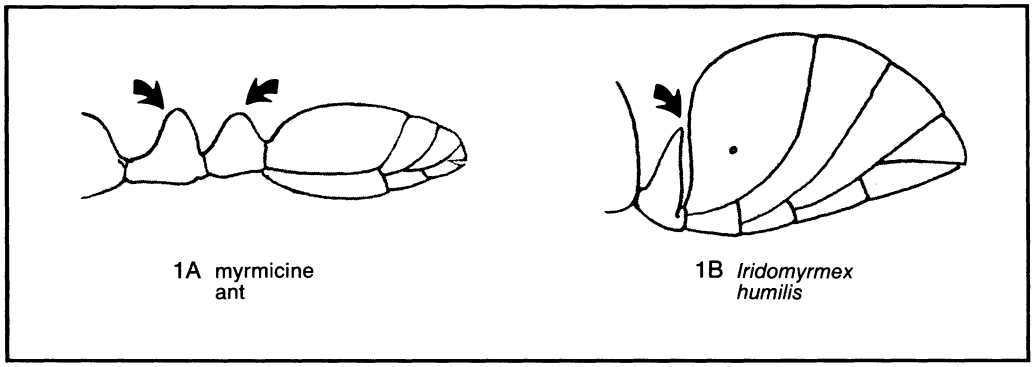


Figure 17.4 Larva, **larger yellow ant,** *Acanthomyops interjectus.* (Drawing by C. Feller.)

KEY TO WORKERS

Drawings by A.D. Cushman unless otherwise noted.

1 Pedicel with 2 segments (1A) ---------- 2
Pedicel with 1 segment (1B) ---------- 9



1A myrmicine ant

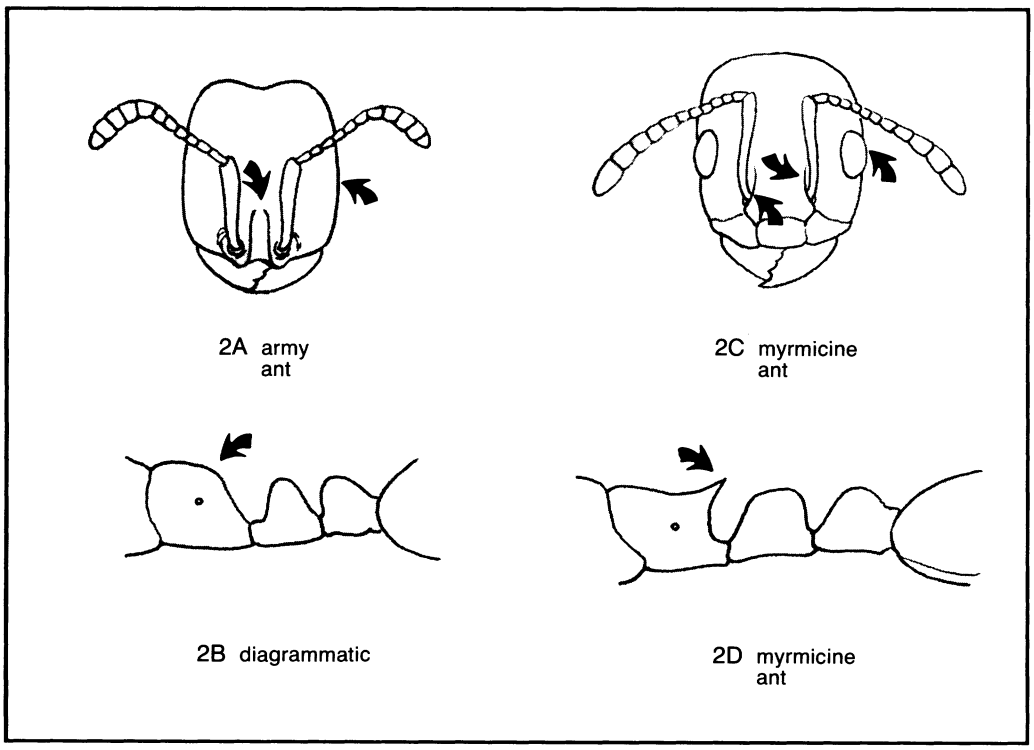
1B *Iridomyrmex humilis*

2 Frontal carinae close together, not covering antennal insertions; antennae inserted very close to mouth; eyes absent or very small and ocellus-like (2A); pl. 135A-C ---------- army ants, Dorylinae

Propodeum usually unarmed (2B).

Frontal carinae widely separated, each with a lobe that partially covers antennal insertions; antennae inserted away from mouth; eyes usually large and multifaceted (2C); pl. 136-142, 143A&B. Myrmicinae (myrmicine ants) ---------- 3

Propodeal spines present (2D) or absent.



2A army ant

2C myrmicine ant

2B diagrammatic

2D myrmicine ant

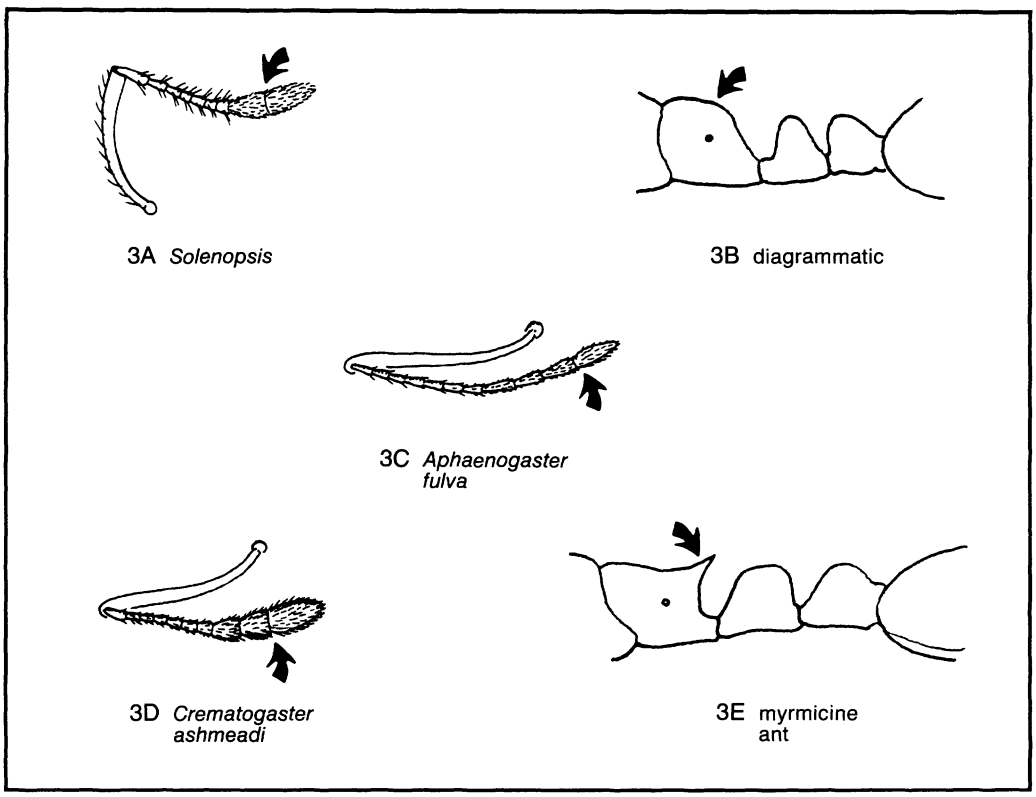
Myrmicinae

3 Antenna with 10 segments, the last 2 segments forming a distinct club (3A)-------- 4

Propodeum unarmed (3B).
Drawings 3A&C&D by C. Feller.

Antenna with more than 10 segments, either without a distinct club (3C) or with 3 or 4 segments forming a club (3D)---------- 5

Propodeal spines present (3E) or absent.



4 Eye small, usually with 4 to 6 facets (pl. 136A); workers monomorphic---------- *Solenopsis*

The **thief ant,** *Solenopsis molesta* (pl. 136A), occurs throughout most of the United States. The workers are minute (1.3 to 1.8 mm long) and yellowish in color. They are omnivorous, feeding on many household foods. They apparently prefer foods of high protein content. They may nest in buildings, invading cabinets, shelves, and containers.

Eye large, multifaceted (pl. 136B&C); workers polymorphic; pl. 136B&C, 137A ---------- fire ants, *Solenopsis*

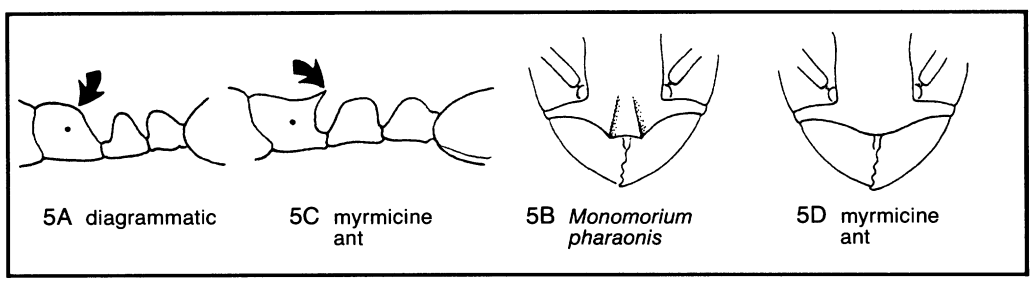
Body 1.6 to 6 mm long and usually reddish brown or blackish. These species usually nest in mounds in the soil but foraging workers may enter buildings; includes the fire ants of southern United States, 2 species of which have been introduced from South America.

5 Propodeum without spines or teeth (5A)---------- 6

Clypeus usually bicarinate (5B).

Propodeum with spines (5C)---------- 7

Clypeus not bicarinate (5D).



5A diagrammatic 5C myrmicine ant 5B *Monomorium pharaonis* 5D myrmicine ant

6 Integument (except for abdomen) uniformly finely punctate and subopaque (pl. 137B) ---------- **pharaoh ant,** *Monomorium pharaonis*

Body color light brown to yellowish. Distribution: widely distributed around the world by commerce; found in most cities and towns in the United States where it infests hotels, apartment buildings, groceries, and other places where food is handled commercially; nests in buildings and feeds on a wide variety of foods.

Integument shining, impunctate, sometimes with some transverse striations on posterior margin of head and epinotum (pl. 137C, 138A&B) ----------other species of *Monomorium*

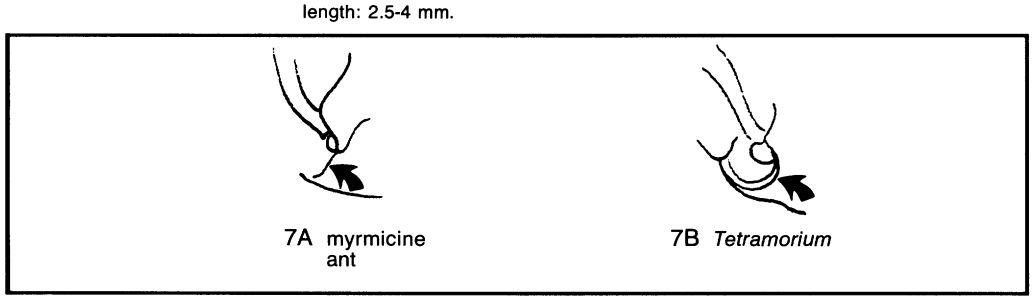
Most species have habits similar to those of *M. pharaonis.*

7 Clypeus without a sharp, raised margin in front of antennal insertion (7A) ----------other species of Myrmicinae

Body length and antennal form variable. See pl. 138-142 for selected representatives of the genera *Aphaenogaster, Atta, Crematogaster, Pheidole,* and *Ochetomyrmex;* each has representatives that may be found in buildings and food storage areas.

Posterior border of clypeus forming a sharp, raised margin in front of antennal insertion (7B). Genus *Tetramorium*---------- 8

Antenna with a 3-segmented club (see 3D); body length: 2.5-4 mm.



7A myrmicine ant 7B *Tetramorium*

8 Head without an antennal sulcus (pl. 143A); head and thorax with longitudinal striations; body color brownish to black----------**pavement ant,** *Tetramorium caespitum*

Distribution: a common species throughout most of Europe and the United States; largely confined to metropolitan areas; nests in soil, under objects, in rotting wood, and sometimes in wood of homes; omnivorous; may feed on household foods, preferring meats or grease.

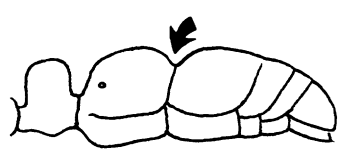
Head with antennal sulcus (pl. 143B); head and thorax usually rugulose; color yellowish or brownish----------other North American species of *Tetramorium*

A few species of *Tetramorium* are found in southern United States; they may infest buildings, as does *T. caespitum,* but they are not as common as the pavement ant.

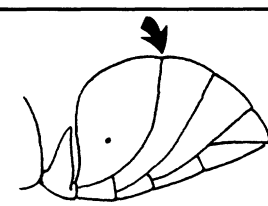
9 Gaster with a distinct constriction between the first and second gastric segments (9A) ---------- ponerine ants, Ponerinae

Species of this subfamily are not known to be associated with the food industry.

Gaster entire (9B)---------- 10



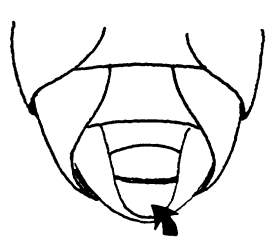
9A ponerine ant



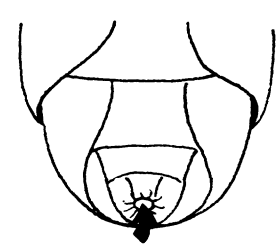
9B *Iridomyrmex humilis*

10 Acidopore absent (anal slit is transverse, subapical, and ventral) (10A). Dolichoderinae (dolichoderine ants); pl. 143C, 144---------- 11

Acidopore present (terminal, circular, and usually surrounded by a fringe of hairs) (10B). Formicinae (formicine ants); pl. 145-150 ---------- 14



10A dolichoderine ant



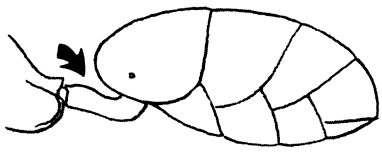
10B formicine ant

Dolichoderinae

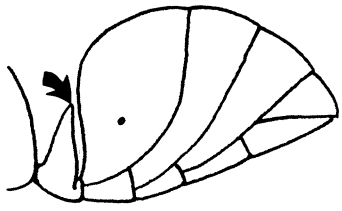
11 Petiolar node vestigial (11A). Genus *Tapinoma*---------- 12

Petiole in lateral view slender and attached to ventral side of gaster (11A).

Petiolar node suberect to erect, usually easily seen in profile (11B)---------- 13



11A *Tapinoma sessile*



11B *Iridomyrmex humilis*

12 Body a uniform light brown to black, 2.4 to 3.3 mm long; pl. 143C ----------**odorous house ant,** *Tapinoma sessile*

Distribution: northern Mexico, United States, southern Canada; nests in soil, under objects, under bark, in stumps, in plant cavities, and in a wide variety of other sites; omnivorous, feeding on a wide variety of household foods but preferring sweets.

Head and thorax brownish or black; antennae, legs, and gaster whitish to yellowish; length 1.3 to 1.5 mm; pl. 144A----------*Tapinoma melanocephalum*

Distribution: widely distributed by commerce in the warmer regions of the world; in higher latitudes, may be found in heated buildings; nests in a wide variety of habitats; omnivorous but prefers sweet substances.

13 Propodeum in profile short (about twice as high as long) (pl. 144B) ---------- **Argentine ant,** *Iridomyrmex humilis*

Thorax usually without erect hairs; propodeum without a conical posterior elevation. Distribution: widely distributed by commerce; in the United States it is found mostly in the Southern States and in California; nests in a wide variety of habitats, such as soil, rotten wood, bird nests, bee hives and under objects on the ground; feeds on almost any kind of food but is especially attracted to sweets; it is a persistent household pest wherever it is found.

Propodeum not twice as high as long (pl. 144C&D)-------- other species of Dolichoderinae

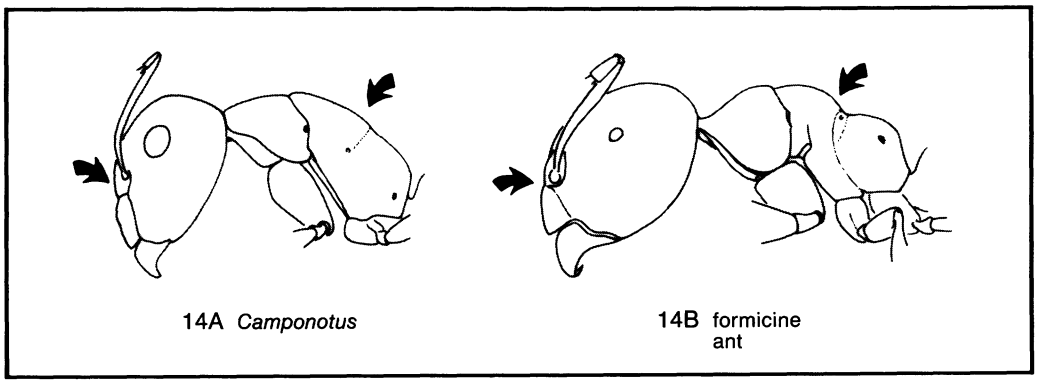
Thorax usually with some erect hairs; propodeum with (pl. 144D) or without (pl. 144C) a posterior conical elevation.

Formicinae

14 Antenna inserted far from posterior margin of clypeus; thorax in profile usually evenly curved (14A); pl. 145, 146, 147A&B----------carpenter ants, *Camponotus*

Mostly larger species ranging in length from 4 to 12 mm. Distribution: throughout the United States; commonly nest in wood; nest in wooden buildings usually only when wood is moist or has begun to rot, but can enlarge nests into adjacent sound wood; omnivorous, taking virtually all kinds of food in households.
Drawings 14A&B by C. Feller.

Antenna inserted at or very near posterior margin of clypeus; thorax irregularly curved in profile (14B) ---------- 15



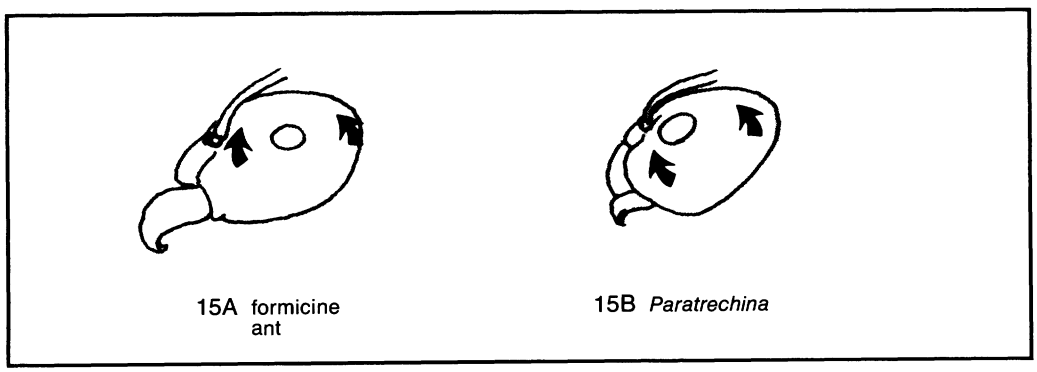
14A *Camponotus* 14B formicine ant

15 Eye closer to posterior margin of head than to base of mandible (15A); pl. 147C, 148, 149, 150A---------- other species of Formicinae

Antennal scape and thoracic dorsum usually without stiff setae. This is a large subfamily with representatives found throughout the United States. Some, such as *Lasius* spp., nest in lawns and open fields; the yellowish *Acanthomyops* spp. often nest next to foundation walls; species of other genera nest under objects or construct large mounds; some commonly enter buildings in search of food; most feed on virtually any food but many prefer sweets.

Eye closer to base of mandible than to posterior margin of head (15B). Genus *Paratrechina* ---------- 16

Antennal scape and thoracic dorsum usually with stiff hairs.



15A formicine ant 15B *Paratrechina*

16 Antennae and legs disproportionately long; body slender (pl. 150B)
---------- **crazy ant,** *Paratrechina longicornis*

Suberect to erect hairs usually absent from antennal scape. Distribution: widely distributed by commerce throughout the warmer regions of the world; established in southern United States, but found only in buildings farther north; nests in a wide variety of habitats—in trash, refuse piles, soil, in various locations in buildings, and under objects on the ground; omnivorous but preferring sweets.

Antennae and legs not disproportionately long; body robust (pl. 150C)
---------- other species of *Paratrechina*

Stiff suberect to erect hairs always present on thorax and tibiae and sometimes present on scape. Several species key out here; they are found mostly in eastern and southern United States; some are occasional household pests and may often be found where food is stored.

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Notes and Sketches

United States Department of Agriculture

Agricultural Research Service

and

United States Department of Health and Human Services

Public Health Service

Food and Drug Administration

Agriculture Handbook No. 655

Insect and Mite Pests in Food

An Illustrated Key

Volume 2

United States
Department of
Agriculture

National Agricultural Library

Plate 2. Some **moths** (Lepidoptera) associated with the food industry (body lengths for each species are shown in millimeters in parentheses): A, **webbing clothes moth,** *Tineola bisselliella* (5-7.5) (Tineidae); B, **brown house moth,** *Hofmannophila pseudospretella* (7.5-10) (Oecophoridae); C, **lesser wax moth,** *Achroia grisella* (♂7-9; ♀9.5-12) (Pyralidae); D, *Monopis crocicapitella* (5-7) (Tineidae); E, **Angoumois grain moth**, *Sitotroga cerealella* (6-9) (Gelechiidae); F, G, **Indianmeal moth,** *Plodia interpunctella* (6-8.5) (Pyralidae); H, **rice moth**, *Corcyra cephalonica*(♂7.5-9; ♀8.5-11) (Pyralidae); I, **Mediterranean flour moth,** *Anagasta kuehniella* (9-11) (Pyralidae); J, **tobacco moth,** *Ephestia elutella* (7-9) (Pyralidae); K, **European grain moth,** *Nemapogon granella* (5-7) (Tineidae); L, **stored nut moth,** *Paralipsa gularis* (♂8.5-12; ♀8.5-13.5) (Pyralidae); M, **greater wax moth,** *Galleria mellonella* (♂9.5-11.5; ♀13-16) (Pyralidael); N, **whiteshouldered house moth,** *Endrosis sarcitrella* (7-9.5) (Oecophoridae); O, **meal moth,** *Pyralis farinalis* (♂7.5-11.5; ♀13-15) (Pyralidae).

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
Cushman '76

United States Department of Agriculture

Agricultural Research Service

and

United States Department of Health and Human Services

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Insect and Mite Pests in Food

An Illustrated Key

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Part 2

18

CLASSES AND ORDERS:

ARTHROPODS AND INSECTS (ARTHROPODA, INSECTA)

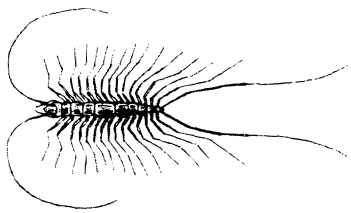
George T. Okumura

Okumura Biological Institute
6669 Fourteenth Street
Sacramento CA 95831

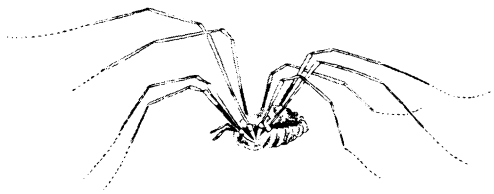
KEY TO ADULTS

Drawings by C.S. Papp unless otherwise noted.[1]

1 With more than 10 pairs of legs; body usually elongate (1A)---------- 2
With less than 10 pairs of legs; body usually not elongate (1B)---------- 3

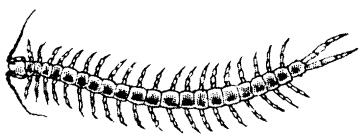


1A *Scutigera forceps*



1B harvestman

2 Most body segments with 1 pair of legs (2A)----------**centipedes,** Chilopoda
Most body segments with 2 pairs of legs (2B)----------**millipedes,** Diplopoda

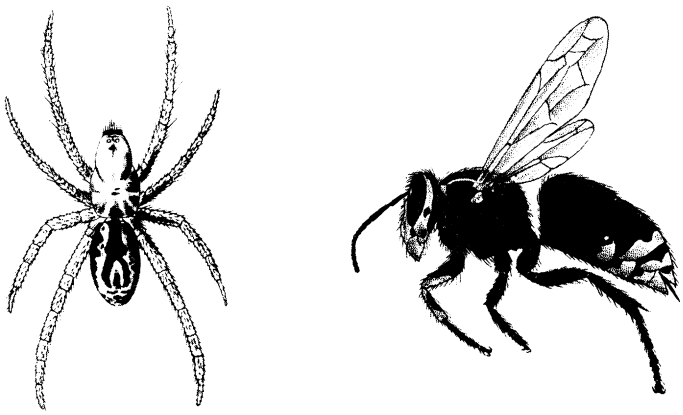


2A centipede

2B millipede

[1]Drawings 1B, 4A, 4B, 8B, 10A, 14B, 15A, 21A, 21B, 24A, 29A, 29B, and 30B from *The Common Insects of North America* by Lester A. Swan and Charles S. Papp. Reprinted by permission of Harper & Row, Publishers, Inc.; copyright 1972 by Lester A. Swan and Charles S. Papp.

3 With 4 or more pairs of legs, 1 or 2 body regions, and either 2 pairs of antennae or none; wings absent (3A) ---------- 4
With 3 pairs of thoracic legs, 3 major body regions, and 1 pair of antennae; often with 1 or 2 pairs of wings (3B). Insecta (**insects**) ---------- 5

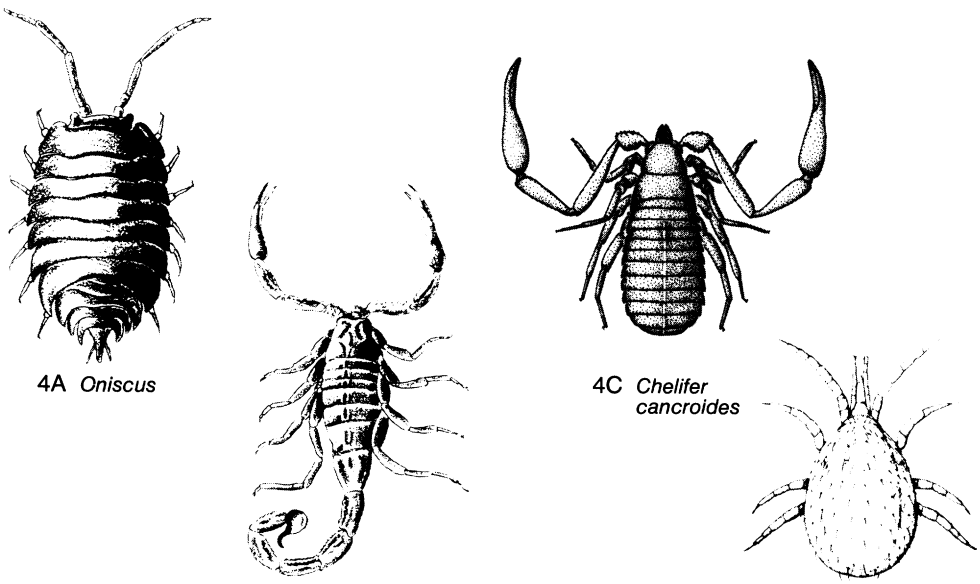


3A spider

3B *Vespula maculata*

4 With 5 or more pairs of legs and 2 pairs of antennae (one pair may be difficult to see) (4A) ----------crustaceans, Crustacea
With 4 pairs of legs; antennae absent (4B-D) ---------- **arachnids**, Arachnida
FOR KEY TO MITES, SEE CHAPTER 1

Drawing 4C by C. Feller



4A *Oniscus*

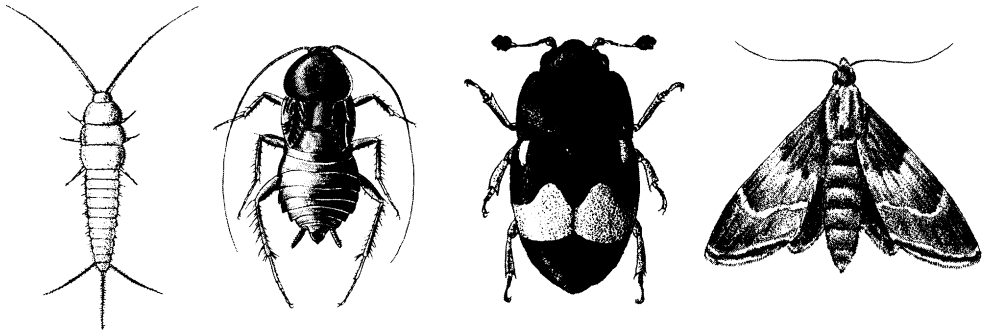
4B scorpion

4C *Chelifer cancroides*

4D mite

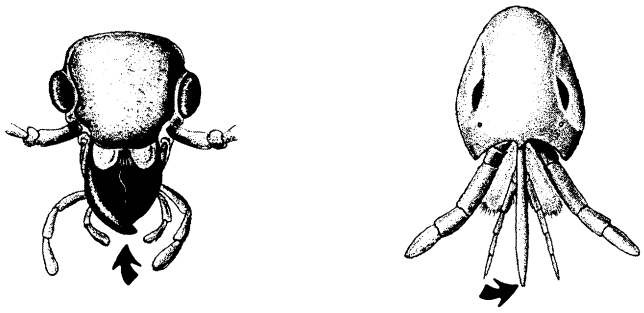
Insecta

5 Wings absent (5A) or rudimentary (5B)---------- 6
Wings present (5C, 5D) (but may be nonfunctional)---------- 21



5A lepismatid 5B *Blatta orientalis* 5C *Carpophilus hemipterus* 5D *Pyralis farinalis*

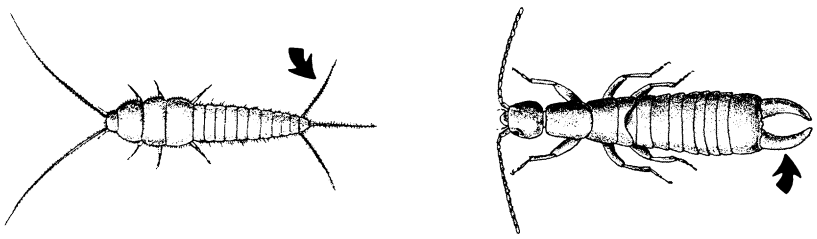
6 With jaws (chewing mouthparts) (6A)---------- 7
With a long beak or stylets (sucking mouthparts) (6B)---------- 15



6A grasshopper 6B flea

7 With 3 long filaments at tip of abdomen (7A)----------silverfish, Thysanura
FOR KEY TO SILVERFISH, SEE CHAPTER 21

Without 3 caudal filaments (7B)---------- 8

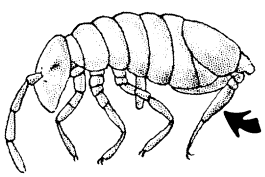


7A lepismatid 7B earwig

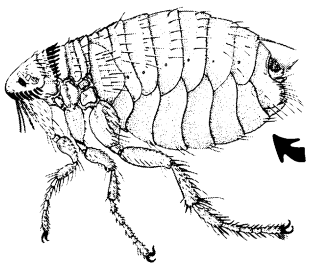
8 Abdomen with no more than 6 segments; springlike appendage usually present on posteroventral surface of abdomen (8A) ----------**springtails,** Collembola
FOR KEY TO SPRINGTAILS, SEE CHAPTER 20

Abdomen with more than 6 segments; springlike appendage absent (8B)---------- 9

Segmentation is usually readily apparent (see 11A-D) in the abdomens of the Hymenoptera included in this Handbook, but it is often very difficult to see all of the segments that may be present. Therefore, when the abdomen consists of a propodeum, petiole, and gaster (as in 11A-D), the reader may assume that more than 6 segments are present.

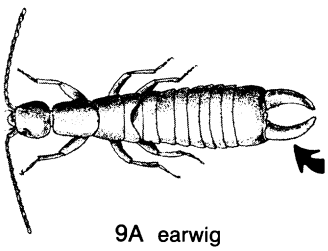


8A springtail

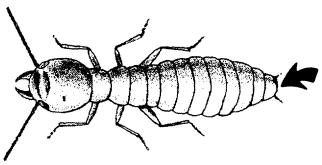


8B *Ctenocephalides felis*

9 Forcepslike appendage present at tip of abdomen (9A)------**earwigs,** Dermaptera (in part)
Forcepslike appendage absent (9B) ---------- 10

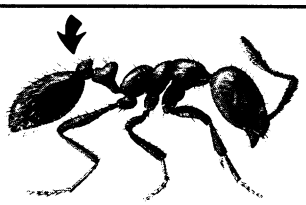


9A earwig

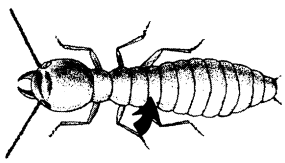


9B termite (worker)

10 Abdomen strongly constricted at base (10A). Hymenoptera (ants, parasitic wasps) (in part) ---------- 11
Abdomen not strongly constricted at base (10B) ---------- 12



10A *Monomorium minimum*

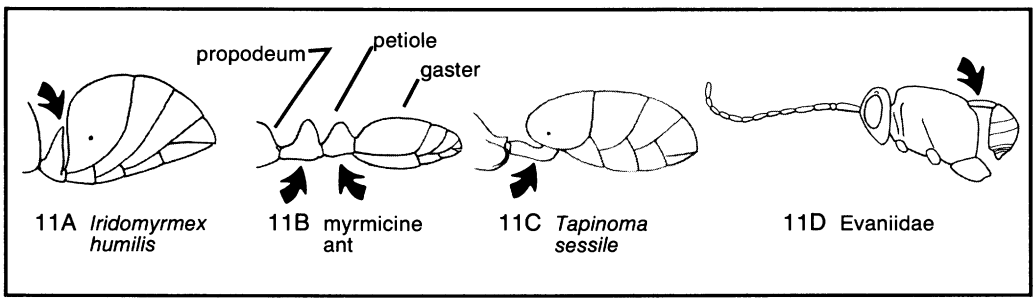


10B termite (worker)

11 One (11A) or two (11B) petiolar nodes present----------**ants,** Formicidae
FOR KEY TO ANTS, SEE CHAPTER 17

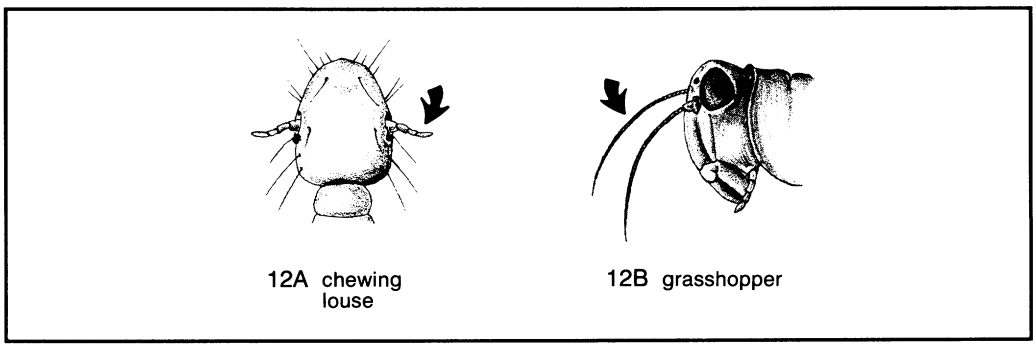
Caution: The petiolar node is vestigial in the workers of *Tapinoma sessile* (11C) and *T. melanocephalum.*
Drawings 11A-C by A.D. Cushman; 11D by G. Gordh and P. Mote.

Petiolar node absent (11D) ----------parasitic wasps
FOR KEY TO PARASITIC WASPS, SEE CHAPTER 26



11A *Iridomyrmex humilis* 11B myrmicine ant 11C *Tapinoma sessile* 11D Evaniidae

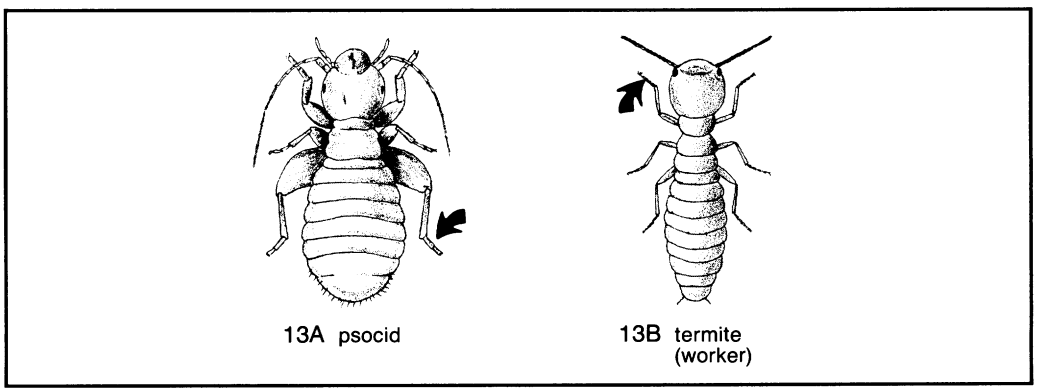
12 Antenna with fewer than 8 segments (12A)----------**chewing lice,** Mallophaga
Antenna with more than 8 segments (12B)---------- 13



12A chewing louse 12B grasshopper

13 Tarsus with 1 to 3 segments (13A)----------**psocids,** Psocoptera
FOR KEY TO PSOCIDS, SEE CHAPTER 22

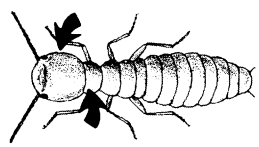
Tarsus with 4 or 5 segments (13B)---------- 14



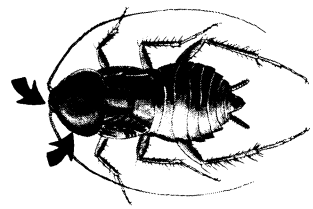
13A psocid 13B termite (worker)

14 Width of pronotum less than length of head (14A)----------**termites,** Isoptera

Width of pronotum greater than length of head (14B) (pronotum covers head of some species) ----------**crickets, cockroaches,** etc., Orthoptera *s.l.* (in part)
FOR KEY TO COCKROACHES, SEE CHAPTER 2



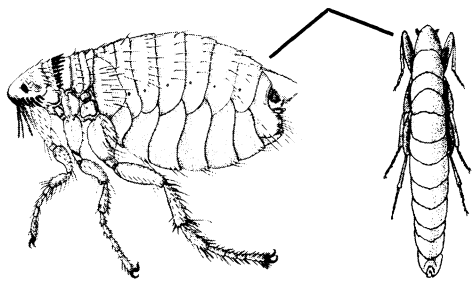
14A termite (worker)



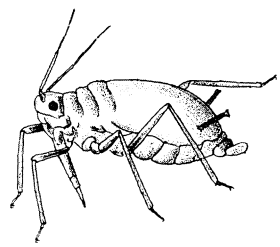
14B *Blatta orientalis*

15 Body extremely compressed (flattened from side to side) (15A)--------**fleas,** Siphonaptera

Body not compressed (may be depressed—flattened dorsoventrally—or roughly cylindrical) (15B) ---------- 16



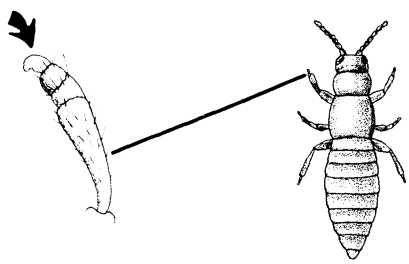
15A *Ctenocephalides felis*



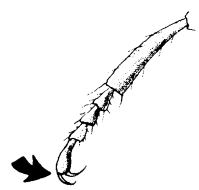
15B aphid

16 Tarsus terminating in a protrusible bladder (16A) ----------**thrips,** Thysanoptera (in part)
FOR KEY TO THRIPS, SEE CHAPTER 23

Tarsus terminating in 1 or 2 claws (16B)---------- 17



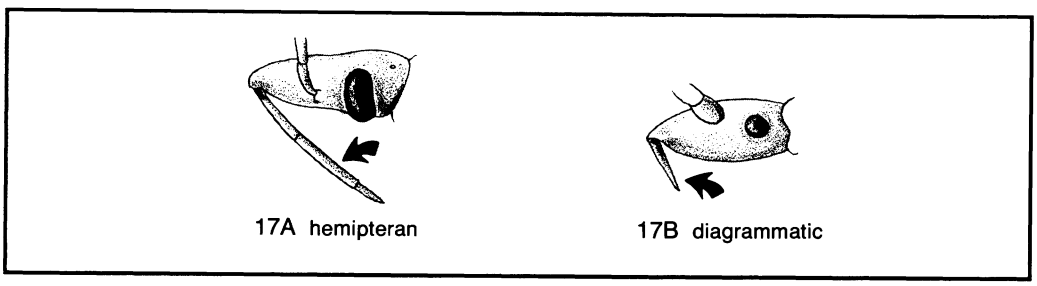
16A thrips



16B diagrammatic

17 Beak jointed (17A) ---------- 18
Beak not jointed (17B) ---------- 20

If the mouthparts appear to be retracted into the head (thus difficult to observe) and the tarsi have only one segment, go to couplet 20.



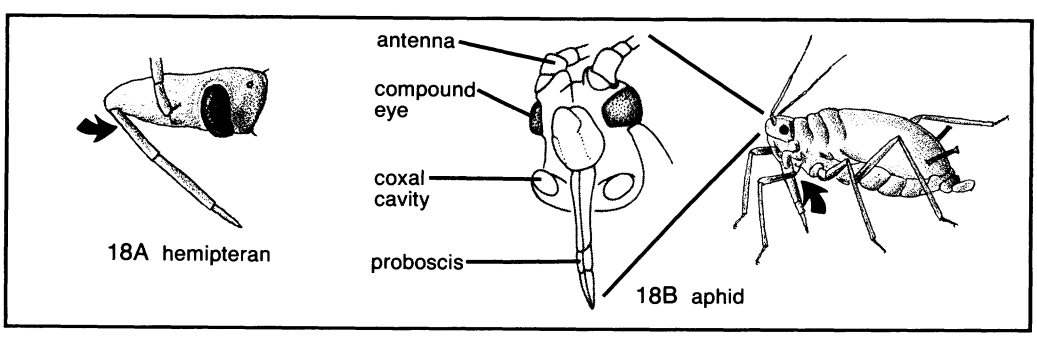
17A hemipteran

17B diagrammatic

18 Beak arising from front of head (18A) ---------- **true bugs,** Hemiptera (Heteroptera) (in part)

Beak arising from posteroventral part of head (18B). Hemiptera (Homoptera) (homopterans) (in part) ---------- 19

Drawing 18B-detail (head of *Myzus persicae*) by C. Feller.



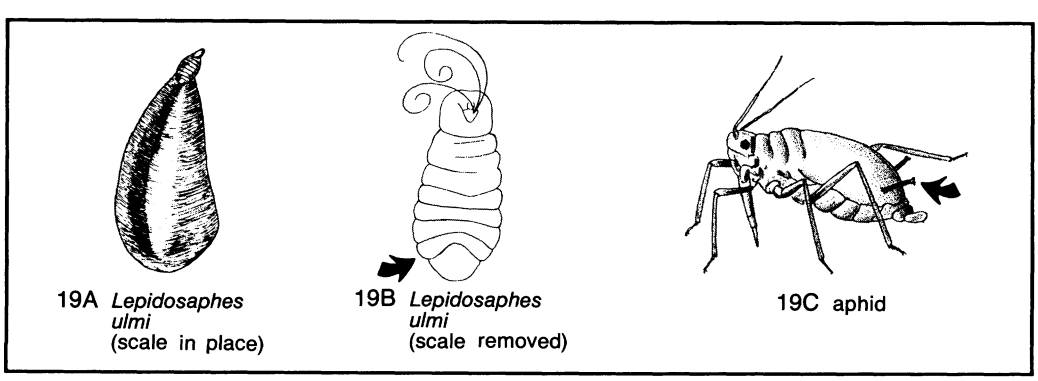
18A hemipteran

18B aphid

19 Body of female covered by scalelike structure (19A); cornicles absent (19B) ---------- females, **scale insects,** Coccoidea
FOR KEY TO SCALES, SEE CHAPTER 25

Drawings 19A&B from *Microscopic-Analytical Methods in Food and Drug Control*, 1960.

Scalelike cover absent; cornicles present (19C) ---------- **aphids,** Aphididae
FOR KEY TO APHIDS, SEE CHAPTER 24



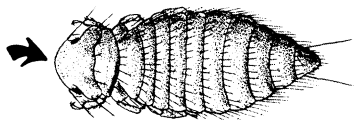
19A *Lepidosaphes ulmi* (scale in place)

19B *Lepidosaphes ulmi* (scale removed)

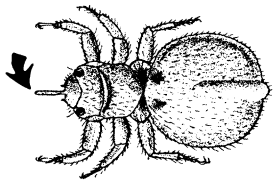
19C aphid

20 Mouthparts retracted into head (not protruding from front of head) (20A) ----------**sucking lice,** Anoplura

Mouthparts not retracted into head (20B). Diptera (flies) (in part) ----------**sheep ked,** *Melophagus ovinus*

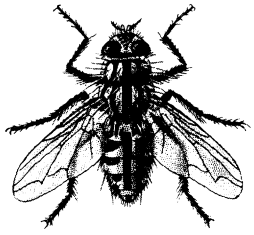


20A *Menopon gallinae*

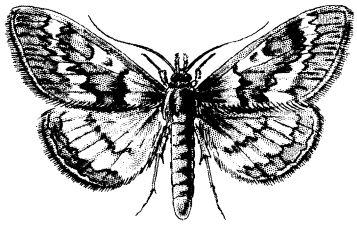


20B *Melophagus ovinus*

21 With 1 pair of wings (21A) ---------- 22
With 2 pairs of wings (21B) ---------- 23



21A *Sarcophaga sarraceniae*

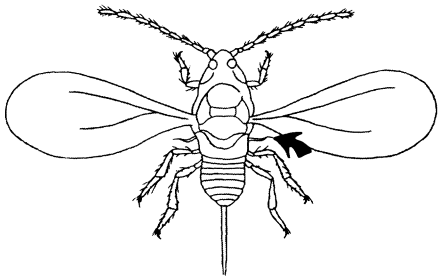


21B *Ostrinia nubilalis*

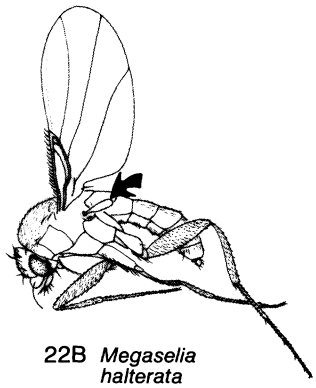
22 Vestigial hind wings (hamulohalterae) lanceolate (22A); mouthparts absent ---------- males, **scale insects,** Coccoidea

Drawing 22A from *Microscopic-Analytical Methods in Food and Drug Control,* 1960; 22B by C. Feller.

Vestigial hind wings (halteres) capitate (22B); mouthparts present ----------**flies,** Diptera (in part)



22A *Lepidosaphes ulmi*

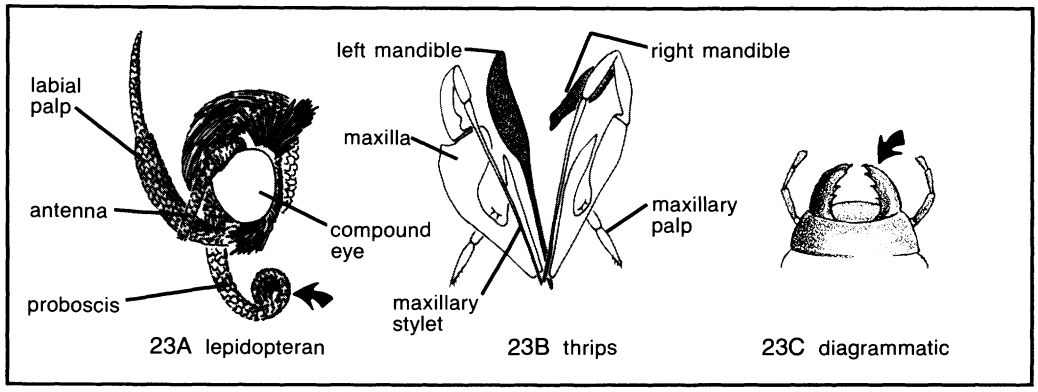


22B *Megaselia halterata*

23 With sucking mouthparts (23A)---------- 24

The mouthparts of thrips (23B) are minute, complex, and difficult to see, but the absence of prominent, chewing-type mandibles is readily apparent, at least.
Drawings 23A&B by C. Feller.

With chewing mouthparts (23C)---------- 27

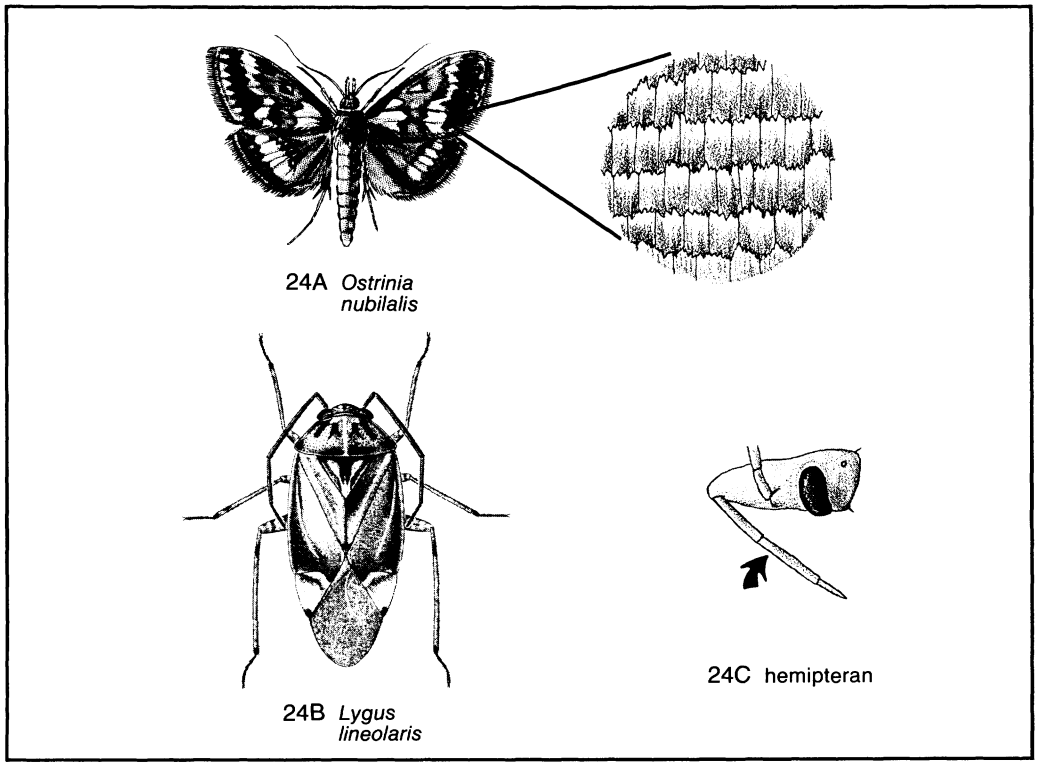


23A lepidopteran 23B thrips 23C diagrammatic

24 Wing densely covered with scales (24A); head with a coiled proboscis (see 23A) ----------**moths,** Lepidoptera
FOR KEY TO MOTHS, SEE CHAPTER 14

Wing not scaled (24B); proboscis not coiled (24C) ---------- 25

Drawing 24B by C. Feller.



24A *Ostrinia nubilalis*

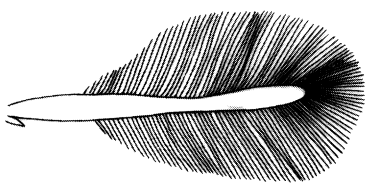
24B *Lygus lineolaris*

24C hemipteran

25 Wing with long fringe hairs (25A)----------**thrips,** Thysanoptera (in part)
FOR KEY TO THRIPS, SEE CHAPTER 23

Drawing 25A by C. Feller.

Long fringe hairs absent from wing (25B)---------- 26

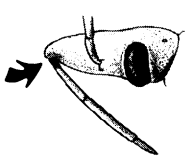


25A *Haplothrips graminis*

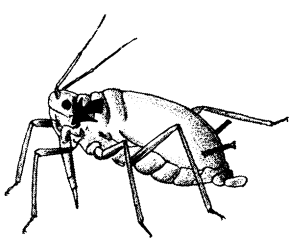
25B aphid

26 Beak arising from front of head (26A)---------**true bugs,** Hemiptera (Heteroptera) (in part)

Beak arising from posteroventral part of head (26B)
----------**leafhoppers, aphids,** etc., Hemiptera (Homoptera) (in part)
FOR KEY TO APHIDS, SEE CHAPTER 24



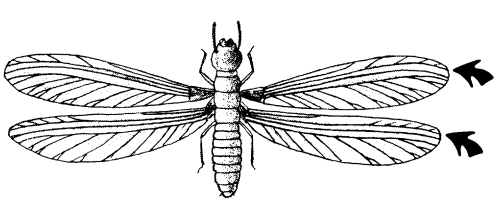
26A hemipteran



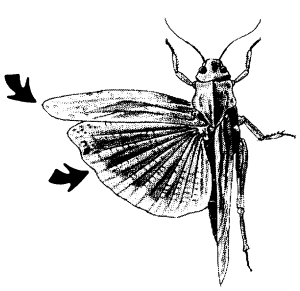
26B aphid

27 Front and hind wings membranous and similar in texture (may or may not be similar in size) (27A)---------- 28

Front and hind wings dissimilar in texture, the forewing leathery, horny, or paperlike, the hind wing membranous (27B) ---------- 29



27A termite (reproductive)

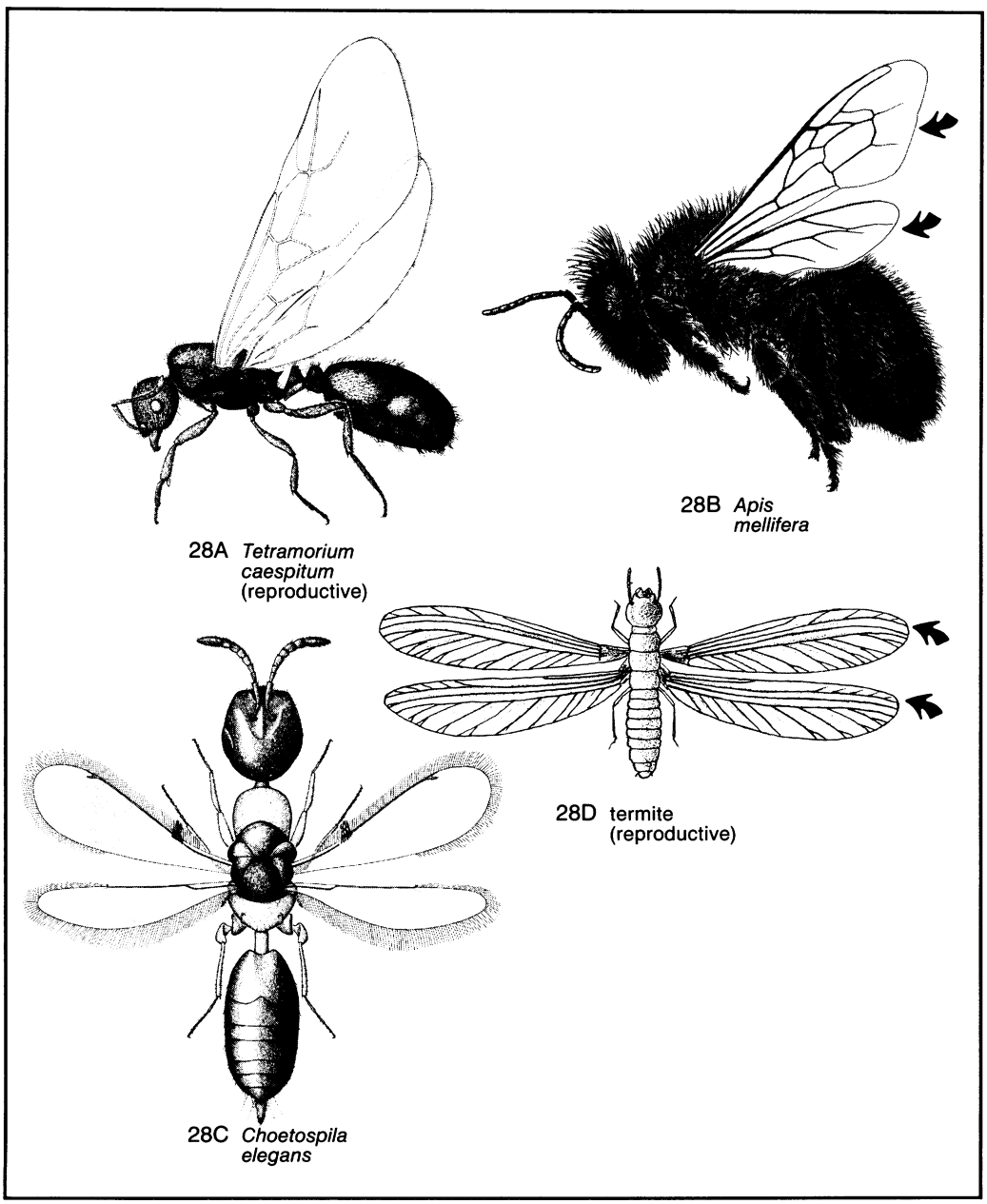


27B *Dissosteria carolina*

28 Hind wing much smaller than front wing (28A, 28B)
----------**ants, bees, wasps,** Hymenoptera (in part)
FOR KEY TO ANTS, SEE CHAPTER 17
FOR KEY TO PARASITIC WASPS, SEE CHAPTER 26

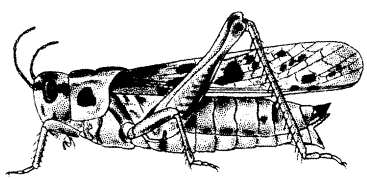
Hind wing usually shorter than front wing, but if front and hind wings are essentially similar in length (as in 28C), then the venation is greatly reduced. See also 3B, 10A, 11A-D.
Drawings 28A-C by C. Feller.

Front and hind wings similar in size (28D) ----------**termites,** Isoptera (in part)

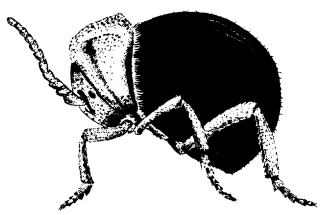


29 Front wing leathery or paperlike, with distinct veins (29A)
---------- grasshoppers, cockroaches, etc., Orthoptera *s.l.* (in part)
FOR KEY TO COCKROACHES, SEE CHAPTER 2

Front wing horny or leathery, without distinct veins (but may be ridged) (29B)------ 30



29A *Camnula pellucida*



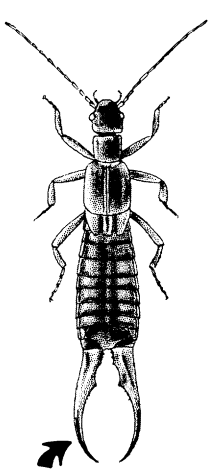
29B *Mezium americanum*

30 With forcepslike appendage at tip of abdomen ----------**earwigs,** Dermaptera (in part)

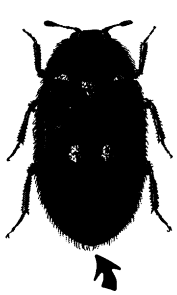
Wings always very much shorter than abdomen.

Without forcepslike appendage (30B)----------**beetles,** Coleoptera
FOR KEY TO BEETLES, SEE CHAPTER 3

If wings are abbreviated (as in Staphylinidae), then forceps are absent; wings commonly cover abdomen (30B) or nearly so (see 5C).



30A earwig



30B *Attagenus pellio*

Notes and Sketches

19 ORDERS OF LARVAL ENDOPTERYGOTA (INSECTA)[2]

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Identification of the larvae of the holometabolus insects is often more difficult than identification of the adults. Furthermore, when only incomplete or fragmentary specimens are available, the task is even more difficult and requires at the very least a considerable knowledge of insect morphology. Often, a knowledge of the life history of an insect lends credence to an identification based on an analytical key. Also, the overall habitus of a larva often identifies it as readily as one person recognizes another. Illustrations, keys, and descriptions in the existing literature, some of which is cited here (*1-16*), are often helpful aids to identification.

Certain morphological characters are a dead giveaway as to the identity of a larva, for example, the hastisetae of some dermestids or the three tarsal "claws" of blister beetle triungulins (Meloidae). Before advanced microscopic work was possible, these last structures were accepted as true claws (ungues) and from this feature the term "triungulin" was coined. Other larvae that resembled meloid triungulins, even though they had no claws or clawlike structures [for example, Strepsiptera and Rhipiphoridae (Coleoptera)], were also called triungulins (more properly, triungulinoids).

Larvae of the Holometabola are often divided into five or six types based on general body form. Thus, some are termed campodeiform (fig. 19.1A) because the form is basically that found in the genus *Campodea* (Campodeidae, order Diplura—formerly in Thysanura). Larvae of Meloidae (fig. 19.5) are good examples of the campodeiform habitus. Elateriform larvae (fig. 19.1B) resemble wireworms (Elateridae)—elongate, cylindrical, usually heavily sclerotized, with head capsule frequently somewhat flattened. Vermiform larvae (fig. 19.1C), as the name implies, are wormlike—elongate, often annulate, lacking legs, and usually having no distinct head. Flea larvae (Siphonaptera), even though they have a distinct head, and maggots (Diptera) are vermiform. Scarabaeiform larvae (fig. 19.1D) are C-shaped, usually stout-bodied (grublike), and resemble the white grubs of the beetle family Scarabaeidae. Eruciform larvae (fig. 19.1E; the term comes from the Latin stem *eruca* meaning caterpillar) are typical caterpillars with a distinct head, thoracic legs, and prolegs with crochets on some of the abdominal segments. These terms for the various larval body types are also used to describe the successive larval stages of insects that undergo hypermetamorphosis (heteromorphosis). This is a remarkable process in which the larva assumes a different form at each succeeding molt. Hypermetamorphosis occurs primarily in parasitic insects of the orders Strepsiptera, Coleoptera (Meloidae, Rhipiphoridae), Diptera (Acroceridae, Bombyliidae, Nemestrinidae), Neuroptera (Mantispidae), and Hymenoptera (hypermetamorphosis in the last group is rather different from the kind summarized in the next few paragraphs).

Most hypermetamorphic insects start out as mobile, campodeiform larvae that actively seek out their hosts. Then they change into parasites at the first molt and often enter a scarabaeiform stage, a grublike form with legs, antennae, and other appendages greatly reduced. This is often followed by a coarctate stage somewhat like the dipteran puparium in being legless and covered by the heavily sclerotized cuticle of the larva. This stage is highly resistant to desiccation and other adverse environmental conditions. In the Meloidae there emerges from the coarctate form yet another larval stage that is brief and nonfeeding; this is followed by true pupation and eventual emergence of the adult.

Strepsipteran, rhipiphorid, and meloid triungulins are included here because they may become accidentally entrapped in honey or because they are associated with pollen or flowers that may be used as or used in human food. How they might come to be there may be deduced from their life histories. Strepsipteran triungulins apparently ride the host bee to its nest from whatever flowers it happens to visit. Meloid triungulins (except those that attack grasshopper eggs) and rhipiphorid triungulins hatch from eggs deposited on or near flower blossoms. When a bee visits the flower, the triungulins attach themselves to the bee and ride back to the nest where they dispose of the host's egg and any other competition, molt into a different stage and subsist on pollen and honey. Honeybees (*Apis mellifera*) are merely accidental, dead-end hosts. The life cycles of triungulins can be successfully completed only if the larvae find the right species of various flower-visiting, solitary or semisocial bees (Andrenidae, Anthophorinae, Colletinae, Halictidae, and Hylaeinae).

[2]Excluding Neuroptera *sens. lat.*, Mecoptera, and Trichoptera.

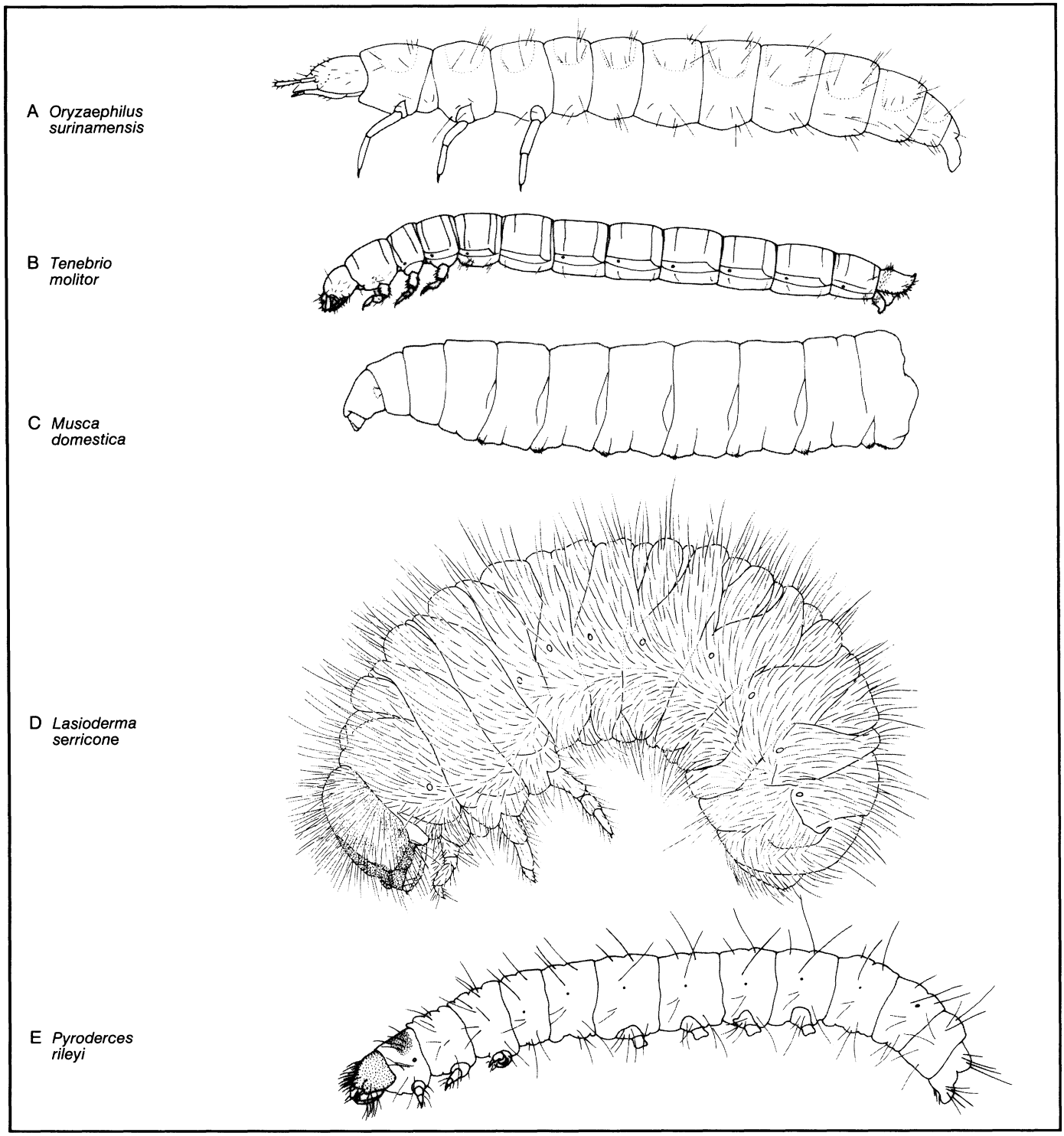


Figure 19.1. Types of insect larvae. A, campodeiform; B, elateriform; C, vermiform; D, scarabaeiform; E, eruciform. (Drawings by C. Feller.)

This is, of course, a most precarious way to make a living. Larval mortality in these groups is, therefore, exceedingly high. These insects have developed an effective way to overcome high mortality: The production of enormous numbers of eggs and larvae per female. For example, over 3,000 larvae have been recorded from a single female strepsipteran.

Any source of flower heads or pollen for use in studies such as on allergies, food fads, and flavorings could readily be contaminated by these larvae. The probability of finding them in food, however, remains extremely low.

The following key to selected orders of immature insects also includes certain infraordinal taxa (*Fannia, Eristalis,* Stratiomyidae, Rhipiphoridae, Meloidae) because the different members of a given order are so highly variable that it is impossible to bring them all out at the same point in the key. Only the first stage larvae (triungulins) of Strepsiptera, Meloidae, and Rhipiphoridae are included in this key. The characters of the other taxa treated here refer to the last larval instar. A further caution should be mentioned here, namely, that this is not a comprehensive key to the insect orders. It is distinctly biased toward those insects that are pests of stored food, are parasites of stored-food pests, or are in some other way associated with food.

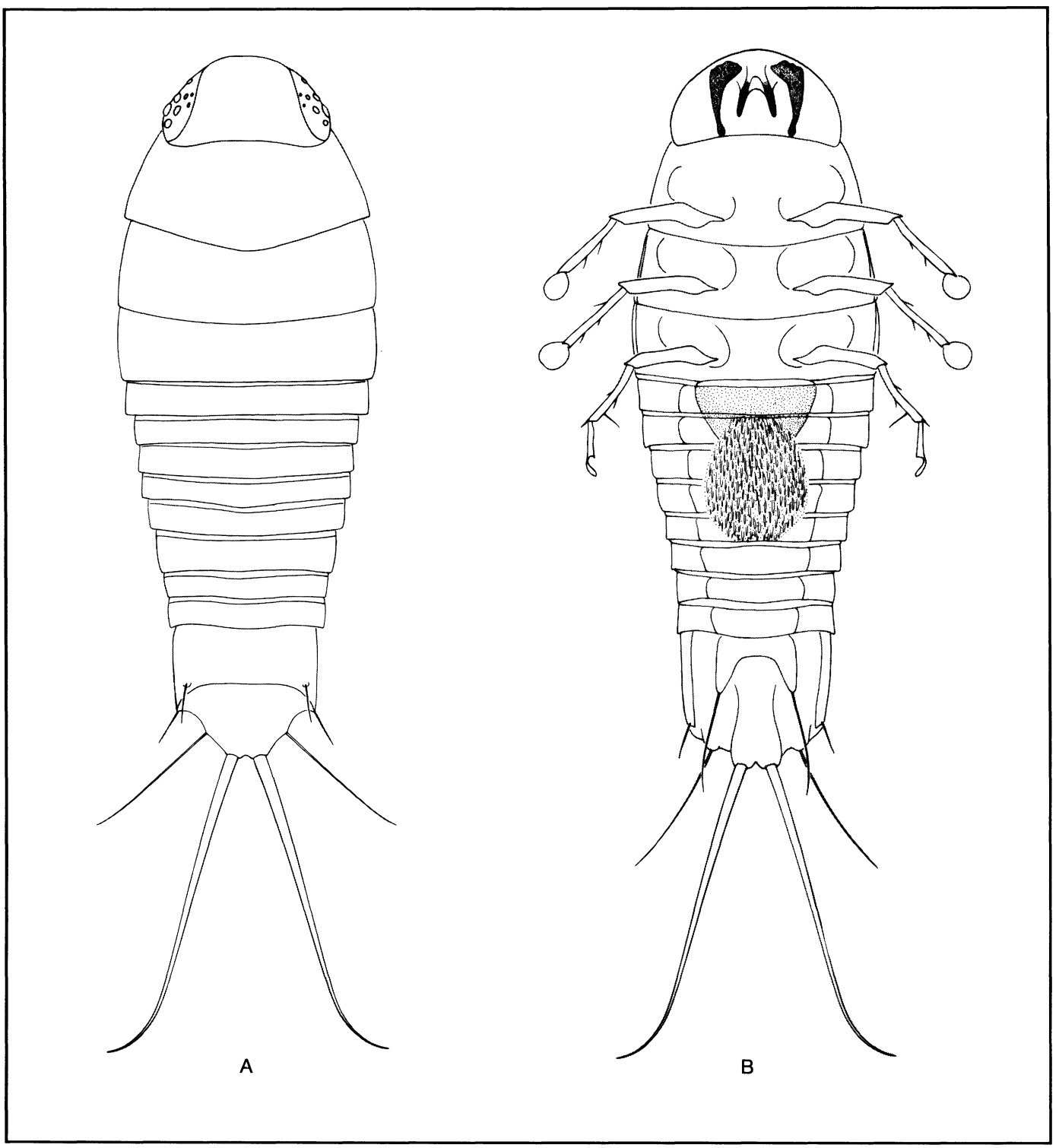


Figure 19.2. *Xenos peckii* Kirby (Stylopidae, Strepsiptera), triungulin: A, dorsal view; B, ventral view. (Drawings by C. Feller.)

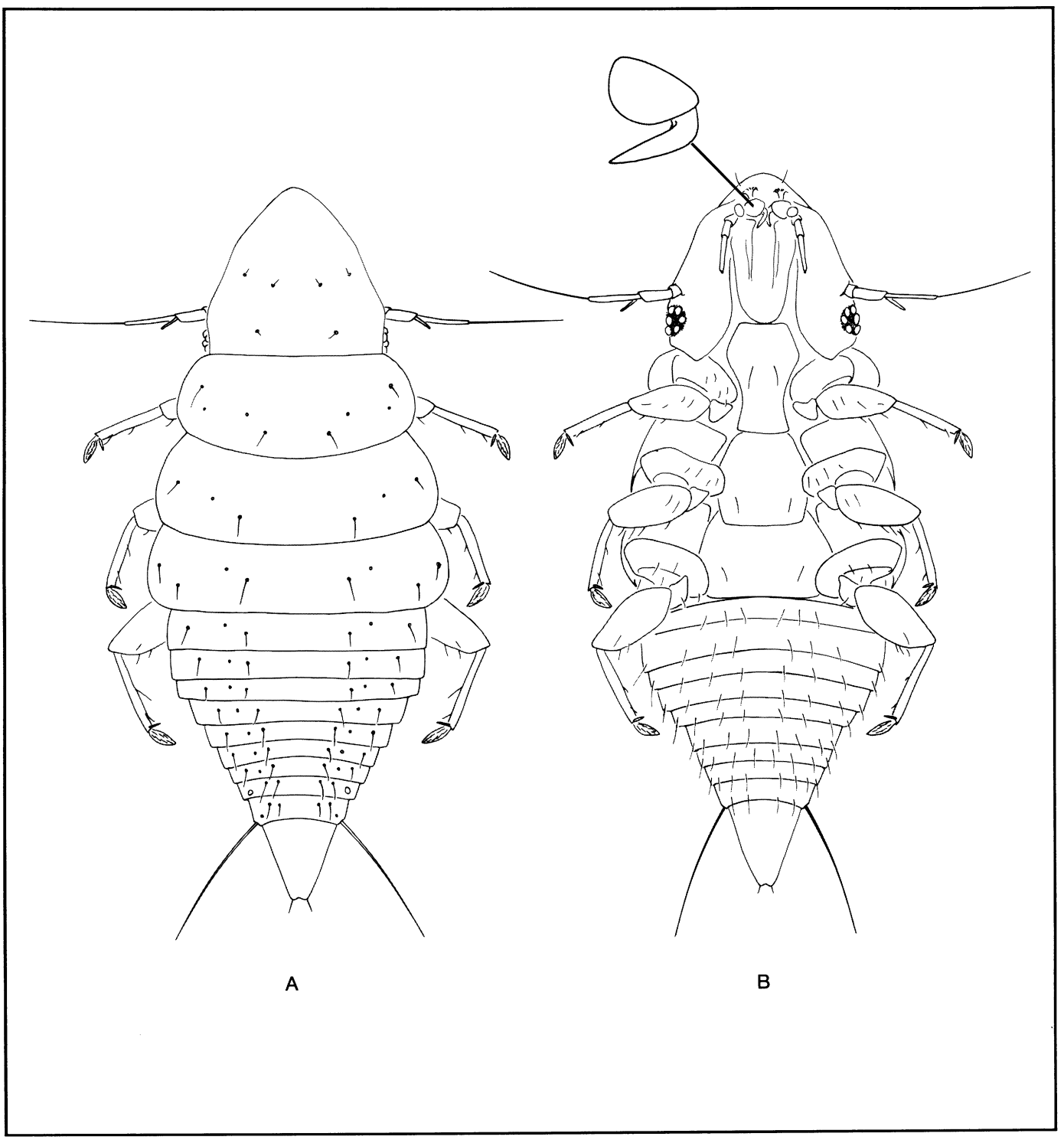


Figure 19.3. Triungulin larva of a wedge-shaped beetle (Rhipiphoridae): A, dorsal view; B, ventral view, with detail of right mandible. (Drawings by C. Feller.)

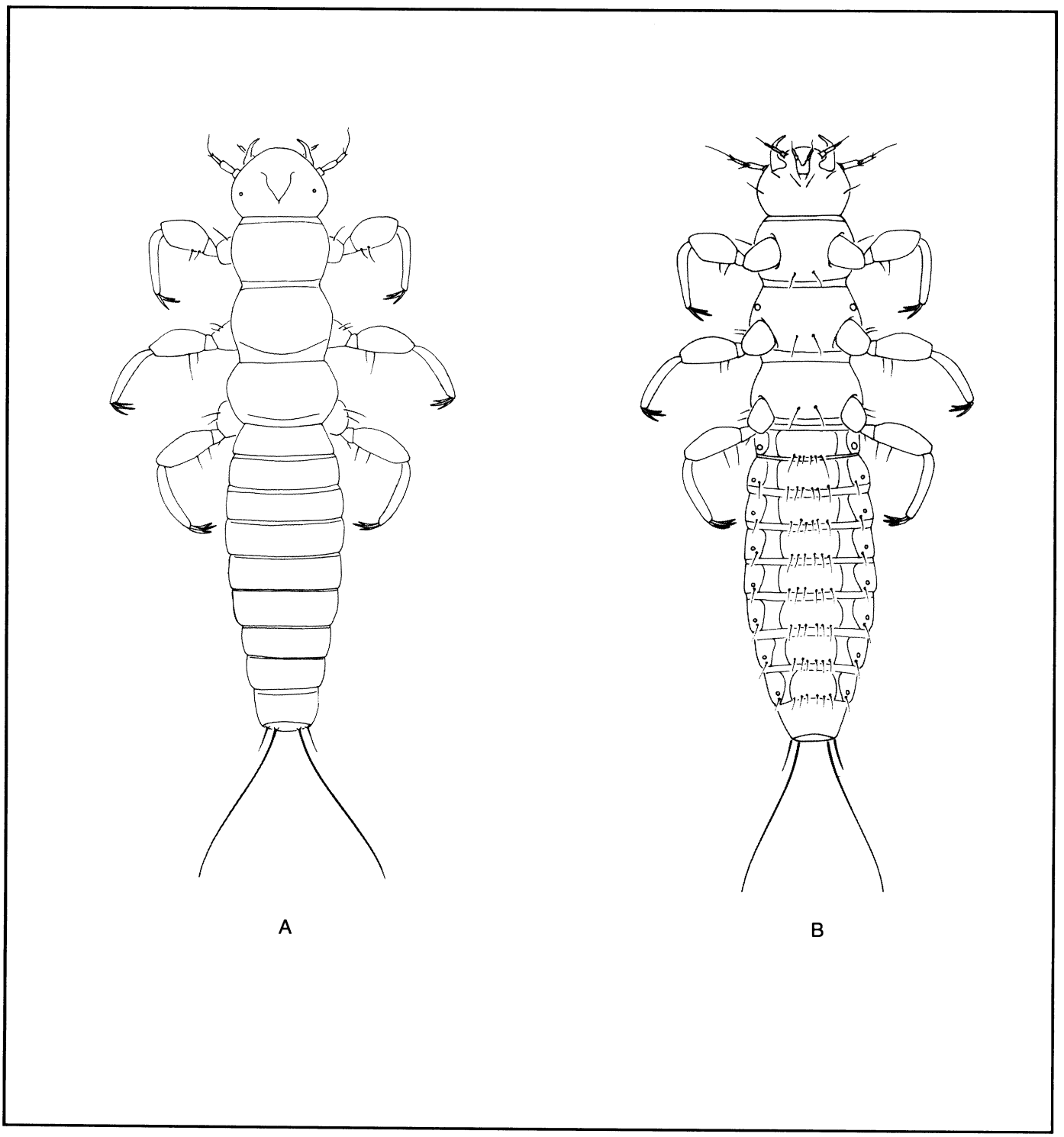


Figure 19.4. Triungulin larva of *Meloe* sp. (Meloinae, Meloidae): A, dorsal view; B, ventral view. (Drawings by C. Feller.)

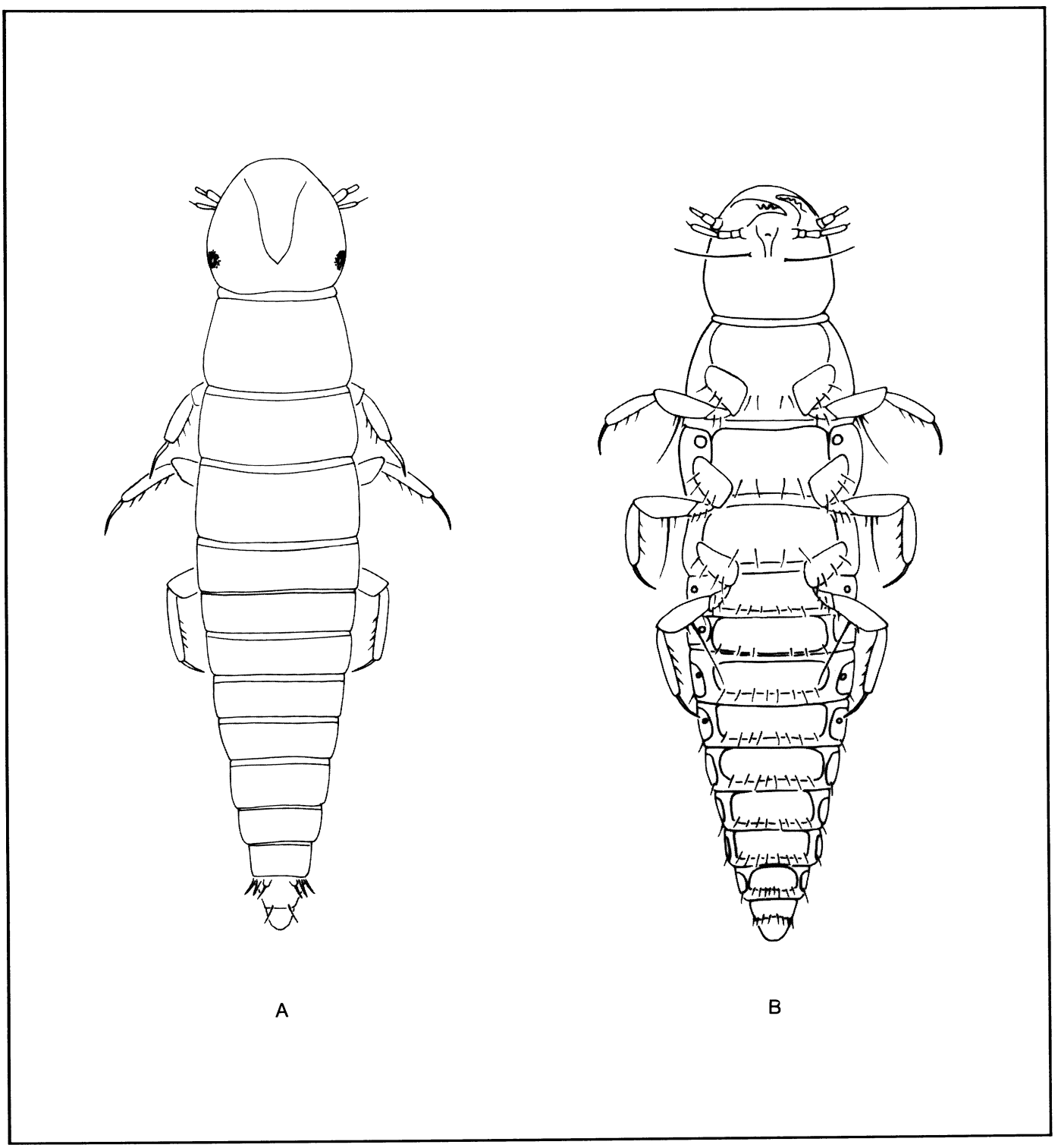


Figure 19.5. Nemognathine triungulin (Nemognathinae, Meloidae): A, dorsal view; B, ventral view. (Drawings by C. Feller.)

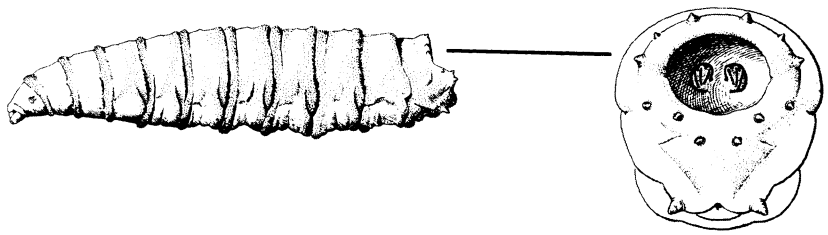
KEY
Drawings by C. Feller unless otherwise noted.

1 Typical maggots (1A); body tapering to a subacute head; posterior end somewhat truncate with 2 spiracles on posterior aspect (1B); mouthparts consisting of mouth hooks and internal pharyngeal sclerites (1C)----------**flies,** Diptera (in part)
SEE CHAPTER 16

Body circular in cross section (1B); prolegs absent; head capsule unsclerotized (1A) or only weakly sclerotized.
Drawings 1A&B by A.D. Cushman.

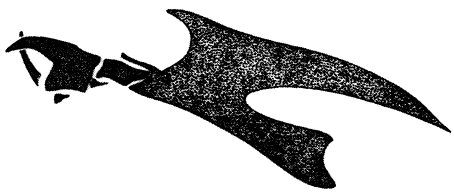
Not typical maggots (1D); body not tapered anteriorly; posterior end not truncate; spiracles not present on posterior aspect of posterior end; mouthparts not consisting of mouth hooks and internal pharyngeal sclerites---------- 2

Body round, oval, or flattened in cross section; mouthparts may be absent or vestigial; prolegs may be present or absent.

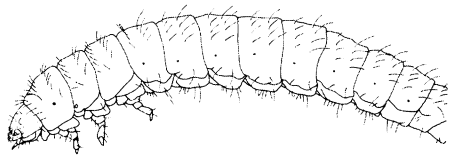


1A *Sarcophaga crassipalpis*

1B



1C muscoid fly (diagrammatic)



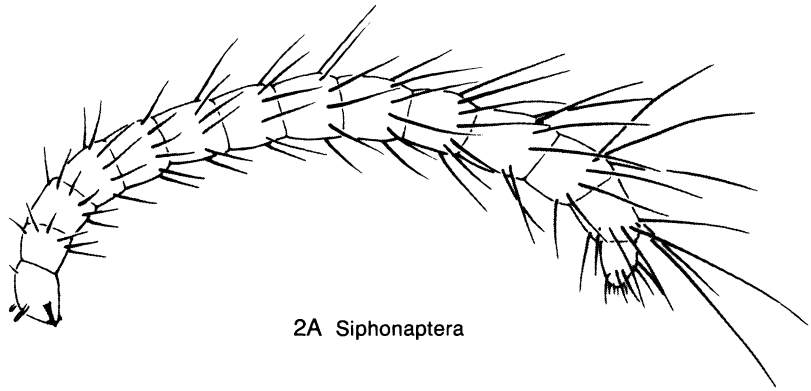
1D *Byturus tomentosus*

2 Each thoracic and abdominal segment with several long setae (2A); abdominal apex with a pair of short, subanal processes----------**fleas,** Siphonaptera

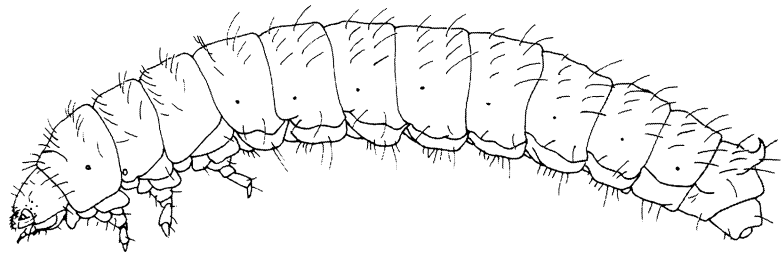
Body vermiform, very slender and elongate, usually less than 10 mm in length; antennae and mouthparts visible; legs and prolegs absent.

Long setae absent from some or all thoracic and abdominal segments (2B); abdominal apex without a pair of short, subanal processes---------- 3

Body may or may not be vermiform, but if so, then it is not as slender as in 2A; length usually more than 10 mm; legs and prolegs usually present; if prolegs are absent, then body form is not vermiform.



2A Siphonaptera



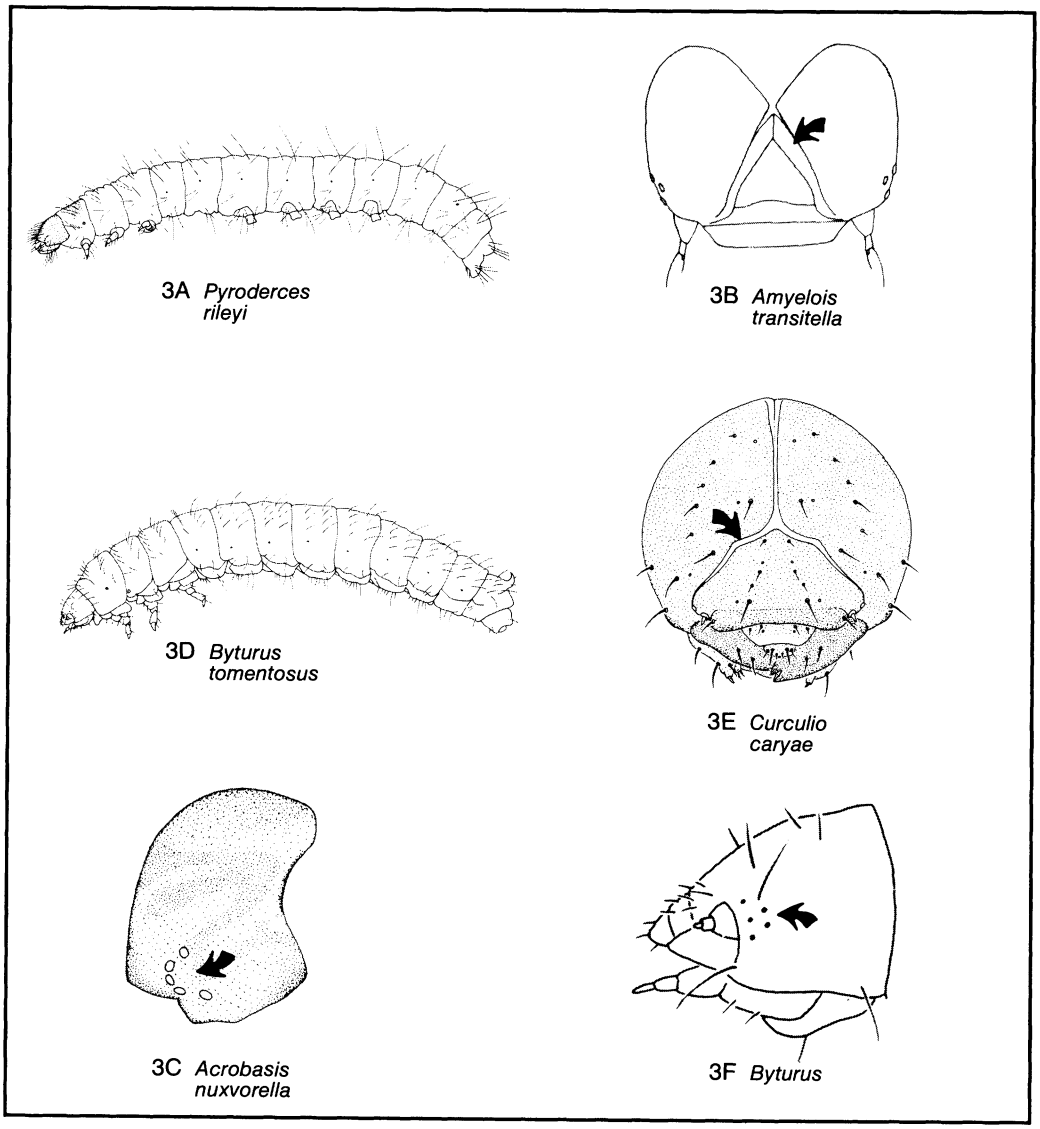
2B *Byturus tomentosus*

3 Larva eruciform (3A); adfrontal areas present (3B); prolegs and/or crochets on abdominal segments V and VI (3A); apical abdominal segments not comprising an elongate, contractile tube (3A)----------**moths,** Lepidoptera
SEE CHAPTER 15

Simple eyes (ocelli or stemmata) present, often arranged in a semi circle (3C); typical mouthparts present and visible; prolegs or crochets may also be present on abdominal segments III, IV, and XI.

Larva not eruciform (3D); adfrontal areas absent (3E); prolegs and/or crochets absent from abdominal segments V and VI, or if present on V and VI, then apical abdominal segments comprising a slender, elongate, contractile tube (see 6A)- 4

Simple eyes, if present, usually not arranged in a semicircle (3F); mouthparts variable.

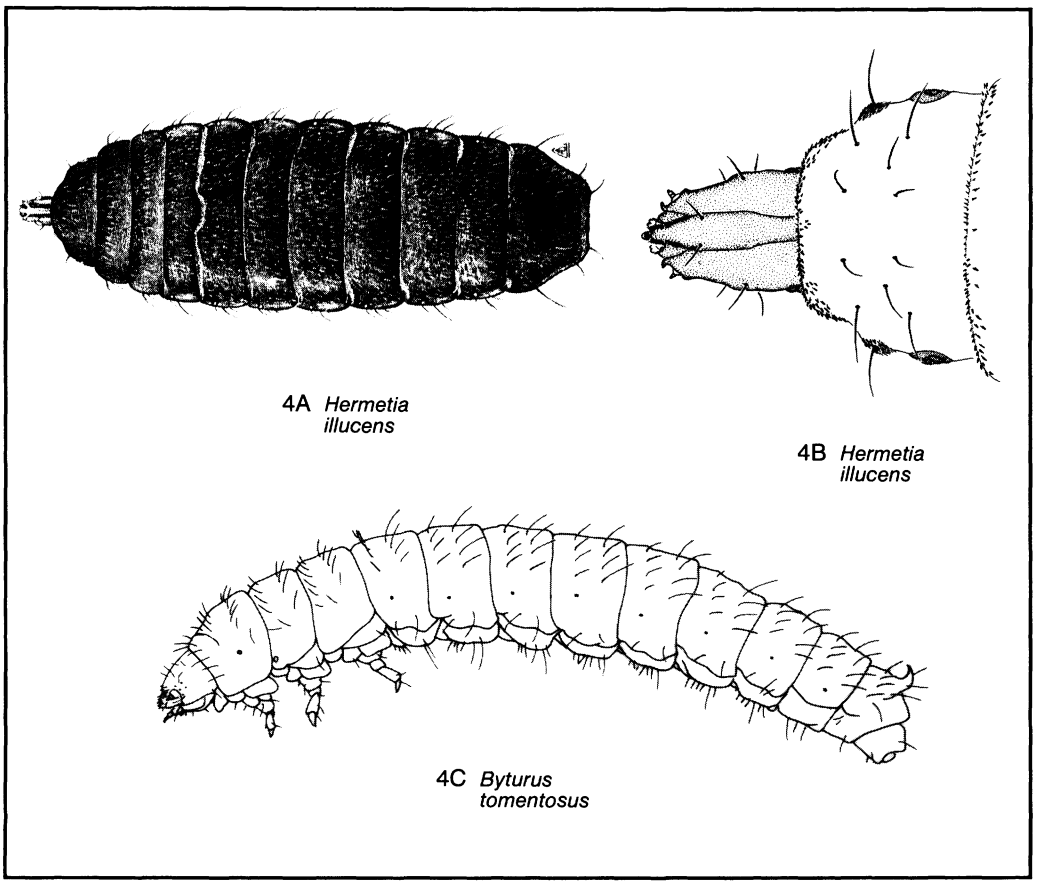


4 Body surface rough, shagreened (4A). Diptera (**flies**) (in part)
----------**soldier flies,** Stratiomyidae

Head capsule heavily sclerotized (4B); body depressed and elongate, without dorsal and lateral spinelike processes and without elongate and contractile posterior abdominal segments (4A); mandibles inconspicuous (vestigial or absent), but mouthparts in general not reduced to fleshy remnants; thoracic legs absent. CAUTION: Other fly larvae (all much smaller than *Hermetia illucens*) with definite head capsules (but without a rough, shagreened body surface)—Scatopsidae, Psychodidae, Sciaridae, Scenopinidae—should be taken out at this point and referred to Chapter 16.

Body surface not rough or shagreened (4C)---------- 5

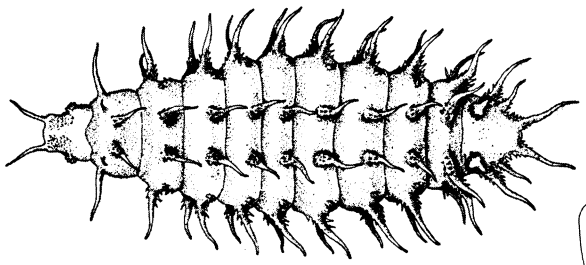
Head capsule may or may not be sclerotized (if sclerotized, then thoracic legs usually present); body not depressed; or body depressed but not elongate (as in *Murmidius ovalis*); or body elongate with dorsal and lateral spinelike processes (see 5A); or body elongate without dorsal and lateral spinelike processes but with posterior abdominal segments elongate and contractile (see 6A); thoracic legs present or absent (if absent, then mandibles either conspicuous or mouthparts in general reduced to fleshy remnants).



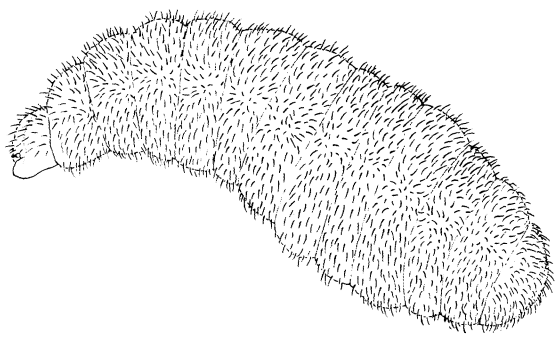
5 Body moderately depressed (not saclike, minute, or campodeiform; not round in cross section), bearing spiny or fleshy processes or tubercles dorsally and laterally (5A); apical abdominal segments not elongate and contractile. Diptera (**flies**) (in part) ----*Fannia*
SEE CHAPTER 16

Head capsule minute, weakly developed. CAUTION: Some species of Phoridae also have dorsal and lateral lobes; see Chapter 16.
Drawing 5A from 9.

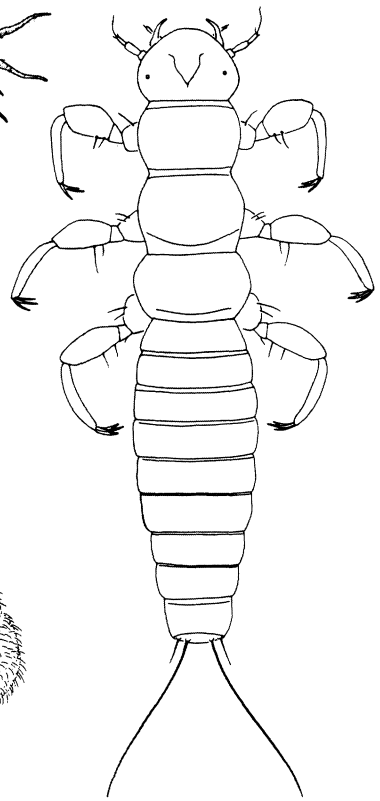
Body round in cross section (posterior abdominal segments may be elongate and contractile) (see 6A); or body saclike (5B); or body minute and campodeiform (5C)---- 6



5A *Fannia canicularis*



5B *Acanthomyops interjectus*

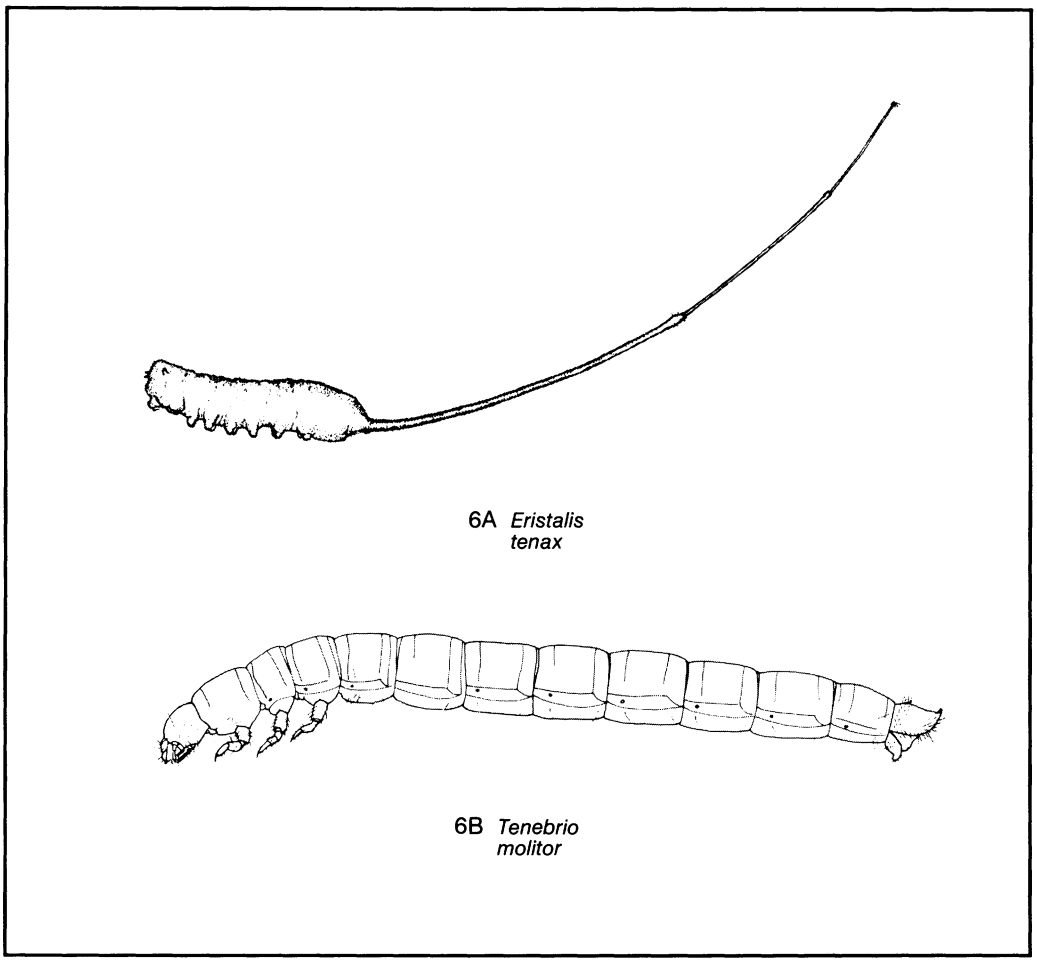


5C *Meloe*

6 Posterior end of abdomen extended into a slender, 3-segmented, elongate, contractile breathing tube (6A). Diptera (**flies**) (in part). Syrphidae (**flower flies**)----------*Eristalis*
SEE CHAPTER 16

CAUTION: Some fly larvae in the families Drosophilidae, Psychodidae, and Sepsidae have tubelike, posterior abdominal extensions; see Chapter 16.

Posterior end of abdomen not tubelike (6B)---------- 7



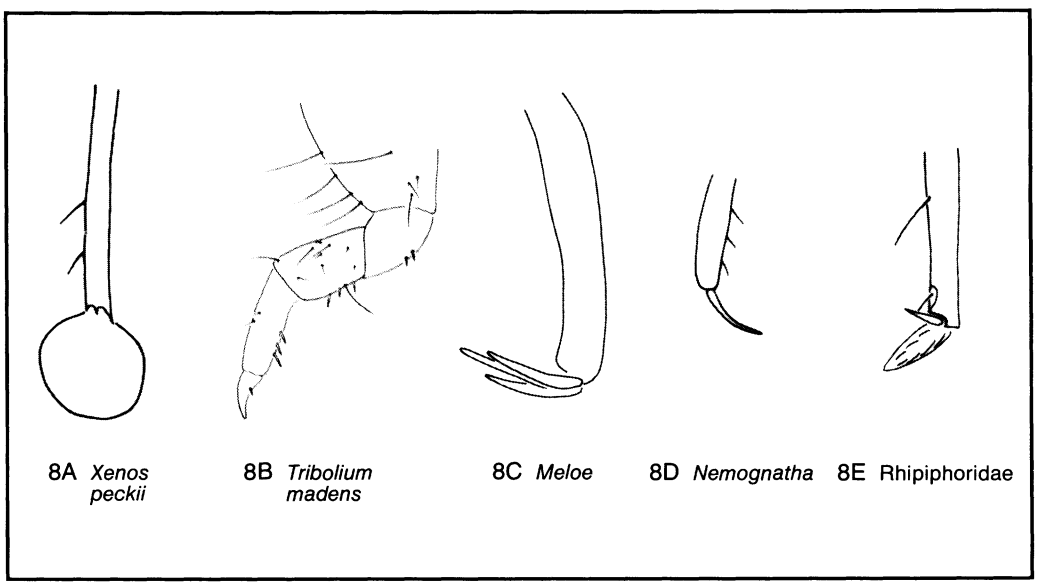
7 Thoracic legs present (as in 6B)---------- 8
Thoracic legs absent (as in 12A) or vestigial (as in 12C)---------- 12

8 Tarsi I and II consisting of short or long bristles or of pulvilliform pads (8A) ----------twisted-wing parasites, Strepsiptera

Minute campodeiform larvae (fig. 19.2)—larval body straight, not hypognathous (length usually less than 1 mm, often less than 0.5 mm); antennae and mouthparts vestigial or absent (fig. 19.2B); trochanters absent (fig. 19.2B) (trochanters are absent in all stages that exhibit legs); one pair of very long caudal setae present (fig. 19.2).

Tarsi either appearing typically coleopteran in form (8B) or consisting only of clawlike structures (8C, 8D, 8E)---------- 9

Larger larvae (length greater than 1 mm) of variable form (figs. 19.2-19.5)—campodeiform, scarabeiform, elateriform; mouthparts usually well developed and evident; trochanters usually present; long caudal setae present (fig. 19.4) or absent (fig. 19.5).



9 Tarsus distinct, with 1 or 2 claws evident (see 8B)----------**beetles,** Coleoptera (in part) SEE CHAPTER 4

Body form variable; caudal tufts of setae sometimes present. See also 3E&F, 4C, 12C.

Tarsus highly modified (see 8C-E). Coleoptera (**beetles**) (in part)---------- 10

Larva a campodeiform triungulin (larval body straight, not hypognathous); antennae and mouthparts well developed; caudal tufts absent; 1 or 2 pairs of caudal setae present; body length greater than 0.5 mm, ranging up to 3.5 mm.

10 With 3 or more pairs of ocelli (fig. 19.3B); labial palp absent (fig. 19.3B) ----------wedge-shaped beetles, Rhipiphoridae

Gula extremely short (almost absent); tarsus with pulvillus and minute claw (claw much shorter than pulvillus) (see 8E).

With 1 or 2 pairs of ocelli (fig. 19.4A); labial palp present (fig. 19.4B). Meloidae (**blister beetles**) ---------- 11

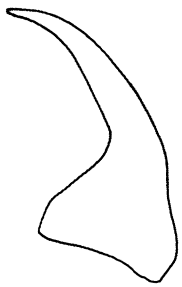
Gula well developed; labial palp 2-segmented; tarsus composed either of a single claw (see 8D) or of a strong claw bracketed by 2 strong setae, giving a 3-clawed appearance (see 8C).

11 Mandible entire (11A) or with toothlike emarginations. Meloinae (meloine blister beetles); fig. 19.4 ----------*Meloe*

With 1 pair of ocelli (fig. 19.4A). See also 8C.

Mandible with 2 or more prominent, toothlike ridges (11B); fig. 19.5 ----------nemognathine blister beetles, Nemognathinae

With 1 or 2 pairs of ocelli (fig. 19.5A). See also 8D.



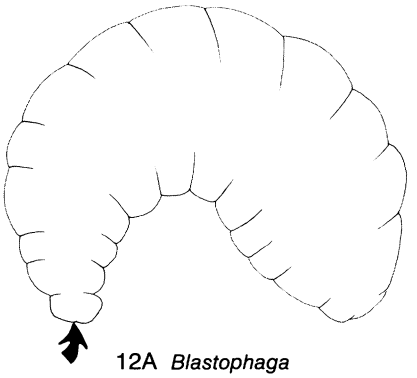
11A *Meloe*

11B *Nemognatha*

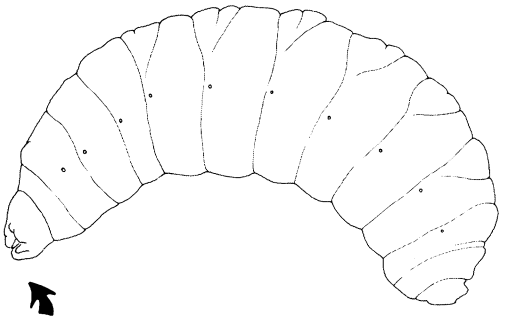
12 Head capsule unsclerotized or only weakly sclerotized (12A, 12B); mouthparts reduced to fleshy remnants or weakly sclerotized mandibles
----------**ants, bees, wasps,** Hymenoptera

See also 5B.

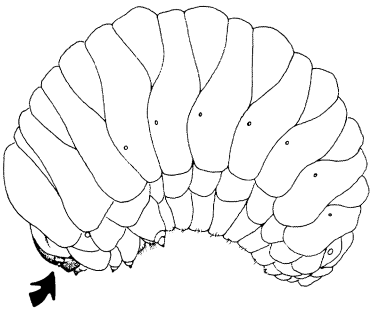
Head capsule well sclerotized, with distinct mouthparts (12C)
----------**beetles,** Coleoptera (in part)
SEE CHAPTER 4



12A *Blastophaga psenes*



12B *Apis mellifera*



12C *Bruchus pisorum*

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20 SPRINGTAILS (COLLEMBOLA)

Harold George Scott

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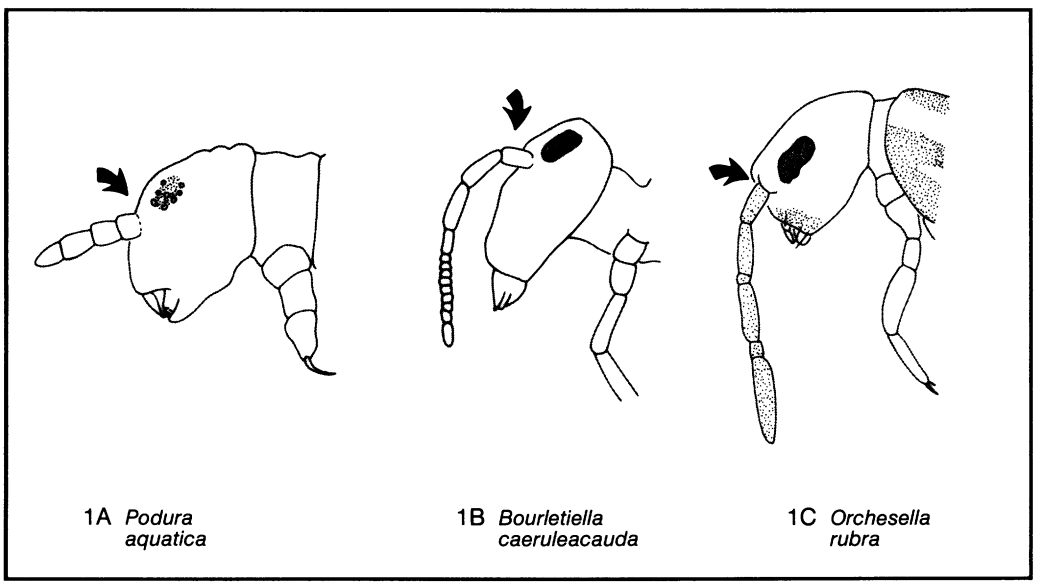
Metairie LA 70001

KEY

Drawings by C.J. Stojanovich and C. Feller unless otherwise noted.

1 Antenna inserted at, just before (1A), or distinctly behind (1B) middle of head ----- 2
Antenna inserted well forward on anterior half of head (1C)---------- 3

This key is based on *8* and *14*. See couplet illustration 11A for selected anatomical details.

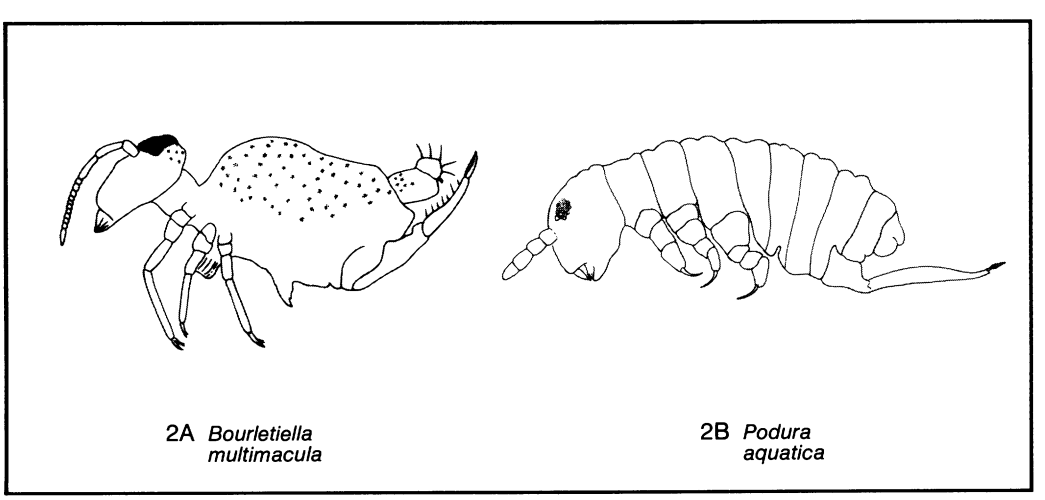


1A *Podura aquatica* 1B *Bourletiella caeruleacauda* 1C *Orchesella rubra*

2 Body globular (2A)----------Suborder Symphypleona

Species of this suborder have not been reported from stored foods.

Body elongate (2B). Suborder Metaxypleona---------- 4

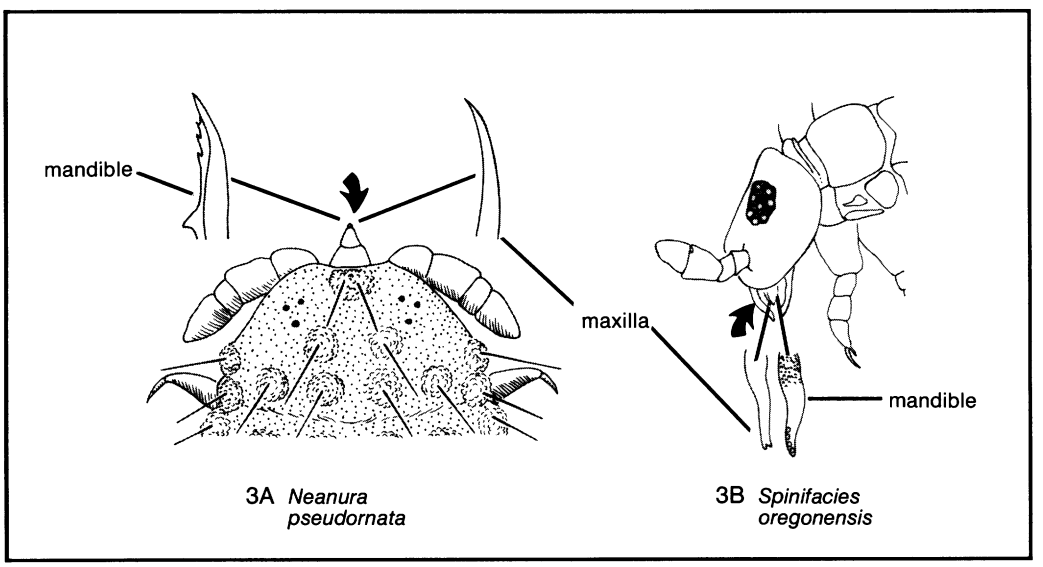


2A *Bourletiella multimacula* 2B *Podura aquatica*

3 Mouthparts conelike (3A)---------- Suborder Neoarthropleona

Species of this suborder have not been reported from stored foods.

Mouthparts not conelike (3B). Suborder Arthropleona ---------- 5



3A *Neanura pseudornata*

3B *Spinifacies oregonensis*

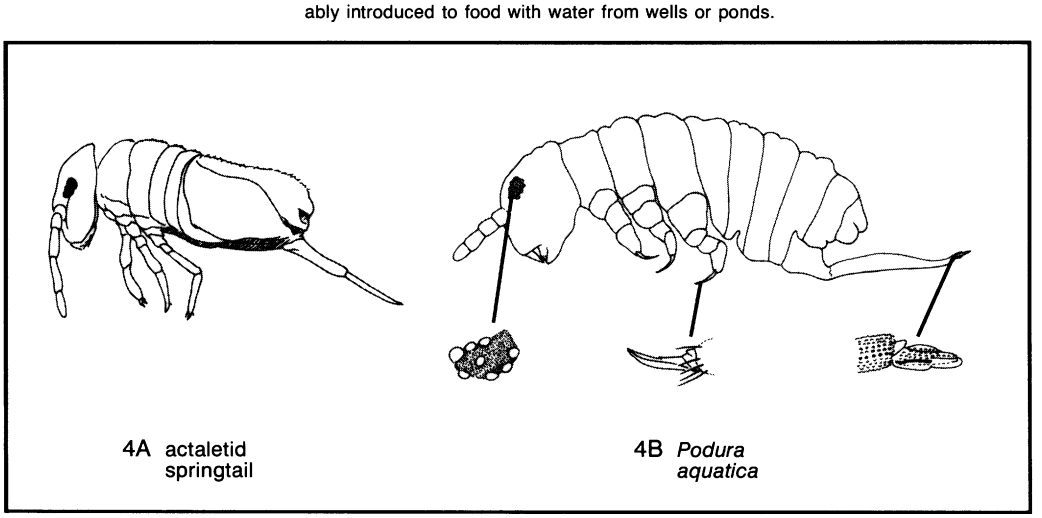
Suborder Metaxypleona

4 Abdomen with 4 or 5 apparent segments (4A)---------- actaletid springtails, Actaletidae

Species of this family have not been reported from stored foods.

Abdomen with 6 apparent segments (4B). Poduridae (podurid springtails) ---------- *Podura aquatica*

Distribution: cosmopolitan on freshwater surfaces; probably introduced to food with water from wells or ponds.



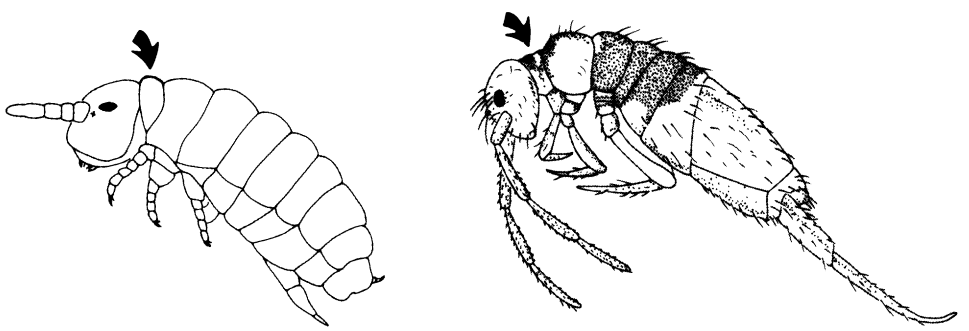
4A actaletid springtail

4B *Podura aquatica*

Suborder Arthropleona

5 Pronotum well developed (5A). Superfamily Hypogastruroidea (hypogastruroid springtails)---------- 6

Pronotum reduced (5B). Superfamily Entomobryoidea (entomobryoid springtails)-------- 10



5A *Hypogastrura japonica*

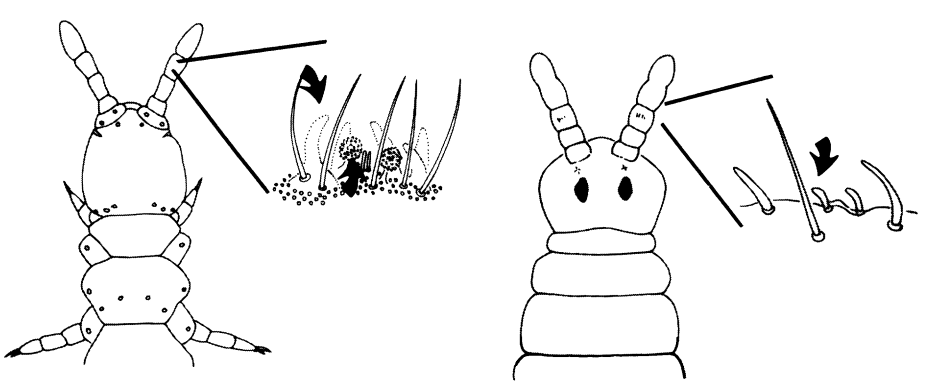
5B *Entomobrya atrocincta*

6 Sense organ on antennal segment III with rods and cones (6A). Onychiuridae (onychiurid springtails) ---------- 7

Eyes absent (6A).
Detail of sense organ redrawn by C. Feller from *EB07* (see chapter 28).

Sense organ on antennal segment III with rods only (6B). Hypogastruridae (hypogastrurid springtails) ---------- 8

Eyes usually present (6B).



6A *Onychiurus armatus*

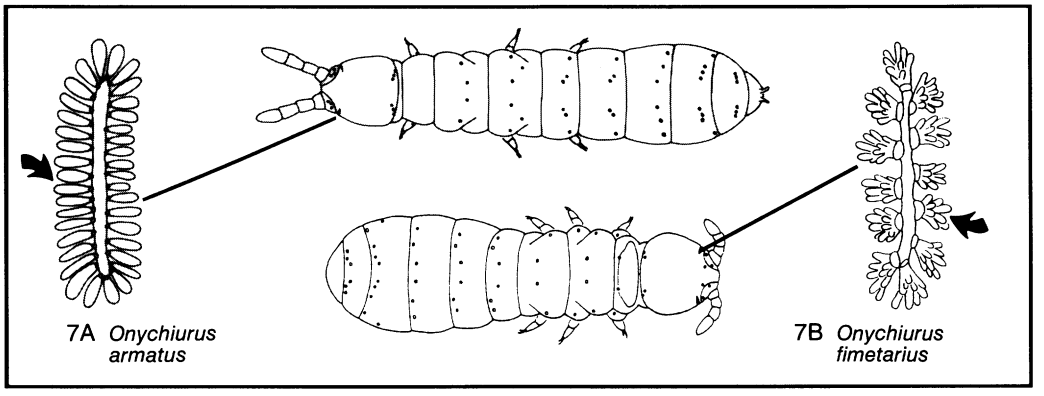
6B *Hypogastrura japonica*

7 Postantennal organ with simple vesicles (7A)----------*Onychiurus armatus*

Distribution: cosmopolitan; reported from indoor flower pots (*6*) and as a common domestic species (*18*). See also 6A.

Postantennal organ with compound vesicles (7B)----------*Onychiurus fimetarius*

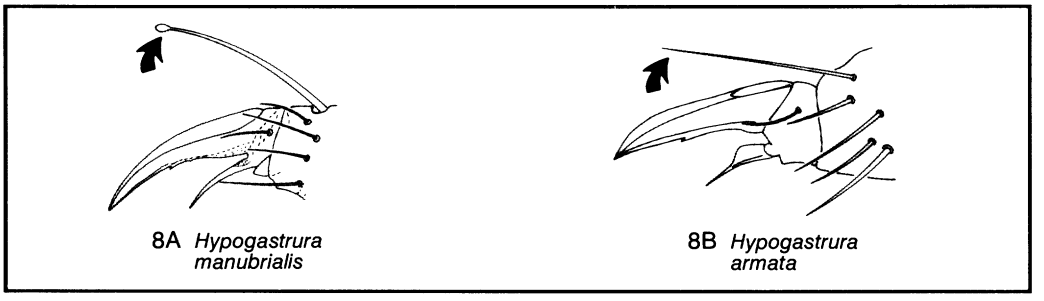
Distribution: cosmopolitan; reported from indoor flower boxes (*6*) and as a common domestic species (*18*).



8 Tarsal tenent hair capitate (8A)----------*Hypogastrura manubrialis*

Distribution: probably cosmopolitan; reported as a common domestic species (*18*).

Tarsal tenent hair not capitate (8B) ---------- 9

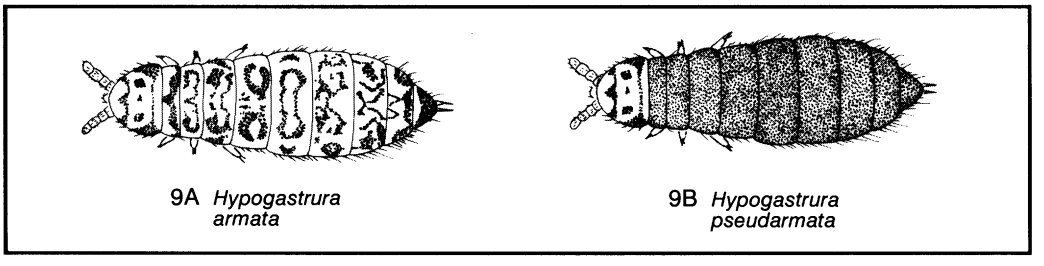


9 Body marbled (9A)----------*Hypogastrura armata*

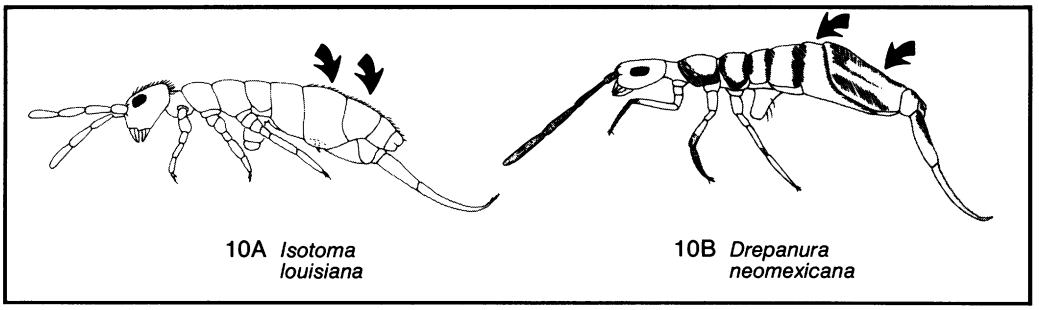
Distribution: cosmopolitan; reported invading houses (*5*); associated with domestic water supplies (*6, 11*).

Body not marbled (9B)---------- *Hypogastrura pseudarmata*

Distribution: Nearctic; reported swarming on and in houses (*6*).



10 Abdominal segment IV less than twice as long as abdominal segment III (10A), or terminal abdominal segments fused ---------- 11
Abdominal segment IV at least twice as long as abdominal segment III (10B); terminal segments not fused. Entomobryidae (entomobryid springtails) ---------- 12



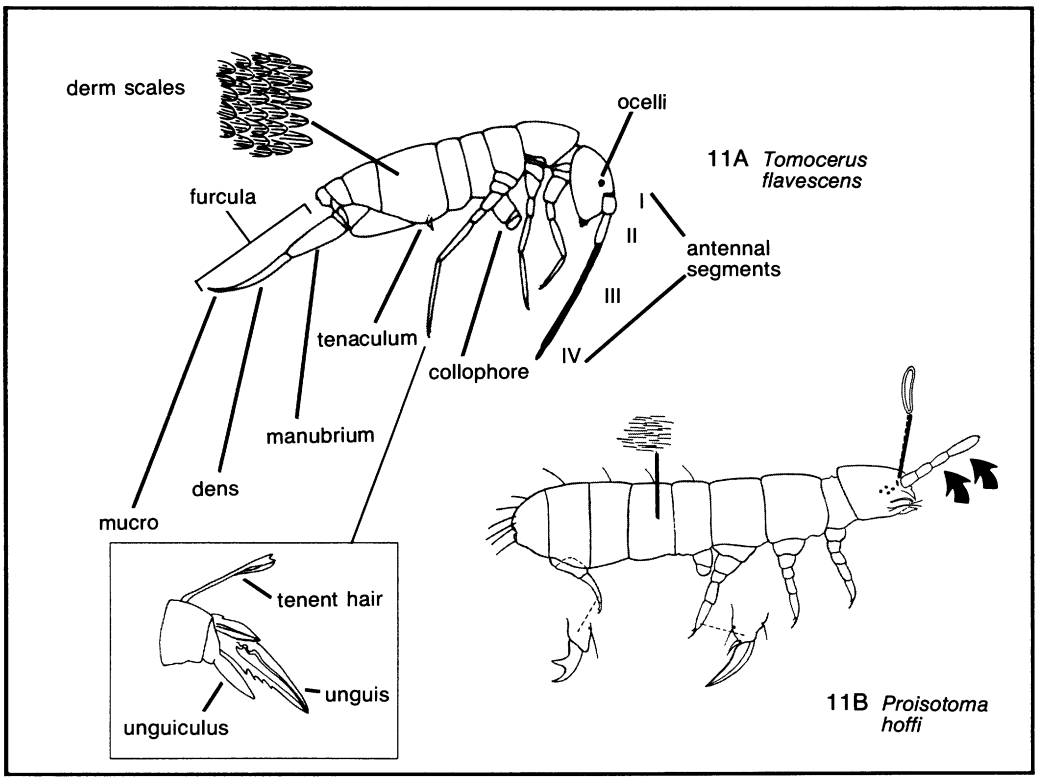
10A *Isotoma louisiana*

10B *Drepanura neomexicana*

11 Antennal segments III and IV subsegmented (11A). Tomoceridae (tomocerid springtails) ---------- *Tomocerus*

Distribution: cosmopolitan; common in houses. See *16* for a key to the Nearctic species.

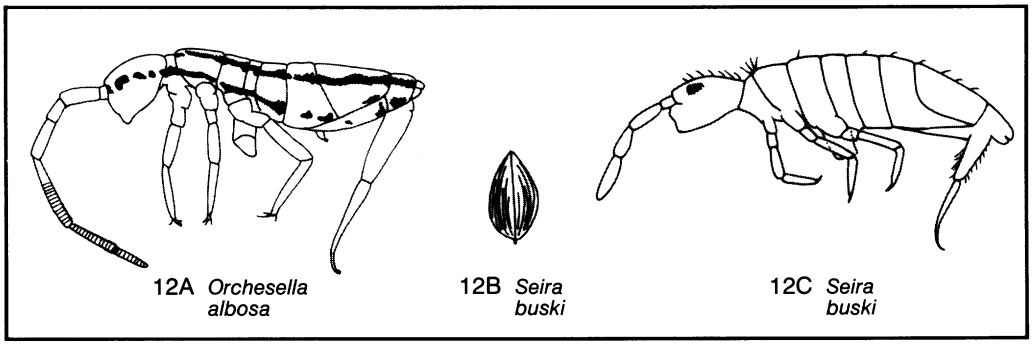
Antennal segments III and IV not subsegmented (11B). Isotomidae (isotomid springtails) ---------- 22



11A *Tomocerus flavescens*

11B *Proisotoma hoffi*

12 Body scales absent (12A) ---------- 13
Body scales (12B) (see also derm scales of 11A) present (12C) ---------- 18



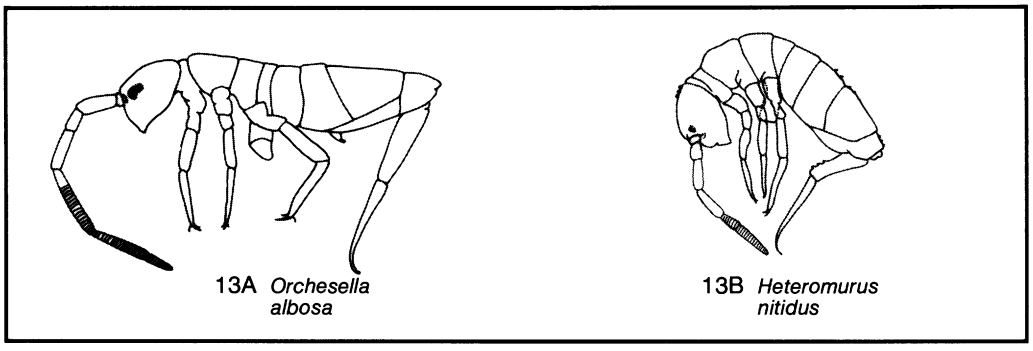
12A *Orchesella albosa* 12B *Seira buski* 12C *Seira buski*

13 Antenna with 6 segments (13A) ---------- *Orchesella albosa*

Distribution: Holarctic. Reported infesting people in Texas; some moldy household item (perhaps bedding) was probably involved (*18*).

Antenna with 4 or 5 segments (13B) ---------- 14

Antennal details of 13A&B by C. Feller.

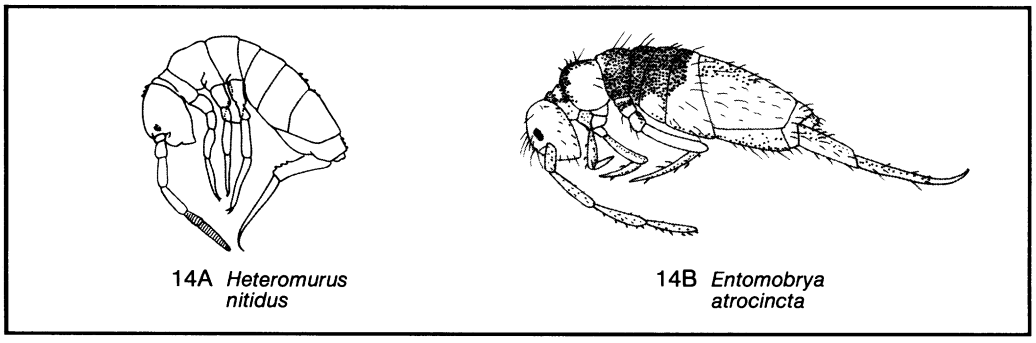


13A *Orchesella albosa* 13B *Heteromurus nitidus*

14 Antenna with 5 segments (14A) ---------- *Heteromurus*

Distribution: cosmopolitan; common in houses.

Antenna with 4 segments (14B). Genus *Entomobrya* ---------- 15

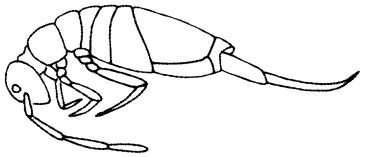


14A *Heteromurus nitidus* 14B *Entomobrya atrocincta*

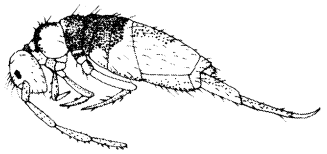
15 Body without stripes (15A)----------*Entomobrya griseoolivata*

Distribution: cosmopolitan; reported as a common domestic species (*18*) and as infesting human hair (Richard W. Fay, 1958, personal communication).

Body with stripes (15B)---------- 16



15A *Entomobrya griseoolivata*



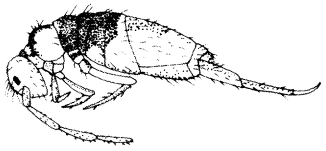
15B *Entomobrya atrocincta*

16 Some body segments striped (16A)----------*Entomobrya atrocincta*

Distribution: cosmopolitan; reported from indoor flower pots containing *Poinsettia pulcherrima* (*13*) and as infesting powdered milk (*17*).

All body segments striped (16B)---------- 17

16B redrawn by C. Feller from *EB07* (see chapter 28).



16A *Entomobrya atrocincta*

16B *Entomobrya nivalis*

17 Head with a dorsal spot (17A)----------*Entomobrya nivalis*

Distribution: cosmopolitan; a common domestic species (*18*); reported infesting the sack house of a flour mill (*9*, *11*) and as causing dermatitis in man (*3*). See also 16B.

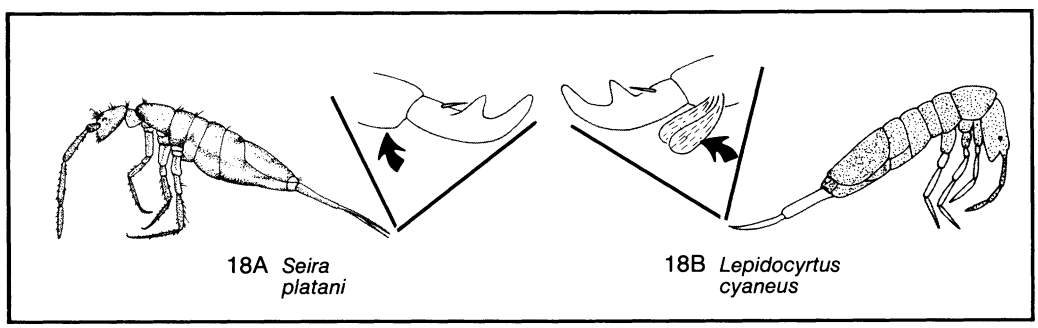
Head without a dorsal spot (17B)----------*Entomobrya purpurascens*

Distribution: Holarctic; associated with human dwellings (*1*).

17A *Entomobrya nivalis*

17B *Entomobrya purpurascens*

18 Dens without ventral scales (18A)---------- 19
Dens with ventral scales (18B) ---------- 21

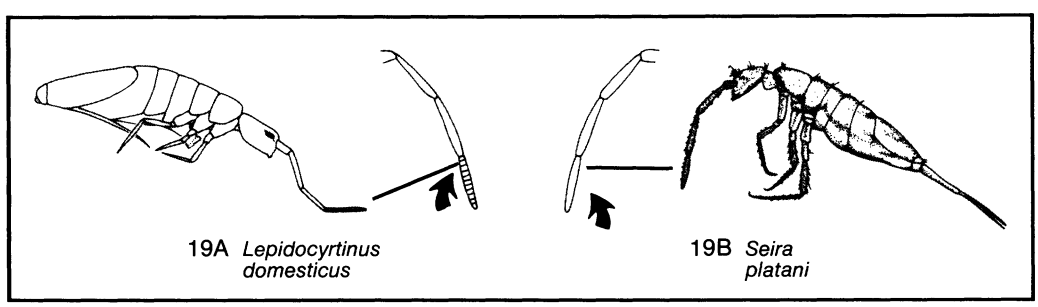


18A *Seira platani* 18B *Lepidocyrtus cyaneus*

19 Segment IV of antenna annulate (19A)----------*Lepidocyrtinus domesticus*

Distribution: cosmopolitan; associated with houses (*4*).

Segment IV of antenna not annulate (19B). Genus *Seira* ---------- 20



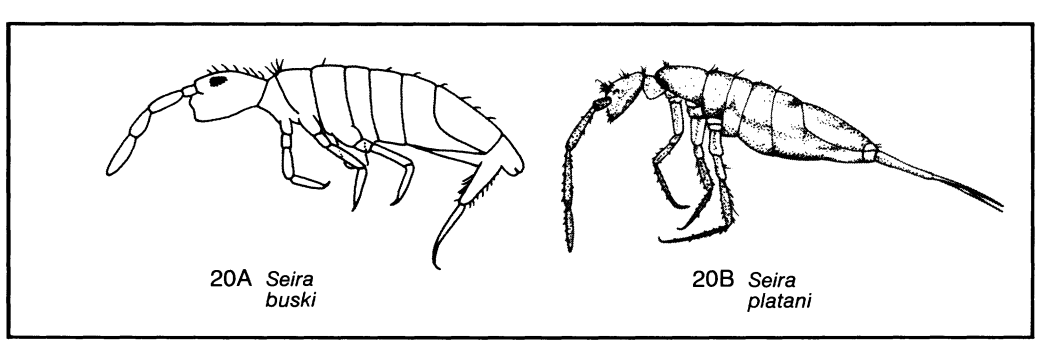
19A *Lepidocyrtinus domesticus* 19B *Seira platani*

20 Body entirely blue (20A)----------*Seira buski*

Distribution: Holarctic; associated with houses (*7, 18*); reported as an accidental parasite of man (*2*).

Body marked with blue (20B)----------*Seira platani*

Distribution: cosmopolitan; associated with houses (*7*) and stored food (*17*); reported infesting insulation in a refrigeration plant (*10*) and as infesting human hair (Richard W. Fay, 1958, personal communication).



20A *Seira buski* 20B *Seira platani*

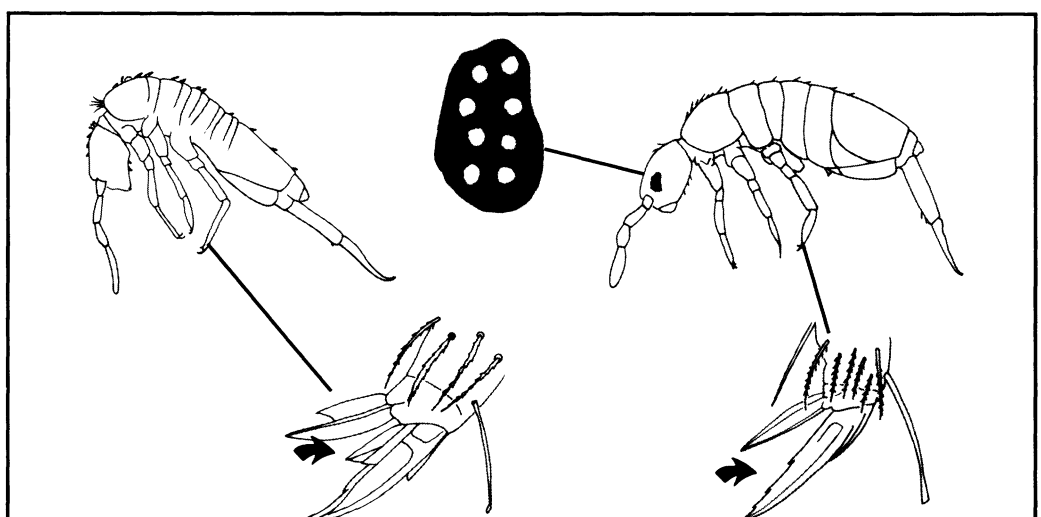
21 Basal teeth of unguis winglike (21A)---------- *Pseudosinella*

Usually fewer than 8 ocelli; many species are white and blind. Distribution: cosmopolitan; associated with houses (*5*).

Detail of tarsus (21A) redrawn by C. Feller from *EB01* (see chapter 28).

Basal teeth of unguis not winglike (21B)---------- *Lepidocyrtus curvicollis*

Eye with 8 ocelli. Distribution: cosmopolitan; associated with cellars (*4*) and houses (*18*).



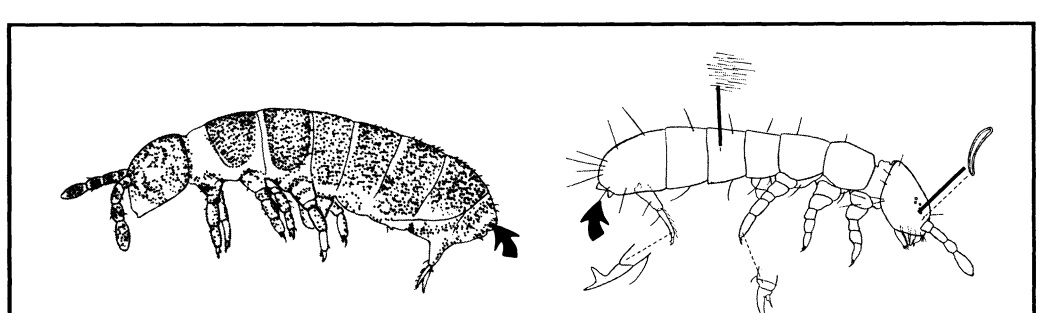
21A *Pseudosinella*

21B *Lepidocyrtus curvicollis*

22 Anus terminal (22A)---------- *Proisotoma frisoni*

Distribution: Nearctic; a common domestic species (*18*); reported from potted *Ficus elasticus* (*12*).

Anus ventral (22B)---------- 23



22A *Proisotoma frisoni*

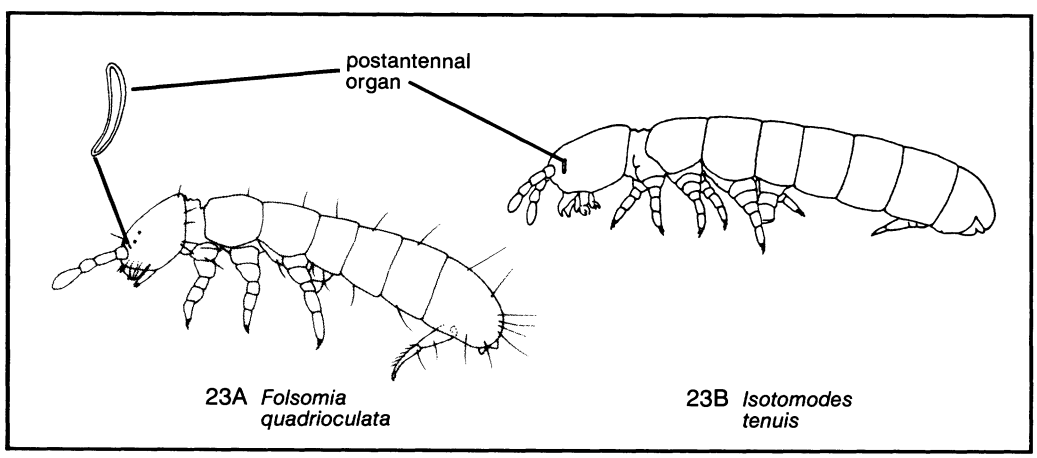
22B *Folsomia hoffi*

23 Ocelli present (23A)----------*Folsomia quadrioculata*

Distribution: Holarctic; a common domestic species (*18*); reported from indoor flower pots (*6*). Some *Folsomia* have an incomplete suture between abdominal segments IV and V.

Ocelli absent (23B)---------- *Isotomodes tenuis*

Distribution: Nearctic; a common domestic species (*18*); reported from indoor flower pots (*15*).



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Notes and Sketches

21 SILVERFISH (THYSANURA)

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New York NY 10024

*Deceased

Synanthropic species are found in two of the three families of Thysanura. *Nicoletia phytophila* (Nicoletiidae) occurs in greenhouses, under flowerpots and in soil, and may cause damage to cultivated plants. All other synanthropic species belong to the Lepismatidae (*1*). They are found in human habitations and in warehouses where they feed on starchy substances, such as paper, cardboard, and books, on various stored grains and their products (e.g., flour, oats, peanuts), and on certain fabrics. The most commonly encountered species are *Acrotelsa collaris, Ctenolepisma longicaudata, Thermobia domestica,* and *Lepisma saccharina*. The first is restricted to the tropics; the others occur most frequently in areas of temperate climate. The remaining species contained in the key are also, but less commonly, found associated with man. Since synanthropic Thysanura are dispersed by man, the original range of most species is not known. Because the actual range of most species is so large and so incompletely known, their recorded distribution is not indicated here.

Most characters used in the key are easily understood. Of special interest are the larger setae (macrochaetae), which are either glabrous (3A) or minutely spinulose (3C). On the thoracic nota and abdominal sternites and tergites, the macrochaetae are either single (4A) or arranged in one or several transverse series, the so-called bristlecombs (4B). The number and distribution of the bristlecombs furnishes generic and specific characters. The macrochaetae are caducous (easily dislodged); in preserved specimens frequently only the respective sockets can be seen. Care is thus required for a correct observation of the macrochaetal pattern.

KEY

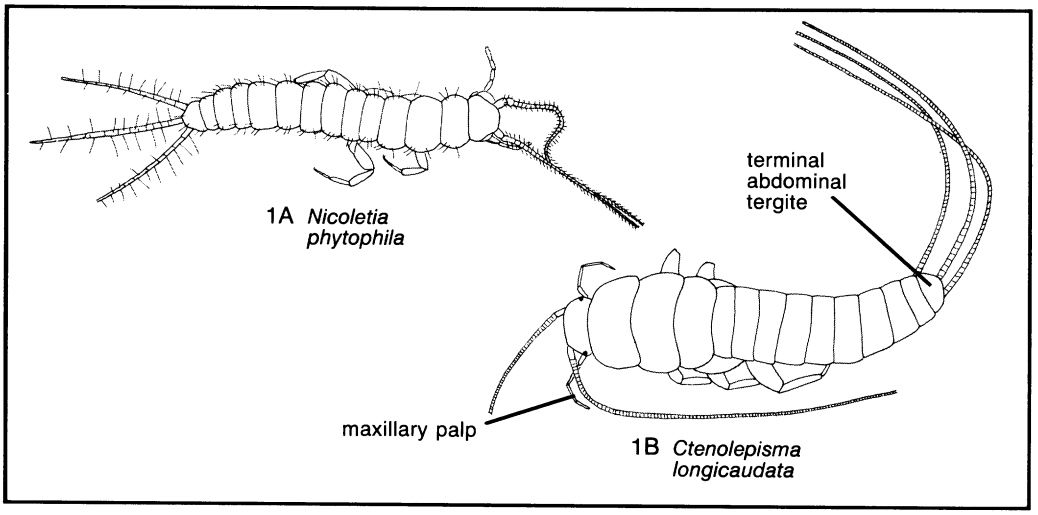
Drawings by P. Wygodzinsky.

1 Eyes absent (1A); scales absent in species mentioned here. Nicoletiidae (nicoletiid silverfish) ---------- *Nicoletia phytophila*

Reference: *2.*

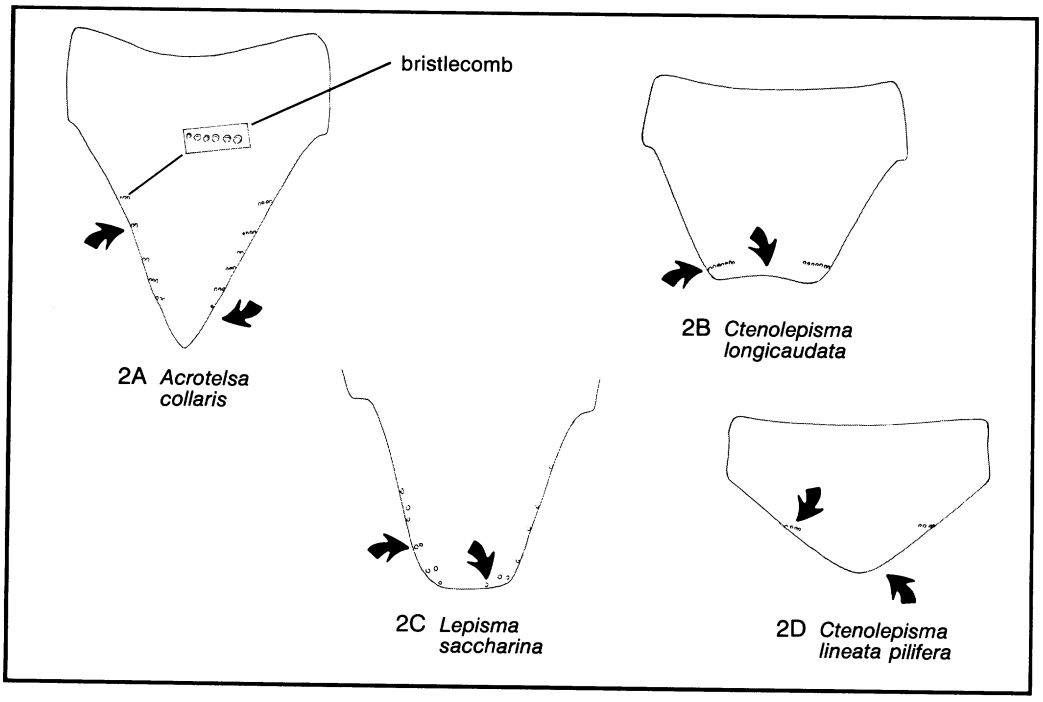
Eyes present (1B); scales present. Lepismatidae (**firebrats and silverfish**) ---------- 2

Reference: *1.*



2 Last abdominal tergite distinctly pointed, with several bristlecombs on each side (2A) ---------- *Acrotelsa collaris*

Last abdominal tergite not distinctly pointed, usually with only 1 subapical bristlecomb on each side (but rarely with 1 or 2 supernumerary ones) (2B, 2C, 2D) ---------- 3



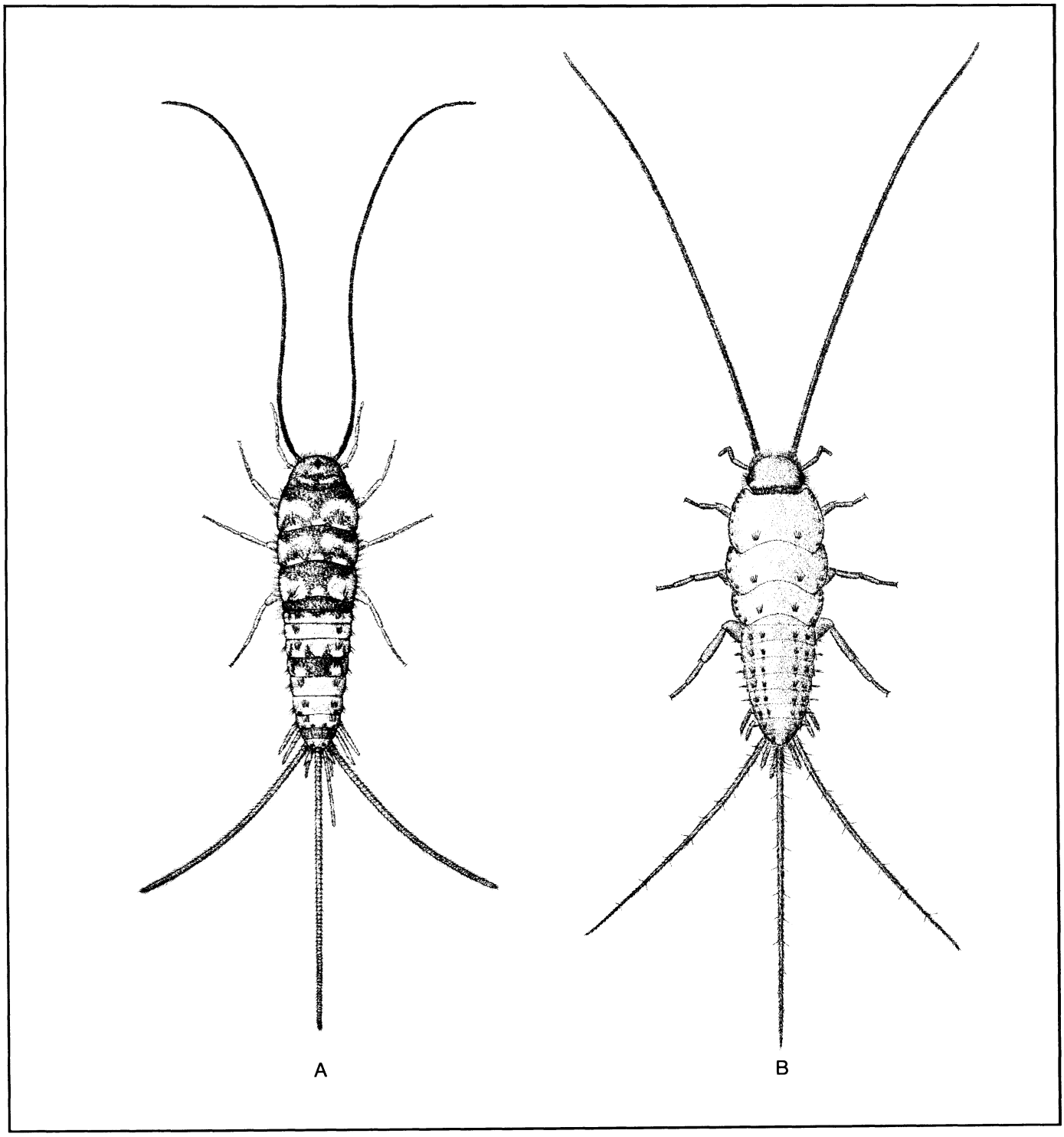
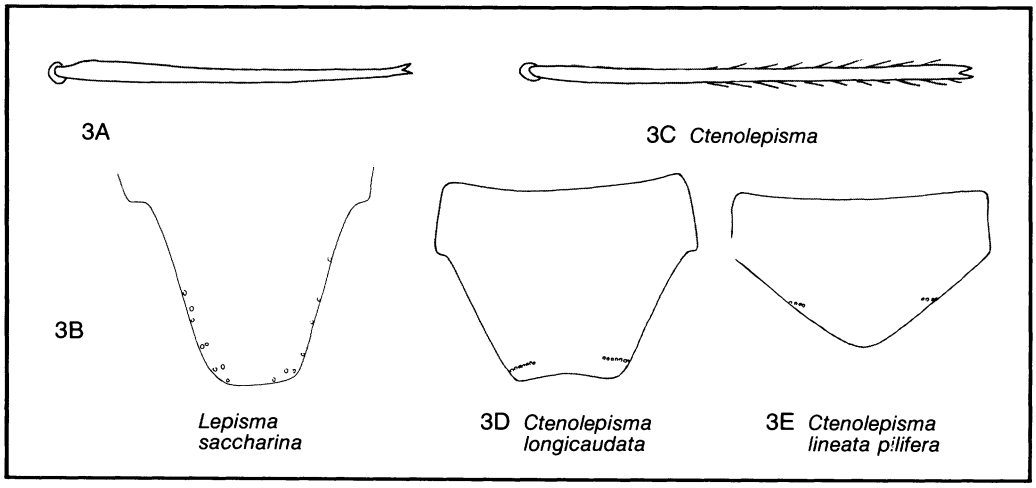


Figure 21.1. Silverfish (Lepismatidae). A, **firebrat,** *Thermobia domestica;* B, fourlined silverfish, *Ctenolepisma lineata pilifera.* (Drawings by C. Feller.)

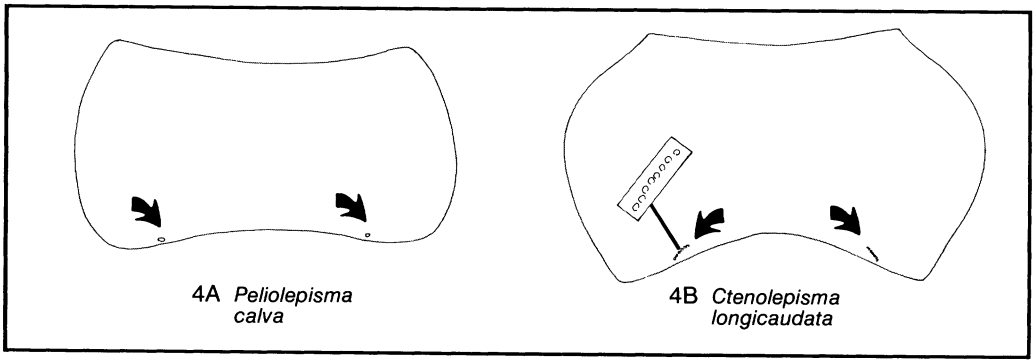
3 Macrochaetae smooth, often bifid apically (3A); last abdominal tergite elongate, with posterior margin truncate or feebly rounded (3B) ----------common silverfish, *Lepisma saccharina*

Macrochaetae spinulose under high magnification (3C); last abdominal tergite short and broad, with posterior margin straight, emarginate (3D) or bluntly pointed (3E) 4



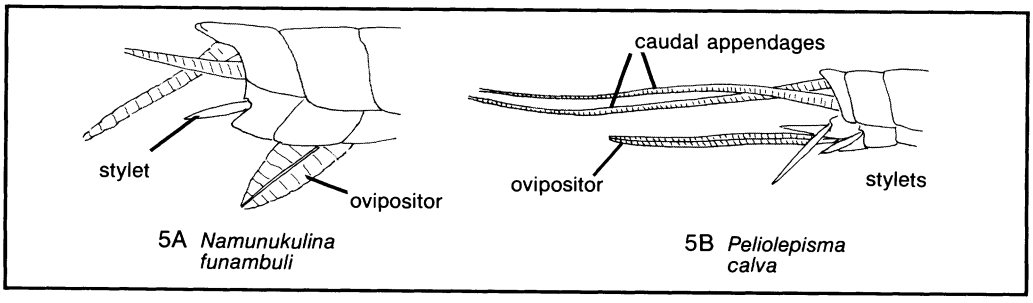
4 Hind margins of thoracic nota with 1 + 1 single macrochaetae (4A)---------- 5

Hind margins of thoracic nota with 1 + 1 bristlecombs consisting each of at least 2 macrochaetae (4B)---------- 6



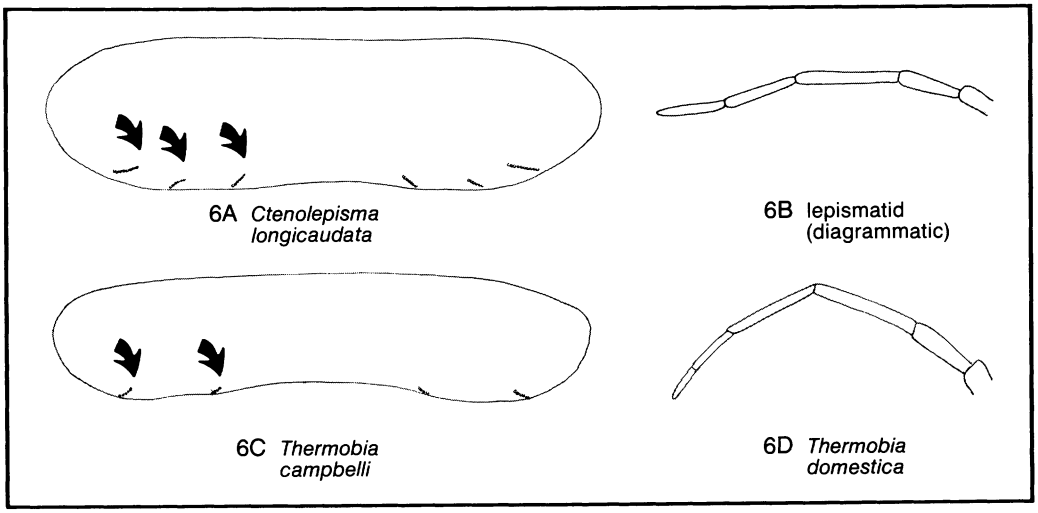
5 Abdominal stylets in 1 pair only; caudal appendages shorter than abdomen; ovipositor subconical, not extending beyond tip of abdomen (5A)----------*Namunukulina funambuli*

Abdominal stylets in 2 pairs; caudal appendages as long as or longer than abdomen; ovipositor elongated, rod-shaped, projecting beyond apex of abdomen (5B) ---------- *Peliolepisma calva*



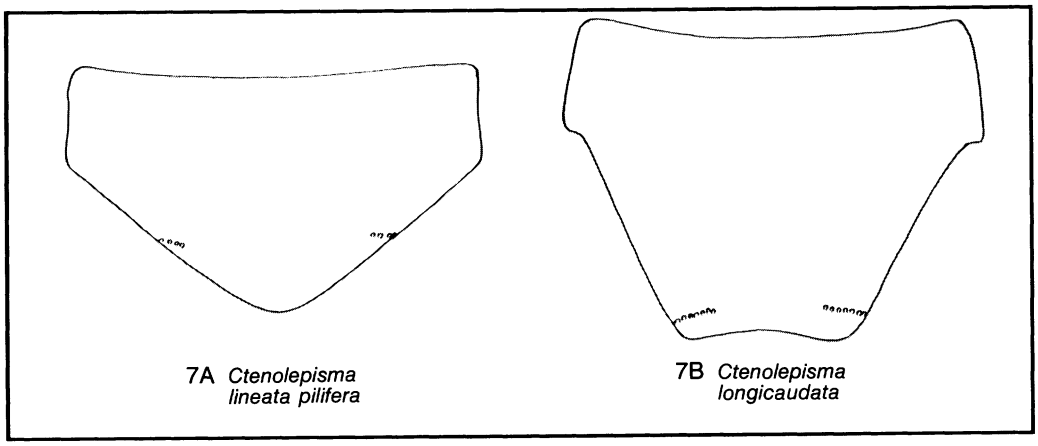
6 Several abdominal tergites with 3 + 3 bristlecombs (6A); maxillary palp invariably with 5 segments (6B) ---------- 7

Abdominal tergites with no more than 2 + 2 bristlecombs (6C); maxillary palps with 5 (6B) or 6 (6D) apparent segments ---------- 9



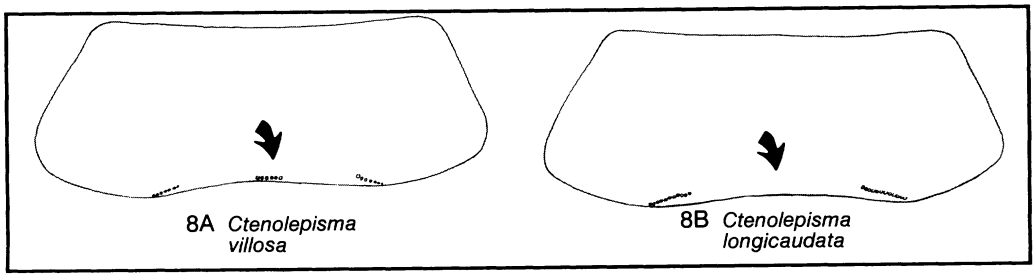
7 Abdominal tergite X subtriangular (7A); fig. 21.1B ---------- fourlined silverfish, *Ctenolepisma lineata pilifera*

Abdominal tergite X with posterior margin straight or faintly emarginate (7B) ------- 8



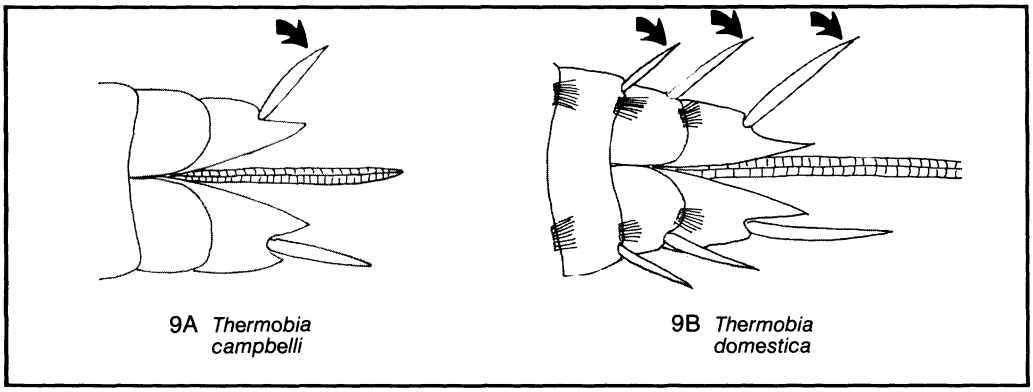
8 Median bristlecombs present on abdominal sternites II to VI (8A) -----*Ctenolepisma villosa*

Median bristlecombs absent from abdominal sternites (8B) ----------gray silverfish, *Ctenolepisma longicaudata*



9 Abdominal stylets present in 1 pair only (9A); intact specimens uniformly gray dorsally----------*Thermobia campbelli*

Abdominal stylets present in 2 or 3 pairs (9B)---------- 10

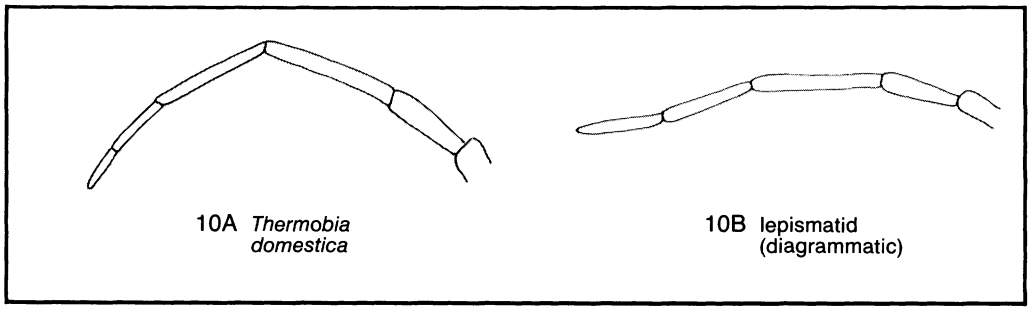


9A *Thermobia campbelli*

9B *Thermobia domestica*

10 Maxillary palp with 6 apparent segments (10A); scales of dorsum forming complex pattern in intact specimens; fig. 21.1A---------- **firebrat,** *Thermobia domestica*

Maxillary palp with 5 segments (10B); pattern of dorsum unknown ----------*Thermobia aegyptiaca*



10A *Thermobia domestica*

10B lepismatid (diagrammatic)

References Cited

1 Wygodzinsky, P.
1972. A review of the silverfish (Lepismatidae, Thysanura) of the United States and the Caribbean area. American Museum Novitates 2481:1-26.

2 Wygodzinsky, P.
1980. A survey of the Nicoletiinae of Europe (Nicoletiidae, Thysanura, Insecta). American Museum Novitates 2695:1-24.

Notes and Sketches

22 PSOCIDS (PSOCOPTERA)

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The Order Psocoptera (*16, 20, 25-28*) contains many forms which seem adaptable to living in human habitations. The fifty species included in this key undoubtedly do not represent all of the species that are found in stored foods, but, to my knowledge, they represent all such species mentioned in the literature through 1982. Few surveys have been made of psocids in domestic situations; additional surveys will probably yield other species.

Certain generic and specific names which have appeared in the psocidological literature are either not used in this key or are used in a different sense, namely: *Atropos* Leach, a synonym of *Trogium* Illiger; *Ectopsocus pumilis* (Banks), a name erroneously applied by Chapman (*8*) to *Ectopsocopsis cryptomeriae* (Enderlein) and used in that sense by all North American authors until 1965 (*4*); *Hemipsocus roseus* (Hagen), unidentifiable; *Liposcelis divinatorius* (Müller), unidentifiable; *Liposcelis granicola* Broadhead, synonym of *L. bostrychophilus* Badonnel; *Liposcelis simulans* race A Broadhead, synonym of *L. kidderi* Hagen; *Liposcelis subfuscus* Broadhead, synonym of *L. corrodens* Heymons; *Psocatropos lachlani* Ribaga, unidentifiable; *Psocatropos slossonae* Banks, probably a synonym of *P. microps* (Enderlein); *Tapinella africana* Badonnel, synonym of *Nanopsocus oceanicus* Pearman; *Troctes* Burmeister, synonym of *Liposcelis* Motschulsky.

The following comments on structures mentioned in the key may be of value to the nonspecialist. The antennae of psocids are filiform, generally nearly as long as to longer than the body. The mouthparts are of the chewing type, with laciniae in the form of elongate rods. The lacinial tips often provide useful characters (see couplet 16 in the key). Venation of the forewing (see couplets 4, 5, 18, 47) is often used in determinations. In female psocids abdominal sternum VIII (subgenital plate), somewhat enlarged and variously modified (see couplets 49, 51, 53), underlies the genital chamber. To the sides of this plate, and sometimes partially covered by it, lie the gonapophyses, the ovipositor valvulae (see couplets 44, 49), typically three on each side, but sometimes reduced to one. Abdominal sternum IX (hypandrium) of the male is comparable to the subgenital plate. The hypandrium has characters useful for separating some species (see couplets 7, 13). The XI abdominal segment is reduced to the epiproct (a single lobe above the anus) and to the paraprocts (lobes on each side of the anus). These structures may provide characters of specific value (see couplets 7, 48).

Because of the small size of psocids, it is often necessary for the taxonomist to prepare slides of cleared and stained parts before attempting an identification. Even counts of antennal segments can be difficult on whole specimens. Starting with material preserved in 80% ethanol, one can obtain suitable results with the following procedures.

1. Cut off head and posterior third of abdomen and place them in a tube containing 10% aqueous KOH solution.
2. Place the tube in a water bath and allow it to sit at room temperature until the parts sink to the bottom.
3. While waiting for the parts to sink, remove wings and legs from one side, pass them through absolute ethanol, then through euparal essence in a spot plate, and mount in euparal.
4. Bring the parts in KOH slowly to a boil on a hot plate and allow to cool to room temperature.
5. Pass the parts through one or two baths of distilled water in a spot plate, then through 80% ethanol.
6. If staining is desirable, place the parts in a saturated 95% ethanol solution of acid fuchsin for 0.5 to one hour in a spot plate, covering the well to prevent evaporation.
7. Pass the parts through one to two baths of absolute ethanol.
8. Pass each part separately through euparal essence, and place in a drop of euparal on a slide.
9. For the terminal abdominal segments, cut with a microknife by pressure against the slide to each side of the subgenital plate or hypandrium, and set this structure apart from the remainder of the parts; cut to each side of the valvulae and set this piece apart; separate the phallosome from the hypandrium and set these two pieces apart from the rest. The remaining parts are the clunium (fused terga VIII-X or IX-X), epiproct, and paraprocts.
10. With fine needles, tease paraprocts apart ventral to the anus.
11. Arrange the parts and add cover slip.
12. Dissect the head as follows. With fine needles remove the antennae and set them apart; loosen the maxillary cardines (= basal sclerites; singular, cardo) from head wall; break through mandibular attachments on one side; push off mouthparts as a group, or cut first through membrane at base of labrum; remove head capsule from the preparation and store separately; tease off labrum and mandibles.
13. Arrange the parts on the slide and add cover slip.

With very small specimens, such as *Liposcelis,* one can dispense with the dissections. It suffices to cut fine holes in the lateral abdominal cuticle to facilitate clearing, and to carry out the clearing, staining, and mounting procedures outlined above.

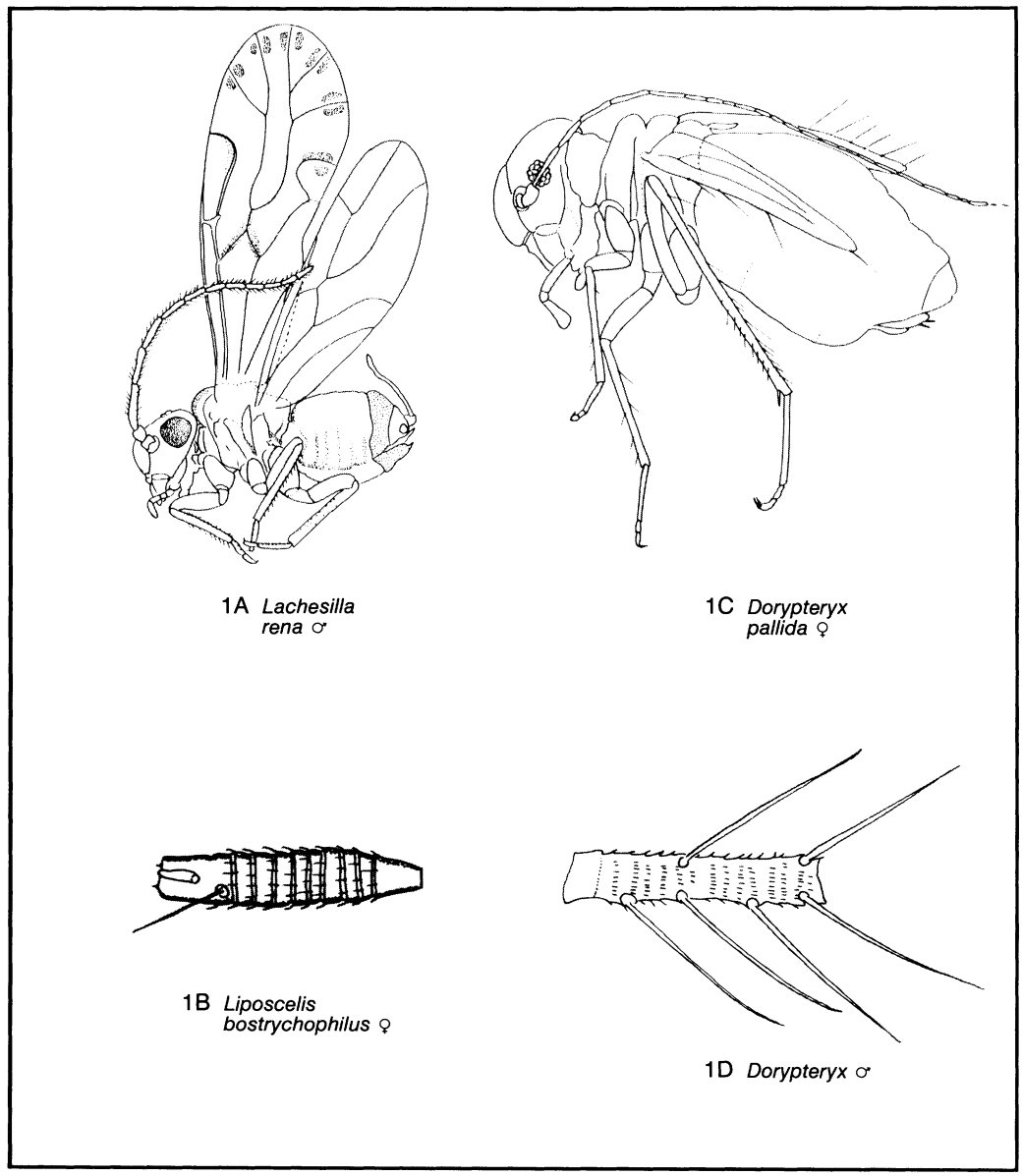
KEY
Drawings by E.L. Mockford unless otherwise noted.

1 Antenna with 13 to 15 segments (1A); if 15 segments present, some or all flagellar segments secondarily annulated (1B)---------- 2

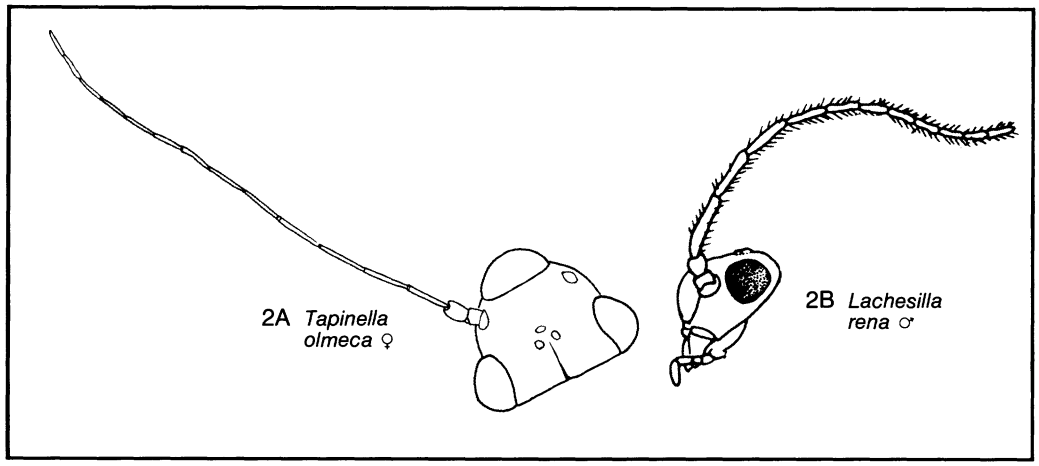
Tarsi 2- (1A) or 3-segmented.

Antenna with more than 20 segments (1C); segments never secondarily annulated, but often with whorls of microtrichia (1D). Suborder Trogiomorpha---------- 3

Tarsi 3-segmented (1C).

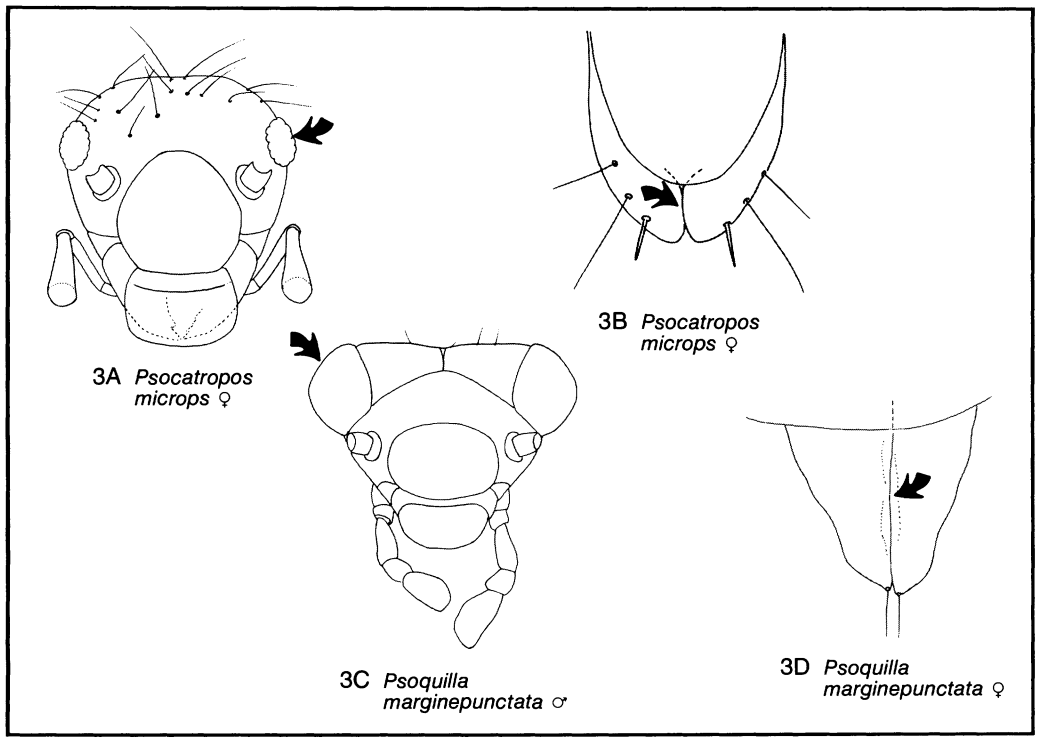


2 Antenna 15-segmented (2A), with secondary annulations (apparent only under high magnification). Suborder Troctomorpha---------- 18
Antenna 13-segmented (2B), lacking secondary annulations. Suborder Psocomorpha 43



Suborder Trogiomorpha

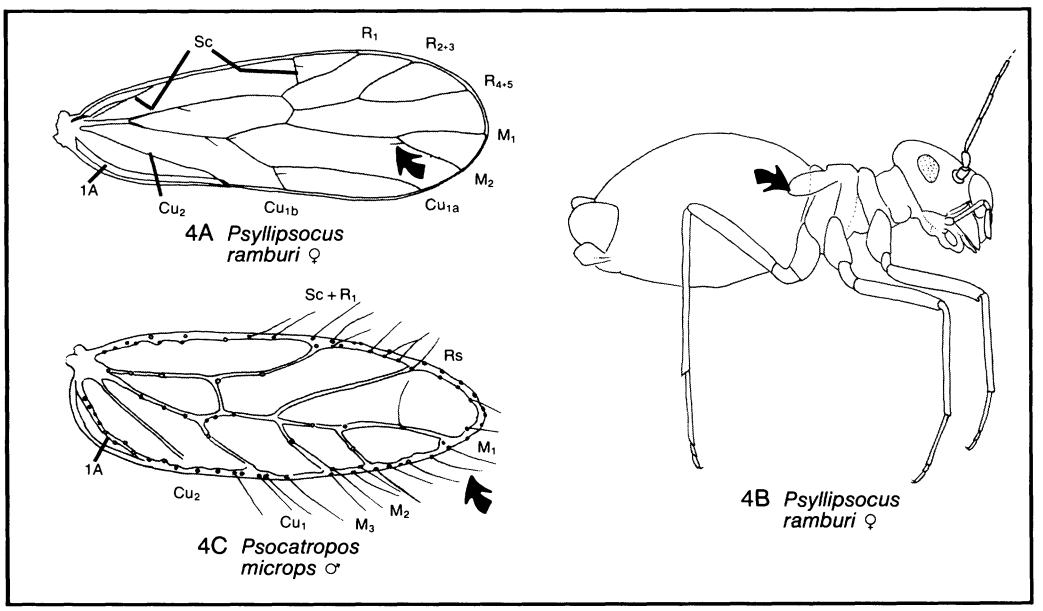
3 Head in anterior view relatively narrow, with compound eyes subdorsal (3A); ovipositor valvulae of opposite sides separated by a space or touching only at their apices (3B). Group Psocatropetae. Psyllipsocidae---------- 4
Head in anterior view relatively broad, with compound eyes contiguous with dorsal surface (3C); ovipositor valvulae of opposite sides joined along midline (3D). Group Atropetae ---------- 8



4 Forewing bearing only short setae (4A), or individuals micropterous (4B) ---------- *Psyllipsocus ramburi*

Cosmopolitan; in caves and houses. References: *1, 9-12, 27.*

Forewing beset with long setae (4C) ---------- 5



4A *Psyllipsocus ramburi* ♀

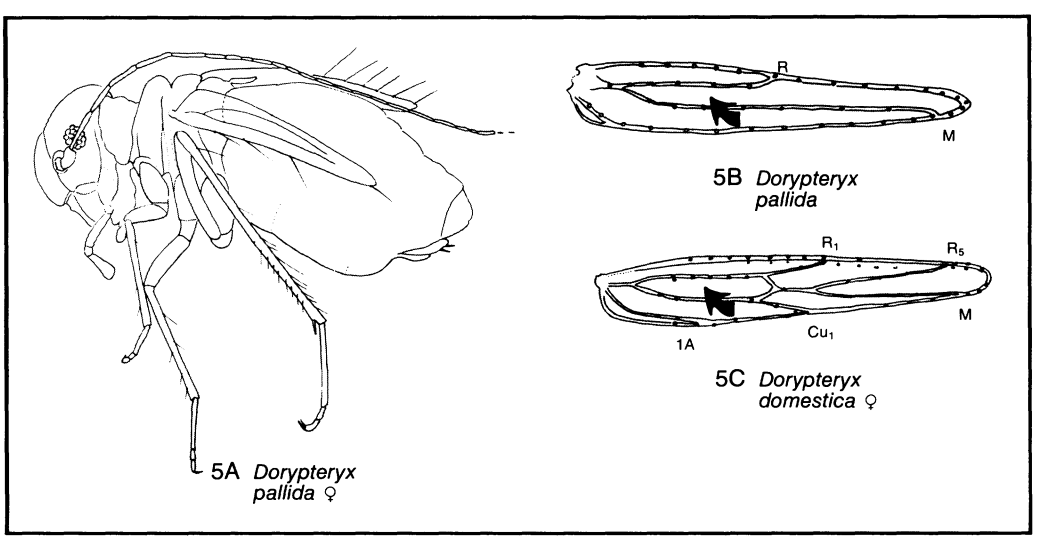
4B *Psyllipsocus ramburi* ♀

4C *Psocatropos microps* ♂

5 Forewing with only 2 longitudinal veins, both branching from a single basal vein; no closed cells (5A, 5B) ---------- *Dorypteryx pallida*

Known from domestic situations in Philadelphia, and in central and southern Europe, and from a cave in Egypt. References: *9-11.*

Forewing with more complex venation including at least 1 closed cell (5C) ---------- 6



5A *Dorypteryx pallida* ♀

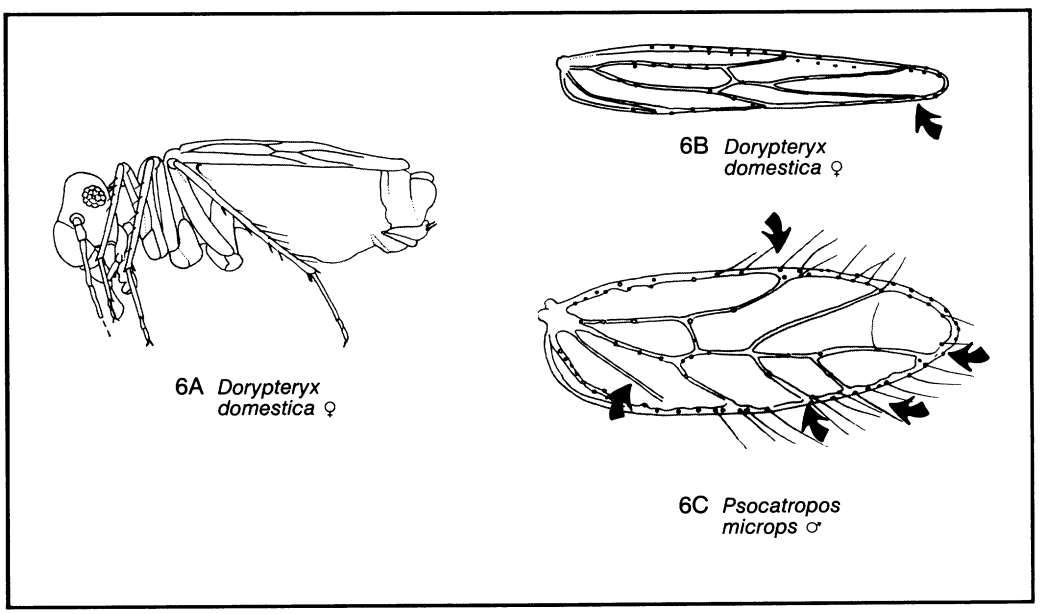
5B *Dorypteryx pallida*

5C *Dorypteryx domestica* ♀

6 Forewing with M simple and Sc and Cu_2 absent (6A, 6B) ----------*Dorypteryx domestica*

Known from buildings in Southern Rhodesia and central Europe. References: *11, 24.*

Forewing with M at least once-branched, and Sc and Cu_2 present (6C). Genus *Psocatropos* ---------- 7

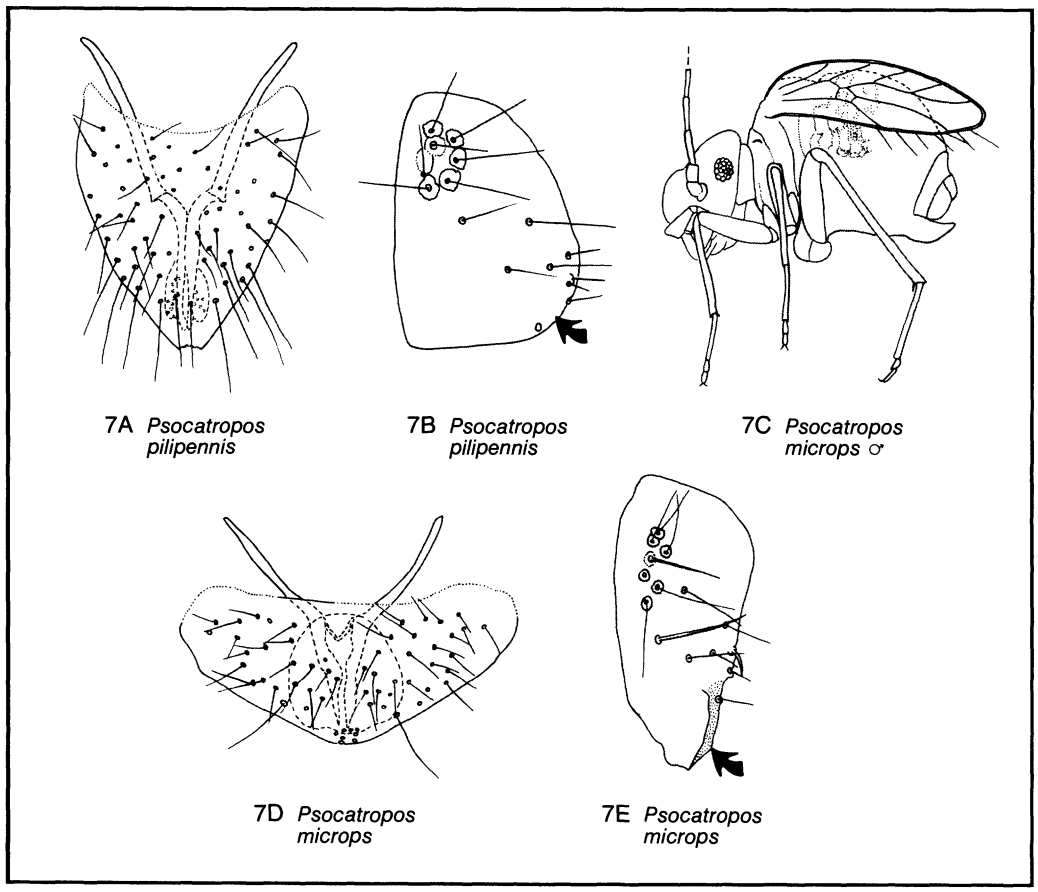


7 Forewing generally reaching or surpassing tip of abdomen; hypandrium longer than its basal width (7A); male paraproct lacking a sclerotized ridge on its distal margin (7B) ----------*Psocatropos pilipennis*

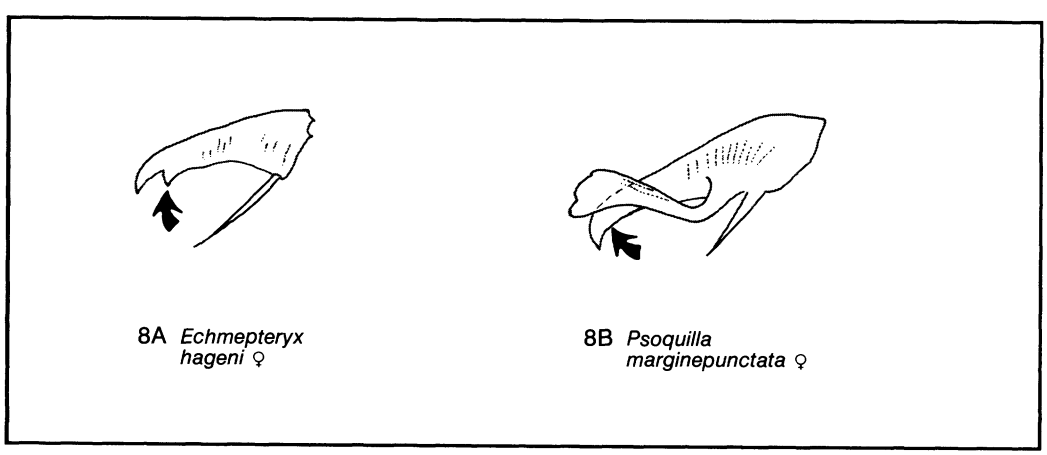
Known from houses in India, Madagascar, and the Seychelles. Reference: *3.*

Forewing generally not reaching (or just barely reaching) tip of abdomen (7C); hypandrium shorter than its basal width (7D); male paraproct pointed ventrally, with a sclerotized ridge on its distal margin (7E) ----------*Psocatropos microps*

Known from houses, stored food, and outdoor situations throughout the tropics. See also 3A, 3B, 4C. References: *3, 5, 13.*



8 Pretarsal claws each with a preapical denticle (8A); body and wings covered with scales (see 9A, 9B). Lepidopsocidae---------- 9
Pretarsal claws without preapical denticle (8B); body and wings lacking scales (see 10A, 10B)---------- 10

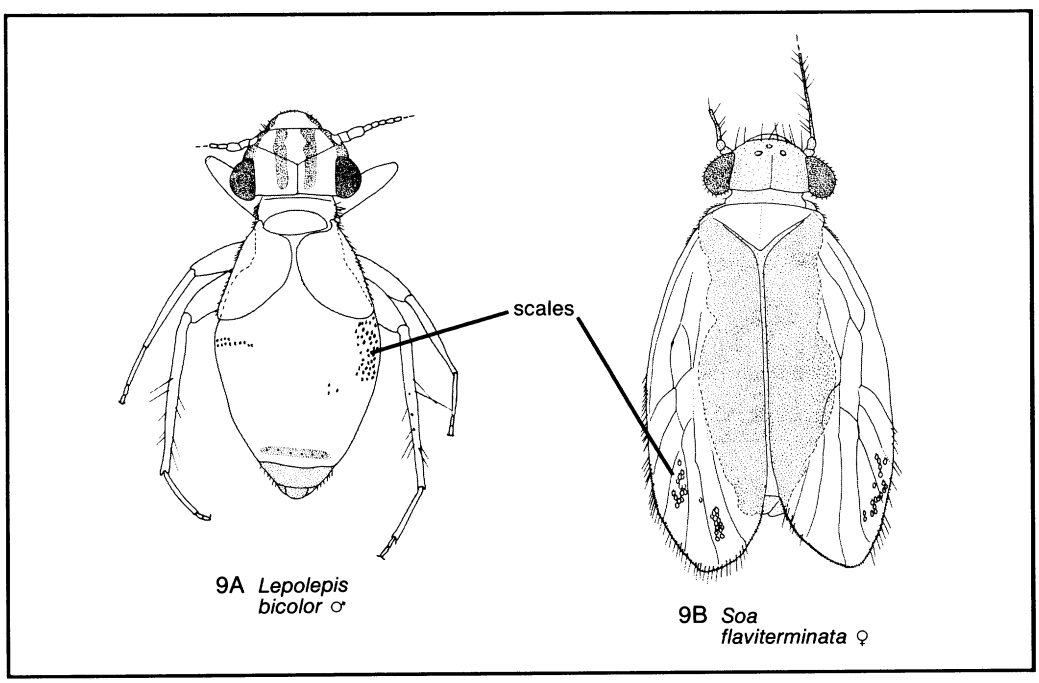


9 Forewings reaching to about posterior margin of abdominal segment I (9A); head marked with 4 longitudinal brown stripes on a creamy yellow background (9A) ----------*Lepolepis bicolor*

Collected from West African peanuts in a British port, and also from India (circumstances not noted). Reference: *7*.

Forewing surpassing posterior margin of abdomen (9B); head a uniform medium brown ---------- *Soa flaviterminata*

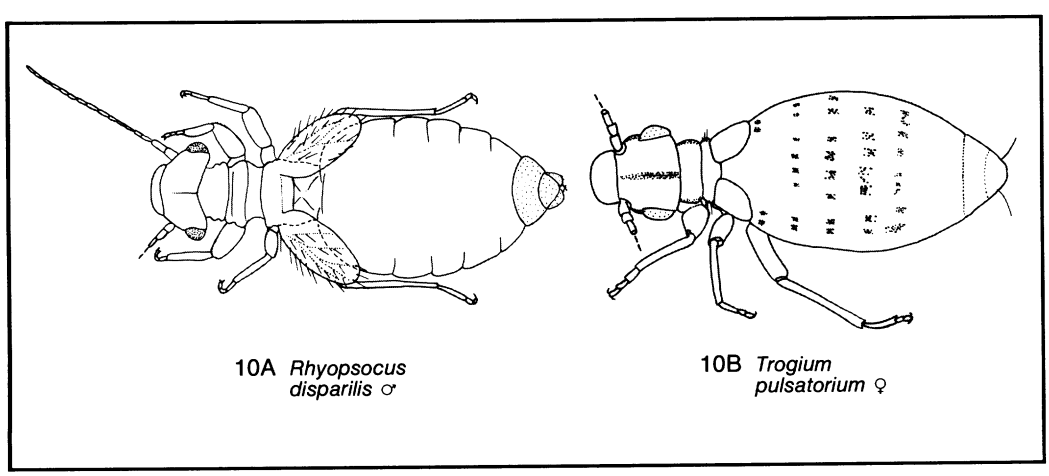
Circumtropical, but recorded from stored foods only in West Africa. References: *5, 9, 15*.



9A *Lepolepis bicolor* ♂

9B *Soa flaviterminata* ♀

10 Forewings well-developed or reduced, but always with veins (10A). Psoquillidae-- 11
Forewings reduced to tiny scales or knobs, never with veins (10B). Trogiidae------ 14



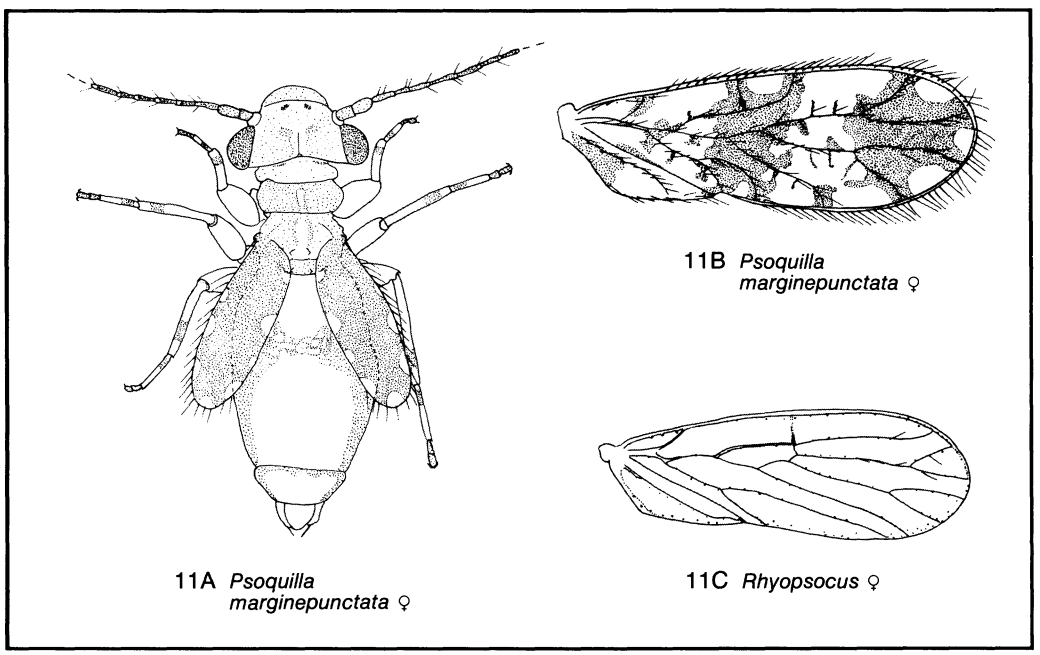
10A *Rhyopsocus disparilis* ♂

10B *Trogium pulsatorium* ♀

11 Forewings marked with a conspicuous pattern of dark and clear areas (11A, 11B) ---------- *Psoquilla marginepunctata*

Circumtropical; introduced into central Europe and southern United States; known mostly from outdoor situations in the tropics, but from stored food in West Africa and from domestic situations outside the tropics. See also 3C, 3D, 8B. References: *1, 5, 9, 19.*

Forewings uniform in color, pale brown to nearly colorless (11C). Genus *Rhyopsocus* 12



11A *Psoquilla marginepunctata* ♀

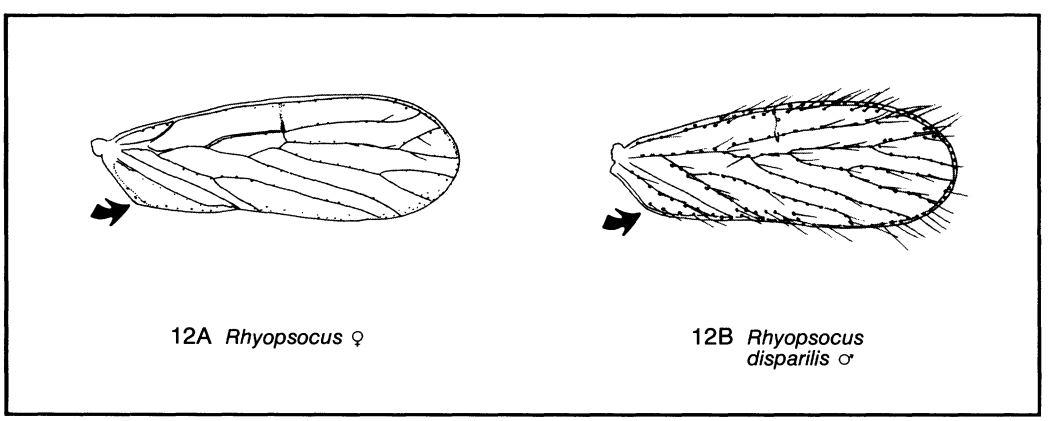
11B *Psoquilla marginepunctata* ♀

11C *Rhyopsocus* ♀

12 Anal lobe of forewing with angular posterior margin (12A) ---------- *Rhyopsocus peregrinus*

Found in a store at Manchester, England. Reference: *17.*

Anal lobe of forewing with rounded posterior margin (12B) ---------- 13



12A *Rhyopsocus* ♀

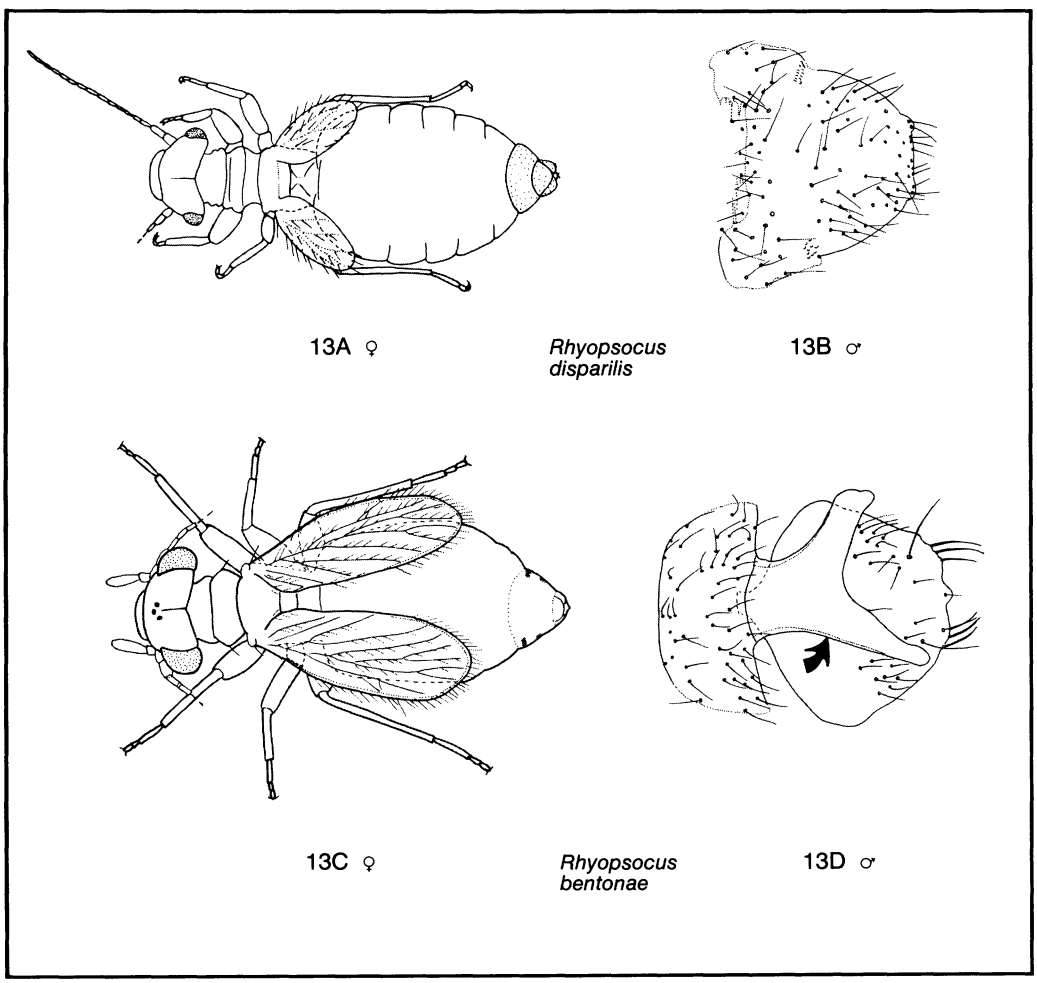
12B *Rhyopsocus disparilis* ♂

13 Body color a pale, creamy-yellow; wings variable in length, reaching as far as the basal fourth of the abdomen in the shortest-winged form (13A) to about tip of abdomen in longest-winged form; hypandrium not partially covered by preceding sternum (13B) ----------*Rhyopsocus disparilis*

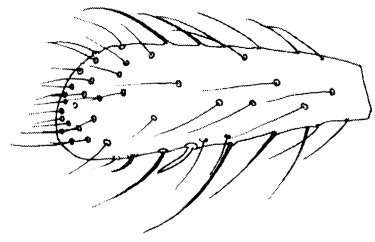
Taken in England and at New York on West African cacao, at United States ports on rice from the Philippines and Japan, on beans from the West Indies, and on pigeon peas from Guyana. References: *4, 5, 19*.

Head and thorax a tawny brown; wings variable in length, extending from about midlength of abdomen (13C) to beyond tip of abdomen; hypandrium partially covered by fishtail-shaped lobe of preceding sternum (13D) -------*Rhyopsocus bentonae*

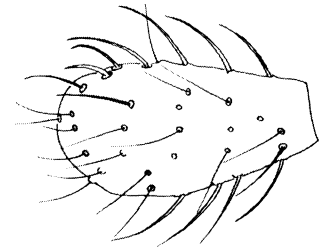
Found in houses in southeastern United States. Reference: *31*.



14 Segment IV of maxillary palp relatively elongate and slender (14A); abdomen uniform in color (see 15B)---------- 15
Segment IV of maxillary palp relatively short and broad (14B); abdomen spotted or mottled (see 17A, 17B)---------- 17



14A *Lepinotus patruelis* ♀

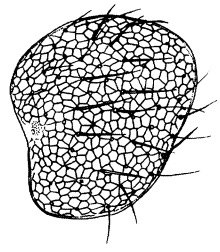


14B *Cerobasis annulata* ♀

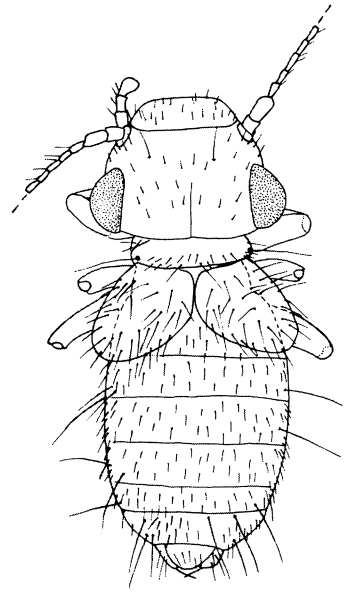
15 Slide-mounted wing with a reticulate pattern (15A); head a uniform yellowish brown (15B)----------**reticulatewinged trogiid,** *Lepinotus reticulatus*

Cosmopolitan; usually in outdoor situations but common in stored grain in the United States. References: *4, 5, 9-11, 21.*

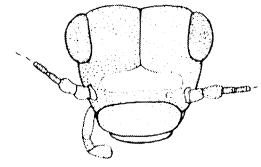
Slide-mounted wing lacking reticulate pattern (15C); head dark brown (15D) or with a dark brown band from compound eye to antennal base (15E)---------- 16



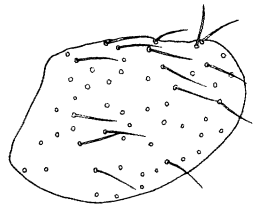
15A *Lepinotus reticulatus* ♀



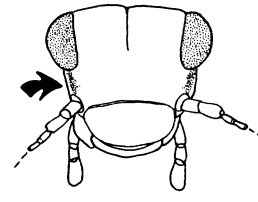
15B *Lepinotus reticulatus* ♀



15D *Lepinotus inquilinus* ♀



15C *Lepinotus patruelis*♀



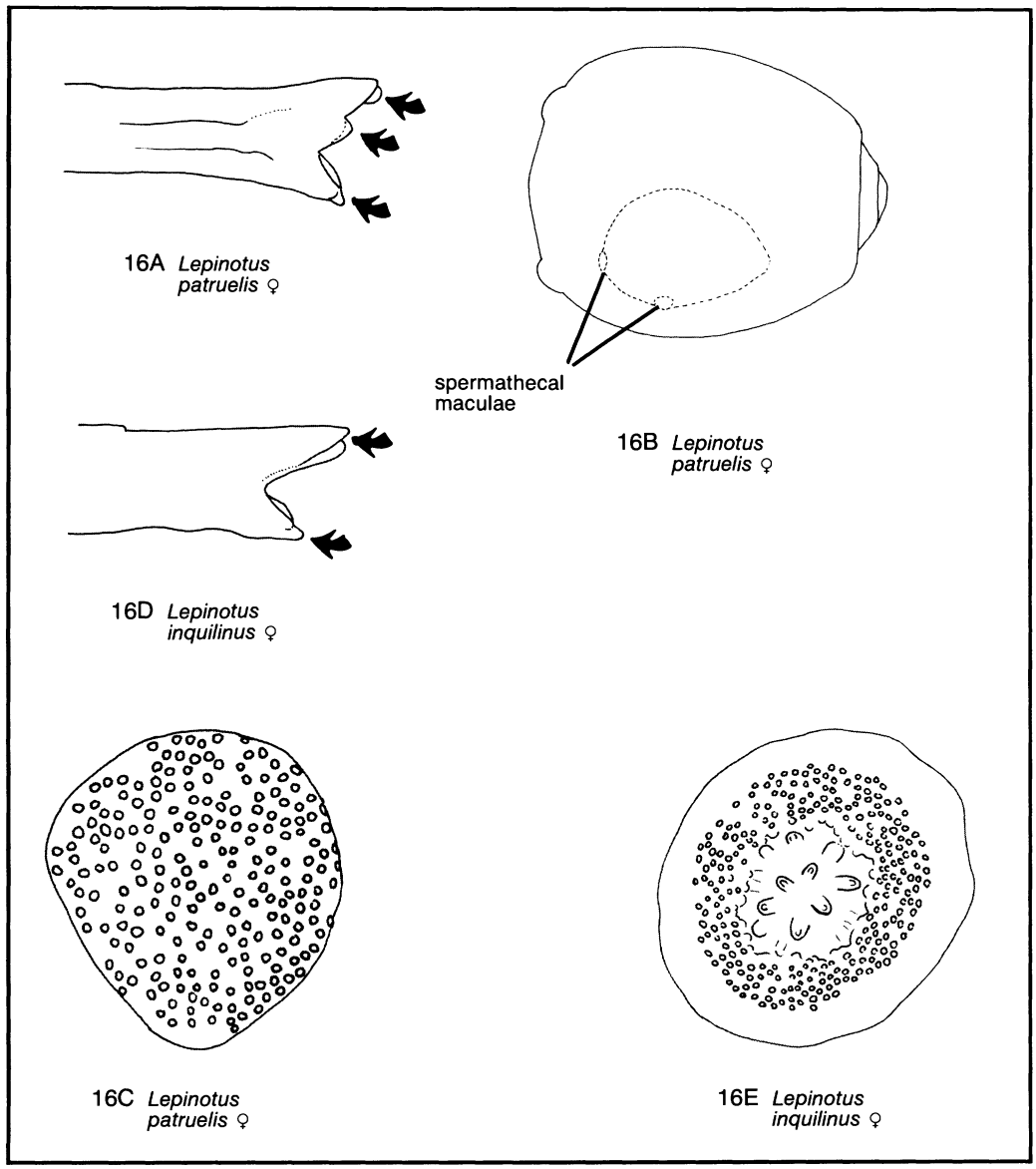
15E *Lepinotus patruelis*♀

16 Lacinial tip distinctly tridentate (16A); spermathecal maculae (16B) each with uniform, minute papillae (16C)----------*Lepinotus patruelis*

Common in houses in central Europe; often seen at United States ports on dried plant materials from central Europe. See also 14A, 15C, 15E. References: *1, 9, 11, 18.*

Lacinial tip bidentate, any medial protuberance being at most a low mound (16D); spermathecal maculae (16B) each with large central spinelike papillae and smaller peripheral granular papillae (16E) ----------*Lepinotus inquilinus*

Relatively common in houses in Europe, North America, Africa, and Madagascar. See also 15D. References: *1, 9, 10, 27.*

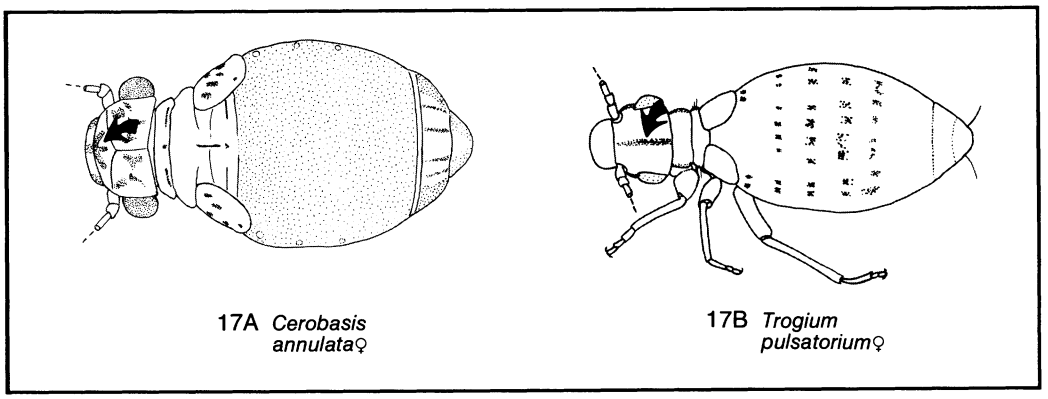


17 Frons with a brown, anchor-shaped mark; wings brown-spotted (17A) ---------- *Cerobasis annulata*

Occurs in houses in Europe and North America. See also 14B. References: *9, 10.*

Frons marked with a dark longitudinal line; wings uniform in color (17B) ---------- **larger pale trogiid,** *Trogium pulsatorium*

Common in houses in Europe and North America. References: *9, 10, 12, 27.*



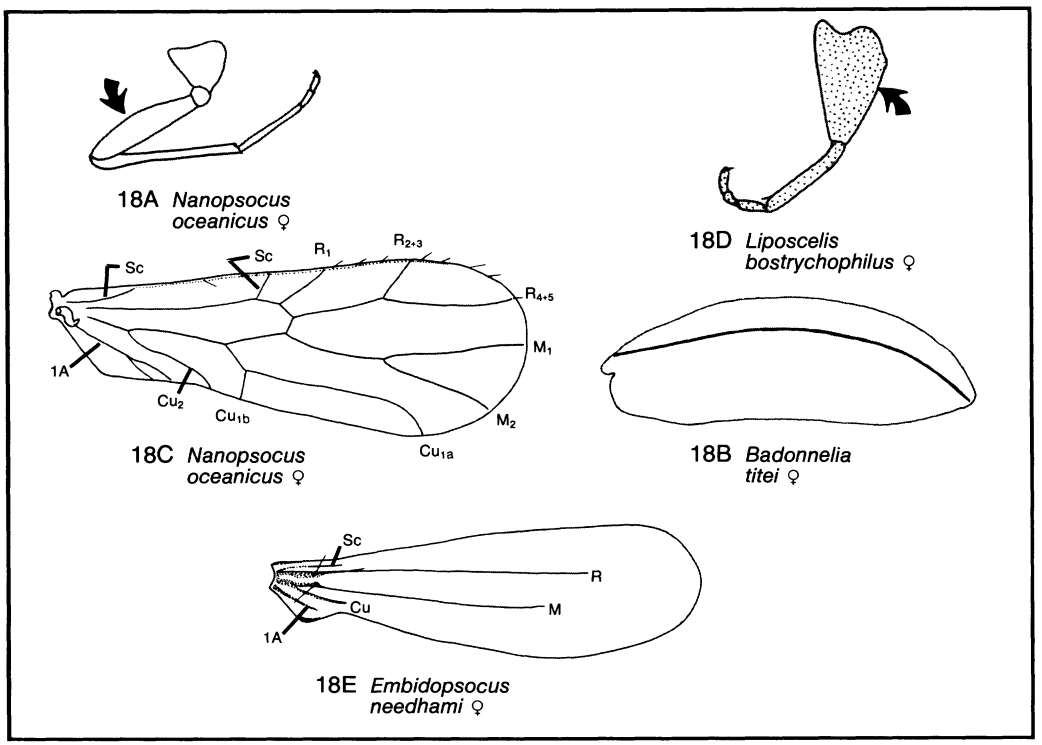
17A *Cerobasis annulata*♀

17B *Trogium pulsatorium*♀

Suborder Troctomorpha

18 Body not depressed; femur III not dilated (18A); forewings, if present, either elytriform, with reduced venation (18B), or with venation essentially complete (18C) ---------- 19

Body depressed; femur III dilated (18D); wings, if present, with venation greatly reduced (18E). Liposcelidae ---------- 20



18A *Nanopsocus oceanicus* ♀

18D *Liposcelis bostrychophilus* ♀

18C *Nanopsocus oceanicus* ♀

18B *Badonnelia titei* ♀

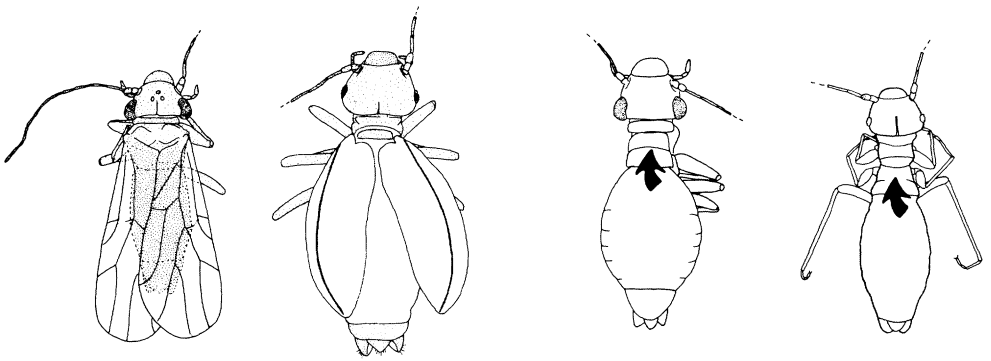
18E *Embidopsocus needhami* ♀

19 Wings, if present, flat, with many veins (19A); apterous forms with mesothorax and metathorax separated by an obvious suture (19B). Pachytroctidae ---------- *Nanopsocus oceanicus*

Occurs in houses in southeastern United States and Japan (also in dried mushrooms in Japan); also known from West Africa and New Hebrides. See also 18C. Reference: *4* (= *Tapinella africana* and *T. pallida*).

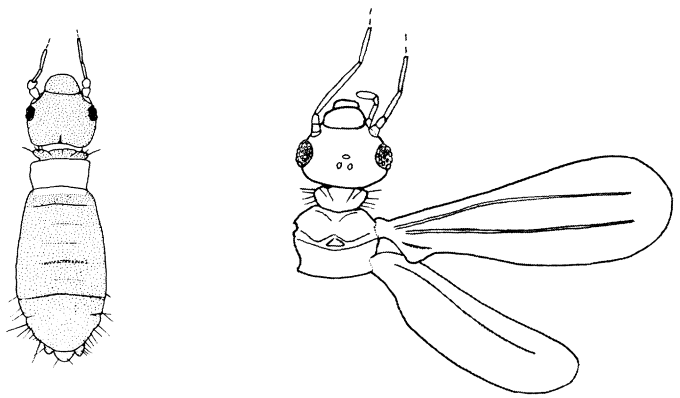
Wings, if present, convex, elytriform, with few veins (19C); apterous forms with mesothorax and metathorax fused (19D). Sphaeropsocidae ---------- *Badonnelia titei*

Known from domestic situations, including stored food, in central Europe and England. References: *9, 11, 22, 23.*



19A *Nanopsocus oceanicus* ♀ 19C *Badonnelia titei* ♀ 19B *Nanopsocus oceanicus* ♀ 19D *Badonnelia titei* ♂

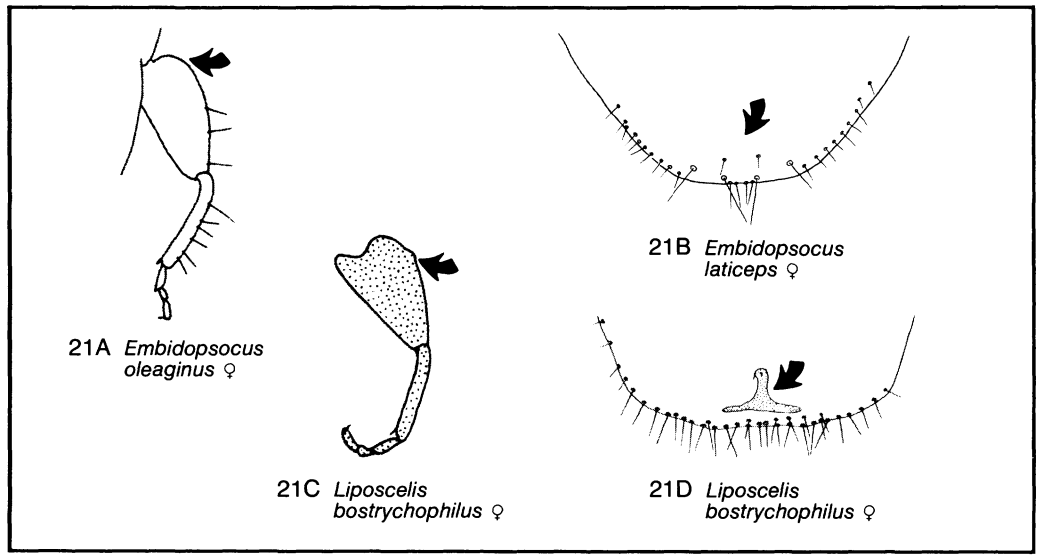
20 Wings and ocelli absent (20A) ---------- 21
Wings and ocelli present (20B) ---------- 22



20A *Liposcelis albothoracicus* ♀ 20B *Embidopsocus laticeps* ♀

21 Femur III moderately broad, without a lateral process (21A); subgenital plate without a T-shaped sclerite (21B) ---------- 22
Femur III very broad, with a small lateral process (21C); subgenital plate with a T-shaped sclerite (21D). Genus *Liposcelis* ---------- 25

Males of *Liposcelis* are determined at present largely by association with females. For some species, males are unknown or nonexistent. The sexes may be distinguished as follows: females larger than males; subgenital plate with T-shaped sclerite (21D); the phallosome (an elongate, partially-enclosed frame above the hypandrium) occupying about half the length of abdomen. Reference: *6*.



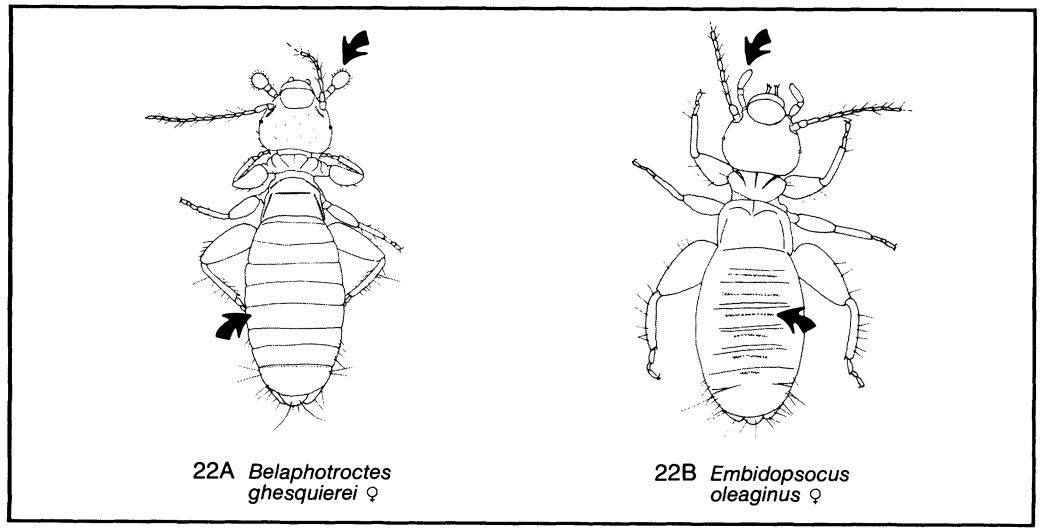
21A *Embidopsocus oleaginus* ♀

21B *Embidopsocus laticeps* ♀

21C *Liposcelis bostrychophilus* ♀

21D *Liposcelis bostrychophilus* ♀

22 Terminal segment of maxillary palp at least slightly dilated (22A); abdominal terga III-VIII each lacking a slender, heavily sclerotized transverse strip (22A). Genus *Belaphotroctes* ---------- 23
Terminal segment of maxillary palp not dilated (22B); abdominal terga III-VIII each with a slender, heavily sclerotized transverse strip (22B). Genus *Embidopsocus* 24



22A *Belaphotroctes ghesquierei* ♀

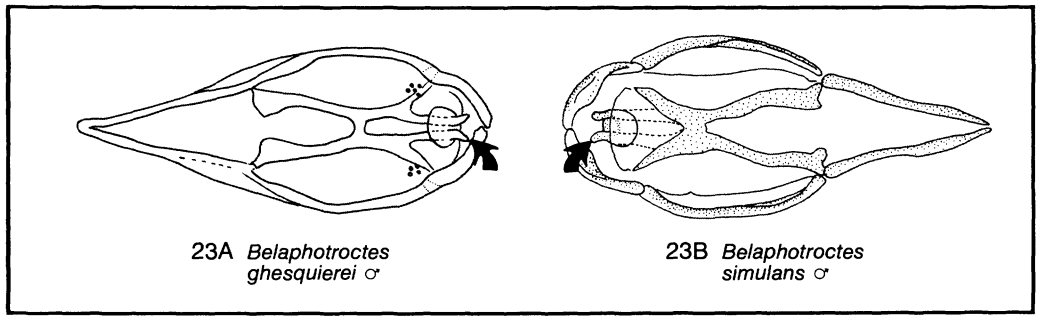
22B *Embidopsocus oleaginus* ♀

23 Endophallic central prongs with pointed tips (23A)----------*Belaphotroctes ghesquierei*

Known from Brazil, Florida, and West Africa, primarily from outdoor situations, but from stored food in West Africa. See also 22A. References: *3-5*.

Endophallic central prongs with blunt tips (23B)----------*Belaphotroctes simulans*

Found in stored food in West Africa.
Drawing adapted from *5* by C. Feller.



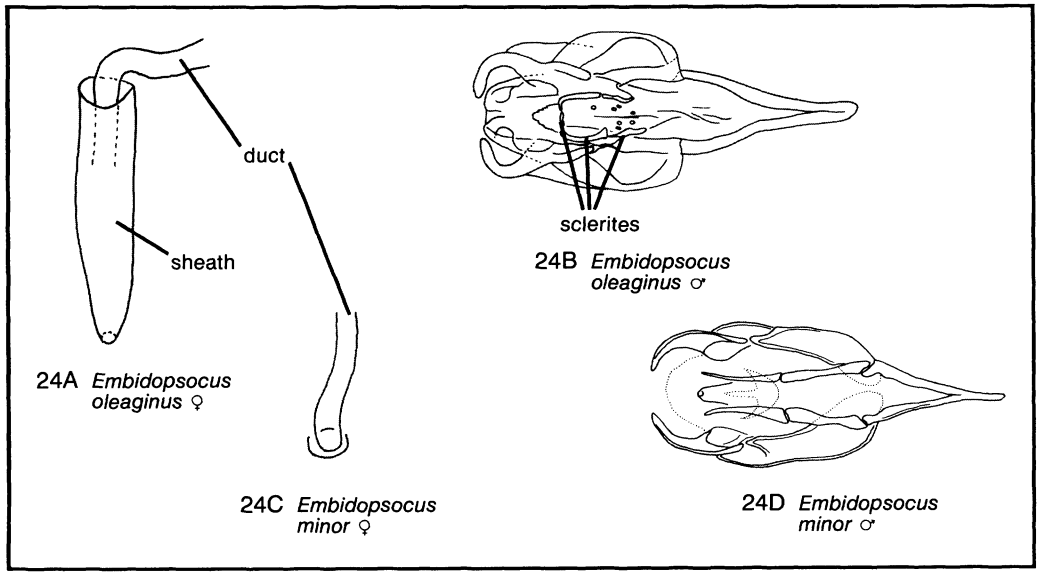
23A *Belaphotroctes ghesquierei* ♂ 23B *Belaphotroctes simulans* ♂

24 Spermathecal duct with sheath around spermapore end (24A); endophallus with arch of small sclerites (24B)----------*Embidopsocus oleaginus*

Associated with stored foods in West Africa, Sri Lanka, and several western Pacific localities (Philippines, Taiwan, Okinawa). See also 21A, 22B. References: *1, 5*.

Spermathecal duct without sheath (24C); endophallus without arch of sclerites (24D) ---------- *Embidopsocus minor*

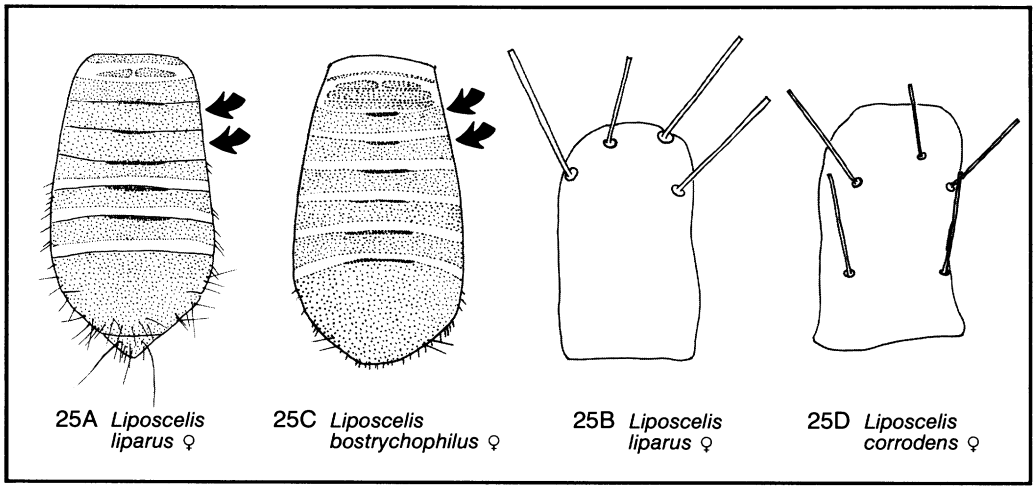
Taken from West African cacao in a British warehouse, and from stored foods in West Africa. References: *5, 19*.
Drawings adapted from *5* by C. Feller.



24A *Embidopsocus oleaginus* ♀ 24B *Embidopsocus oleaginus* ♂ 24C *Embidopsocus minor* ♀ 24D *Embidopsocus minor* ♂

25 Abdominal terga III and IV uniform in color, not presenting, at least in their central portions, a posterior membranous band with sculpture different from their anterior parts (25A); all prosternal setae anterior (25B). Section I ---------- 26

Abdominal terga annulate, with distinct intersegmental membranes in posterior parts of terga III to VII showing different sculpture and paler color than the more sclerotized anterior parts of these segments (25C); prosternal setae either restricted to anterior half (25B) or distributed in both halves (25D). Section II ---------- 34

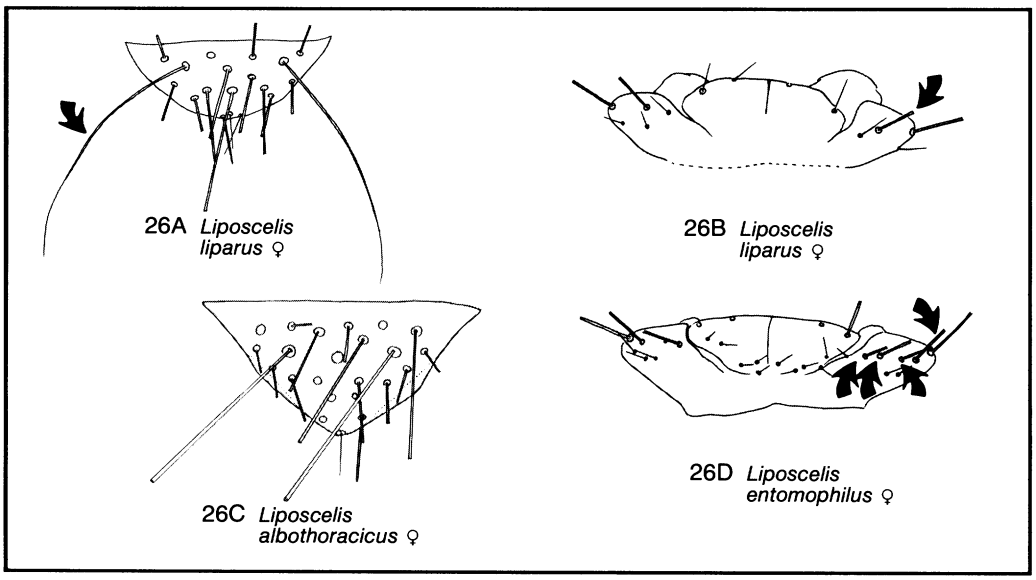


25A *Liposcelis liparus* ♀ 25C *Liposcelis bostrychophilus* ♀ 25B *Liposcelis liparus* ♀ 25D *Liposcelis corrodens* ♀

26 Epiproct with a pair of long, slender, acuminate setae (26A); lateral pronotal lobe with a long, strong humeral seta and a single long supplementary bristle (26B) ---------- *Liposcelis liparus*

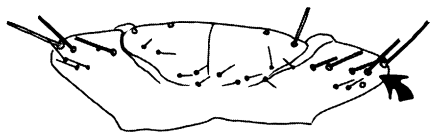
In buildings in England; common in outdoor situations in western United States and South Africa. See also 25A, 25B. References: *6, 9, 11.*

Epiproct without acuminate setae (26C); pronotal lobe with 2 or more supplementary setae (26D), or supplementary setae absent ---------- 27

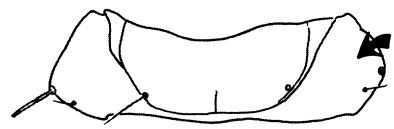


26A *Liposcelis liparus* ♀ 26B *Liposcelis liparus* ♀ 26C *Liposcelis albothoracicus* ♀ 26D *Liposcelis entomophilus* ♀

27 Lateral lobe of pronotum with a transverse row of 2 to 5 strong setae in addition to humeral seta (27A) ---------- 28
Lateral lobe of pronotum with humeral seta and scattered small setae, but without a transverse row of strong setae (27B) ---------- 30



27A *Liposcelis entomophilus* ♀



27B *Liposcelis kidderi* ♀

28 Body without a striking pattern, uniform in color except apical half of abdomen somewhat darker than basal half ---------- *Liposcelis transvaalensis*

Recorded from stored foods in West Africa. Reference: *5.*

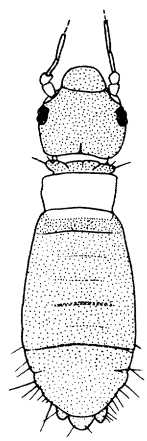
Body marked with a striking pattern of contrasting colors ---------- 29

29 Mesothorax, metathorax, and abdominal segment I white; other portions of body brown (29A) ---------- *Liposcelis albothoracicus*

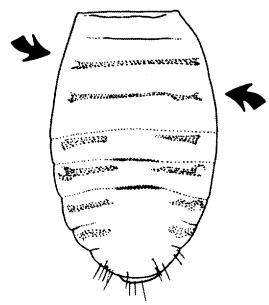
Collected from Turkish millet seed in a ship at Liverpool, England, and from an outdoor locality in southern India. See also 26C. Reference: *7.*

Body generally a creamy yellow, with lateral reddish-brown bands on abdominal terga III to VIII, continuous across terga III and IV (29B) ---------- *Liposcelis entomophilus*

Cosmopolitan; common in stored grain. See also 27A. References: *2, 9, 13.*



29A *Liposcelis albothoracicus* ♀

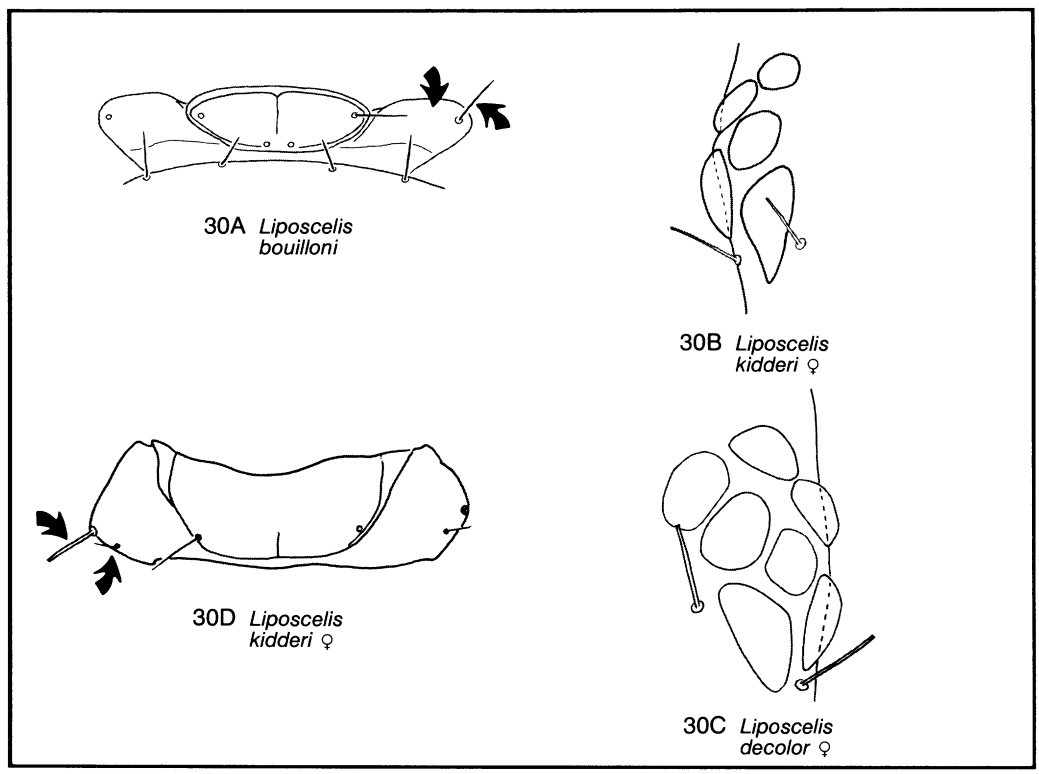


29B *Liposcelis entomophilus* ♀

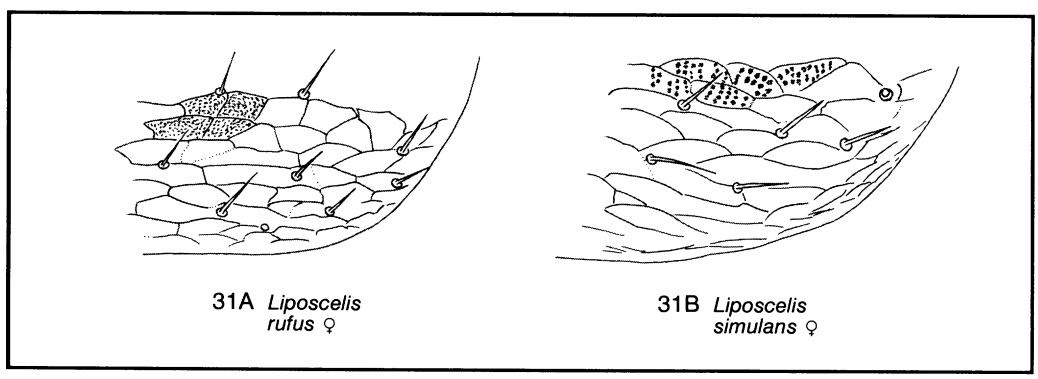
30 Compound eye of both sexes with 4 facets; lateral lobe of pronotum with only humeral seta, no smaller setae (30A) ----------*Liposcelis bouilloni*

From stored coffee in West Africa, and from outdoor situations in Brazil.
Drawing adapted from 5 by C. Feller.

Compound eye of female with 5 (30B) to 7 facets (30C), of male, 4 to 5 facets; lateral lobe of pronotum with humeral seta plus 1 or more smaller setae (30D)---------- 31



31 Vertex sculptured with finely granulate areoles (31A; details shown only in selected areoles) ---------- 32
Vertex sculptured with areoles bearing small tubercles forming anteroposteriorly-oriented wavy lines (31B) ---------- 33



32 Compound eye of female with 5 (see 30B) to 6 facets, of male, 4 to 5 facets; body color medium brown----------*Liposcelis kidderi*

Occurs in houses in Europe and North America. See 30B, 30D. References: *6, 9, 11*.

Compound eye of female with 6 to 7 (usually 7) facets, of male, 5 facets; body color reddish-brown----------*Liposcelis rufus*

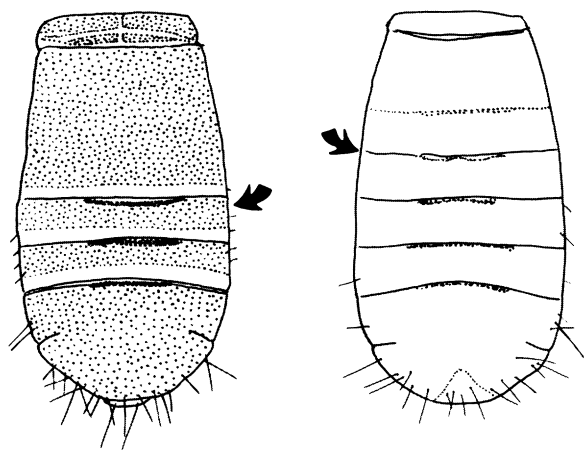
Recorded from a building in Ohio, from an outdoor locality in California, and from England (situation unknown). See 31A. References: *4, 6*.

33 Anterior margins of abdominal terga VI-VIII with prominent dark, transverse, sclerotized strips (33A); body color medium brown----------*Liposcelis simulans*

Known from houses and bird nests in central Europe, England, and the United States; frequently found in stored grain. See 31B. References: *6, 9, 11*.

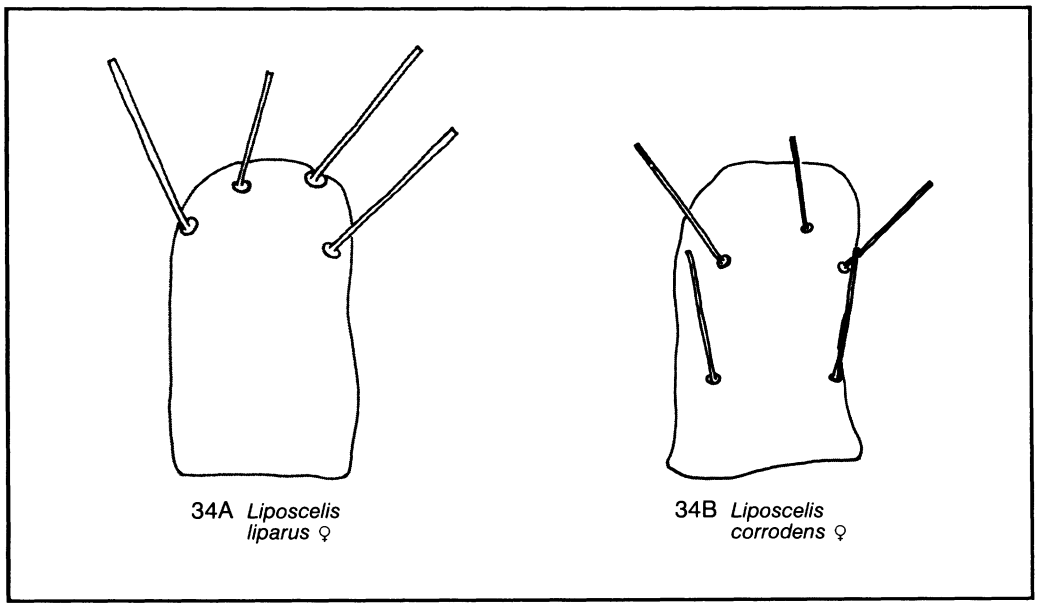
Anterior margins of abdominal terga V-VIII with prominent dark, transverse, sclerotized strips (33B); body color ochre yellow----------*Liposcelis decolor*

Probably cosmopolitan; occurs in houses and in stored agricultural products in Europe and, less commonly, in the United States. See also 30C. References: *2, 4, 6, 11 (= L. terricolis)*.



33A *Liposcelis simulans* ♀ 33B *Liposcelis decolor* ♀

34 Prosternal setae all in anterior half of prosternum (34A)---------- 35
Prosternal setae distributed in both anterior and posterior half of prosternum (34B) 40



35 Compound eye of female with 7 facets ---------- 36
Compound eye of female with fewer than 7 facets---------- 38

36 Lateral lobe of pronotum with transverse row of 4 to 6 long bristles in addition to shorter setae (as in 27A) ----------*Liposcelis pubescens*

Collected from a granary and other buildings in England; also known from central Europe, Argentina, Tristan da Cunha, and New Zealand. References: *6, 9*.

Lateral lobe of pronotum with 1 long bristle (humeral seta) and several shorter setae (as in 27B) ---------- 37

37 Body length of female less than 1 mm; body color a pale reddish-brown ---------- *Liposcelis exiguus varians*

Reported once from stored peanuts in Zaire. References: *4, 5*.

Body length of female 1.2 to 1.4 mm; body color a pale chamois-brown ---------- *Liposcelis mendax*

Occurs in houses in Europe and in stored foods in Zaire. References: *5, 6, 9*.

38 Compound eye of female with 5 facets ----------*Liposcelis mendax*

See also couplet 37.

Compound eye of female with fewer than 5 facets---------- 39

39 Compound eye of female with 4 facets ----------*Liposcelis obscurus*

Collected from wheat caked in the hold of a ship in Bristol, England. References: *9, 15.*

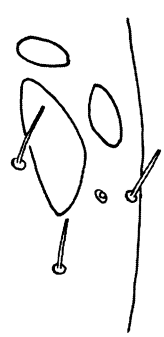
Compound eye of female with 2 facets----------*Liposcelis paetulus*

From a building in England. References: *5, 6, 9.*

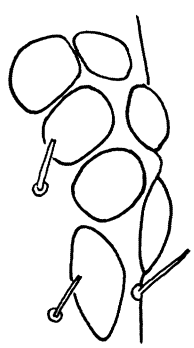
40 Compound eye of female with 3 facets (40A)----------*Liposcelis paetus*

Cosmopolitan; common in stored grain. References: *5, 6, 9, 21.*

Compound eye of female with 5 to 7 facets (40B)---------- 41



40A *Liposcelis paetus* ♀

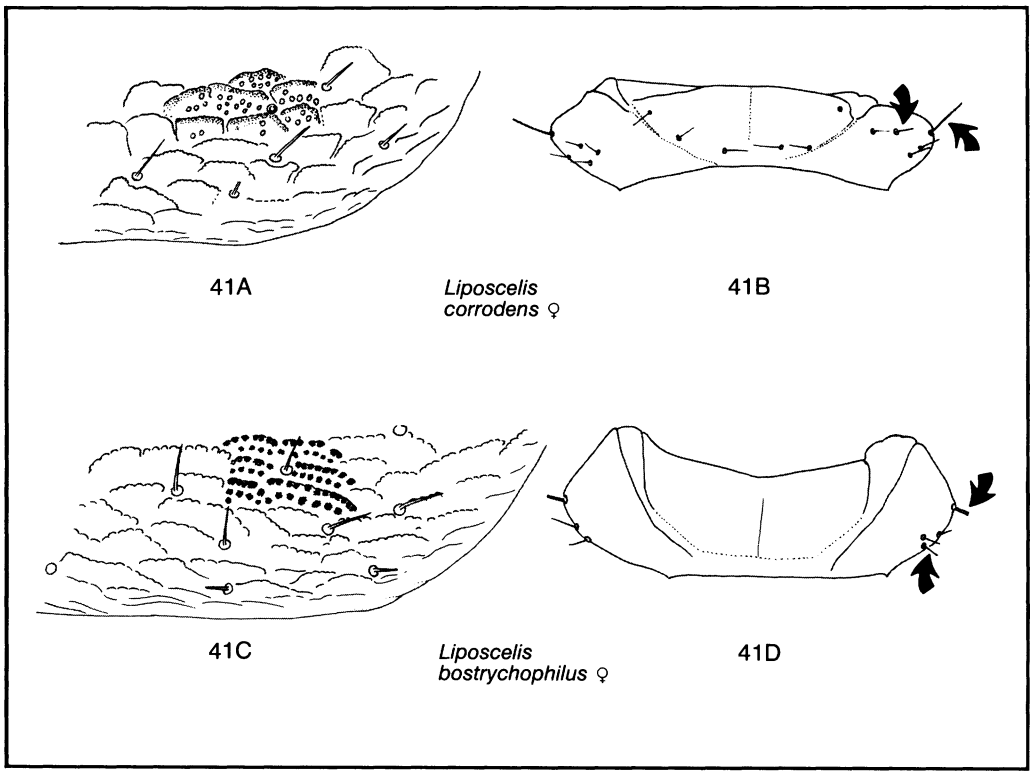


40B *Liposcelis bostrychophilus* ♀

41 Sculpture of vertex and abdominal terga consisting of areoles that are separated by depressed lines and are tuberculate except near their borders (41A; details shown only in selected areoles); lateral lobe of pronotum with humeral seta about 3 times longer than other setae (41B) ----------*Liposcelis corrodens*

Known from Europe, North America, Japan, and Chile; occurs frequently in stored foods. See also 25D. References: *9*.

Sculpture of vertex and abdominal terga consisting of densely tuberculate areoles that are separated by bare spaces and (or) by lines of relatively more pronounced tubecles (41C); humeral seta no more than twice as long as other setae on pronotal lobe (41D) ---------- 42

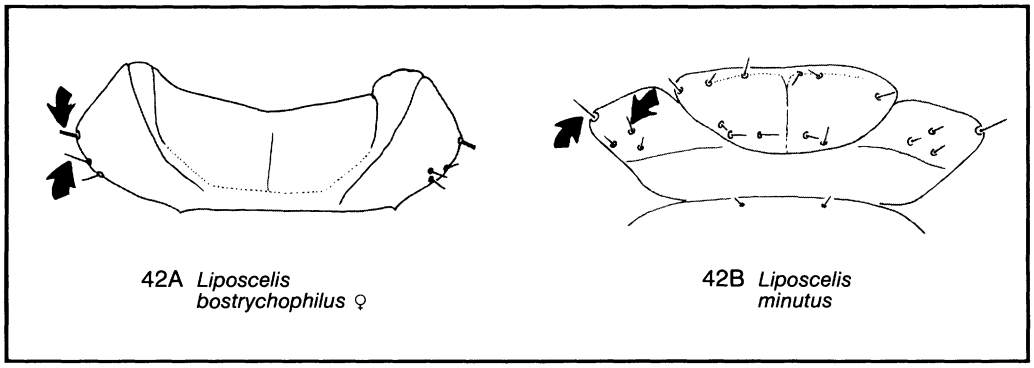


42 Humeral seta about same length as other setae on lateral lobe of pronotum (42A); compound eye of female usually with 7 facets ----------*Liposcelis bostrychophilus*

Cosmopolitan; common in stored grain. See also 1B, 21C, 21D, 40B, 41C. References: *2, 4-6, 9, 13.*

Humeral seta about twice length of other setae on lateral lobe of pronotum (42B); compound eye of female usually with 5 facets ----------*Liposcelis minutus*

Found in stored food in Zaire.
Drawing adapted from *5* by C. Feller.

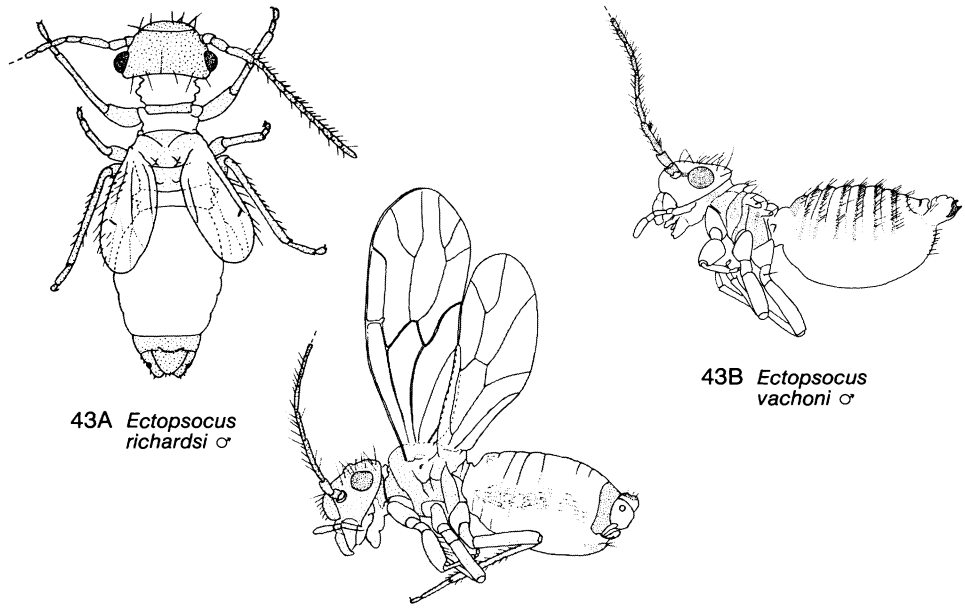


42A *Liposcelis bostrychophilus* ♀

42B *Liposcelis minutus*

Suborder Psocomorpha

43 Individuals brachypterous (43A) (wings not extending beyond midpoint of abdomen) or micropterous (43B)---------- 44
Individuals macropterous (43C) (wings reaching or extending beyond apex of abdomen)---------- 45



43A *Ectopsocus richardsi* ♂

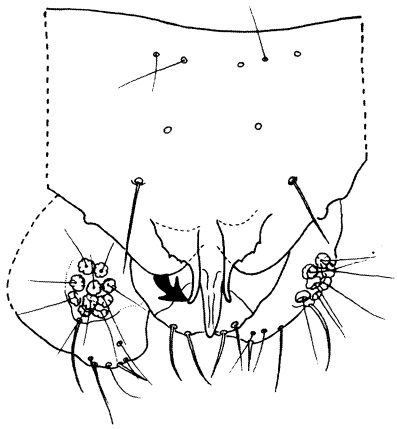
43B *Ectopsocus vachoni* ♂

43C *Ectopsocus vachoni* ♀

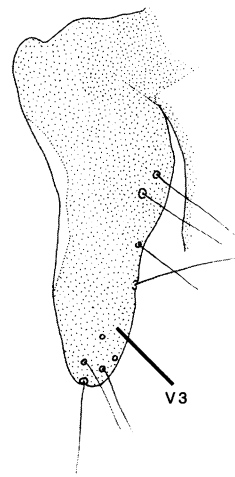
44 Clunium of male with posterodorsal margin bearing a pair of pointed processes (44A); gonapophysis of female a single valvula (44B). Lachesillidae (in part) ----------**cosmopolitan grain psocid,** *Lachesilla pedicularia*

Distributed throughout Europe and North America, primarily in outdoor situations but also common in houses and occasional in stored grain. See also 47A. References: *1, 9, 10, 30.*

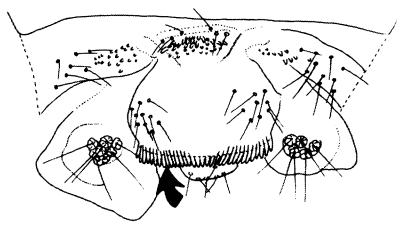
Clunium of male with a transverse comb of small teeth on posterodorsal margin (44C); gonapophysis of female composed of 3 valvulae (44D). Ectopsocidae (in part) ---------- 50



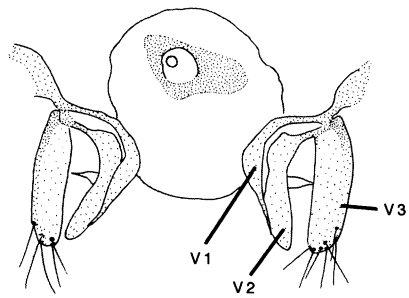
44A *Lachesilla pedicularia* ♂



44B *Lachesilla pedicularia* ♀



44C *Ectopsocus briggsi* ♂

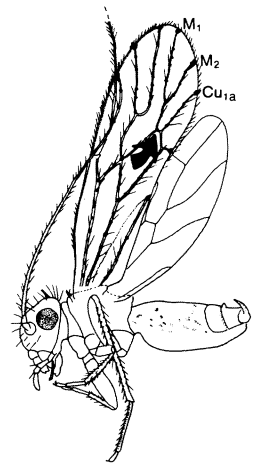


44D *Ectopsocus pumilis* ♀

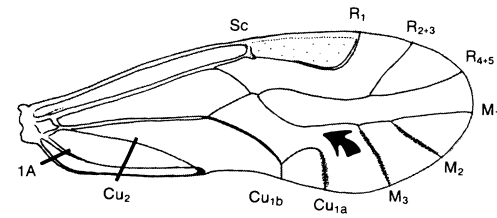
45 Cu_{1a} and M of forewing joined by crossvein; M of forewing 2-branched (45A). Hemipsocidae ---------- *Hemipsocus africanus*

Collected from Mexican pineapples and papayas at United States ports. Reference: *4*.

Cu_{1a} of forewing either absent or not joined to M; M 3-branched (45B) ---------- 46



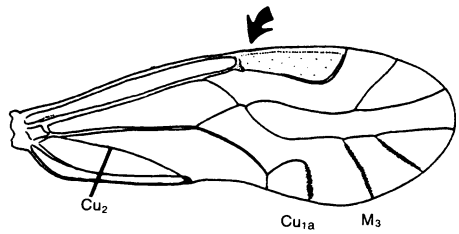
45A *Hemipsocus africanus* ♂



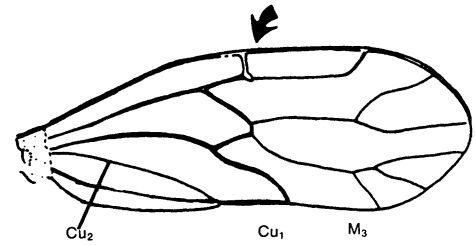
45B *Lachesilla pedicularia* ♀

46 Cu_{1a} present in forewing; pterostigma with basal constriction (46A). Lachesillidae (in part) ---------- 47

Cu_{1a} absent in forewing; pterostigma about as wide at its base as at its middle (46B). Ectopsocidae (in part) ---------- 49



46A *Lachesilla pedicularia* ♀

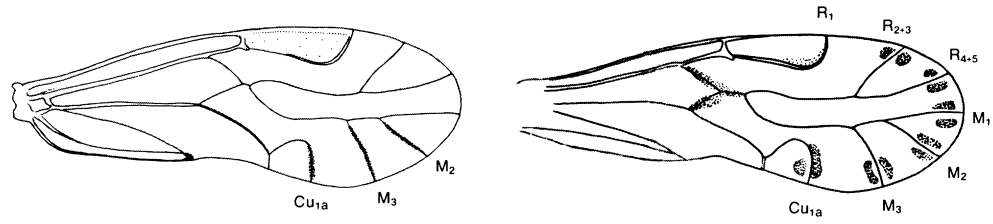


46B *Ectopsocus vachoni* ♀

47 Forewing completely clear, without spots, but with Cu_{1a}, M_2, and M_3 narrowly brown-bordered (47A)----------**cosmopolitan grain psocid,** *Lachesilla pedicularia*

See couplet 44.

Forewing with a cloudy brown spot around distal end of each radial and medial vein and around Cu_{1a} (47B)---------- 48



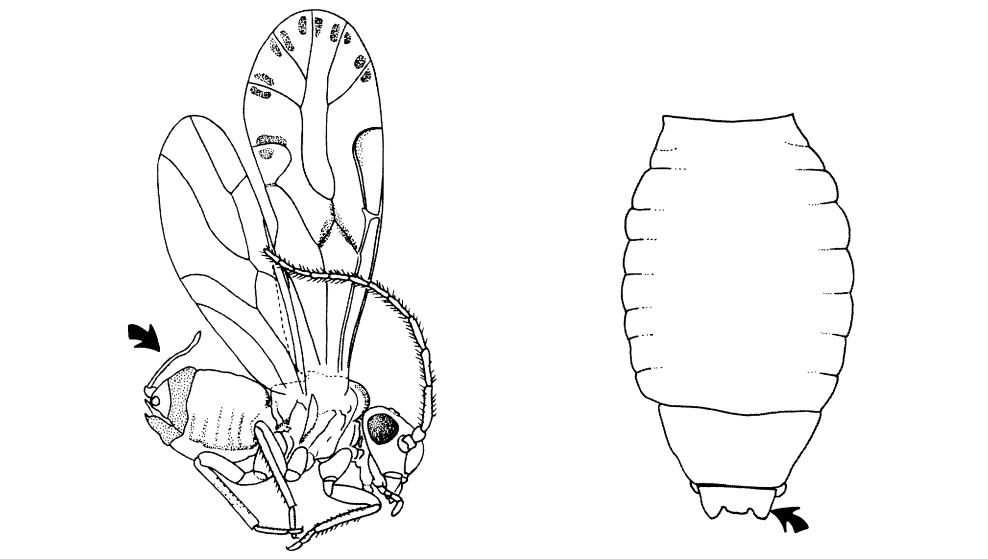
47A *Lachesilla pedicularia* ♀ 47B *Lachesilla rena* ♂

48 Forewing 1.5 to 1.7 mm in length; epiproct of male with an elongate, slender, medial process directed anteriorily on dorsal surface of abdomen (48A) ---------- *Lachesilla rena*

Found once on peas in pods in storage; common on dried soybean plants in fields of western Mexico. Reference: *30*.

Forewing 2.1 to 2.5 mm in length; epiproct with 2 short lateral processes but no medial process (48B) ----------*Lachesilla nubilis*

Widespread in North America, mostly in outdoor situations but also from stored grain. Reference: *30*.

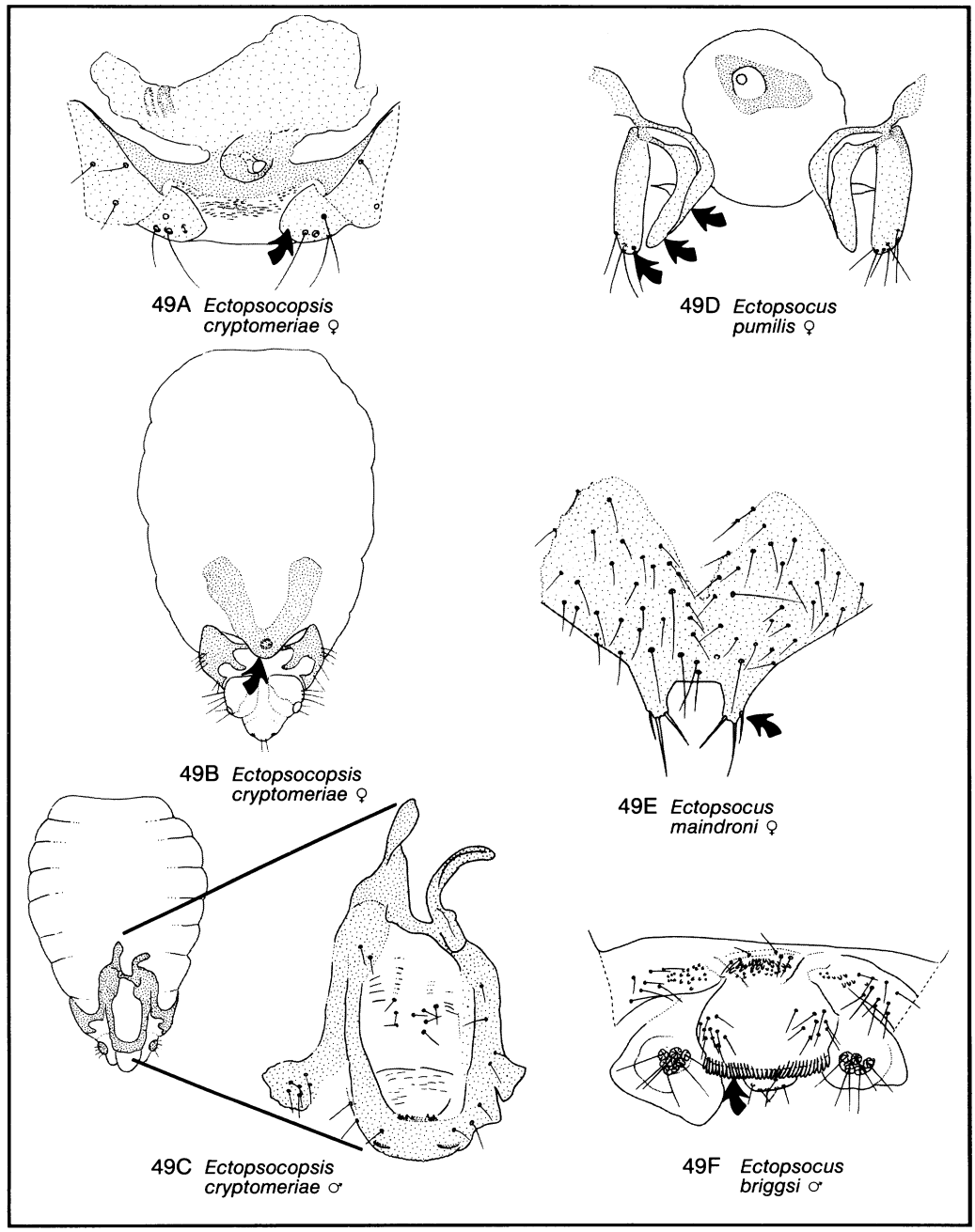


48A *Lachesilla rena* ♂ 48B *Lachesilla nubilis* ♂

49 Gonapophyses of female reduced to a rudimentary third valvula (49A); subgenital plate prolonged posteriorly by a medial process (49B); clunium of male with dorsal apophyses forming a complex clasping organ (49C) ----------*Ectopsocopsis cryptomeriae*

Nearly cosmopolitan; common in stored foods.
Reference: *13*.

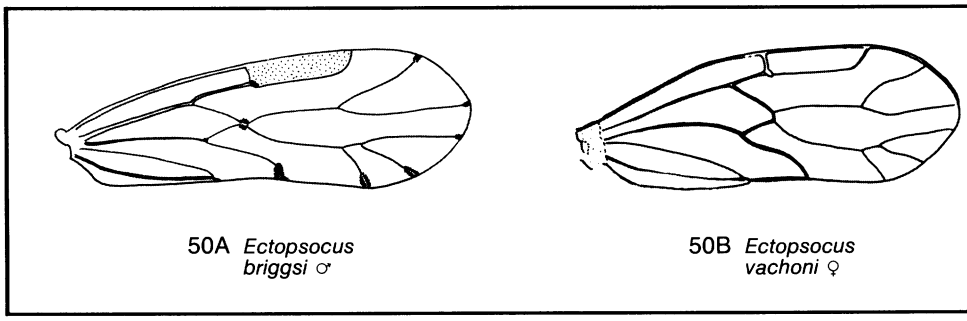
Gonapophyses complete with 3 valvulae (49D); subgenital plate usually bilobed medially (49E); clunium of male carrying dorsally only a transverse comb (49F). Genus *Ectopsocus* ---------- 50



50 Individuals macropterous; forewings with faint pattern of spots, 1 on end of each longitudinal vein and 1 at junction of Rs and M (50A)----------*Ectopsocus briggsi*

Present on most continents; occasionally found in houses along the Pacific coast of the United States; occasionally collected from imported herbs, citrus, and other fruits at United States ports. See also 44C. References: *9, 27.*

Individuals macropterous or short-winged; no spotted pattern on forewings of macropterous individuals (50B) ---------- 51



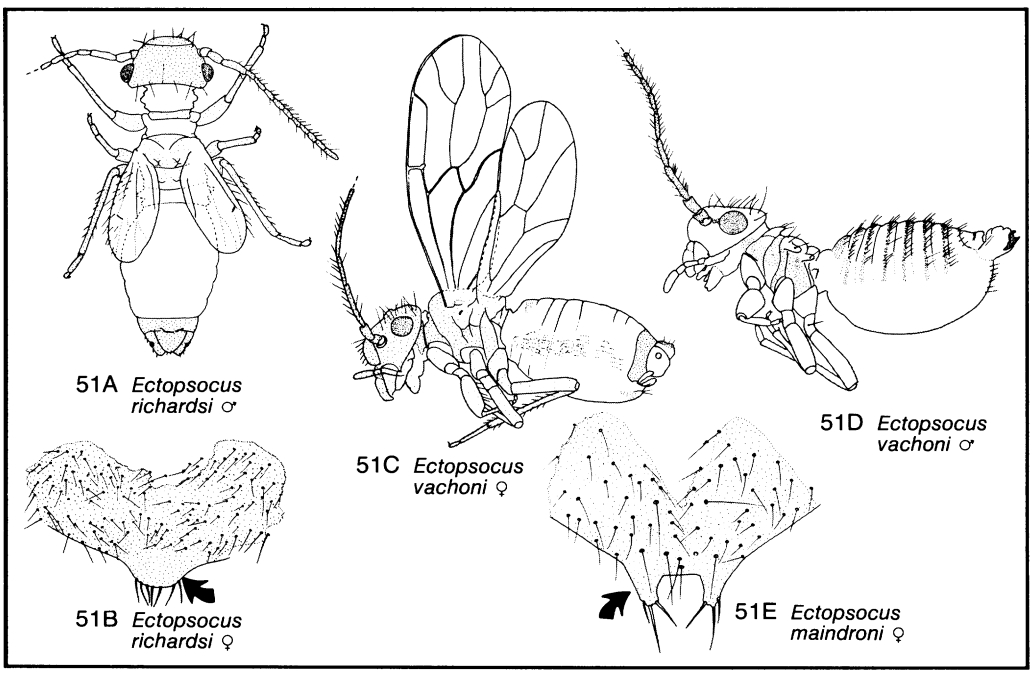
50A *Ectopsocus briggsi* ♂

50B *Ectopsocus vachoni* ♀

51 Head color a medium brown, contrasting with a paler body; adults brachypterous (51A); subgenital plate with a single, rounded, posteromedian lobe (51B) ----------*Ectopsocus richardsi*

Widespread in world trade, usually in stored grain and other dry foods. References: *5, 14, 17, 21, 29.*

Body color approximately uniform throughout; adults macropterous (51C) or micropterous (51D); subgential plate bilobed posterorly (51E)---------- 52



51A *Ectopsocus richardsi* ♂

51B *Ectopsocus richardsi* ♀

51C *Ectopsocus vachoni* ♀

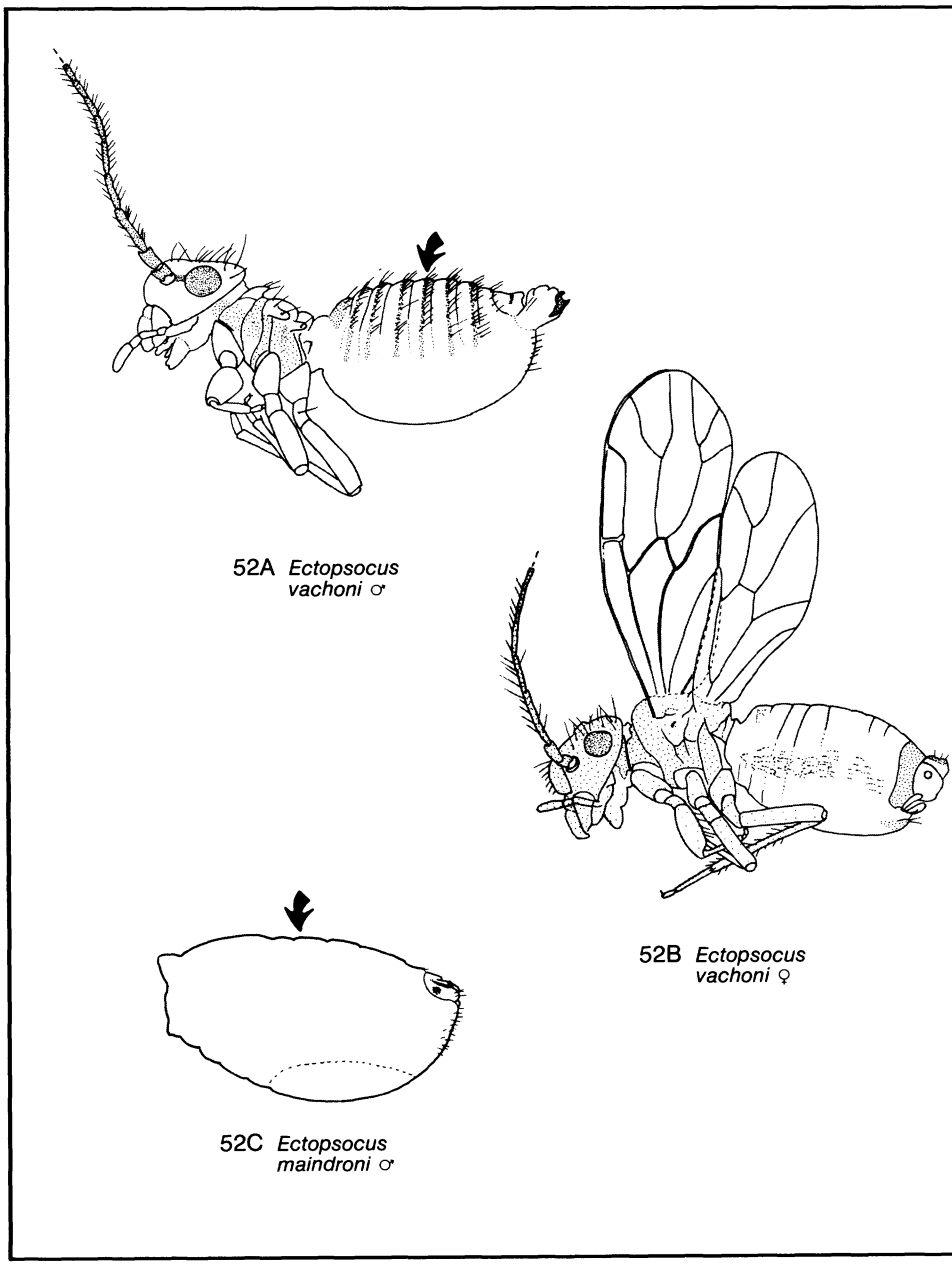
51D *Ectopsocus vachoni* ♂

51E *Ectopsocus maindroni* ♀

52 Males micropterous (52A); females micropterous or macropterous (52B); body color a medium reddish-brown; abdomen with reddish-brown annulations on a paler background (52A)----------*Ectopsocus vachoni*

Widely distributed in the subtropics; collected once from Mexican mixed vegetables on ice at Nogales AZ.
References: *14.* (= *E. dimorphus).*

Adults macropterous (similar to 52B); body color a creamy yellow to pale tawny; abdomen not annulated (52C)---------- 53

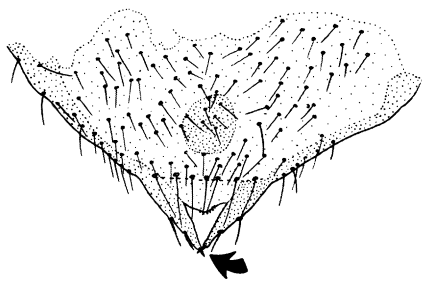


53 Lobes of subgenital plate apically pointed (53A); abdominal venter of male without a posteromedial suture (53B)----------*Ectopsocus pumilis*

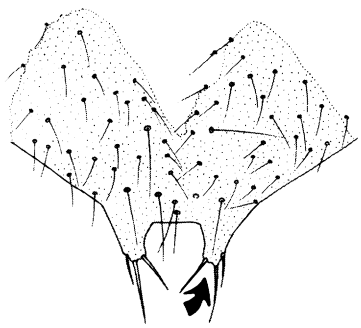
Occurs in houses in Florida, the West Indies, and Hong Kong. See also 44D. Reference: *4*.

Lobes of subgenital plate apically truncated (53C); abdominal venter of male with a posteromedial suture (53D)----------*Ectopsocus maindroni*

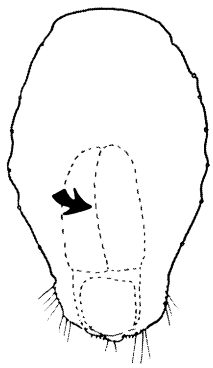
Probably circumtropical; often found around stored foods. See also 52C. Reference: *5*.



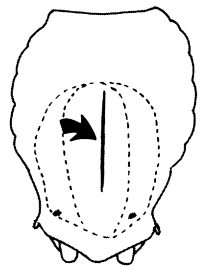
53A *Ectopsocus pumilis* ♀



53C *Ectopsocus maindroni* ♀



53B *Ectopsocus pumilis* ♂



53D *Ectopsocus maindroni* ♂

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23 THRIPS (THYSANOPTERA)

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KEY TO MACROPTEROUS FEMALES OF COMMON SPECIES

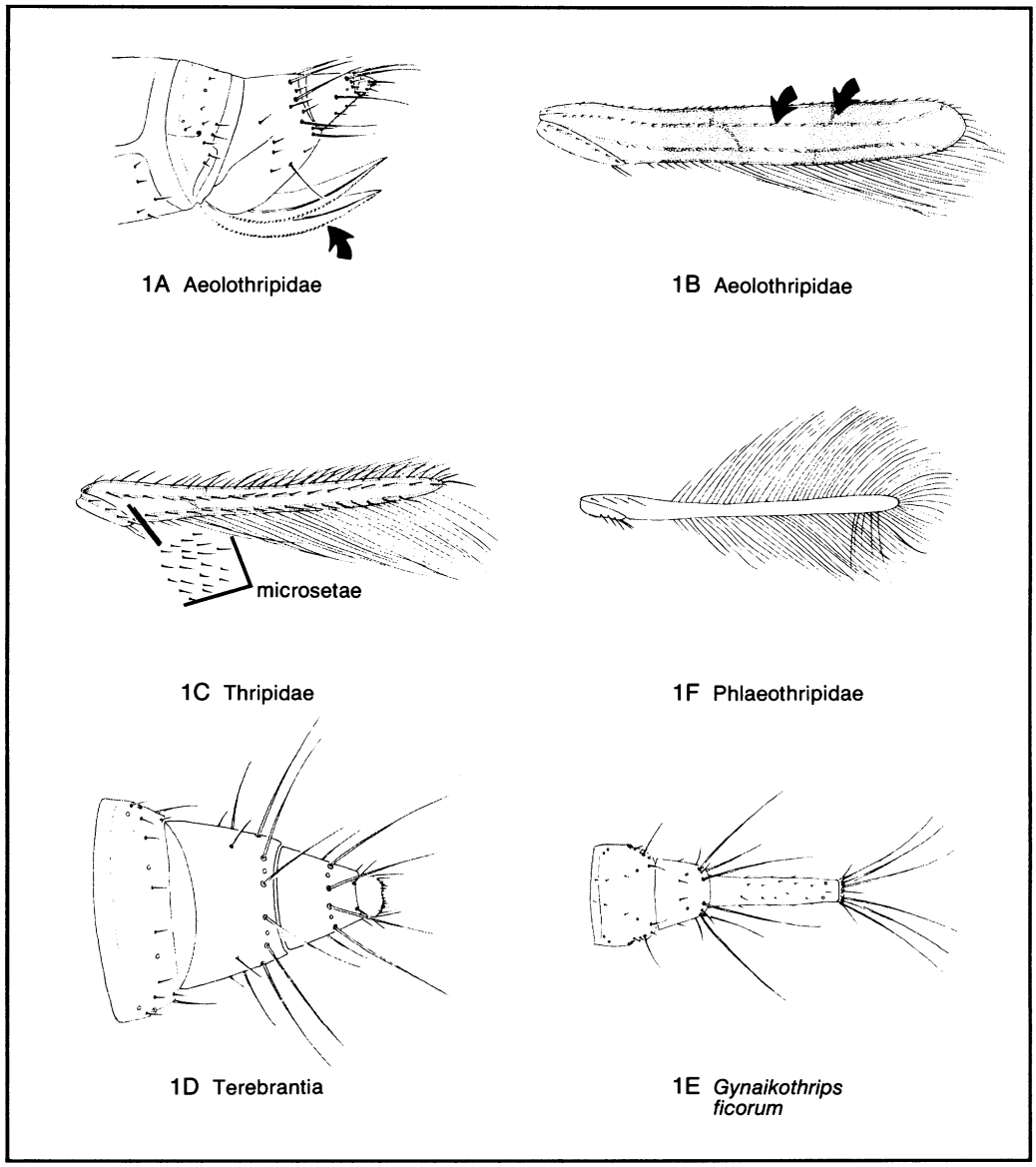
Drawings by C.S. Papp unless otherwise noted.

1 With sawlike ovipositor (1A); forewing with longitudinal veins and sometimes cross veins (1B); wings covered with microsetae (1C). Suborder Terebrantia---------- 2

Last abdominal segment usually conical (1D), rarely tubular.

Without sawlike ovipositor (1E); forewing without longitudinal veins (1F); wings without microsetae. Suborder Tubulifera. Phlaeothripidae---------- 18

Last abdominal segment usually tubular (1E).
Drawing 1E by T. Kono.



1A Aeolothripidae

1B Aeolothripidae

1C Thripidae

1F Phlaeothripidae

1D Terebrantia

1E *Gynaikothrips ficorum*

The assistance of Tokuwo Kono and Steve Nakahara in the preparation of this chapter is gratefully acknowledged.

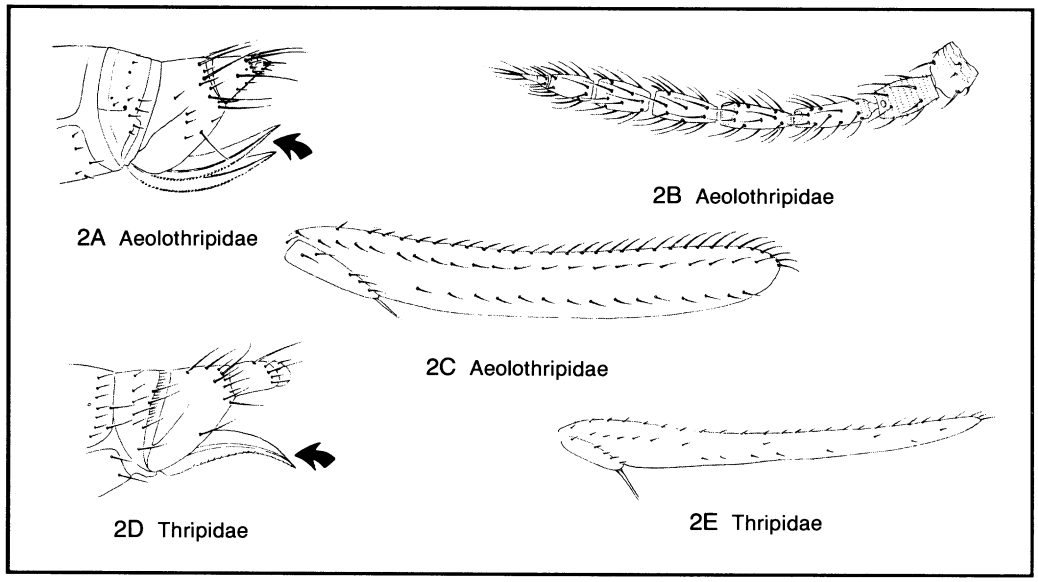
Terebrantia

2 Ovipositor upturned (2A). Aeolothripidae. Genus *Rhipidothrips* ---------- 3

Antenna 9-segmented (2B); wings broad, rounded at tip (2C). The lens-shaped sensoria (2B) on antennal segments III and IV separate this genus from most other members of the family.

Ovipositor downturned (2D). Thripidae ---------- 4

Antenna 6- to 9-segmented; wings usually narrow, pointed at tip (2E). CAUTION: Heterothripidae also keys out at this point, but species of this family are unlikely associates of fruits and vegetables.

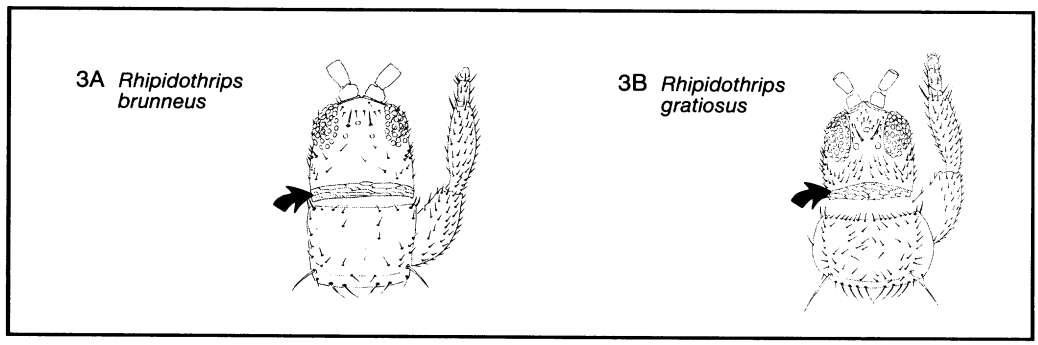


3 Antennal segment II brown; pronotum brown; head with a collar of transverse striations at the posterior margin (3A)----------*Rhipidothrips brunneus*

Distribution: England, Finland, Netherlands, USA (California, Oregon), USSR. Hosts: Grasses.

Antennal segment II yellow; pronotum white, with a small, brown, median blotch in the posterior half; dorsum of head with a collar of polygonal reticulations at the posterior margin (3B)----------*Rhipidothrips gratiosus*

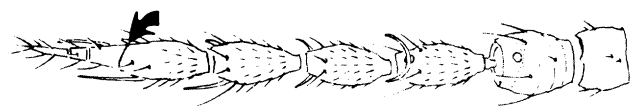
Distribution: Europe, USA (California). Hosts: Oats, grasses.



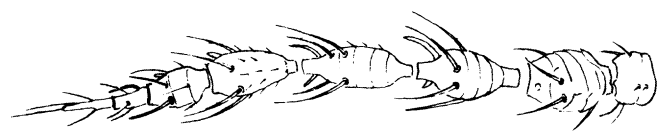
4 Antenna appearing 9-segmented (due to cleavage of segment IV) (4A) ---------- **grass thrips,** *Anaphothrips obscurus*

Body color mainly yellow, with brown markings on base of head, thoracic dorsum, and abdominal tergites. Distribution: Australia, Europe, North America. Hosts: Cereals, grasses, and various other plants.

Antenna 7- or 8-segmented (4B) ---------- 5



4A *Anaphothrips obscurus*



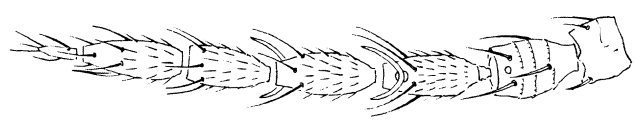
4B Panchaetothripinae

5 Antenna 7-segmented (5A). Genus *Thrips* (in part) ---------- 6

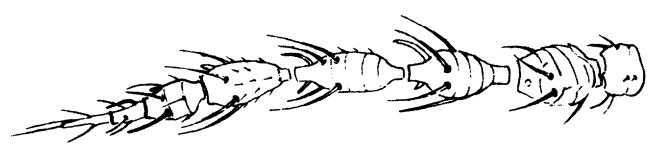
Pronotum with 2 pairs of long posteroangular setae.

Antenna 8-segmented (5B) ---------- 7

Pronotum with or without long posteroangular setae.



5A Thripinae



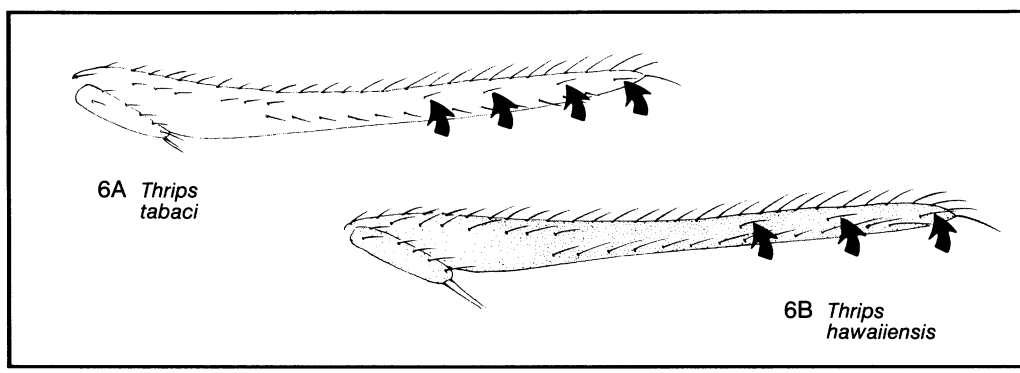
5B Panchaetothripinae

6 Forewing clear; anterior vein with 4 to 6 distal setae (6A); ocellar pigment gray; accessory setae absent from abdominal sternites---------- **onion thrips,** *Thrips tabaci*

Distribution: Cosmopolitan. Hosts: Onions, flowers of many kinds of wild and cultivated plants.

Forewing grayish-brown, clear at base; anterior vein with 3 distal setae (6B); ocellar pigment red; accessory setae present on abdominal sternites II to VII ---------- **Hawaiian flower thrips,** *Thrips hawaiiensis*

Distribution: Australia, Oriental Region, many Pacific islands, USA (District of Columbia, Florida, Georgia, Hawaii, South Carolina, Texas). Hosts: Flowers of numerous cultivated and wild plants.

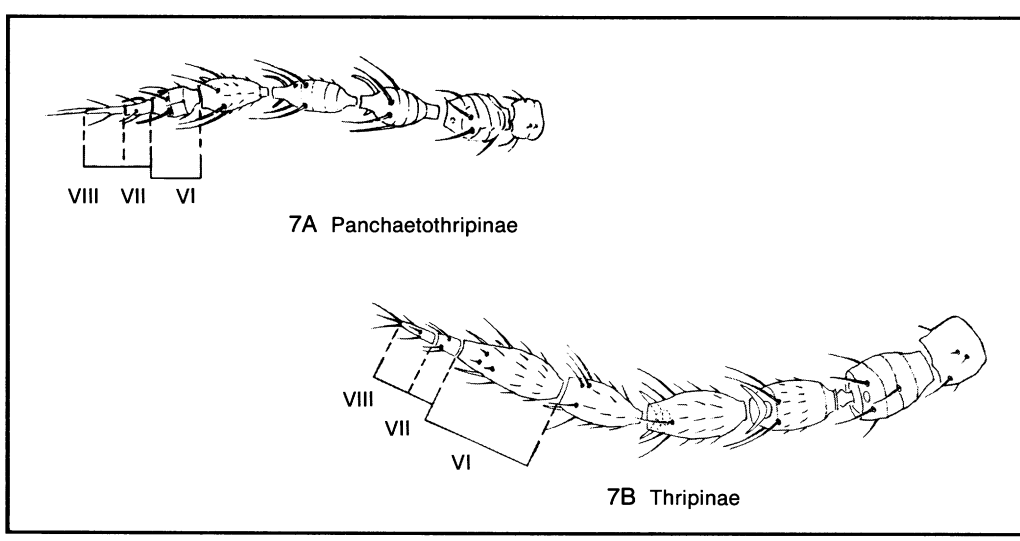


7 Antennal segment VI shorter than combined length of segments VII and VIII (7A); head conspicuously reticulated. Panchaetothripinae ---------- 8

Antennal segments III and IV strongly vasiform (7A).

Antennal segment VI longer than combined lengths of segments VII and VIII (7B); head not conspicuously reticulated. Thripinae---------- 11

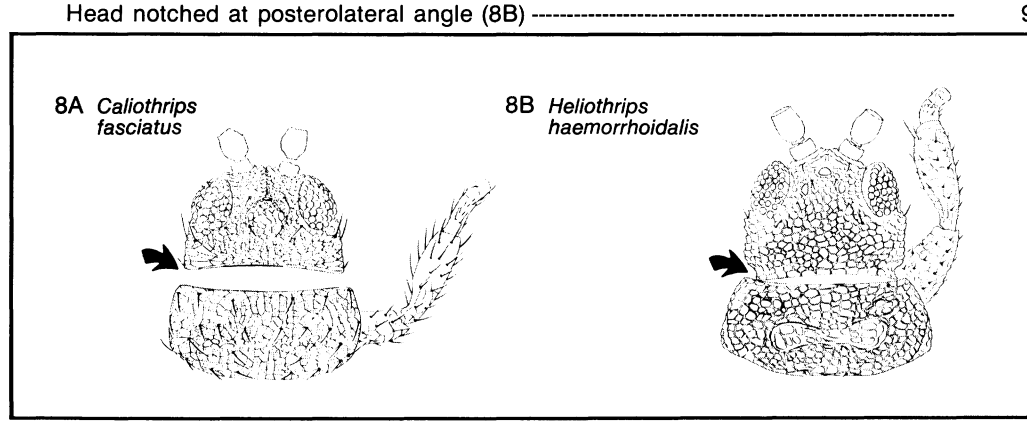
Antennal segments III and IV usually not strongly vasiform (7B).



8 Head not notched at posterolateral angle (8A)---------- **bean thrips,** *Caliothrips fasciatus*

Forewing banded; sides of abdominal tergites reticulated. Distribution: Mexico, USA (New York, Western States in general, including Hawaii). Hosts: Beans, lettuce, oranges; foliage of various garden vegetables; numerous nonfood plants. CAUTION: Some other species of *Caliothrips* may also key out at this point.

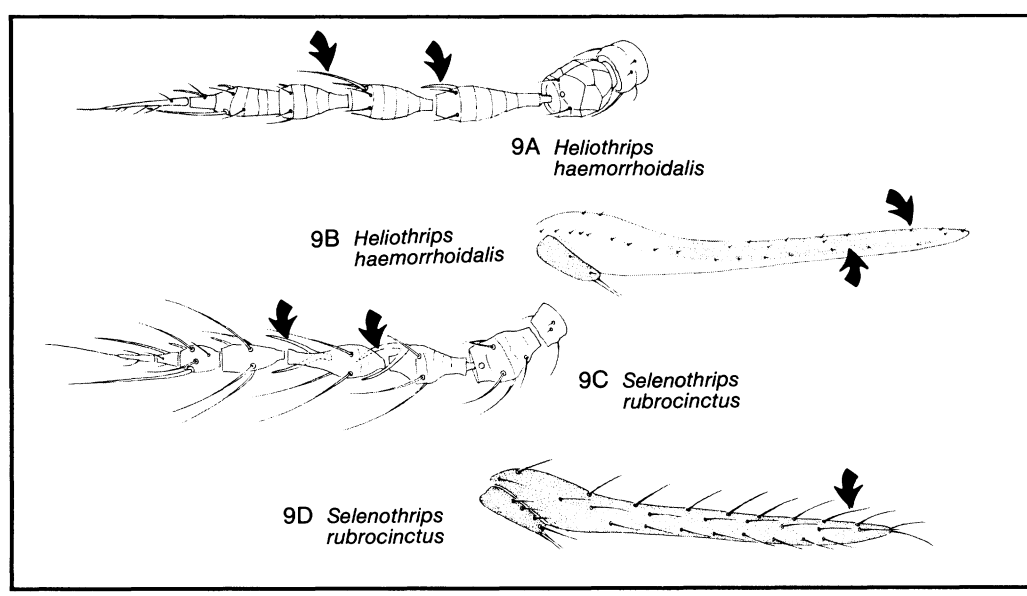
Head notched at posterolateral angle (8B) ---------- 9



9 Antennal segments III and IV with simple sensory trichomes (9A); wing veins with short, inconspicuous setae; forewing clear except for brown posterior vein (9B) ---------- **greenhouse thrips,** *Heliothrips haemorrhoidalis*

Distribution: Africa, Australia, Neotropical Region, Pacific islands, USA; greenhouses in temperate regions. Hosts: Mangoes; numerous nonfood plants. See also 8B.

Antennal segments III and IV with forked sensory trichomes (9C); wing veins with long, conspicuous setae; forewing uniformly brown (9D) or brown with transverse white bands ---------- 10

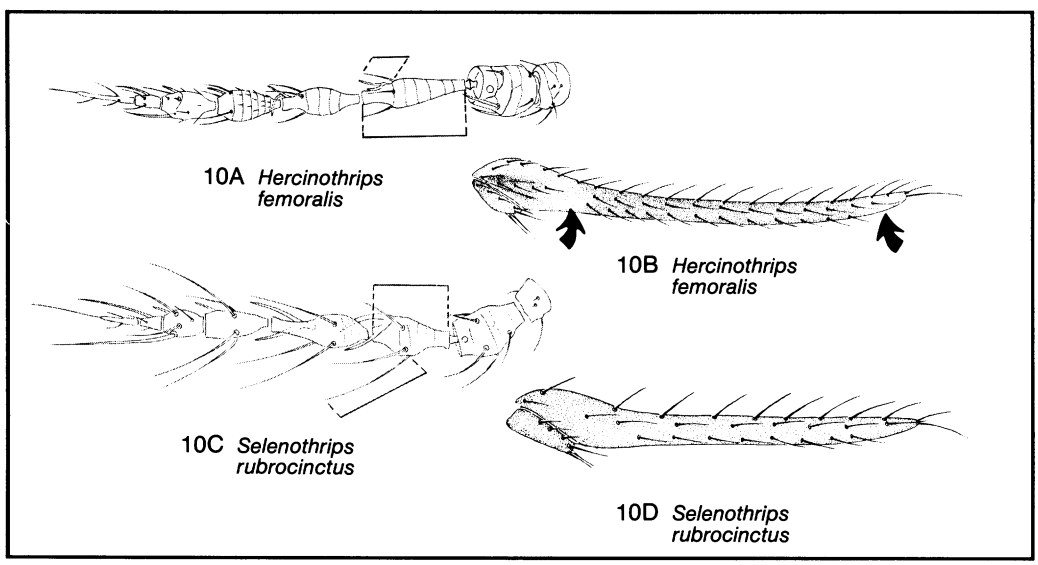


10 Setae on antennal segments III, IV, and V much shorter than their respective segments (10A); forewing with white and dark brown bands (10B)
---------- **banded greenhouse thrips,** *Hercinothrips femoralis*

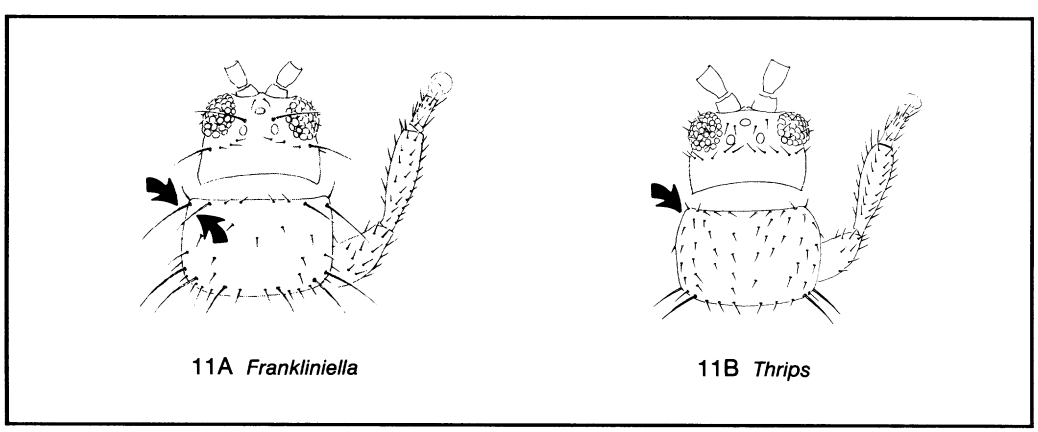
Distribution: Tropical and subtropical regions; USA (California, District of Columbia, Florida, Hawaii, Idaho, Illinois, Massachusetts, Missouri); greenhouses in temperate regions. Hosts: Sugarbeets; numerous wild and cultivated plants.

Setae on antennal segments III, IV, and V much longer than their respective segments (10C); forewing uniformly dark brown (10D)
---------- **redbanded thrips,** *Selenothrips rubrocinctus*

Distribution: Wide occurrence in tropical regions including parts of Africa, Central America, India, Philippines, South America, USA (Florida). Hosts: Mangoes; various fruit trees.



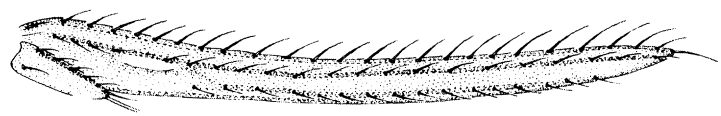
11 Pronotum with 1 pair of long anteroangular and 1 pair of anteromarginal setae (11A); forewing with complete row of setae on anterior vein (see 12A). Genus *Frankliniella* 12
Pronotum without long anteromarginal or anteroangular setae (11B); forewing with a few irregularly-spaced setae on distal half of anterior vein (see 12B)---------- 13



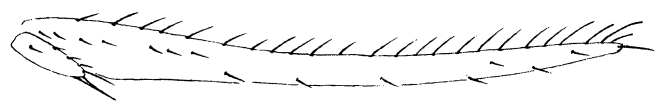
12 Forewing uniformly dark brown (12A)---------- *Frankliniella minuta*

Body dark brown; antenna completely brown, but occasionally with segment III a paler brown; pronotum with alternating short and long posteromarginal setae (see 13B). Distribution: Guatemala, Mexico, Panama, Peru, USA (Colorado, Hawaii, North Dakota, Texas, Wyoming, and several other Western States). Hosts: Flowers of numerous plants.

Forewing clear (as in 12B)----------other species of *Frankliniella*



12A *Frankliniella minuta*

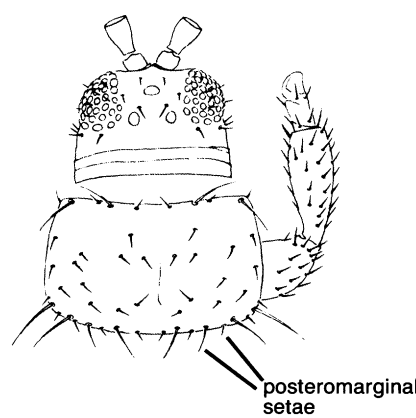


12B *Scirtothrips*

13 Anterior margin of pronotum conspicuously narrower than posterior margin (13A). Genus *Chirothrips*---------- 14

Anterior margin of pronotum equal to or slightly shorter than the posterior margin (as in 13B) ---------- 15

13A *Chirothrips*



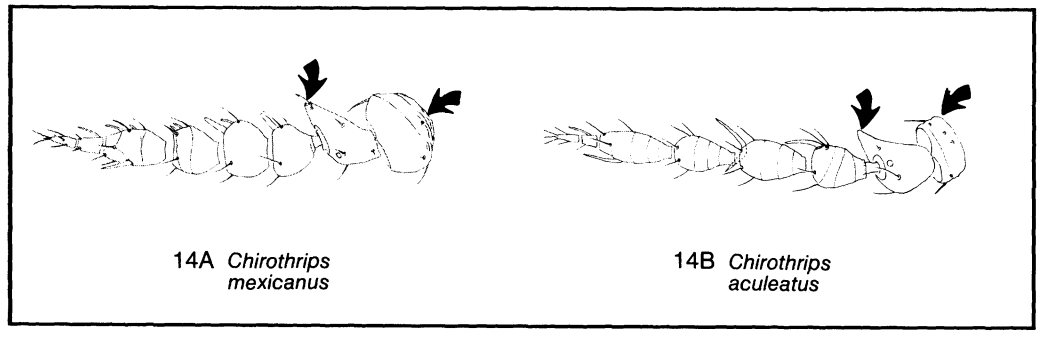
13B *Frankliniella minuta*

14 Antennal segment I large and conspicuously swollen; segment II with a short, stout seta at tip of apical projection; segment IV with a simple sensory trichome (14A); tibia I produced anteriorly on lateral apical margin----------*Chirothrips mexicanus*

Distribution: Caribbean islands, Central and South America, Mexico, Philippines, South Africa, USA (Arizona, California, Florida, Georgia, Hawaii, Louisiana, Oklahoma, Tennessee, Texas). Hosts: Various grasses and other plants.

Antennal segment I not large and conspicuously swollen; segment II without a seta at tip of apical projection; segment IV with a forked sensory trichome (14B); tibia I not produced on lateral apical margin----------*Chirothrips aculeatus*

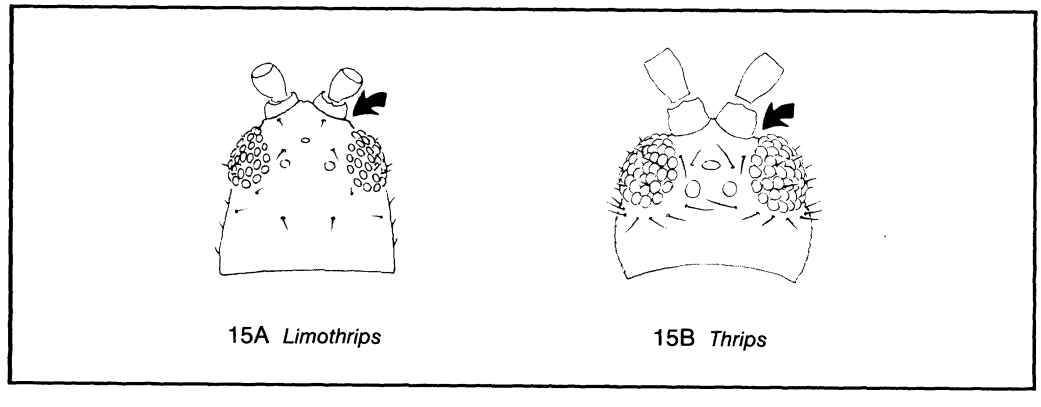
Distribution: Central and southern Europe, England, USA (Pacific Coast). Hosts: Grasses.



14A *Chirothrips mexicanus*

14B *Chirothrips aculeatus*

15 Head produced in front of eyes (15A); abdominal tergite X bearing a pair of stout, spinelike setae. Genus *Limothrips*---------- 16
Head not produced in front of eyes (15B); abdominal tergite X without spinelike setae 17



15A *Limothrips*

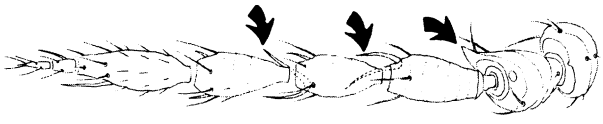
15B *Thrips*

16 Antennal segment II with apical projection; antennal segments III and IV with forked sensory trichomes (16A)----------*Limothrips angulicornis*

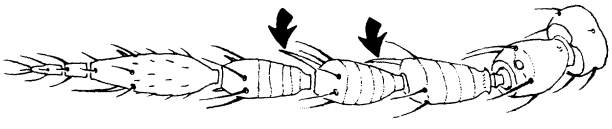
Distribution: Australia, Chile, central and southern Europe, USA (California). Hosts: Grasses and various other plants.

Antennal segment II barrel-shaped; antennal segments III and IV with simple sensory trichomes (16B)----------**grain thrips,** *Limothrips cerealium*

Distribution: Europe, USA, and many other regions of the world. Hosts: Grasses, including oats and other cereals.



16A *Limothrips angulicornis*



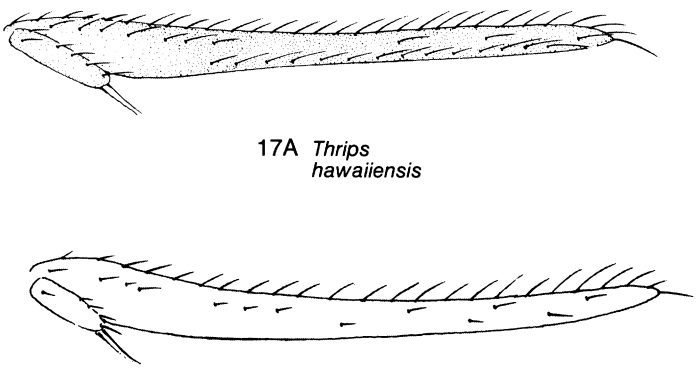
16B *Limothrips cerealium*

17 Forewing grayish-brown, clear at base, with setae in a complete row on posterior vein (17A); abdomen brown, without microsetae; abdominal sternites II to VII with accessory setae; head and thorax yellowish-orange to orange-brown. Genus *Thrips* (in part)---------- **Hawaiian flower thrips,** *Thrips hawaiiensis*

See couplet 6.

Forewing clear, with orange veins and with 3 irregulary-spaced setae on posterior vein (17B); abdomen with numerous microsetae; abdominal sternites II to VII without accessory setae; body yellowish-brown---------- **citrus thrips,** *Scirtothrips citri*

Distribution: USA (Arizona, California). Hosts: Fruits and foliage of orange trees; various nonfood plants. CAUTION: *Sericothrips* also has numerous abdominal microsetae, but there is a complete row of setae on the anterior vein of the forewing. Members of the genus *Sericothrips* are widely distributed in most parts of the world; they feed on grasses, legumes, and many other plants including cucumbers.



17A *Thrips hawaiiensis*

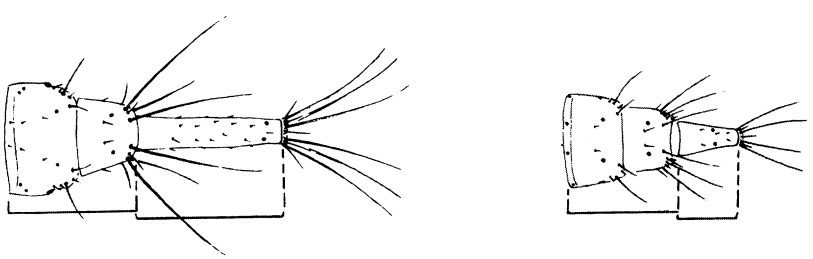
17B *Scirtothrips citri*

Tubulifera

18 Antennal segments III to VIII yellow, with VII and VIII shaded brown; forewing parallel-sided; terminal abdominal segment much longer than combined length of preceding 2 segments (18A)---------- **Cuban laurel thrips,** *Gynaikothrips ficorum*

Distribution: Many tropical countries; occasionally introduced to colder regions. Hosts: Feeds and causes leaf galls on *Ficus* spp.; also found occasionally on some other plants.

Antenna brown with segment III and basal parts of IV and V yellow, or III to VI yellow with apices of V and VI brown; forewing narrowed medially; terminal abdominal segment much shorter than combined length of preceding 2 segments (18B). Genus *Haplothrips* ---------- 19



18A *Gynaikothrips ficorum*

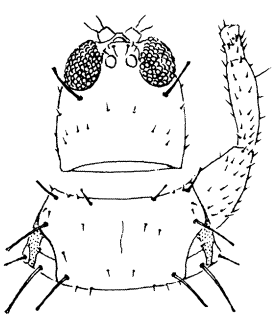
18B *Haplothrips*

19 Head about as long as wide; pronotum with well-developed major lateral setae (19A); internal pigmentation red; antennal segments III and IV and basal parts of V and VI yellow---------- **black flower thrips,** *Haplothrips gowdeyi*

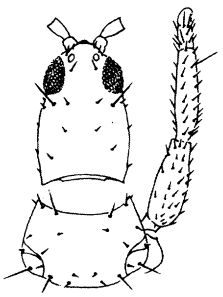
Distribution: Africa, Caribbean islands, Central and South America, India, Israel, Mexico, Pacific islands, USA (California, Florida, Georgia, Hawaii, Texas). Hosts: Flowers of numerous cultivated and wild plants.

Head much longer than wide; pronotum with minute major lateral setae (19B); internal pigmentation purple; antennal segments III and basal parts of IV and V yellow ---------- **black hunter thrips,** *Haplothrips mali*

Distribution: Canada, Mexico, USA. Feeding habits: Predaceous on eggs and immature stages of other insects.



19A *Haplothrips gowdeyi*



19B *Haplothrips mali*

24 APHIDS (APHIDIDAE, HOMOPTERA)

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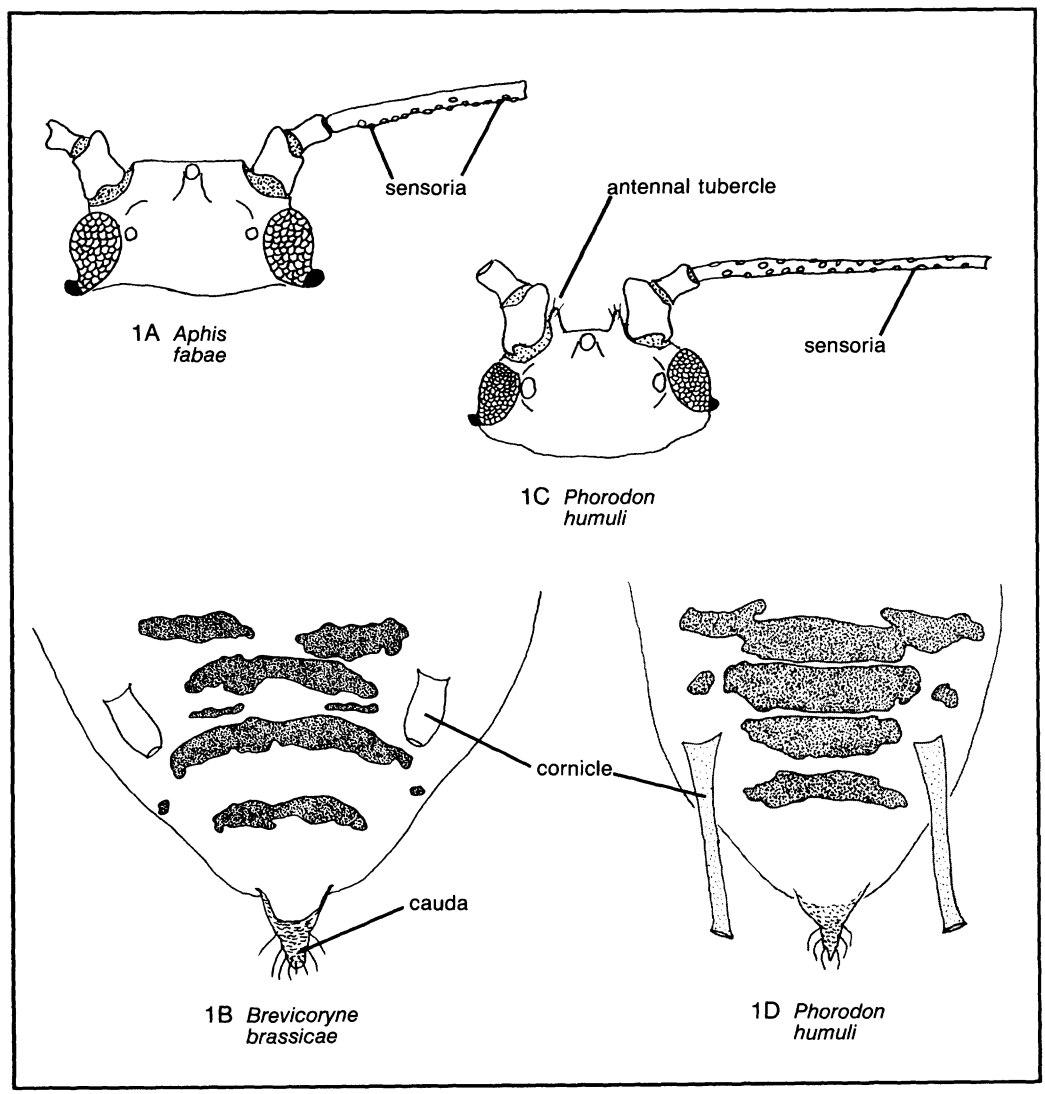
KEY
Drawings by M.B. Stoetzel.

1 Head without prominent antennal tubercles (1A); cornicle never longer than 3 times length of hind tarsus (1B)---------- 2
Head with prominent antennal tubercles (1C); cornicle 3 times or more longer than length of hind tarsus (1D)---------- 3



1A *Aphis fabae*

1C *Phorodon humuli*

1B *Brevicoryne brassicae*

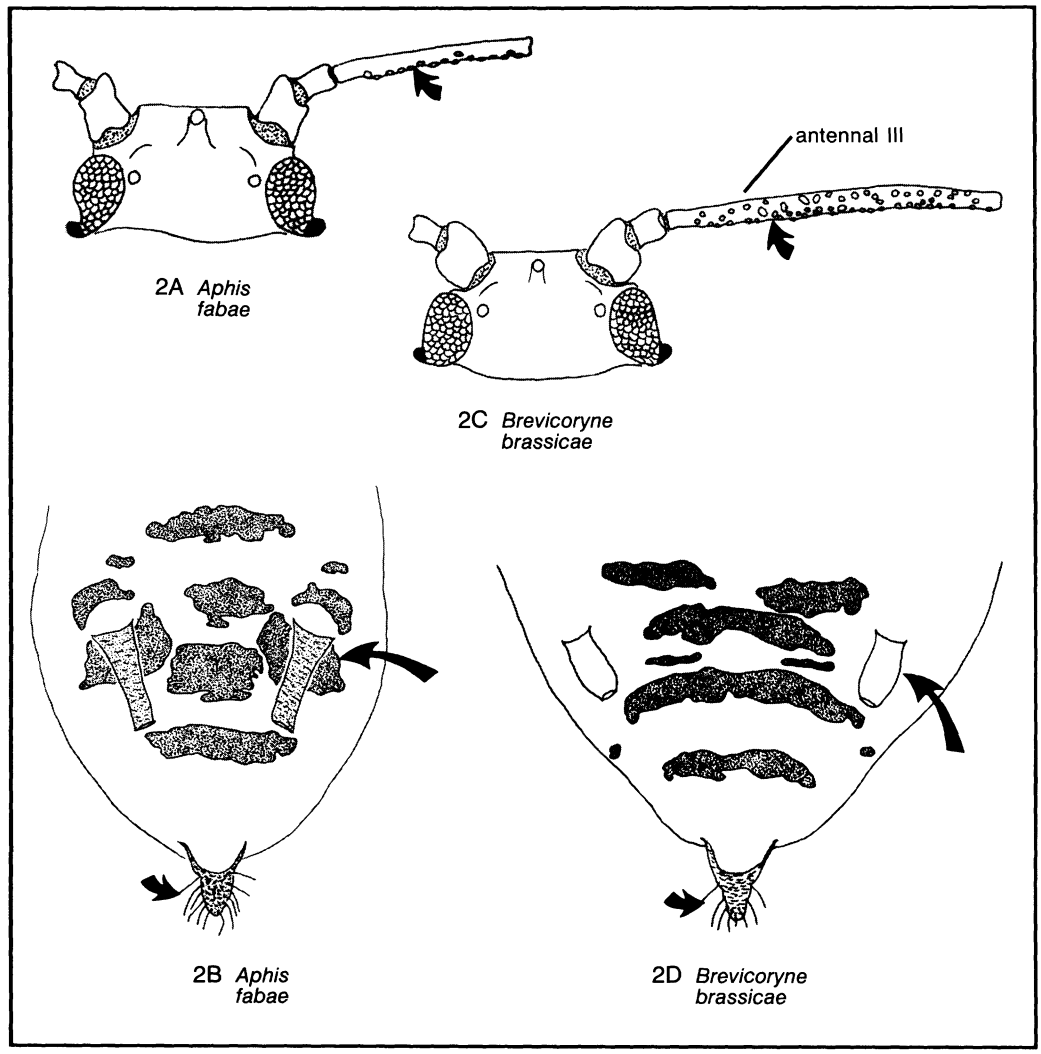
1D *Phorodon humuli*

2 Alata with 12 to 18 sensoria on antennal III (2A); cornicle cylindrical, longer than cauda; cauda bushy with 12 to 14 hairs; abdomen of alata with 4 rows of dark spots and a dark area behind base of each cornicle (2B)----------**bean aphid,** *Aphis fabae*

Distribution: Holarctic, Ethiopian. Hosts: Leaves and stems of *Euonymus* and *Viburnum* as winter hosts, and on various plants (beans, beets, carrots, corn, lettuce, rhubarb, squash) as summer hosts. References: *1, 2, 4-6.*

Alata with 43 to 67 sensoria on antennal III (2C); cornicle swollen, not longer than cauda; cauda tapering, with 6 hairs; abdomen of alata with broken, dusky dashes but no dark area behind base of each cornicle (2D) ----------**cabbage aphid,** *Brevicoryne brassicae*

Distribution: Worldwide. Hosts: Broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, kale, mustard, radishes. References: *1-7.*



2A *Aphis fabae*

2C *Brevicoryne brassicae*

2B *Aphis fabae*

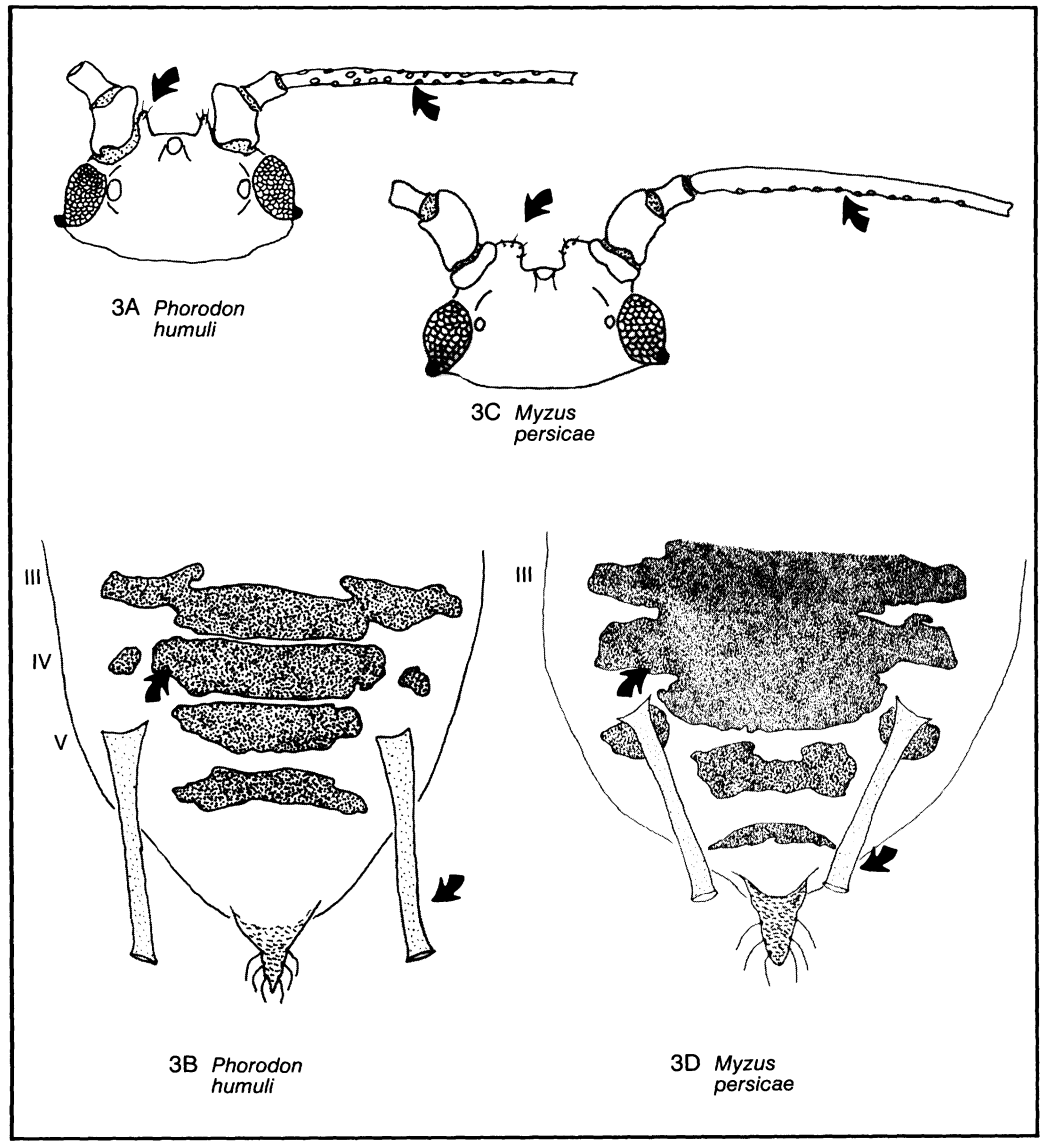
2D *Brevicoryne brassicae*

3 Alata with 23 to 27 sensoria widely distributed on antennal III; inner angle of antennal tubercle with elongate process (3A); cornicle cylindrical on distal half; abdomen of alata with dorsal bands, nearly coalescing, on III, IV and V; no dark area behind base of each cornicle (3B)----------**hop aphid,** *Phorodon humuli*

Distribution: Holarctic. Hosts: Plum leaves in winter and hop leaves in summer. References: *1, 6.*

Alata with 6 to 17 sensoria in a line on antennal III; inner angle of antennal tubercle rounded (3C); cornicle slightly dilated on distal half; abdomen of alata with dorsal patch extending from III to level of cornicle (3D)
----------**green peach aphid,** *Myzus persicae*

Distribution: Worldwide. Hosts: Polyphagous.
References: *1-7.*



3A *Phorodon humuli*

3C *Myzus persicae*

3B *Phorodon humuli*

3D *Myzus persicae*

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Notes and Sketches

25 SCALE INSECTS (COCCOIDEA, HOMOPTERA)

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Scale insects are unique among the Insecta in that the adult females are wingless, neotenic (sexually mature nymphs), and often produce some sort of waxy covering. Adult males (fig. 25.1) superficially resemble small wasps or flies but are unique in having one pair of well-developed wings and a smaller second pair of wings (hamulohalterae). The males lack functional mouthparts and are often short-lived.

The first instar is usually called the crawler because it is generally the only active crawling stage. Immature instars may be recognized as such by their lack of a vulva or aedeagus. In most scale insects the remaining instars, excluding adult males, are sessile, even though some have legs and are capable of moving on the host. Male scales undergo an anomalous kind of complete metamorphosis that involves one or two "pupal" stages before the adult form is reached.

Several characters may be used to distinguish the Coccoidea from other homopterous insects: a single tarsal claw on each leg; a one-segmented tarsus (usually); wingless females; and adult males with one pair of wings and one pair of hamulohalterae.

In the United States there are 15 families of Coccoidea. Aclerdidae (aclerdids), Cerococcidae (cerococcids), Conchaspididae (conchaspidids), Dactylopiidae (cochineal insects), Kermesidae (gall-like scales), Tachardiidae (lac scales), Lecanodiaspididae (false pit scales), and Phoenicococcidae (phoenicococcids) are not included here because they are rarely collected and are unlikely food contaminants. Of the remaining seven relatively commonly collected families, three contain species that might be found in foods.

Foods that commonly have scale insects are citrus, tropical fruits, deciduous-tree fruits, and grapes. The three families often associated with food may be recognized by the following field characters.

Pseudococcidae (**mealybugs**): The body is usually covered with a mealy, white secretion, and the margin of the body, particularly the posterior margin, normally has at least one pair of waxy filaments (fig. 25.2).

Diaspididae (**armored scales**): A solid waxy cover is produced that is separate from the body. The waxy cover may be round, oval, or elongate and incorporates the shed skins of the crawler and second instar (fig. 25.3).

Coccidae (**soft scales**): The body is usually without wax on the upper surface or the wax is transparent. Some species produce a thick, chewing-gumlike wax or a filamentous wax, but in soft scales the wax is attached to the body surface and there are no marginal filaments except those associated with the spiracles (fig. 25.4).

The classification system of scale insects is based primarily on adult females. The following key is restricted to species that occur in the United States and can be used only with adult females mounted on microscope slides and examined with a compound microscope. A handout on scale insect mounting techniques may be obtained by writing to me at the address given above.

Figures 25.5 and 25.7-25.29 are of bilaterally divided adult females (left = dorsal; right = ventral). Figure 25.4 shows the dorsal surface only; figure 25.6, the ventral surface only. Figures 25.7, 25.8, 25.13 and 25.14 do not show dermal morphology in detail. Figures 25.24 and 25.25 lack the multitude of dermal structures apparent on slide-mounted specimens; only diagnostic features are presented in these figures.

KEY
Drawings (figs. 25.4-25.29) by P.J. Hollyoak.

1 Abdominal spiracles present (fig. 25.5)---------- 2
Abdominal spiracles absent (fig. 25.9)---------- 3

2 Anal orifice surrounded by a sclerotized ring on exterior surface of body; anal ring bearing setae and pores (fig. 25.5)----------**ensign scales,** Ortheziidae

Anal orifice without sclerotization on exterior body surface; occasionally with internal tube leading to orifice sclerotized and having pores but not setae (fig. 25.6) ----------**margarodid scales,** Margarodidae

3 Posterior abdominal segments forming a pygidium (fig. 25.9). Diaspididae (**armored scales**)---------- 4
Posterior abdominal segments not forming a pygidium (fig. 25.20)---------- 16

4 Body elongate; body length at least twice greatest width (fig. 25.8)---------- 5
Body round or oval; body length less than twice greatest width (fig. 25.12)---------- 9

5 Median lobes appearing as a single lobe (fig. 25.8). Genus *Pinnaspis*---------- 6
Median lobes separate, appearing as 2 lobes (fig. 25.9)---------- 7

6 Scale cover white; preanal scars present (fig. 25.7) ----------lesser snow scale, *Pinnaspis strachani*

Distribution: Worldwide. Hosts: Polyphagous.

Scale cover brown; preanal scars absent (fig. 25.8)-------**fern scale,** *Pinnaspis aspidistrae*

Distribution: Worldwide. Hosts: Polyphagous; especially ferns, *Citrus, Aspidistra.*

7 With 3 pairs of lobes (fig. 25.9)----------**citrus snow scale,** *Unaspis citri*

Perivulvar pores present or absent. Distribution: Africa, Asia, Australia, Bermuda, Oceania, USA (Florida, Louisiana). Hosts: *Citrus, Severina.*

With 2 pairs of lobes (fig. 25.11). Genus *Lepidosaphes*---------- 8

Perivulvar pores present.

8 Thorax and anterior abdominal segments sclerotized; some abdominal segments with marginal spurs (fig. 25.10)----------**Glover scale,** *Lepidosaphes gloveri*

Distribution: Worldwide. Hosts: Especially *Citrus.*

Thorax and anterior abdominal segments not sclerotized; abdominal marginal spurs absent (fig. 25.11)----------**purple scale,** *Lepidosaphes beckii*

Distribution: Worldwide. Hosts: Especially *Citrus.*

9 Perivulvar pores absent (fig. 25.12)---------- 10
Perivulvar pores present (fig. 25.15)---------- 12

10 Body without prosomal lobes; pygidial lobes converging apically (fig. 25.12) ----------**San Jose scale,** *Quadraspidiotus perniciosus*

Distribution: Africa, Asia, Australia, Cuba, Europe, Mexico, New Zealand, South America, USA (widely distributed). Hosts: Polyphagous, especially *Malus, Prunus,* and most Rosaceae.

Body with large prosomal lobes; pygidial lobes parallel (fig. 25.13). Genus *Aonidiella* 11

11 Scale yellowish on host; without well-developed scleroses anterior to prevulvar apophysis (fig. 25.13)----------**yellow scale,** *Aonidiella citrina*

Distribution: Africa (Guinea, Zaire), Asia (including area around the Black Sea), Australia, Mexico, Oceania (Bonin Islands, New Guinea), South America (Argentina, Chile), USA (California, Florida, Texas). Hosts: Especially *Citrus*.

Scale reddish on host; with well-developed scleroses anterior to prevulvar apophysis (fig. 25.14)----------**California red scale,** *Aonidiella aurantii*

Distribution: USA (Alabama, California, Florida, Georgia, Texas); widespread throughout warm parts of the world. Hosts: Especially *Citrus*.

12 Spiracular pores near anterior spiracles (fig. 25.15)---------- 13
Spiracular pores absent (fig. 25.17)---------- 14

13 Second lobes each with 2 lobules; medial lobes fused at base; with more than 50 perivulvar pores (fig. 25.15)----------**white peach scale,** *Pseudaulacaspis pentagona*
----------white prunicola, *Pseudaulacaspis prunicola*

Distribution: Worldwide: Hosts: Polyphagous; white prunicola, especially *Prunus*.

Second lobes simple, with 1 lobule; median lobes separate at base; with less than 50 perivulvar pores (fig. 25.16)----------**chaff scale,** *Parlatoria pergandii*

Distribution: Worldwide. Hosts: Especially *Citrus*.

14 Prepygidial abdomen with isolated cluster of submarginal, dorsal ducts on each side (fig. 25.17)----------**Florida red scale,** *Chrysomphalus aonidum*

Distribution: Throughout warm areas of the world. Hosts: Polyphagous, especially *Citrus*.

Prepygidial abdomen with submarginal, dorsal ducts scattered along posterolateral margin (fig. 25.18)---------- 15

15 Dorsal tubular ducts less than 5 times as long as wide; median lobes approximately parallel (fig. 25.18)----------**oleander scale,** *Aspidiotus nerii*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: Polyphagous.

Dorsal tubular ducts more than 5 times as long as wide; median lobes apically convergent (fig. 25.19)----------**latania scale,** *Hemiberlesia lataniae*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: Polyphagous.

16 8-shaped pores somewhere on body (normally in a band near body margin) (fig. 25.20)
----------**pit scales,** Asterolecaniidae

8-shaped pores absent (fig. 25.21)---------- 17

17 Anal region with 2 anal plates forming an operculum (fig. 25.21). Coccidae (**soft scales**)---------- 18
Anal region without plates (fig. 25.23)---------- 19

18 Ventral tubular ducts in a band around body margin (absent from area between legs); inner filament of tubular ducts swollen (fig. 25.21)-----**hemispherical scale,** *Saissetia coffeae*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: Polyphagous.

Ventral tubular ducts in area between middle pair of legs (rare or absent near body margin); inner filament of tubular ducts not swollen (fig. 25.22) ----------**brown soft scale,** *Coccus hesperidum*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: Polyphagous. See also fig. 25.4.

19 Body without ostioles, cerarii, and circulus; tubular ducts invaginated; in life, without mealy secretion except on venter; without marginal filaments (fig. 25.23) ----------**eriococcid scales,** Eriococcidae

Body with ostioles, cerarii, circulus, and noninvaginated tubular ducts (fig. 25.24); in life, covered with mealy, white secretion and bearing several marginal filaments (fig. 25.2). Pseudococcidae (**mealybugs**)---------- 20

20 With 18 pairs of cerarii; ventral anal-lobe area with a narrow, sclerotized bar (fig. 25.24) ----------**citrus mealybug,** *Planococcus citri*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: Polyphagous, especially *Citrus*.

With less than 18 pairs of cerarii; without narrow, sclerotized bar on anal lobe (fig. 25.25)---------- 21

21 Oral-rim tubular ducts present (fig. 25.25). Genus *Pseudococcus* ---------- 22
Oral-rim tubular ducts absent (fig. 25.27)---------- 23

22 Many dorsal cerarii with 2 or more associated oral-rim tubular ducts; multiocular pores restricted to posterior 2 or 3 abdominal segments (fig. 25.25) ----------**longtailed mealybug,** *Pseudococcus longispinus*

Distribution: Widespread; occurring out-of-doors in warm areas. Hosts: On many tropical plants. See also fig. 25.2.

Dorsal cerarii with at most 1 associated oral-rim tubular duct; multilocular pores on at least posterior 5 or 6 abdominal segments (fig. 25.26) ----------**grape mealybug,** *Pseudococcus maritimus*

Distribution: USA. Hosts: Especially grapes and deciduous fruit trees.

23 Dorsomedial areas with conical setae about same size as conical cerarian setae (fig. 25.27)----------**coconut mealybug,** *Nipaecoccus nipae*

Distribution: Most warm areas of the world. Hosts: Many hosts, especially palms.

Dorsomedial areas with slender setae unlike conical cerarian setae (fig. 25.28). Genus *Dysmicoccus*---------- 24

24 Setae on dorsomedial area of abdominal segments VIII and IX noticeably longer than setae on rest of dorsum (fig. 25.28)---------**pineapple mealybug,** *Dysmicoccus brevipes*

Distribution: Primarily the New World, but also reported from Africa, Asia, and Oceania. Hosts: Polyphagous, especially pineapple.

Setae on dorsomedial area of posterior abdominal segments about same length as those on rest of dorsum (fig. 25.29)
----------**gray pineapple mealybug,** *Dysmicoccus neobrevipes*

Distribution: Mexico, Oceania. Hosts: Polyphagous.

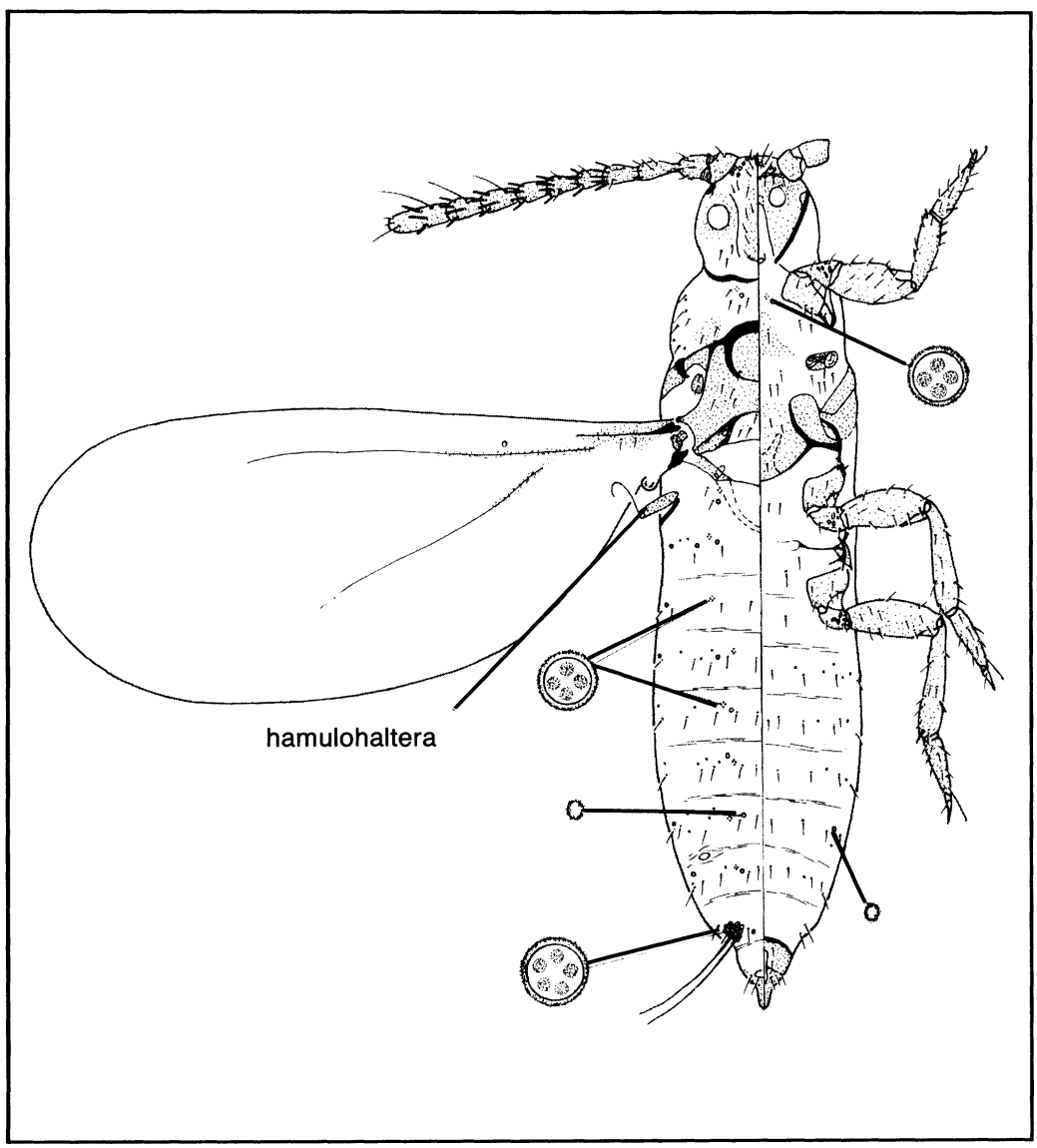

Figure 25.1 *Brevennia rehi* (Lindinger) (Pseudococcidae), male, dorsal (left) and ventral (right) views. (Drawing by D.R. Miller.)

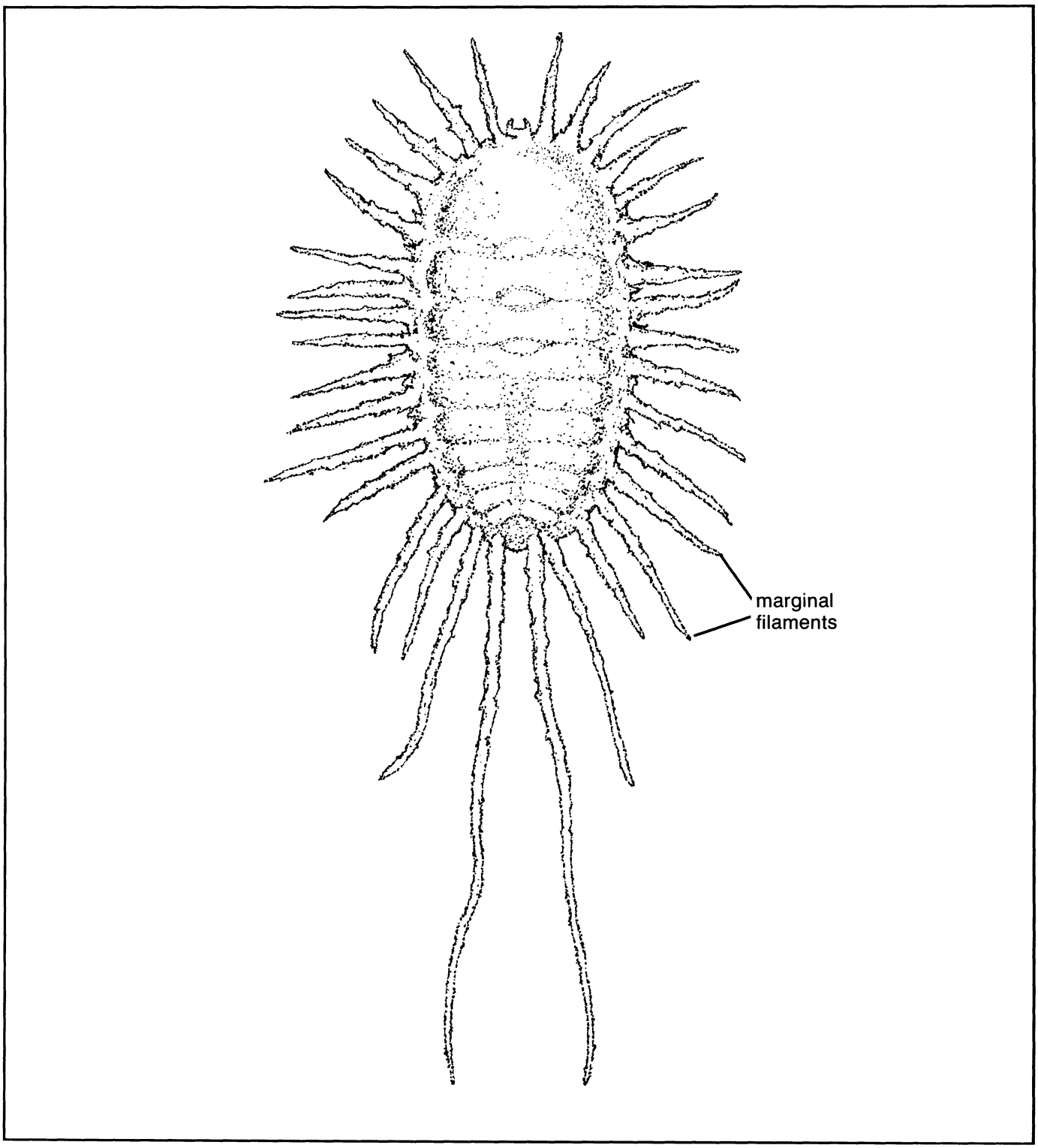

Figure 25.2. **Longtailed mealybug,** *Pseudococcus longispinus* (Pseudococcidae), female, dorsal view. (Drawing by P.J. Hollyoak.)

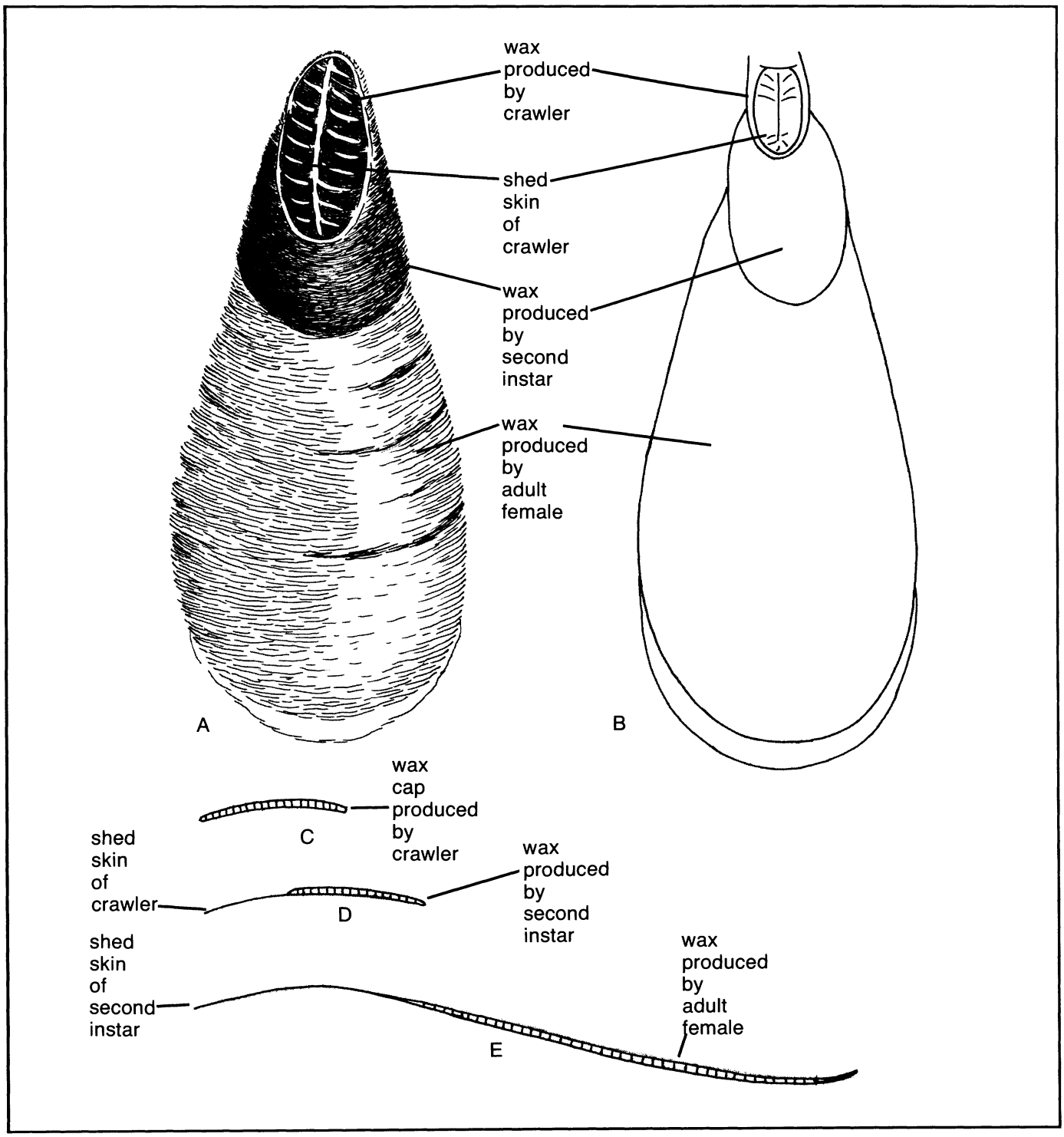

Figure 25.3. An armored scale (Diaspididae): A, scale cover, dorsal view, actual appearance; B, same, diagrammatic; C, D, E, lateral views, diagrammatic, of longitudinal sections through scale cover. (Drawings by J.A. Davidson.)

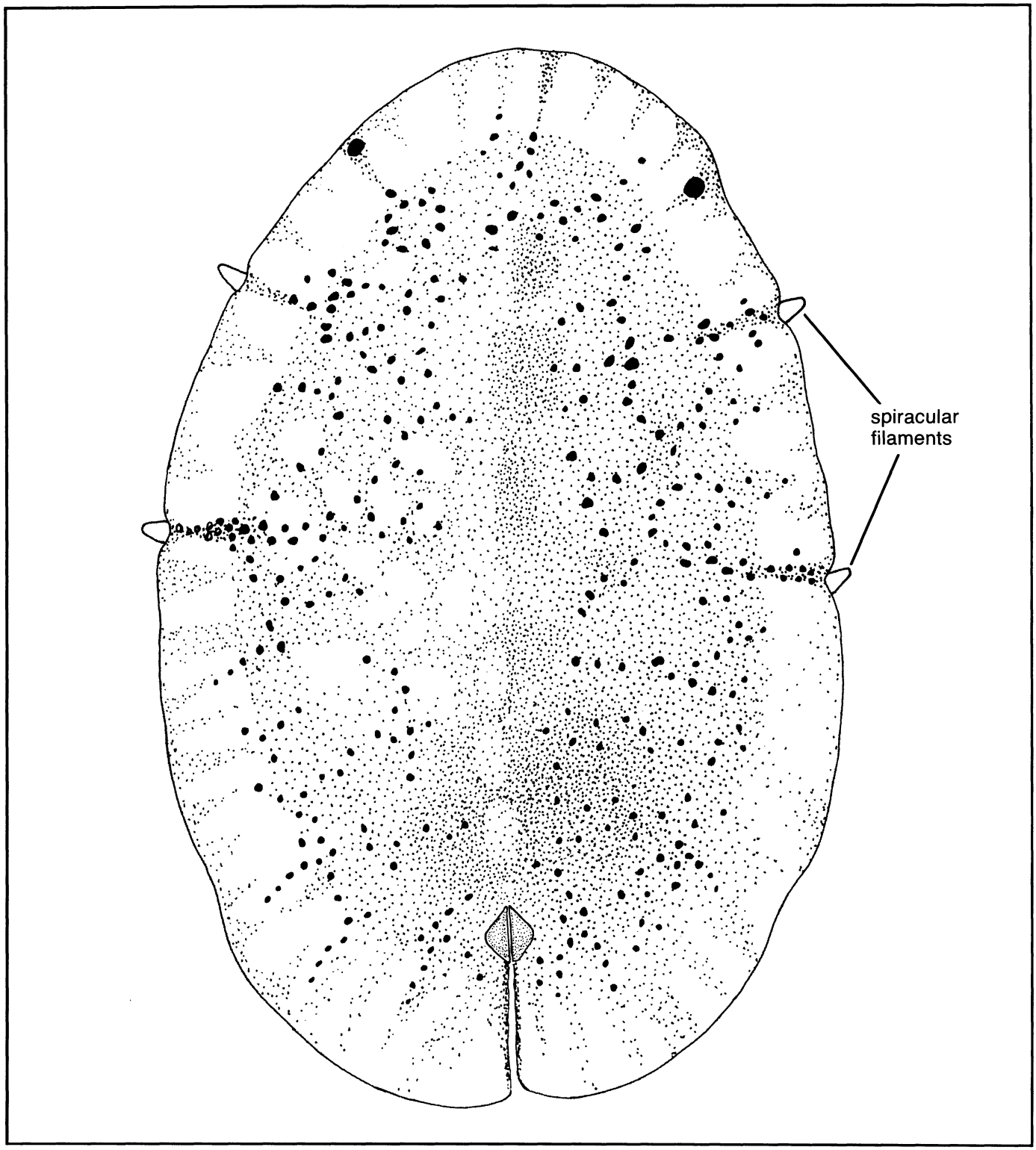

Figure 25.4. **Brown soft scale,** *Coccus hesperidum* (Coccidae), female, dorsal view.

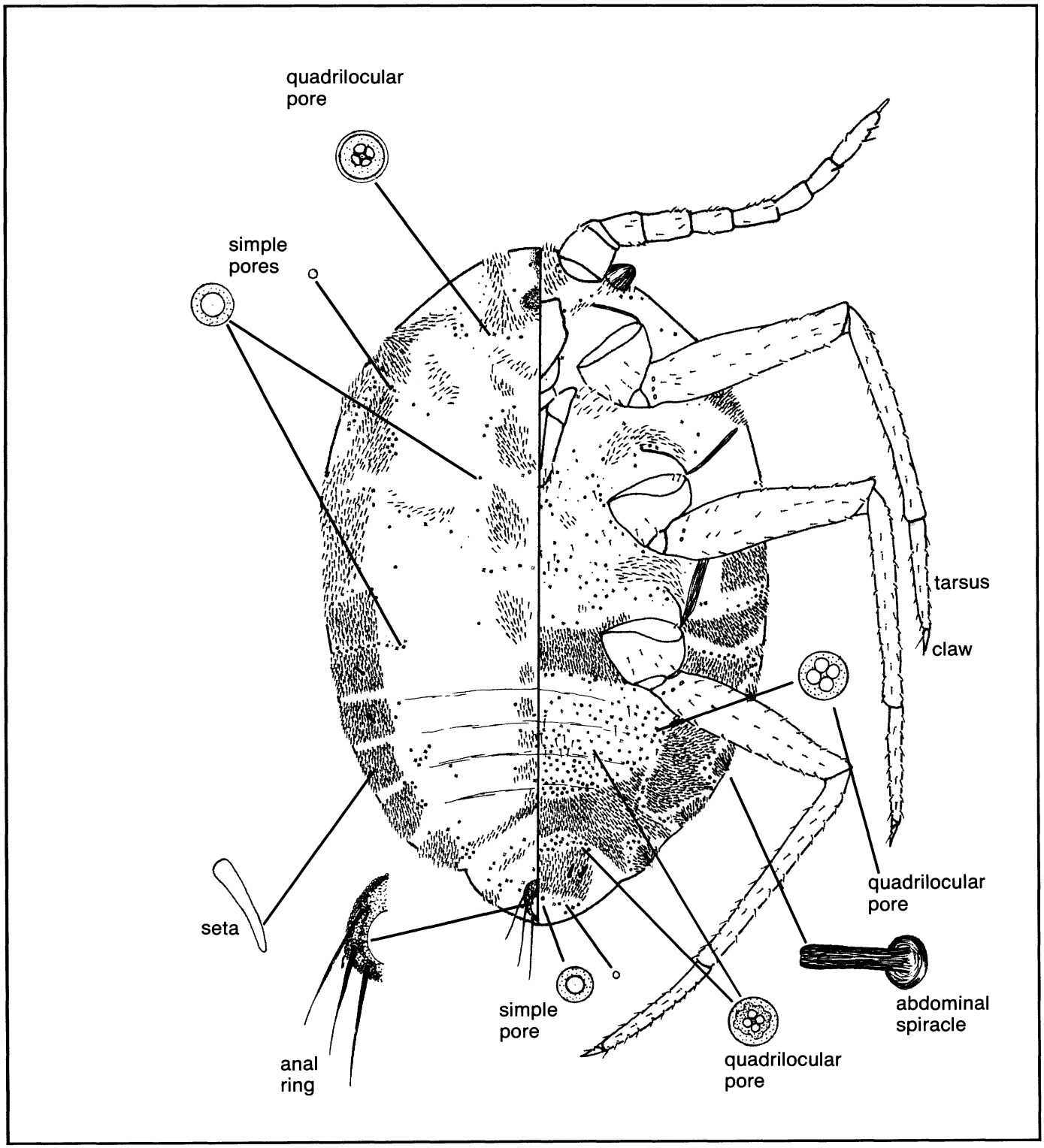

Figure 25.5. **Greenhouse orthezia,** *Orthezia insignis* Browne (Ortheziidae).

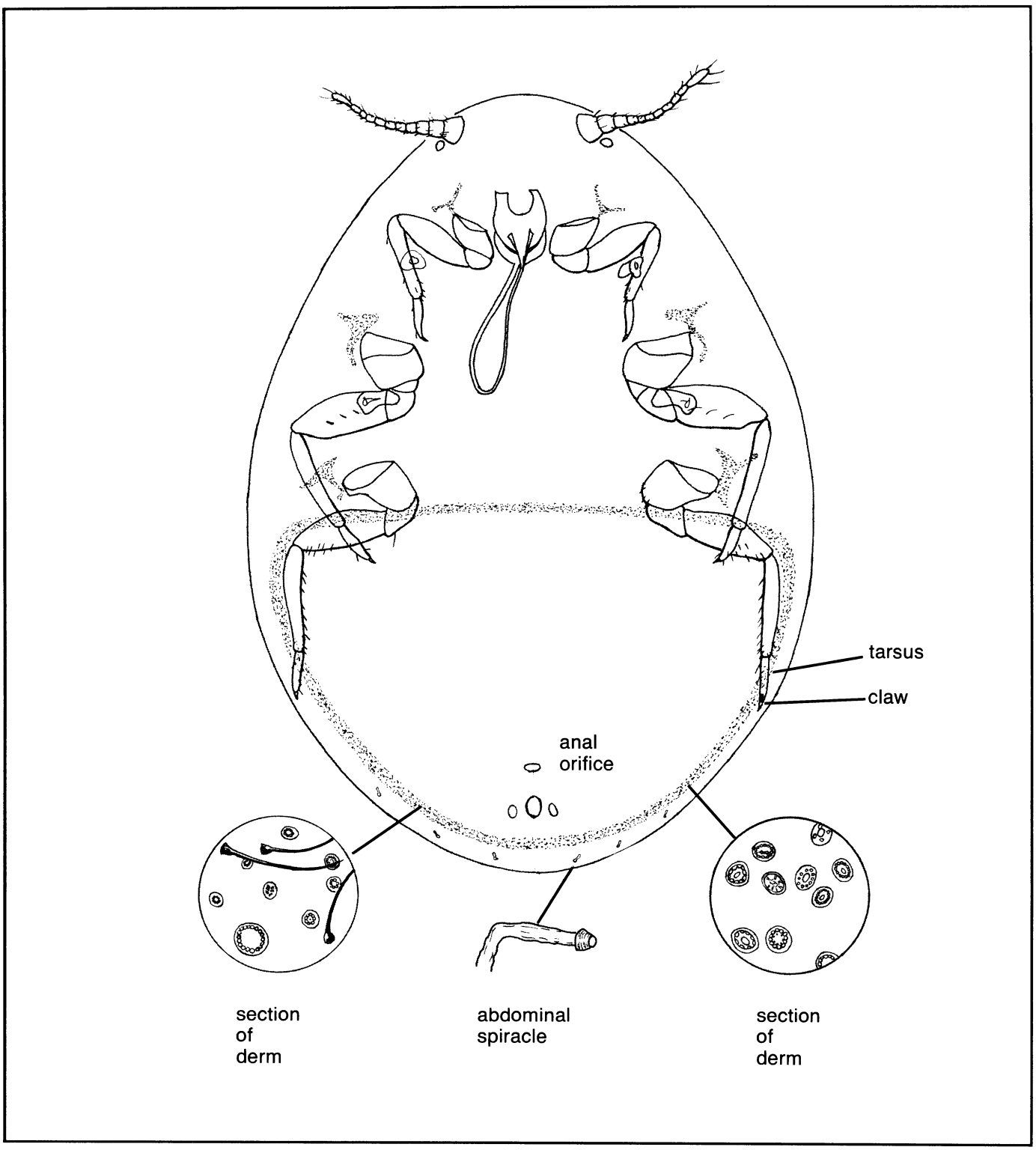

Fig 25.6. *Icerya seychellarum* (Westwood) (Margarodidae).

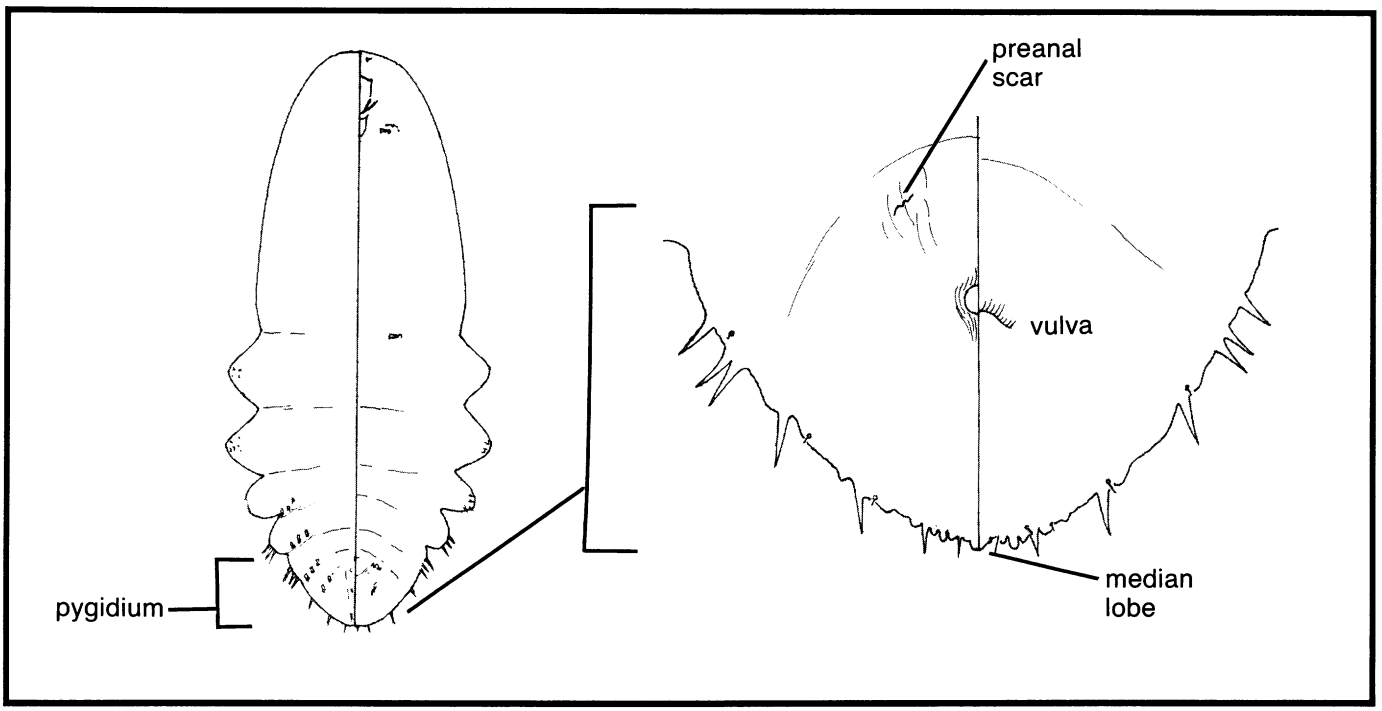

Figure 25.7. **Lesser snow scale,** *Pinnaspis strachani* (Diaspididae).

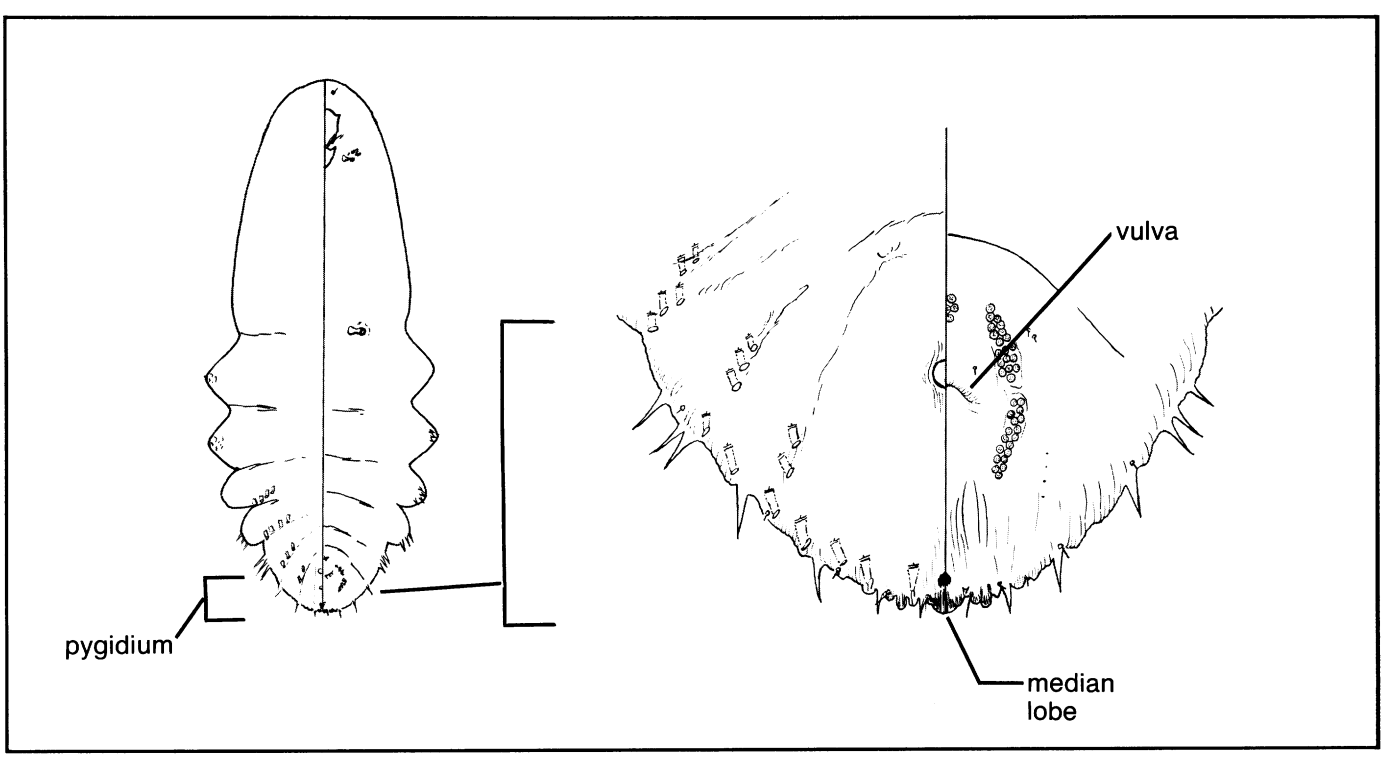

Figure 25.8. **Fern scale,** *Pinnaspis aspidistrae* (Diaspididae).

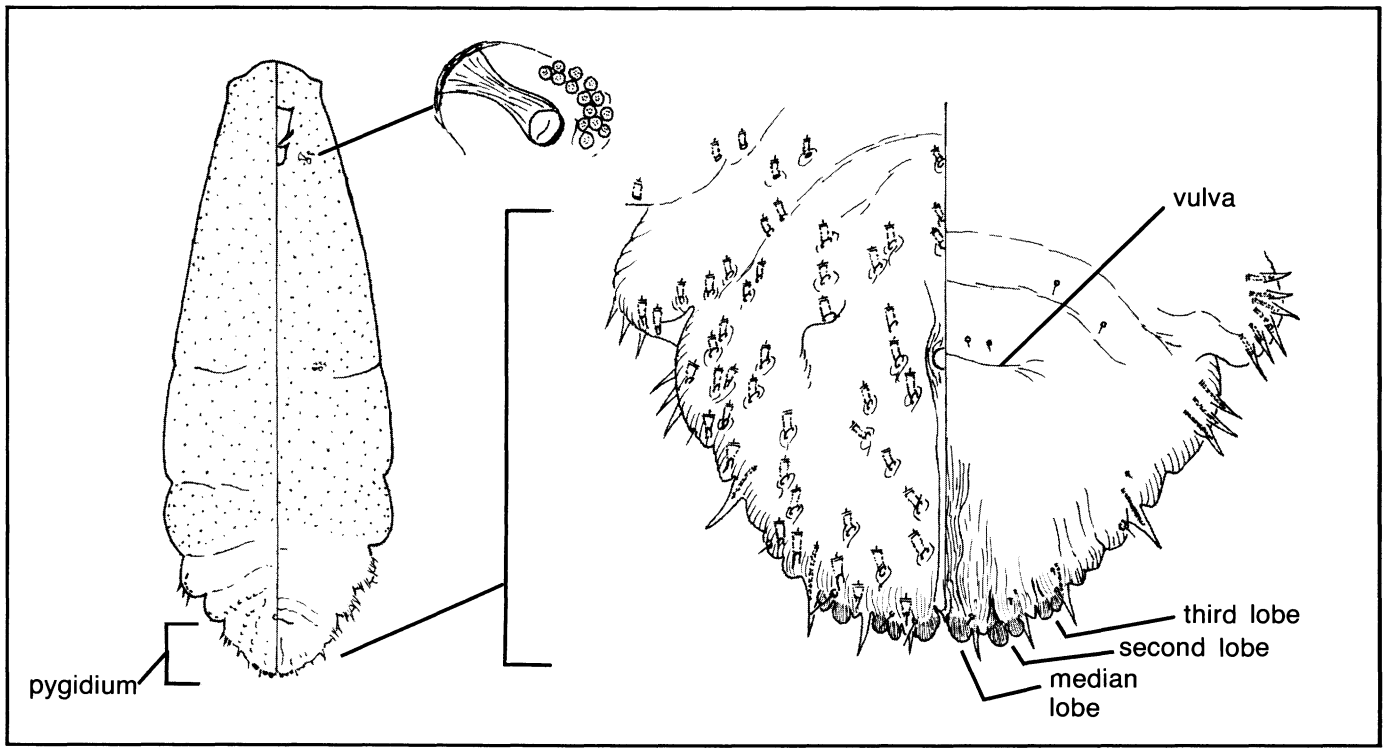

Figure 25.9. **Citrus snow scale,** *Unaspis citri* (Diaspididae).

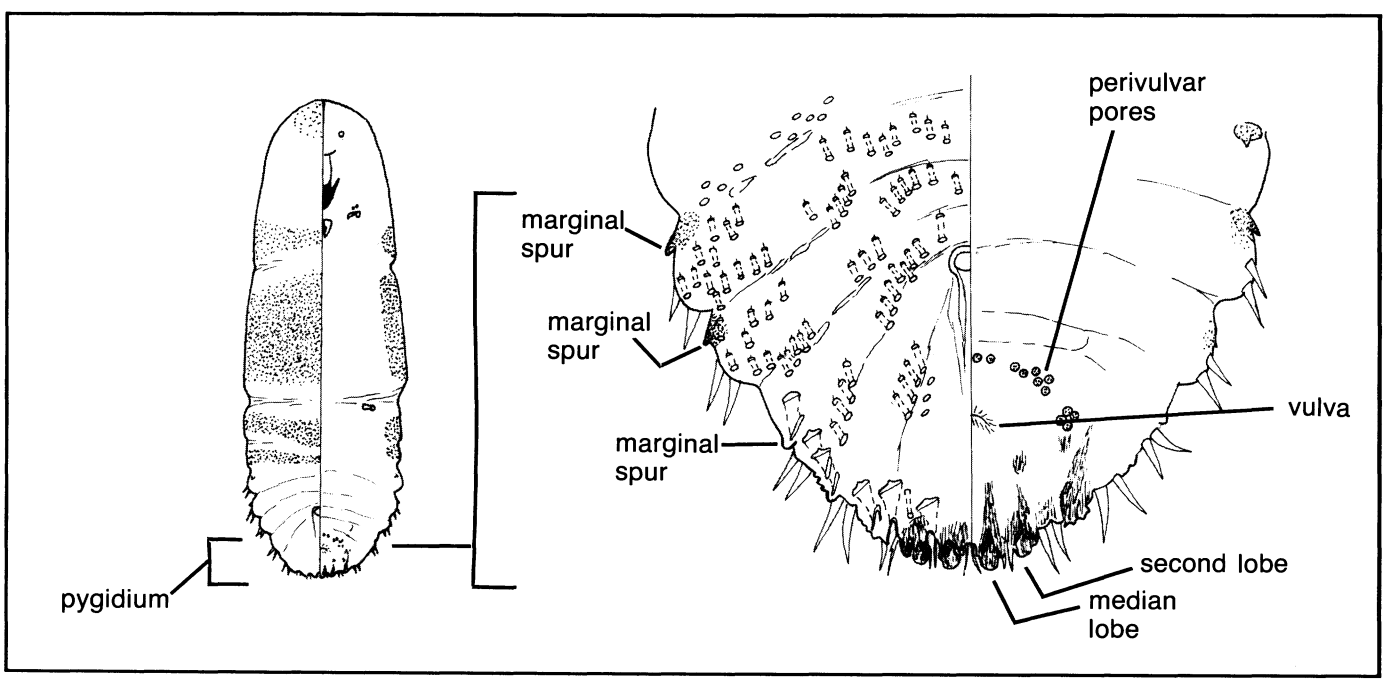

Figure 25.10. **Glover scale,** *Lepidosaphes gloveri* (Diaspididae).

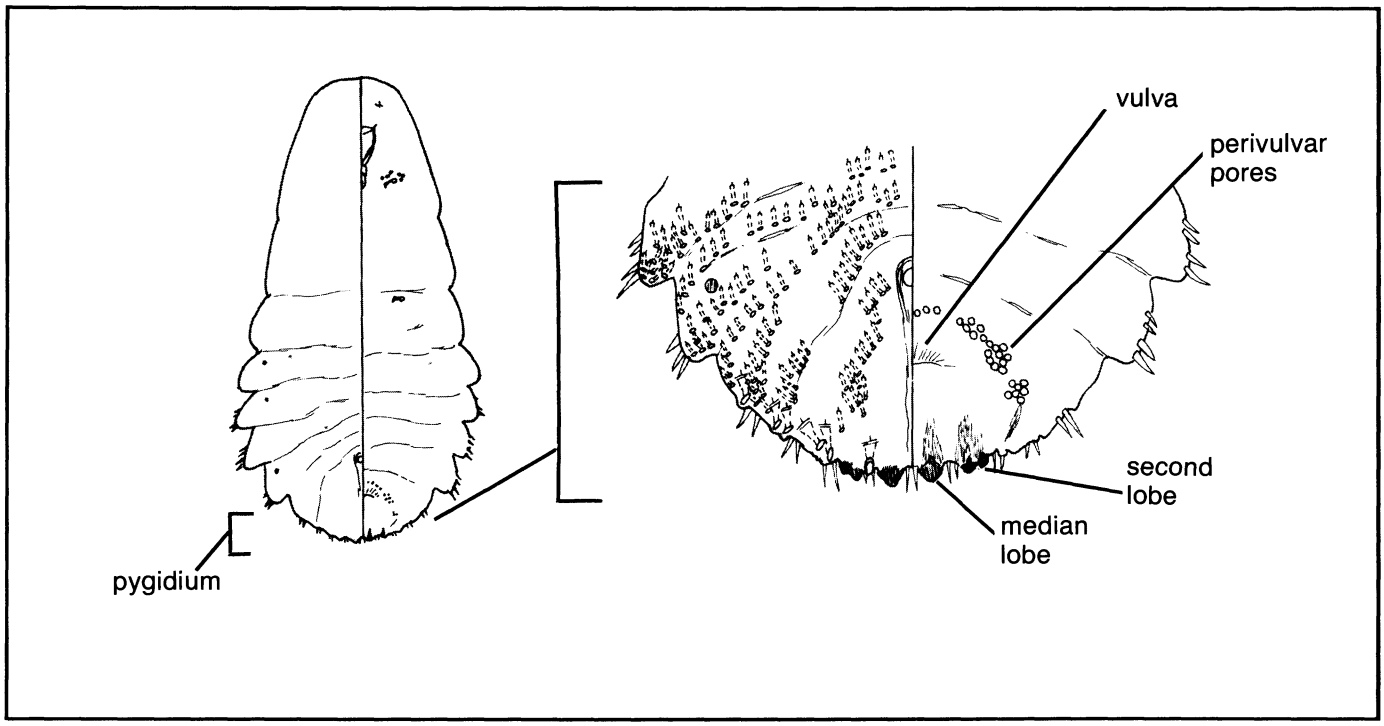

Fig 25.11. **Purple scale,** *Lepidosaphes beckii* (Diaspididae).

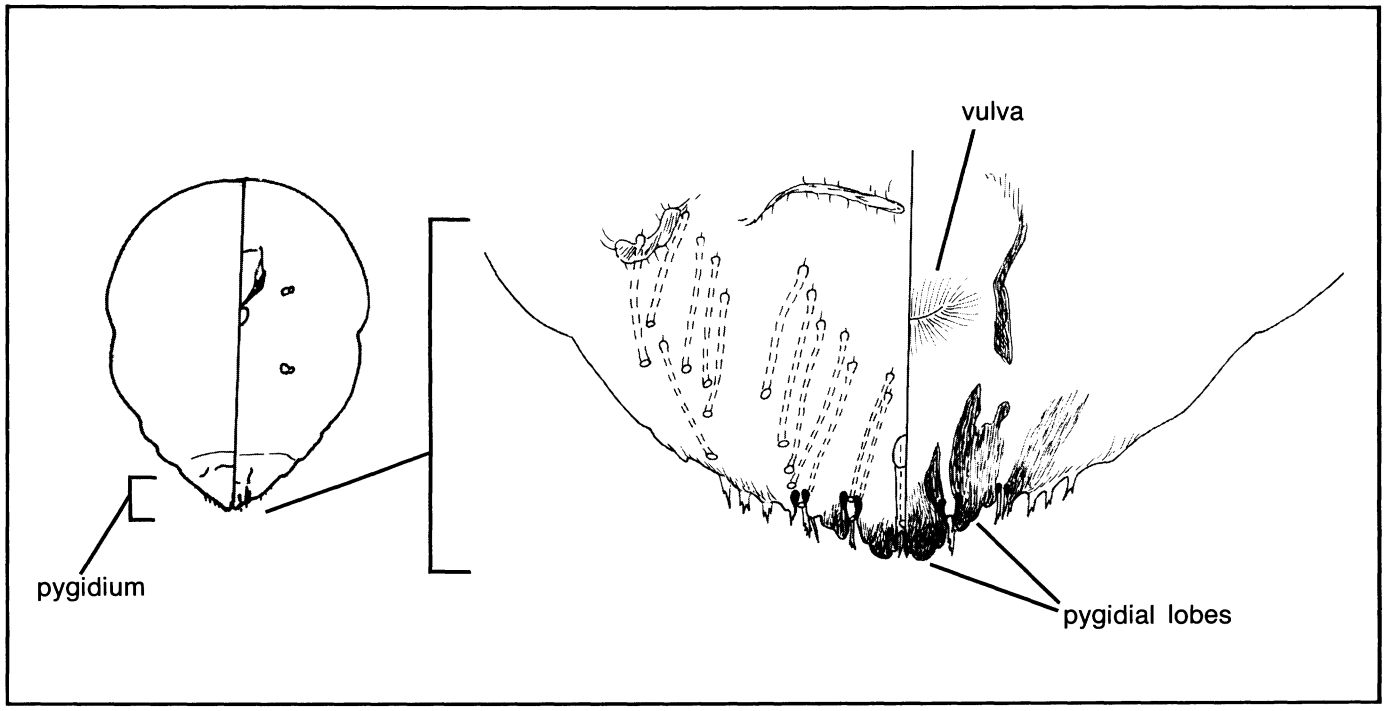

Figure 25.12. **San Jose scale,** *Quadraspidiotus perniciosus* (Diaspididae).

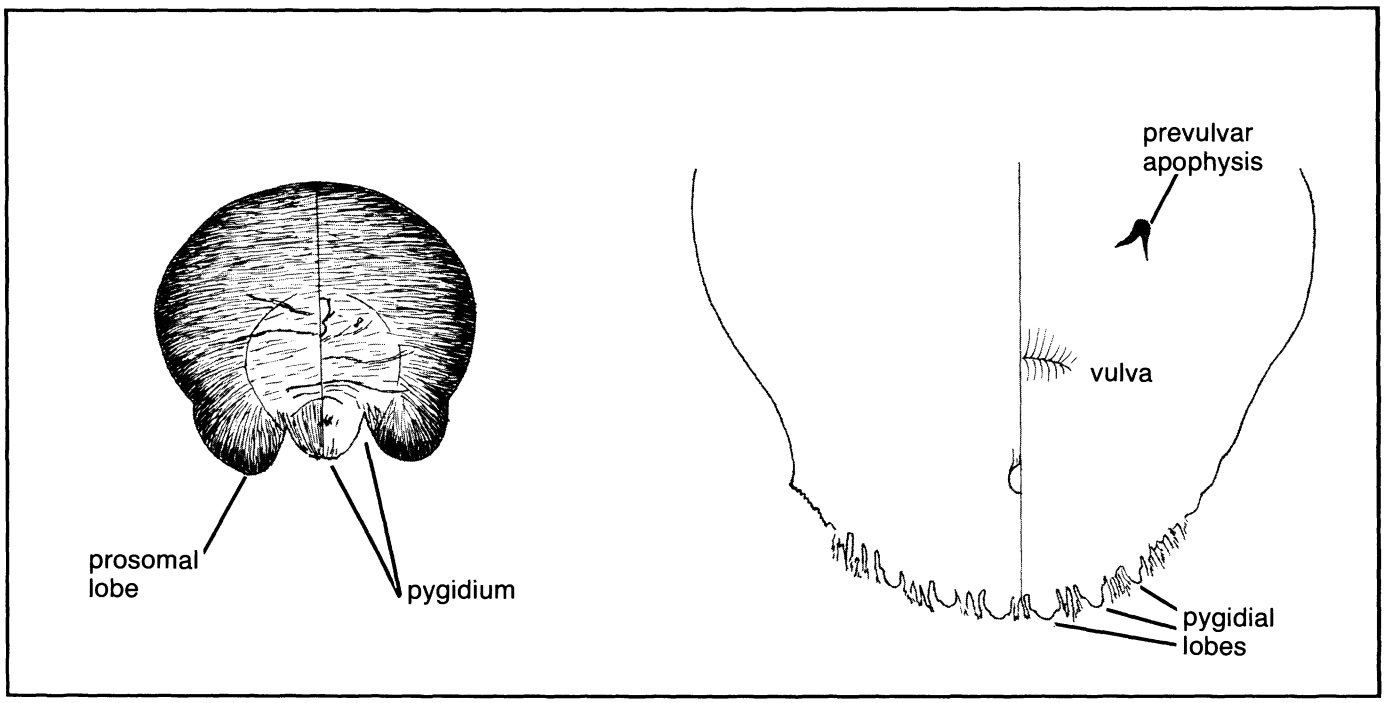

Figure 25.13. **Yellow scale,** *Aonidiella citrina* (Diaspididae): Left, dorsal/ventral habitus; right, dorsal/ventral detail of pygidium.

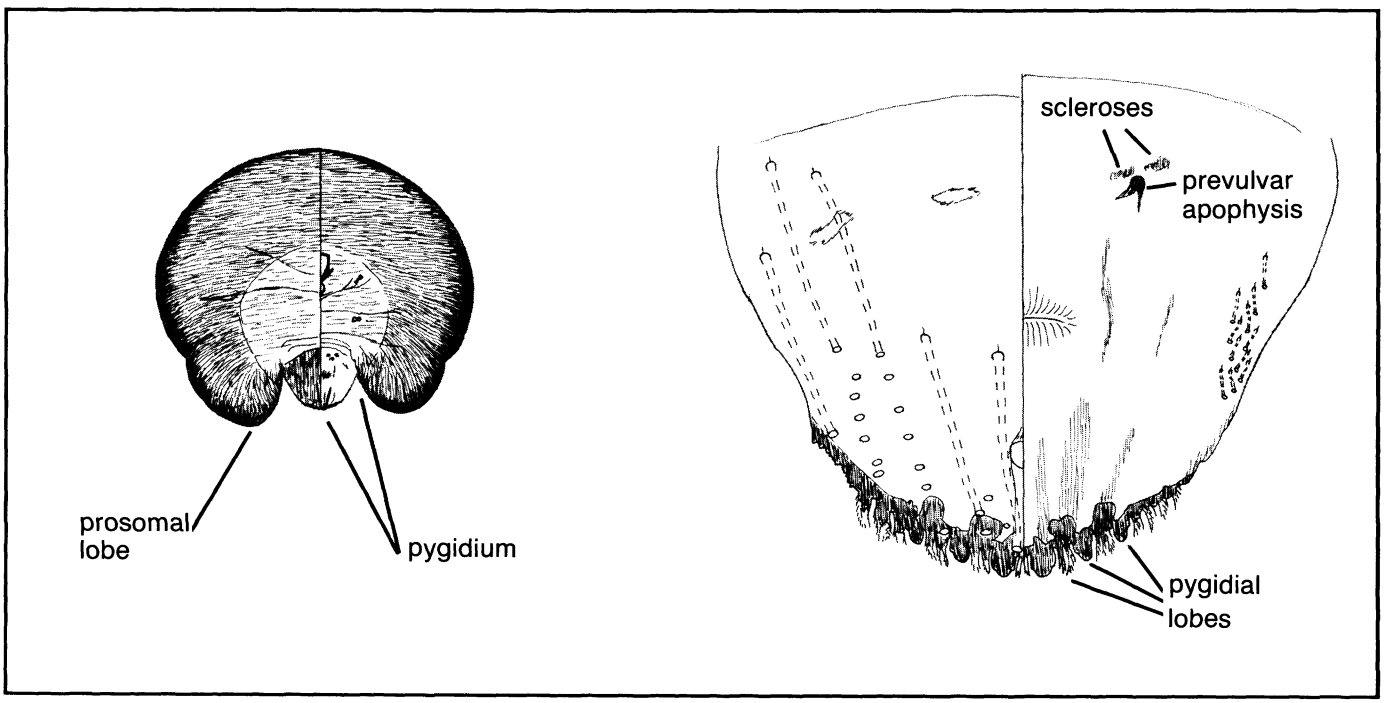

Figure 25.14. **California red scale,** *Aonidiella aurantii* (Diaspididae): Left, dorsal/ventral habitus; right, dorsal/ventral detail of pygidium.

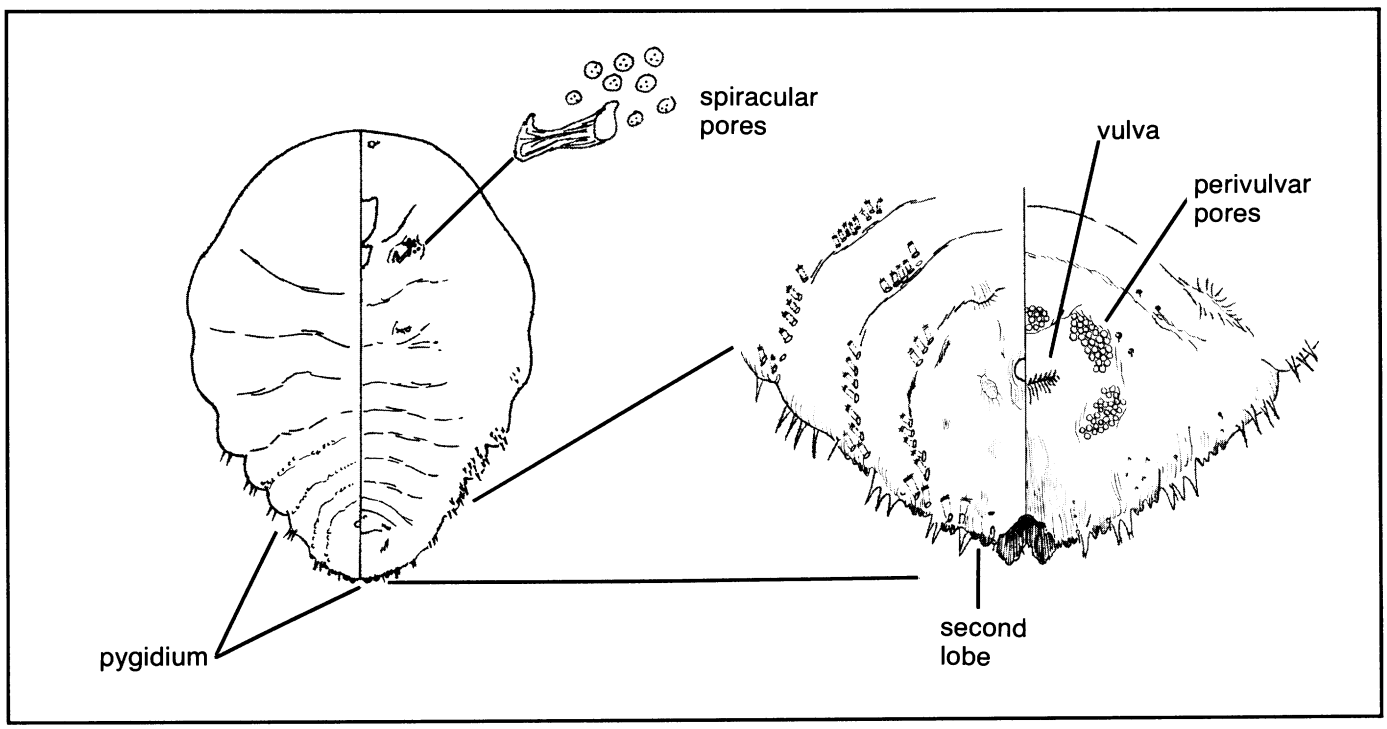

Figure 25.15. **White peach scale,** *Pseudaulacaspis pentagona* (Diaspididae).

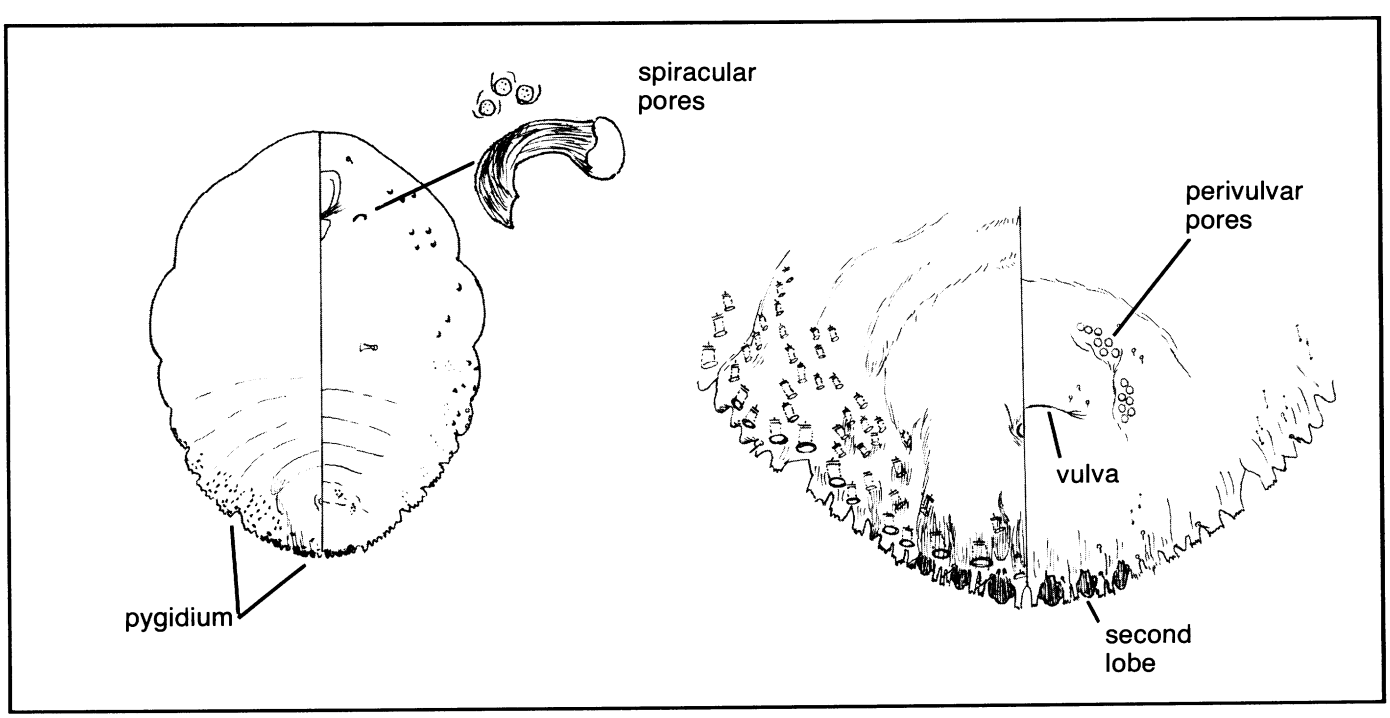

Figure 25.16. **Chaff scale,** *Parlatoria pergandii* (Diaspididae): Left, dorsal/ventral habitus; right, dorsal/ventral detail of pygidium.

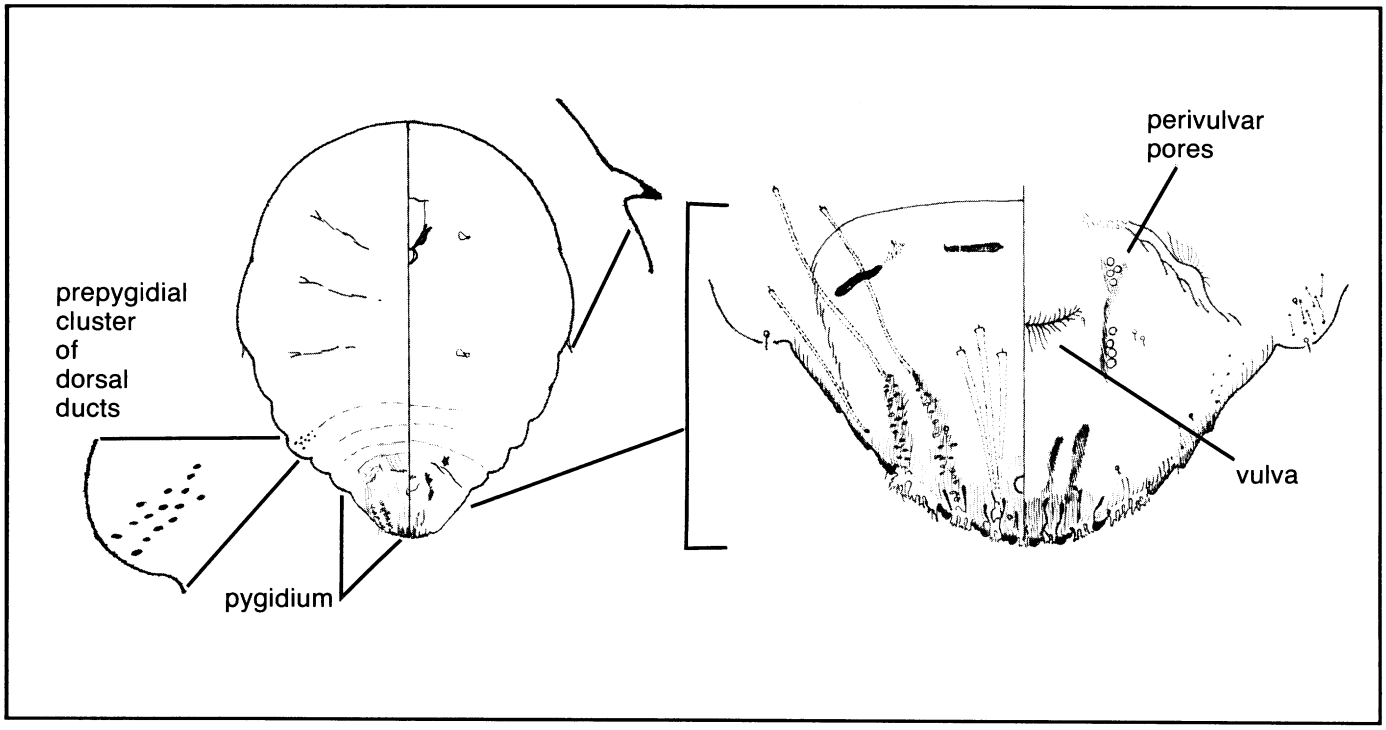

Figure 25.17. **Florida red scale,** *Chrysomphalus aonidum* (Diaspididae)

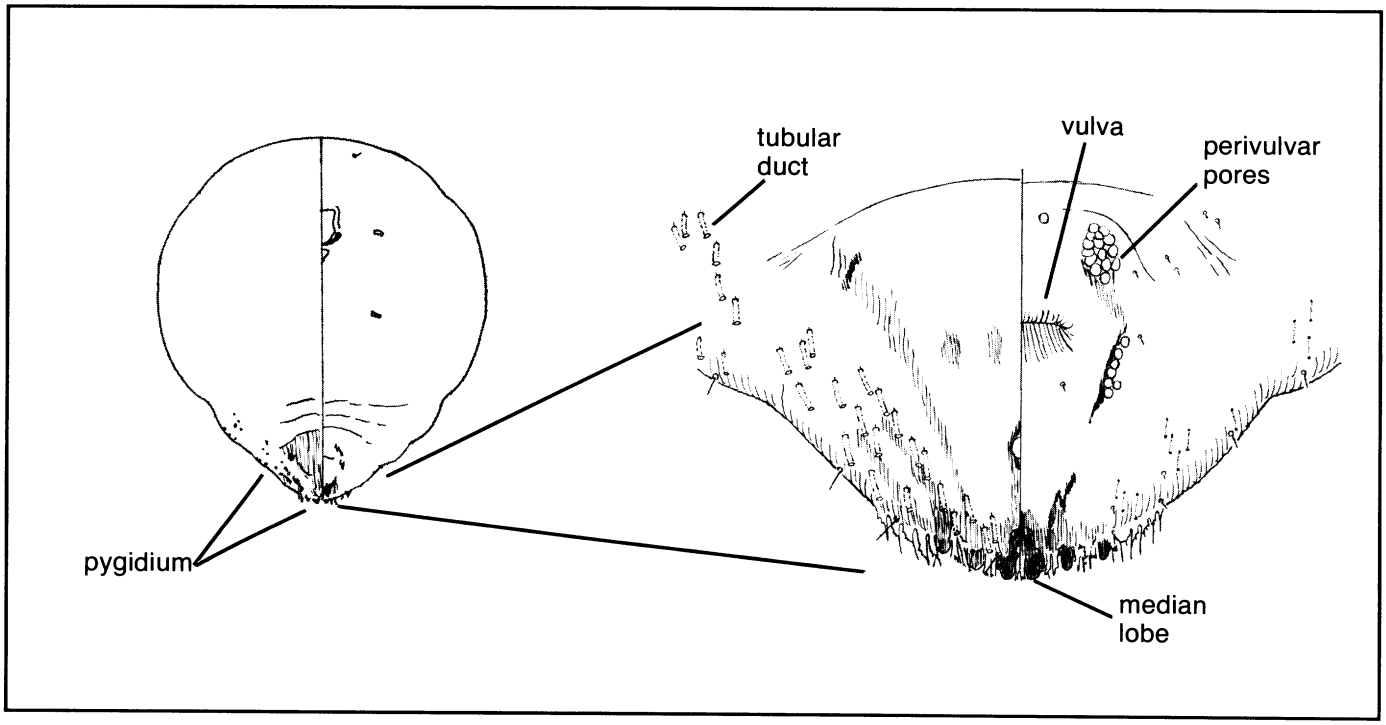

Figure 25.18. **Oleander scale,** *Aspidiotus nerii* (Diaspididae).

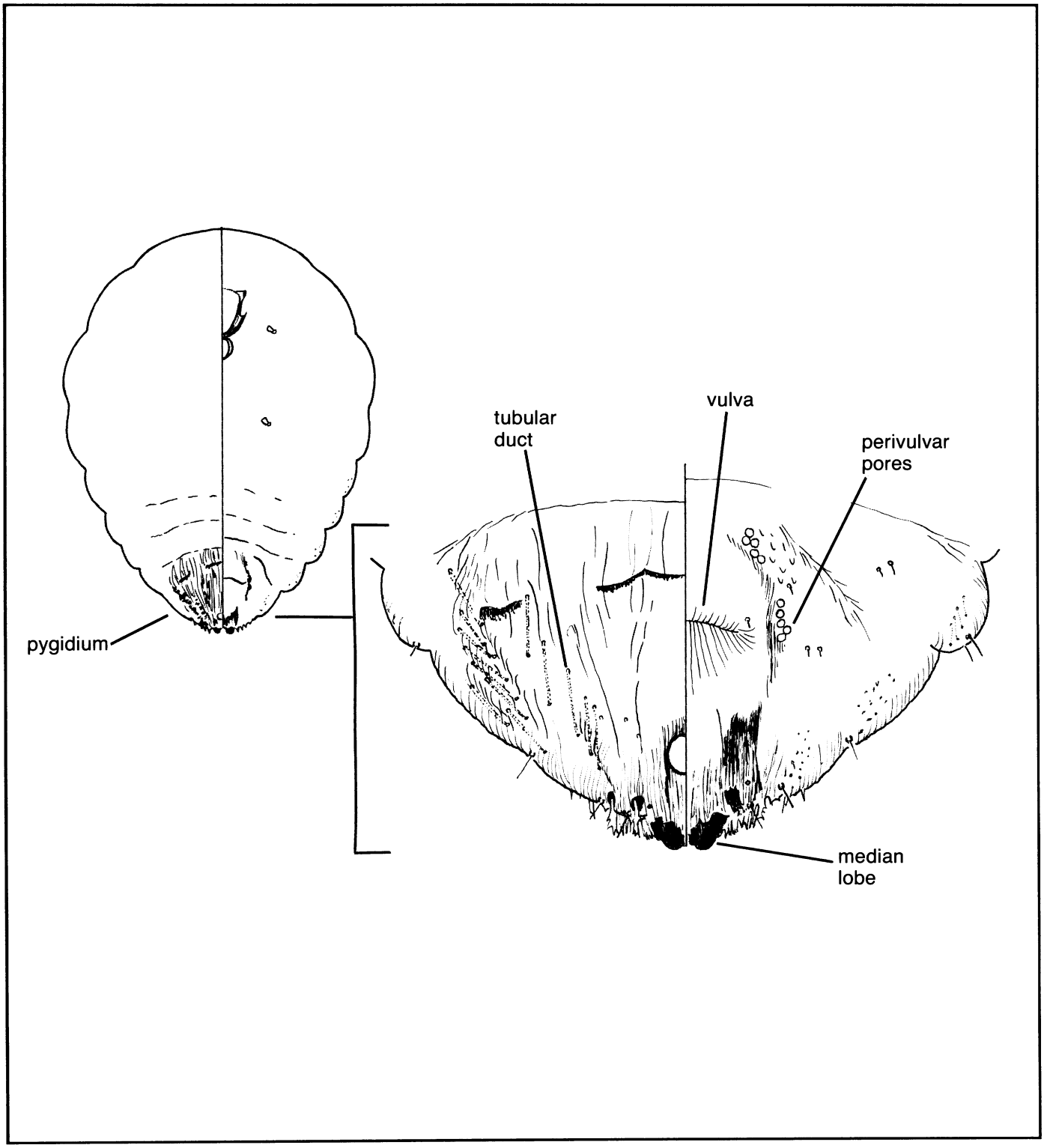

Figure 25.19. **Latania scale,** *Hemiberlesia lataniae* (Diaspididae).

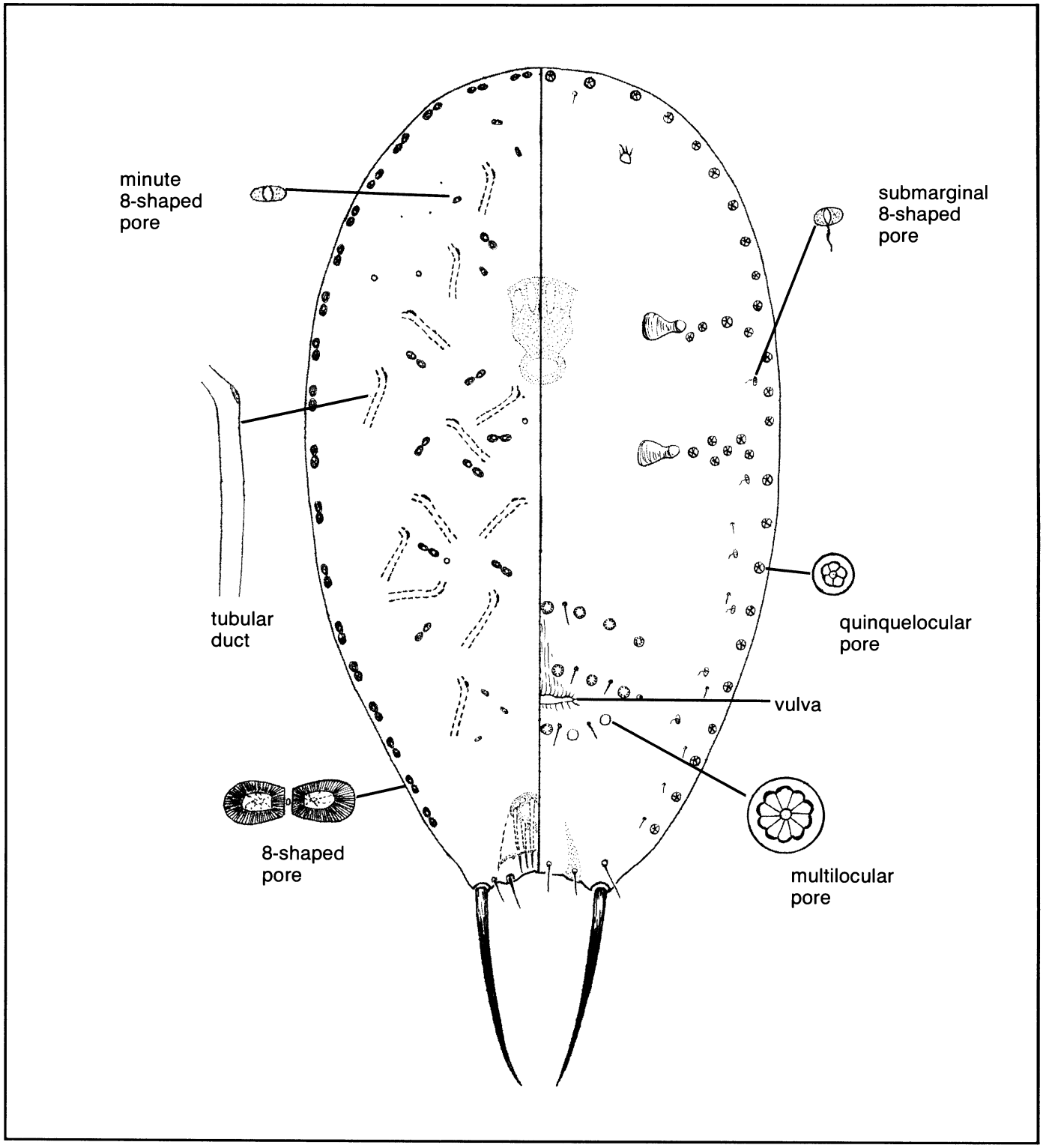

Figure 25.20. A pit scale, *Asterolecanium* sp. (Asterolecaniidae).

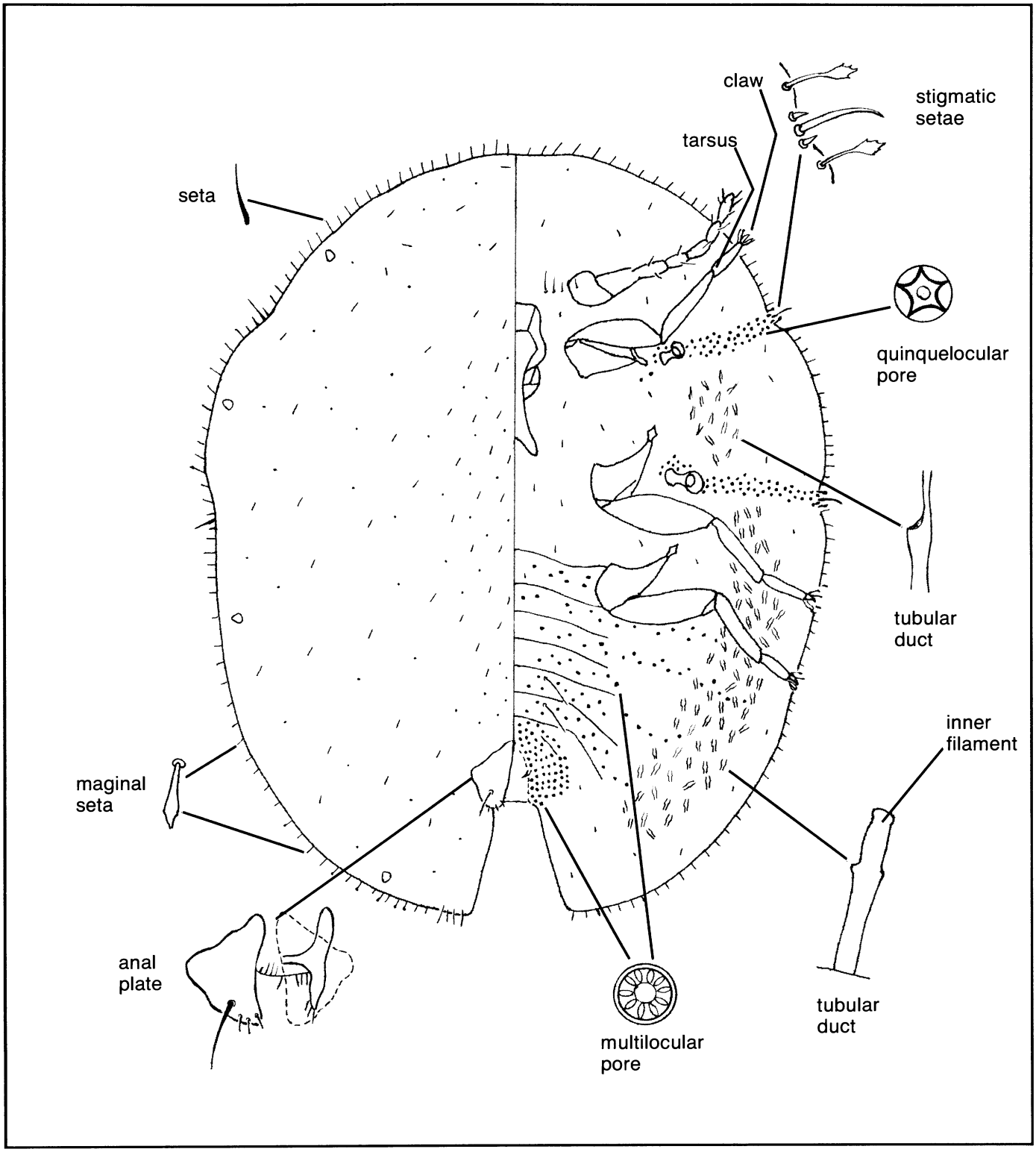

Figure 25.21. **Hemispherical scale,** *Saissetia coffeae* (Coccidae).

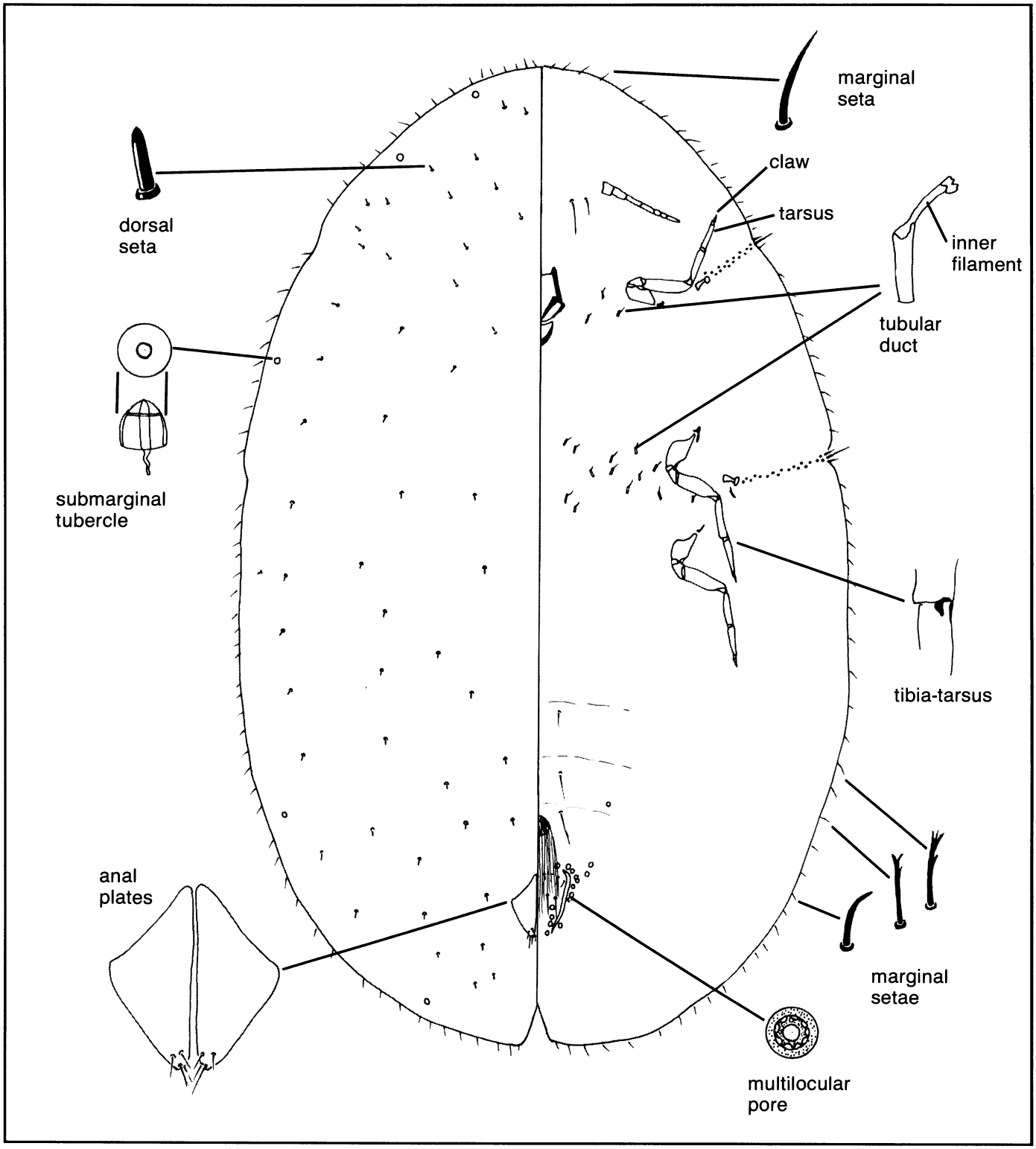

Figure 25.22. **Brown soft scale,** *Coccus hesperidum* (Coccidae).

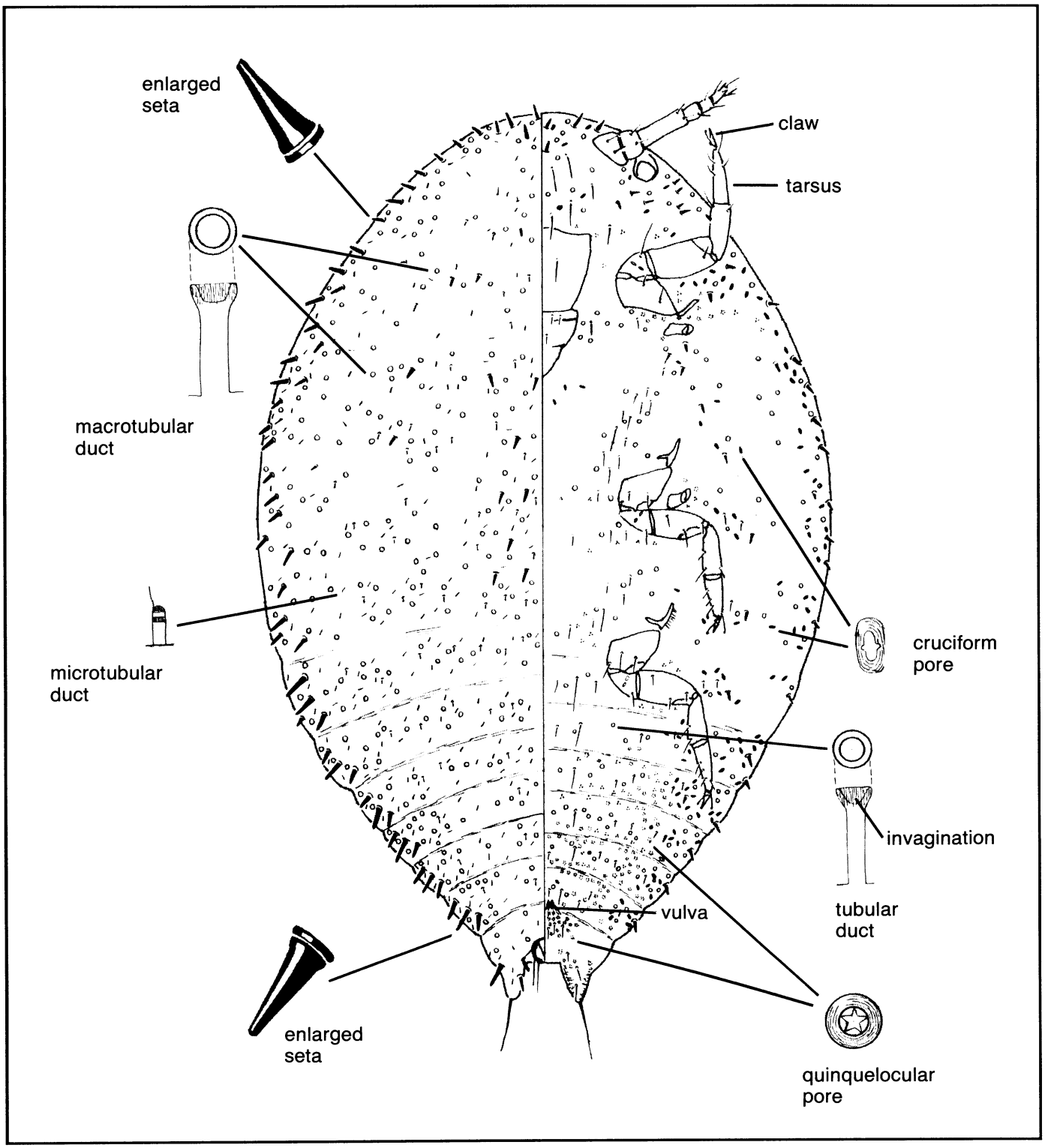

Figure 25.23. *Eriococcus coccineus* Cockerell (Eriococcidae).

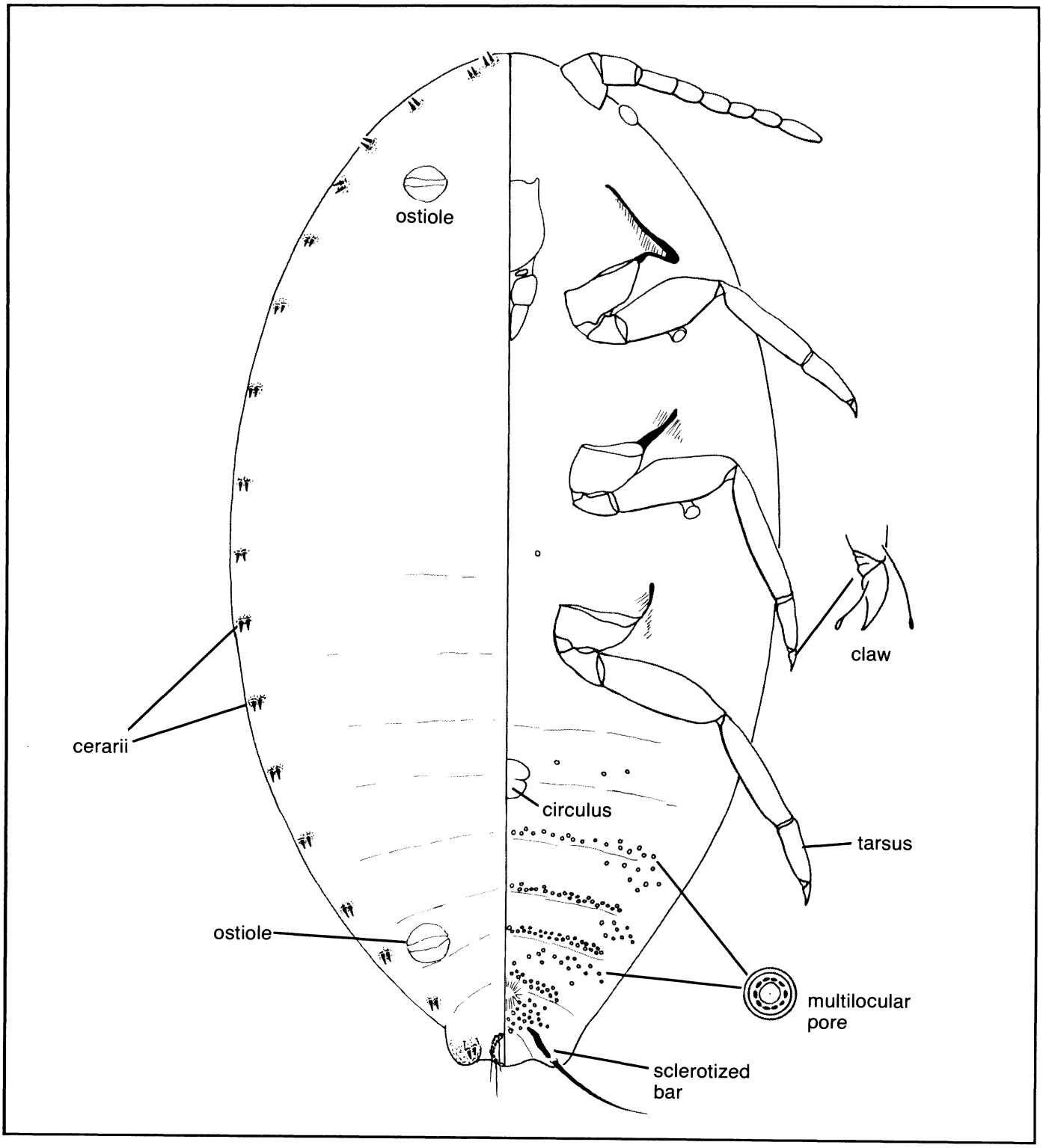

Figure 25.24. **Citrus mealybug,** *Planococcus citri* (Pseudococcidae).

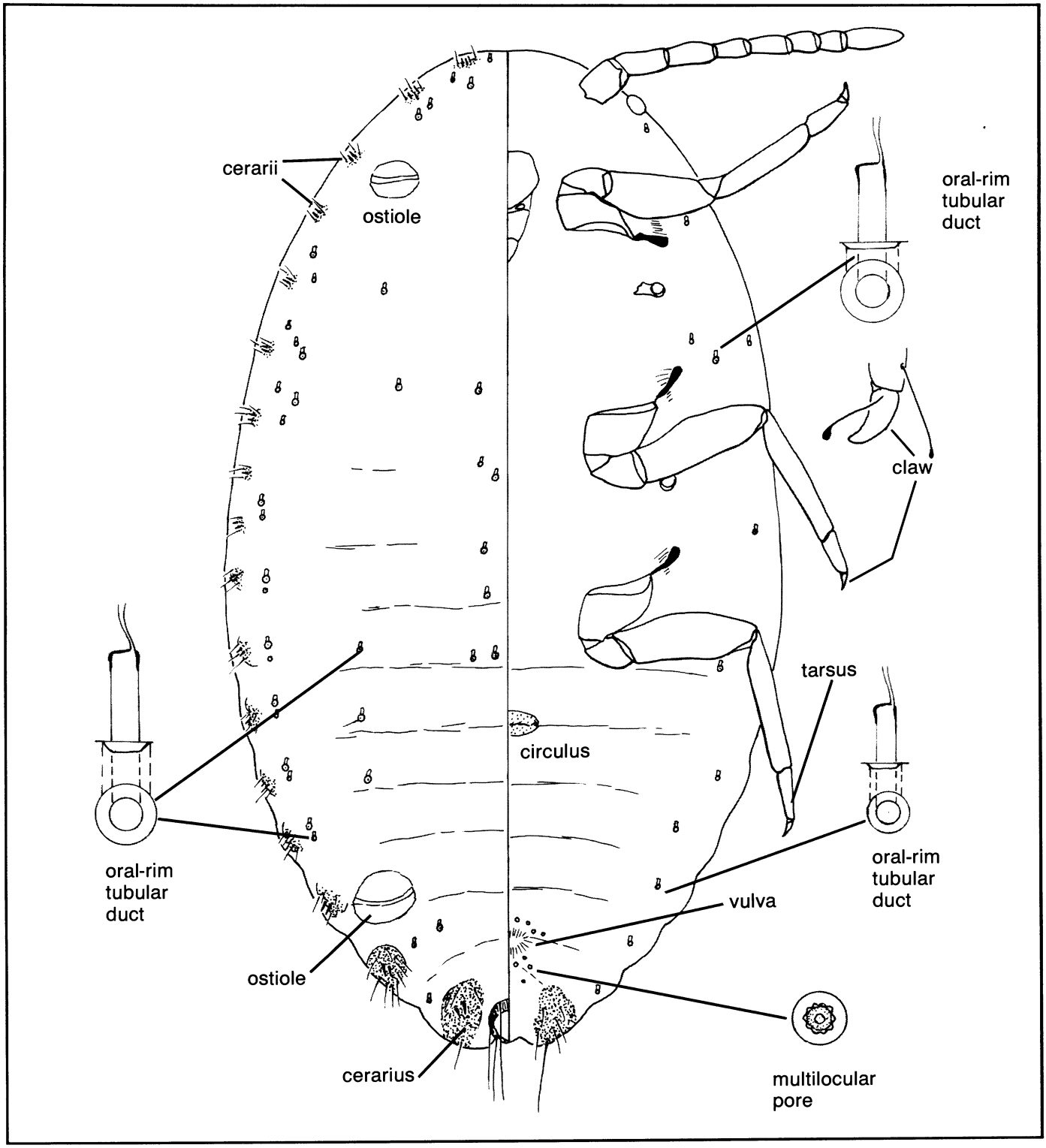

Figure 25.25. **Longtailed mealybug,**
Pseudococcus longispinus (Pseudococcidae).

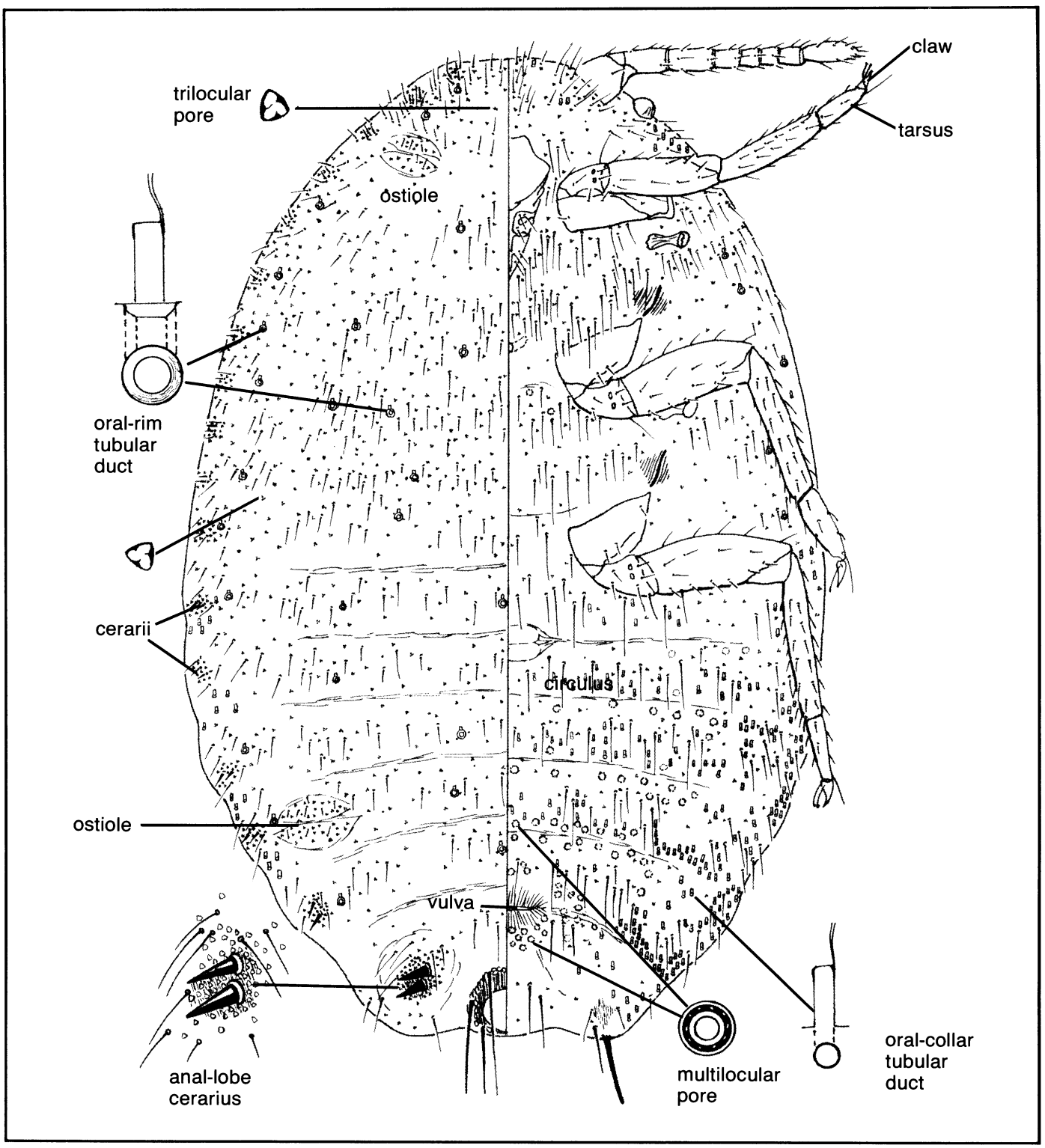

Figure 25.26. **Grape mealybug,** *Pseudococcus maritimus* (Pseudococcidae).

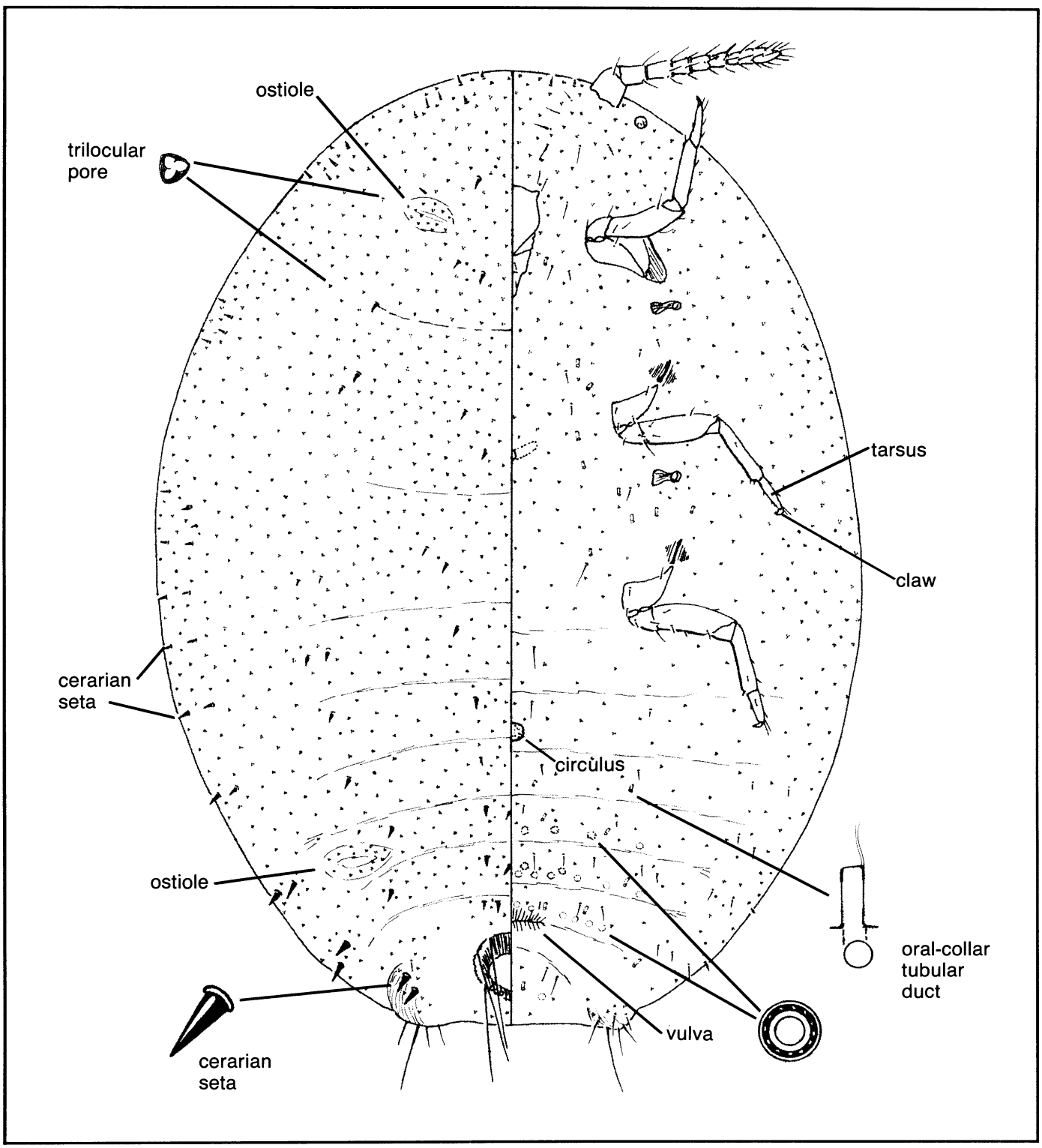

Figure 25.27. **Coconut mealybug,** *Nipaecoccus nipae* (Pseudococcidae).

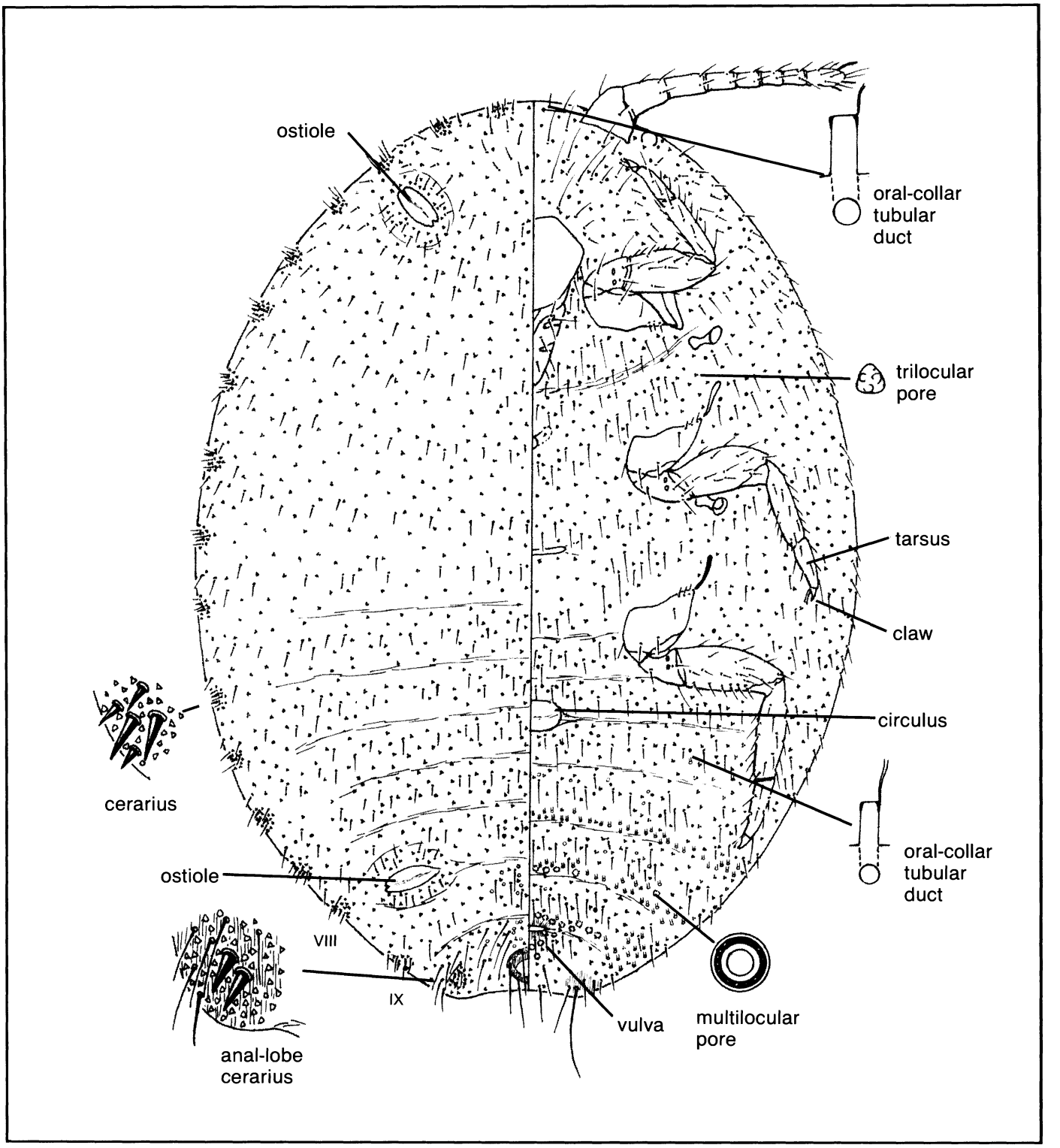

Figure 25.28. **Pineapple mealybug,** *Dysmicoccus brevipes* (Pseudococcidae).

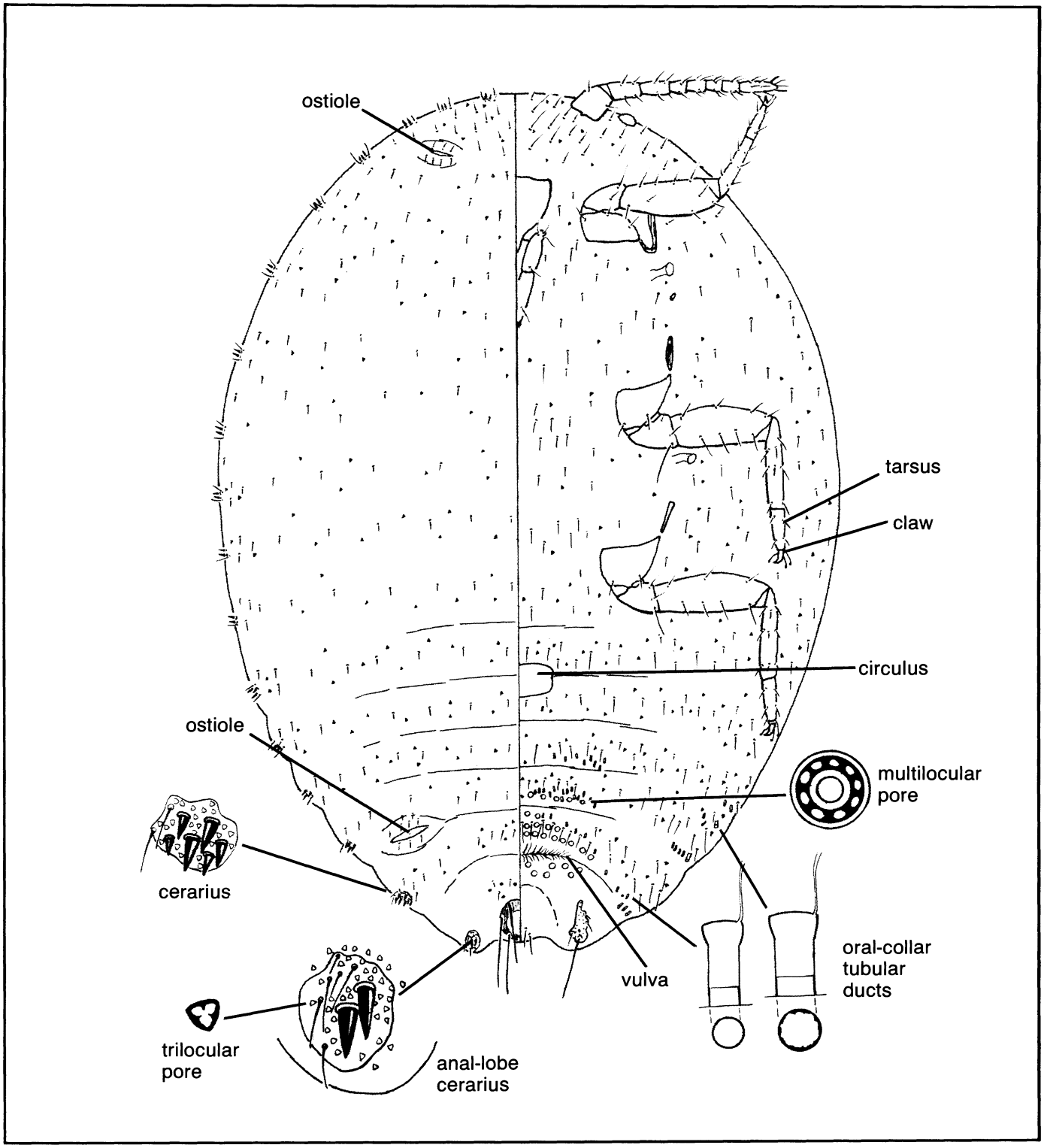

Figure 25.29. **Gray pineapple mealybug,** *Dysmicoccus neobrevipes* (Pseudococcidae).

26 PARASITIC WASPS (APOCRITA, HYMENOPTERA)

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The Order Hymenoptera is among the largest and most highly evolved group within the Class Insecta. More than 100,000 species have been described and ultimately this number will be substantially larger when the taxonomic diversity of this order becomes more fully understood. This order is especially interesting because of its biological diversity. Some species are phytophagous, feeding on many agricultural and ornamental plants, but most of the species are beneficial in that they pollinate angiosperms or prey upon or parasitize destructive insects.

Most of the hymenopterous insects found in stored food are associated with stored-product pests. All the Hymenoptera known to be associated with stored products are members of the Suborder Apocrita (=Clistogastra or Petiolata). These insects may be recognized readily by the characteristic modifications of the thorax and abdomen: The first abdominal segment (propodeum) has become fused with the thorax and separated from the rest of the abdomen by a narrow constriction. The movable portion of the abdomen is called the gaster (the term used in this key) or metasoma *(3)*. Wings, when present, are membranous; hind wings have no more than two closed cells (see fig. 26.2B).

The many species associated with stored products, all belonging to the Suborder Apocrita, do not comprise a homogenous group. Member species belong to several distantly related groups: Ichneumonoidea (Braconidae, Ichneumonidae), Evanioidea (Evaniidae), Chalcidoidea (Chalcididae, Encyrtidae, Eulophidae, Eupelmidae, Eurytomidae, Pteromalidae, Trichogrammatidae), and Chrysidoidea (Bethylidae).

In some species males are rare or unknown, so I have excluded them from consideration here. The following key is based on female wasps. Selected morphological features are shown in figures 26.1 and 26.2, drawings that are based on those of Graham *(2)*. Where specimens for some species were not available for study, I selected characters from the literature. In some instances in this key I have relied heavily on recently published keys, such as that of Evans *(1)* for the Bethylidae. Sometimes it has not been possible to provide keys to species in certain genera because the taxonomy of the group is too uncertain. For example, this key gives generic names only for many pteromalids and trichogrammatids. Specific identifications can be done only by specialists in these groups.

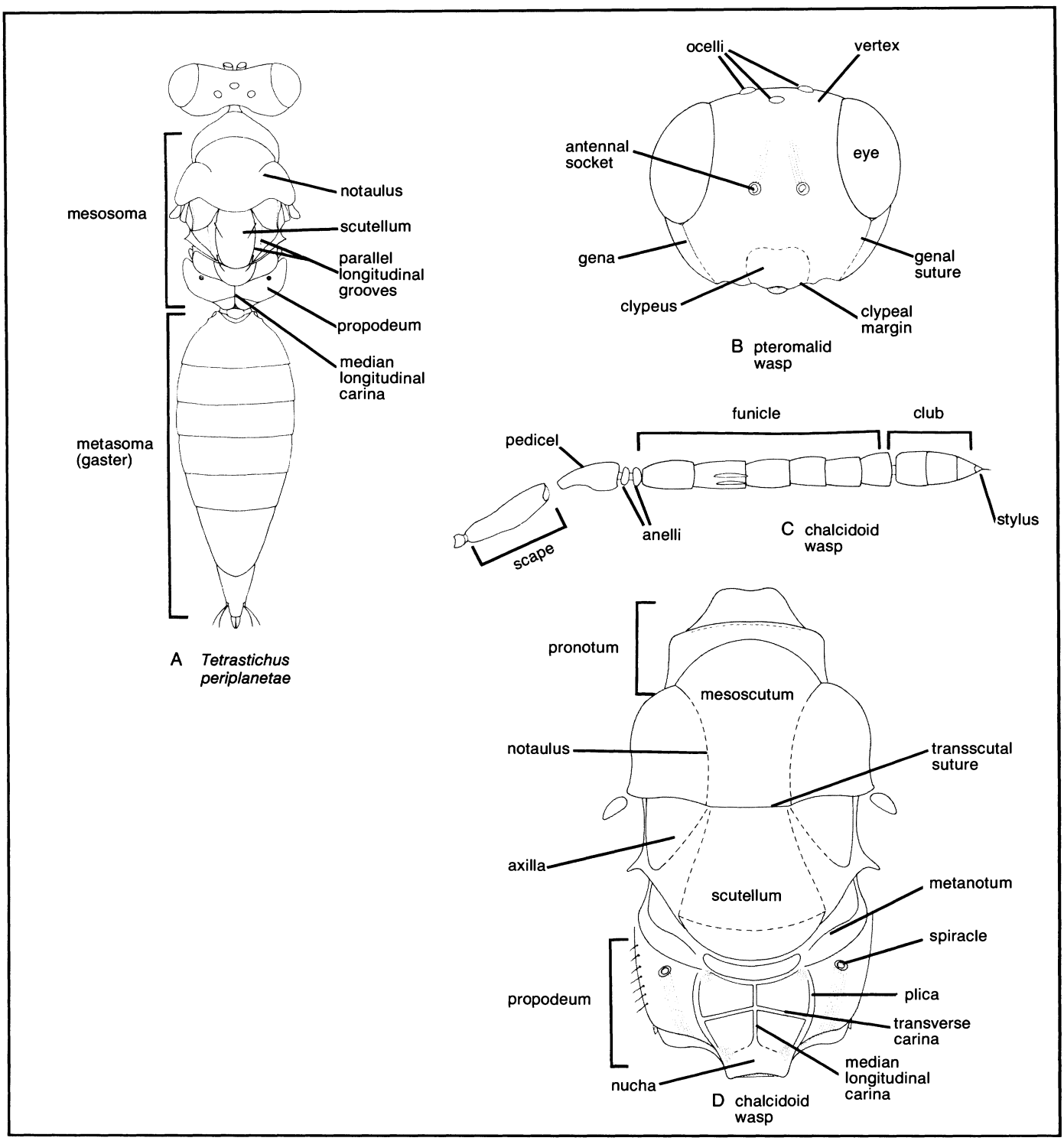


Figure 26.1. Selected morphological features of female Apocrita: A, body, dorsal view; B, head, anterior view; C, antenna; D, thorax, dorsal view. (Drawings by P. Mote.)

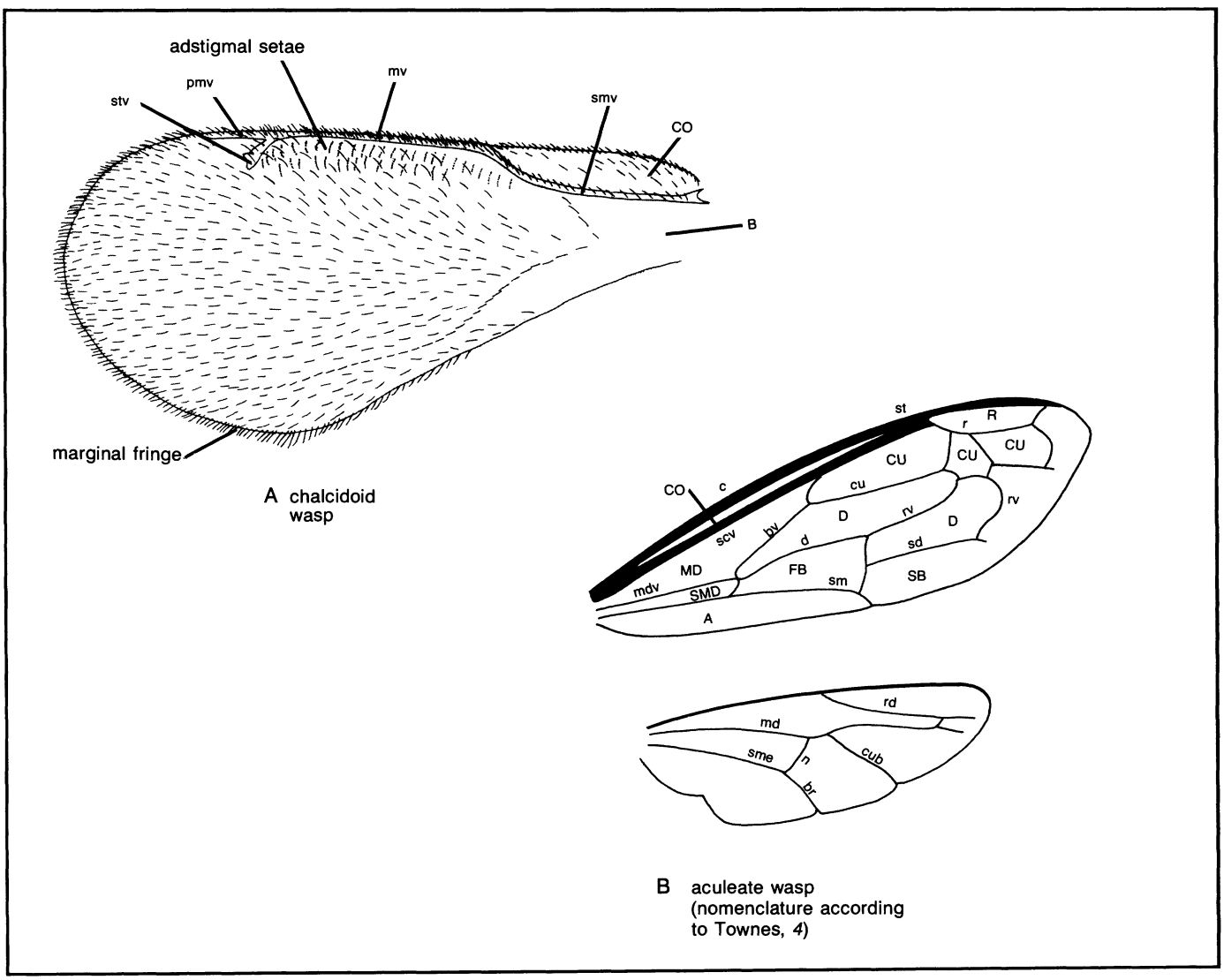


Figure 26.2. Wings of female Apocrita: A, forewing with reduced venation; B, wings with well-developed venation. The abbreviations given here apply to all wing drawings in this chapter. Veins: a, anal; br, brachiella; bv, basal; c, costal; cu, cubital; cub, cubitella; d, discoidal; ic, intercostal; md, mediella; mdv, median; mv, marginal; n, nervellus; pmv, postmarginal; r, radial; rd, radiella; rv, recurrent; scv, subcostal; sd, subdiscoidal; sm, submedius; sme, submediella; smv, submarginal; st, stigma; stv, stigmal; tm, transverse median. Cells: A, anal; AR, areolet; B, basal; CO, costal; CU, cubital; D, discoidal; DC, discocubital; FB, first brachial; FCU, first cubital; FD, first discoidal; M, marginal; MD, median; R, radial; SB, second brachial; SCU, second cubital; SD, second discoidal; SM, submarginal; SMD, submedian; TCU, third cubital; TD, third discoidal. (Drawings by P. Mote.)

KEY TO PARASITICA IN STORED PRODUCTS

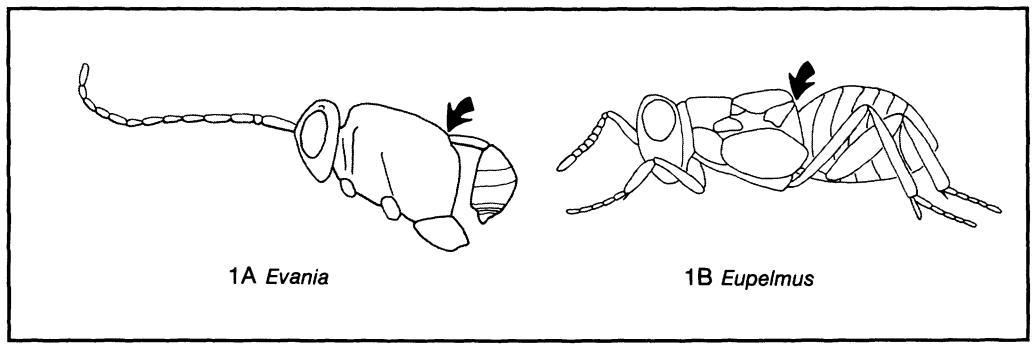
Drawings by G. Gordh, P. Mote, and S. McAlpine.

1 Petiole attached high on propodeum, well removed from coxa III (1A). Evaniidae (**ensign wasps**) ---------- 2

Petiole long, cylindrical; gaster strongly compressed.

Petiole attached near or above base of coxa III (petiole frequently obscured) (1B) ---- 4

Petiole length variable.



1A *Evania* 1B *Eupelmus*

2 Tibia and tarsus III with conspicuous spines -----**lesser ensign wasp,** *Szepligetella sericea*

Distribution: Pacific islands from Hawaii to the Philippines and New Guinea. Hosts: Blattaria (oothecae).

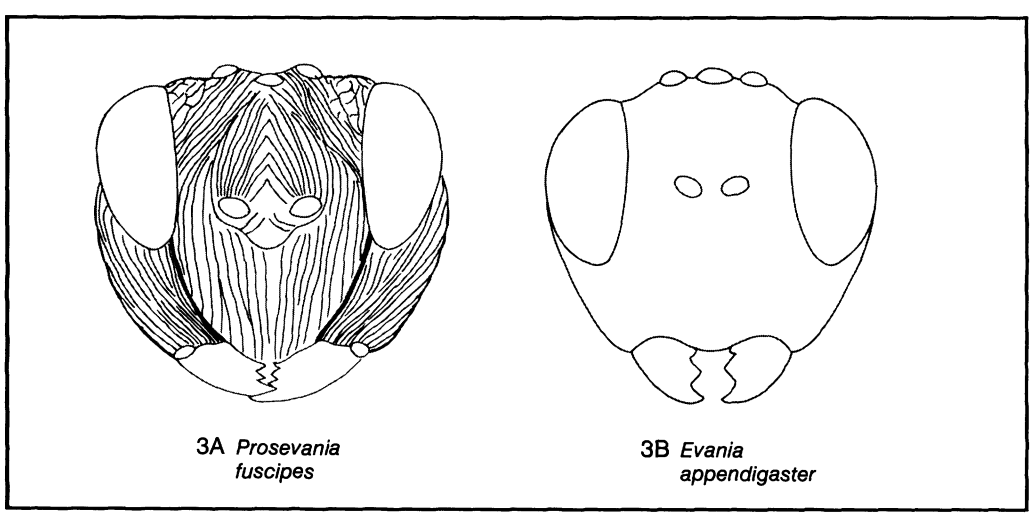
Tibia and tarsus III without conspicuous spines ---------- 3

3 Face and gena with longitudinal oblique striae (3A) ----------*Prosevania fuscipes*

Distribution: Asia, Europe, Nearctic, North Africa. Hosts: Blattaria (oothecae).

Face and gena smooth, bearing a few fine punctures (3B) ---------- *Evania appendigaster*

Distribution: Worldwide. Hosts: Blattaria (oothecae).



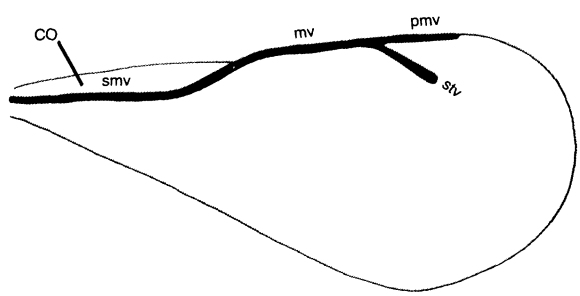
3A *Prosevania fuscipes* 3B *Evania appendigaster*

4 Forewing venation reduced but always with a costal cell, marginal vein, stigmal vein, and usually a postmarginal vein (4A, 12B; compare with 43A&B, 44A&B). Chalcidoidea **(chalcids)** ---------- 5

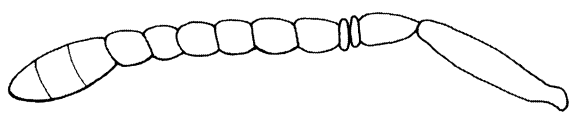
Antenna with 13 or fewer segments, including annular ring segments (4B); antennal club frequently formed from fused segments; postmarginal vein sometimes absent, as in *Tetrastichus* spp. (12D).

Forewing with many veins (4C); or if venation is reduced, then configuration not as above; or wings absent ---------- 35

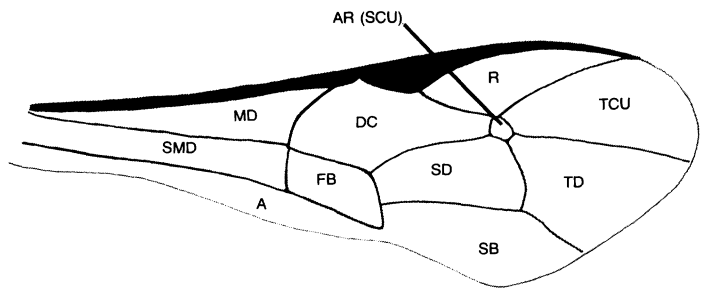
Antenna with 12 or more segments; annular ring segments absent.



4A *Paraolinx typica*



4B *Pteromalus*



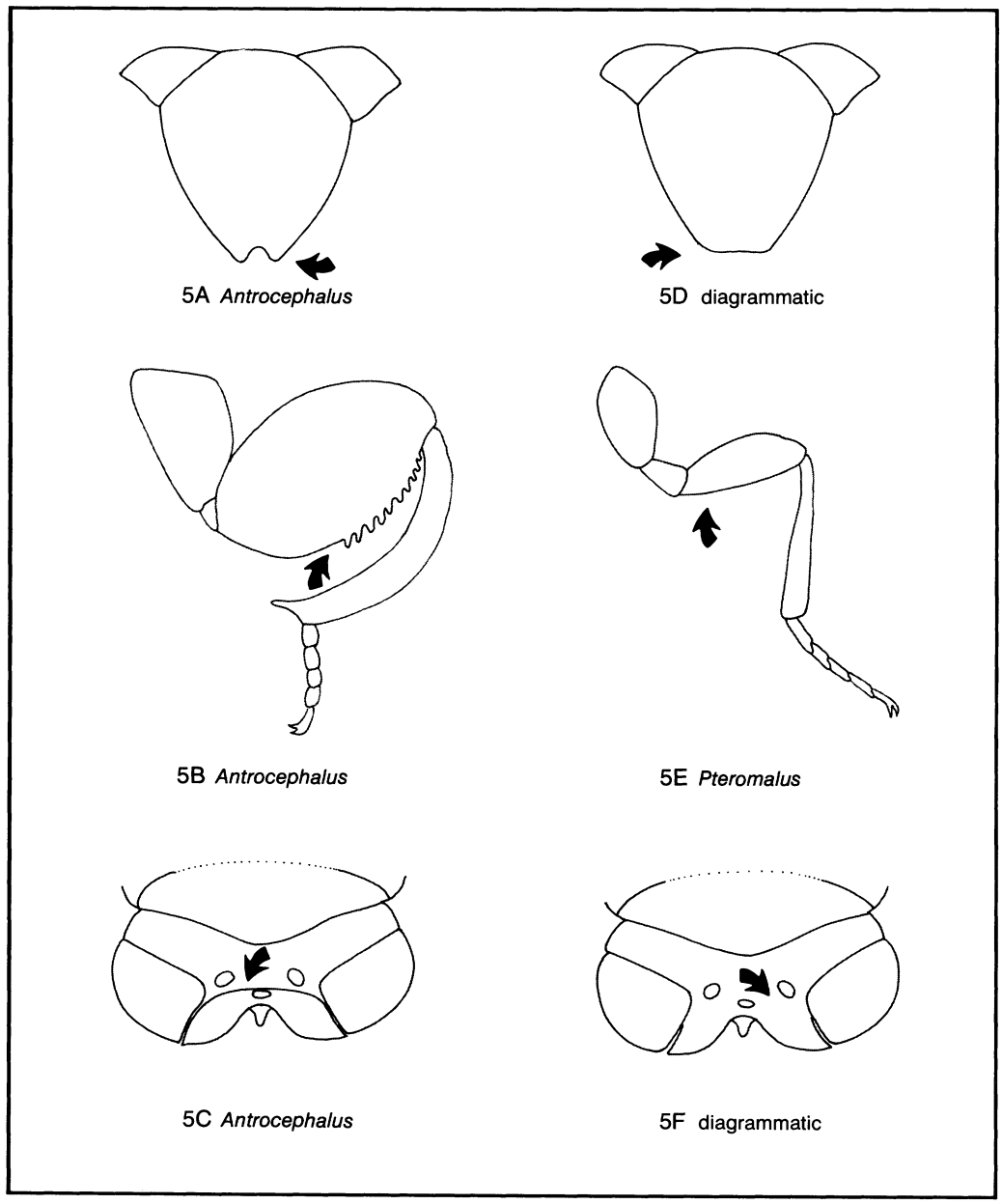
4C ichneumonid wasp

5 Scutellum with 2 toothlike projections (5A). Chalcididae (chalcidids). Genus *Antrocephalus* 6

Body rather robust; coxa and femur III enlarged and plump; femur III often with tubercles along ventral margin (5B); head with a sharp carina along medial margin of compound eye and extending behind median ocellus (5C).

Scutellum without apical projections (5D) ---------- 7

Body not as robust; femur III without tubercles (5E); head usually lacking a sharp carina, but if present, then not extending behind ocellus (5F).



6 Median carina of propodeum curved or arched ----------*Antrocephalus mahensis*

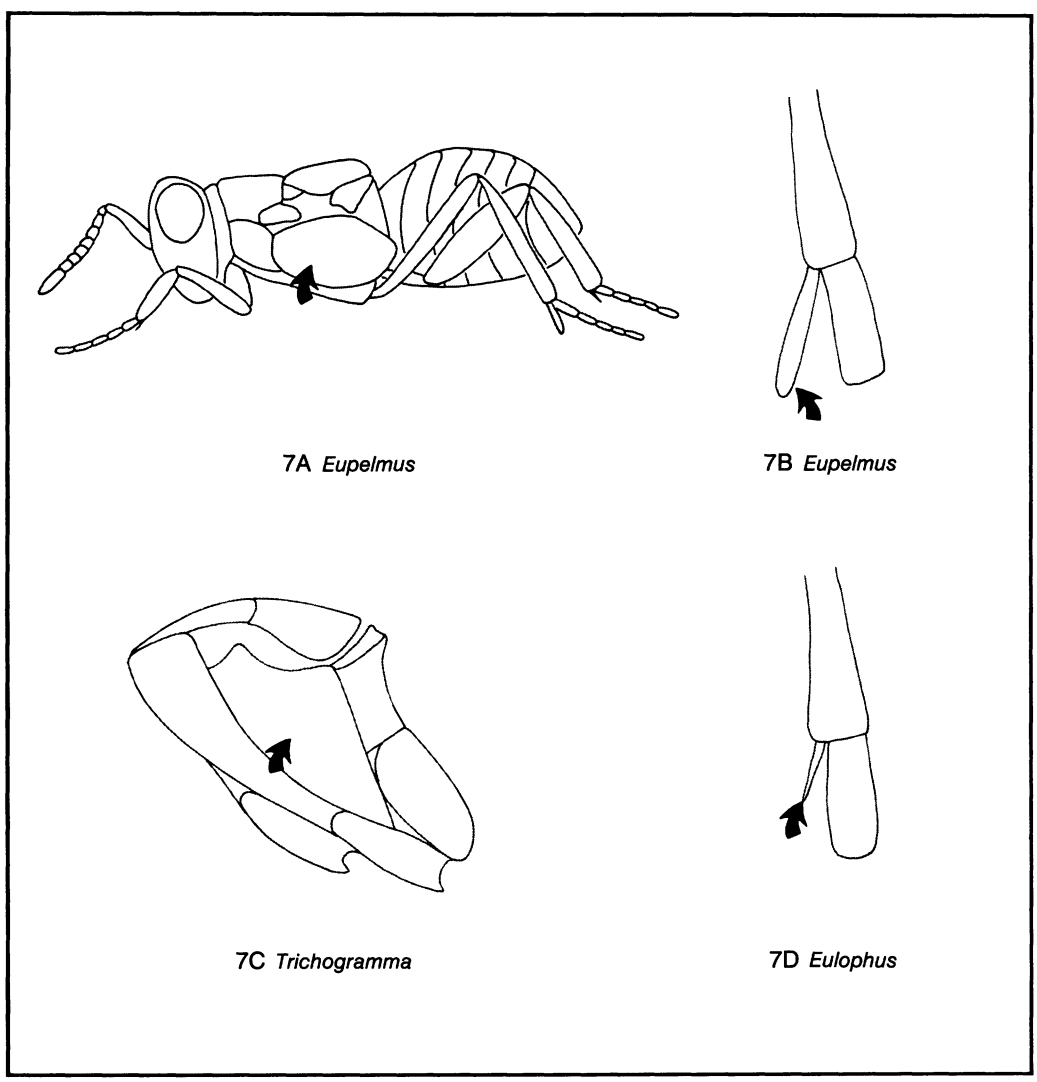
Distribution: Seychelles. Hosts: Pyralidae.

Median carina of propodeum straight ----------*Antrocephalus aethiopicus*

Distribution: Ethiopian. Hosts: Pyralidae.

7 Mesopleuron convex, enlarged, not impressed (7A); pleural sutures not evident in lateral aspect; spur of tibia II enlarged and bluntly rounded apically (7B). Eupelmidae (eupelmids). Genus *Eupelmus* ---------- 8

Mesopleuron not convexly enlarged, usually distinctly impressed (7C); pleural sutures evident; spur of tibia II not enlarged, usually pointed (7D)---------- 9



8 Gonostyli (ovipositor sheaths) mostly whitish but with base and apex dark--- *Eupelmus javae*

Distribution: Indo-Australian. Hosts: Larval Coleoptera.

Gonostyli mostly bluish with yellow coloration surrounding the medial portion ---------- *Eupelmus cushmani*

Distribution: Nearctic. Hosts: *Araecerus fasciculatus*; also known from *Acanthoscelides ochraceicolor* (Pic), *Anthonomus grandis grandis* Boheman, *Cylindrocopturus adspersus* (LeConte), *C. longulus* (LeConte), *Lixus scrobicollis* Boheman, *Mimosestes nubigens* (Motschulsky), *Trichobaris texana* LeConte.

9 Tarsal formula 3-3-3; body minute, less than 0.75 mm long. Trichogrammatidae **(trichogrammatid wasps)**----------*Trichogramma*

Distribution: Worldwide. Hosts: Lepidopteran eggs. See 7C.

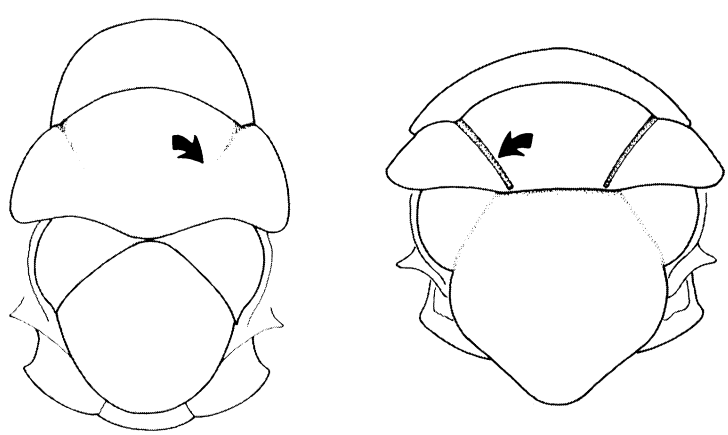
Tarsal formula 4-4-4 or 5-5-5; body length always greater than 1.0 mm---------- 10

10 Tarsal formula 4-4-4. Eulophidae (eulophids)---------- 11
Tarsal formula 5-5-5---------- 16

11 Notauli incomplete, not extending posteriorly to transscutal suture (11A) ---------- *Entedon longiventris*

Distribution: Palearctic. Hosts: Coleopteran larvae.

Notauli complete, extending from posterior margin of pronotum to transscutal suture (11B) 12



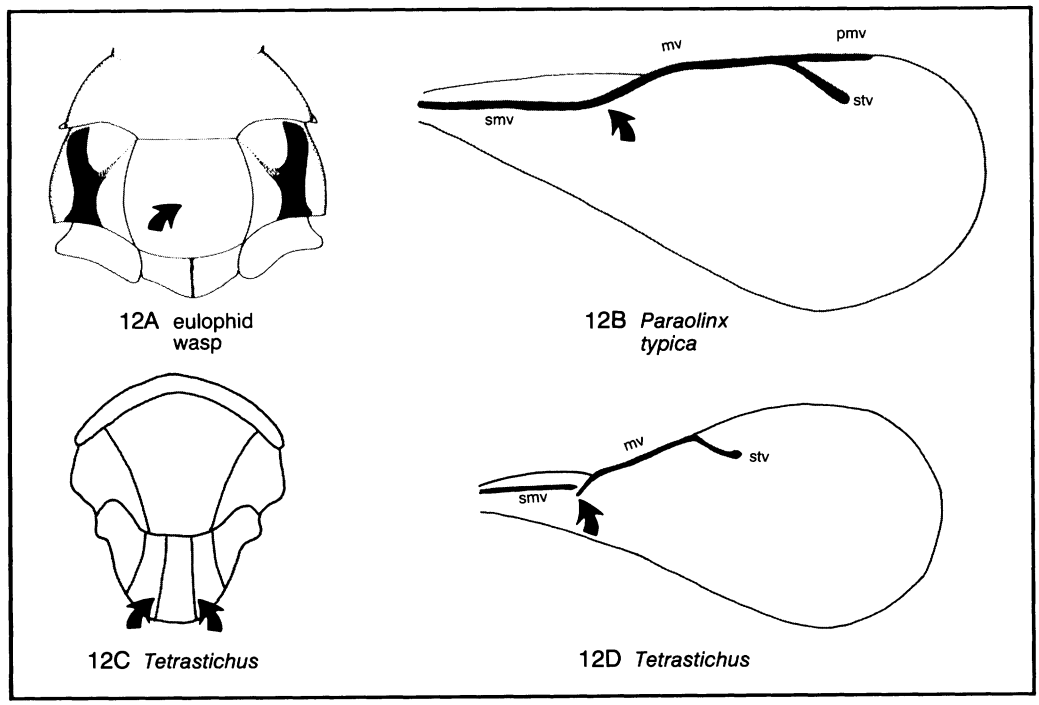
11A eulophid wasp

11B eulophid wasp

12 Scutellum without 2 grooved lines (similar to 12A); postmarginal vein as long as or longer than stigmal vein (12B); submarginal and marginal veins smoothly joined (12B) ---------- *Paraolinx typica*

Formerly called *P. nigriventis.*
Distribution: Eastern Nearctic. Hosts: *Grapholita molesta, Pyroderces rileyi.*

Scutellum with 2 longitudinal, parallel, grooved lines (12C); postmarginal vein absent (12D); submarginal and marginal veins not smoothly joined (12D) ---------- 13



12A eulophid wasp

12B *Paraolinx typica*

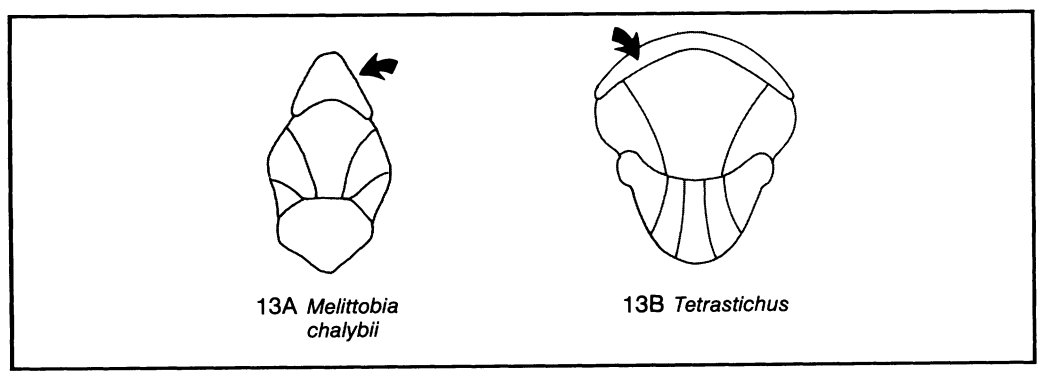
12C *Tetrastichus*

12D *Tetrastichus*

13 Pronotum unusually long, campanulate (13A); thorax depressed; genal suture absent ---------- *Melittobia chalybii*

Distribution: Nearctic. Hosts: Blattaria (oothecae), various Hymenoptera.

Pronotum not unusually long (13B); thorax mostly convex; genal suture present --------- 14



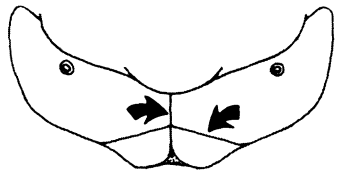
13A *Melittobia chalybii*

13B *Tetrastichus*

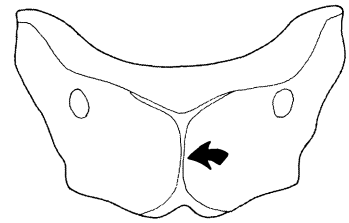
14 Propodeum with a median longitudinal carina and 2 lateral (transverse) carinae (14A) ----------*Tetrastichus periplanetae*

Distribution: Ethiopian. Host: *Periplaneta americana*. See also text figure 26.1A.

Propodeum with only a median longitudinal carina (14B) ---------- 15



14A Tetrastichus periplanetae



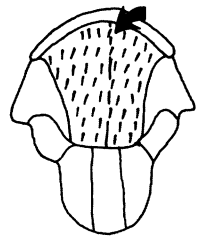
14B *Tetrastichus*

15 Setae on mesoscutum uniformly distributed over surface (contiguous with median longitudinal sulcus) (15A) ---------- *Aprostocetus (Tetrastichodes) hagenowii*

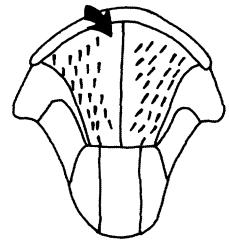
Distribution: Nearctic. Hosts: Blattaria (oothecae).

Setae on mesoscutum arranged in 3 to 5 rows adjacent to notauli (absent from meson) (15B) ----------*Tetrastichus coerulescens*

Distribution: Nearctic. Hosts: Larval Lepidoptera.



15A Aprostocetus hagenowii



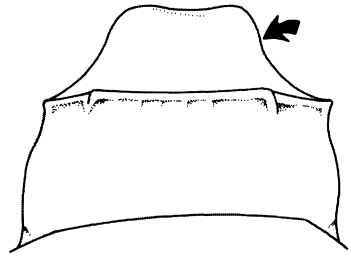
15B *Tetrastichus coerulescens*

16 Pronotum quadrate in outline when viewed from above (16A); gaster compressed. Eurytomidae (**seed chalcids, eurytomids**) ---------- 17

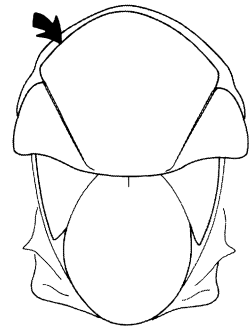
Head and thorax strongly punctate; body without metallic coloration.

Pronotum not quadrate when viewed from above (16B), or if quadrate, then gaster not compressed. Pteromalidae (pteromalids)---------- 19

Head and thorax usually not punctate, but if punctate, then body not robust and usually depressed, with head prognathous; body frequently with metallic or pale coloration.



16A *Eurytoma*



16B pteromalid wasp

17 Metanotum shorter than scutellum when viewed from above; coxa III and petiole each without a dorsal longitudinal channel---------- *Eurytoma tylodermatis*

Distribution: Nearctic. Hosts: Larvae of Lepidoptera and Coleoptera.

Metanotum longer than scutellum when viewed from above; coxa III and petiole with a dorsal longitudinal channel. Genus *Aximopsis* ---------- 18

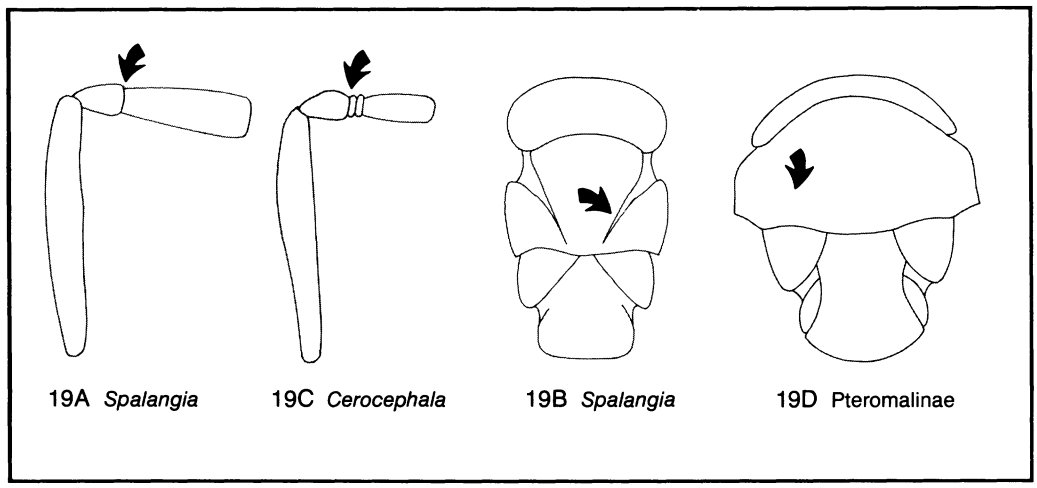
18 Legs mostly reddish ---------- *Aximopsis tephrosiae*

Distribution: Indo-Australia. Host: *Araecerus fasciculatus.*

Legs mostly black---------- *Aximopsis javensis*

Distribution: Indo-Australian. Host: *Araecerus fasciculatus.*

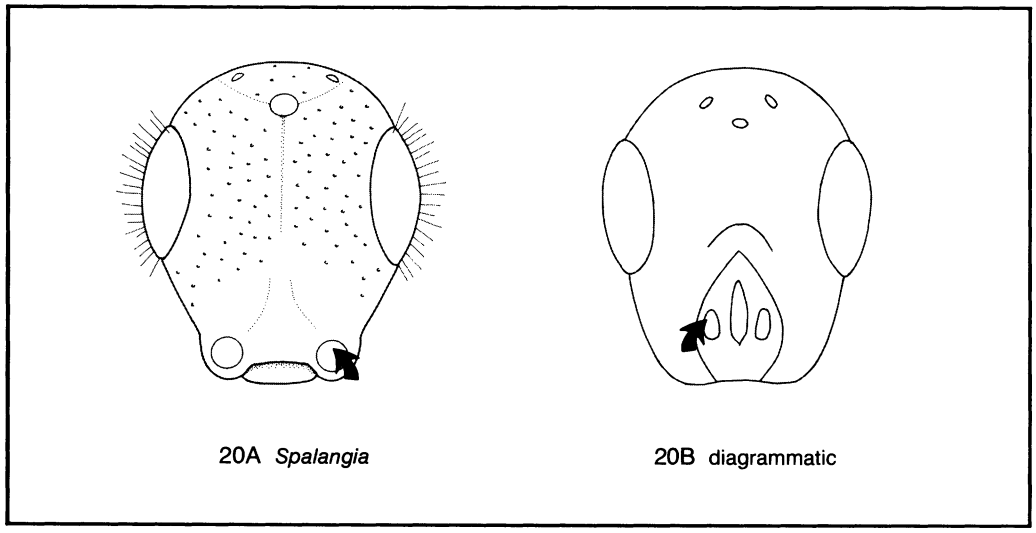
19 Antenna without annular ring segments (19A); notauli complete, extending from pronotum to transscutal suture (19B) ---------- 20
Antenna with at least 1 annular ring segment (19C); notauli incomplete, not extending from pronotum to transscutal suture (19D) ---------- 26



20 Antenna inserted at extreme anterior margin of head on facial lobes that extend ventrad of clypeus (20A); tibia III with 1 spur; body black or weakly metallic; head and thoracic dorsum with pits ---------- *Spalangia*

Distribution: Worldwide. Hosts: Puparia of Diptera. See also 19A&B.

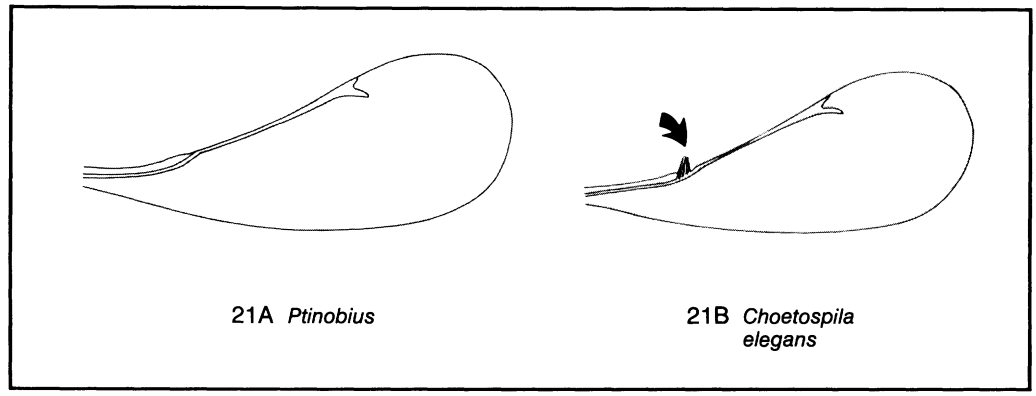
Antenna inserted at a point at least slightly separated from extreme anterior margin of head (not inserted on facial lobes) (20B); tibia III with 2 spurs; body usually a pale color, but if dark, then lacking pits on head and thorax ---------- 21



21 Forewing without a conspicuous tuft of setae at junction of submarginal and marginal veins (21A); eye with conspicuous setae---------- *Ptinobius*

Distribution: Nearctic. Hosts: Coleoptera.

Forewing with a conspicuous tuft of setae at junction of submarginal and marginal veins (21B); eye without conspicuous setae ---------- 22



21A *Ptinobius* 21B *Choetospila elegans*

22 Antennal funicle 5-segmented---------- *Choetospila elegans*

Distribution: Worldwide. Hosts: *Lasioderma serricorne, Stegobium paniceum, Sitophilus granarius, S. linearis, S. oryzae, Sitotroga cerealella.* See couplet illustration 28C in chapter 18.

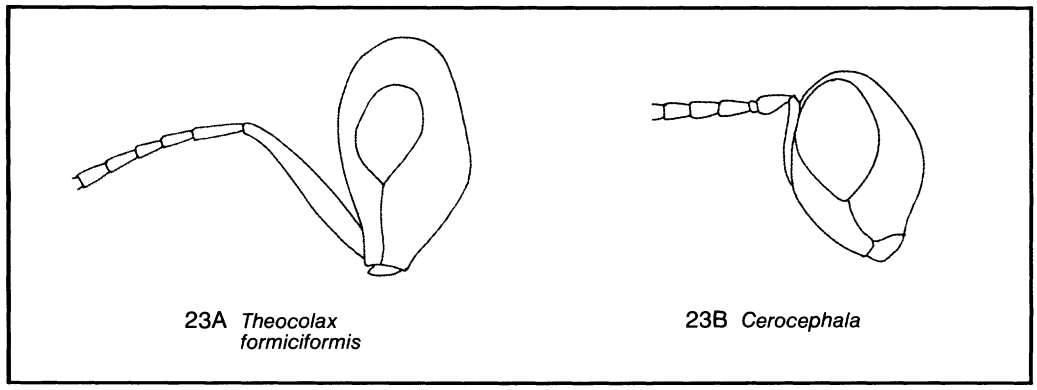
Antennal funicle 6-segmented ---------- 23

23 Antenna inserted well below level of ventral margin of compound eye (23A) ---------- *Theocolax formiciformis*

Usually micropterous. Distribution: Indo-Australian, Palearctic. Hosts: *Anobium* spp.

Antenna inserted at or above ventral margin of compound eye (23B). Genus *Cerocephala*---------- 24

Usually macropterous.



23A *Theocolax formiciformis* 23B *Cerocephala*

24 Pronotum finely and completely longitudinally striate ---------- *Cerocephala aquila*

Distribution: Indo-Australian. Hosts: Coleoptera.

Pronotum smooth ---------- 25

25 Antennal scape less than 3.6 times as long as wide; infuscation of forewing weak or absent ---------- *Cerocephala cornigera*

Distribution: Palearctic. Host: *Hylesinus orni* (Fuchs).

Antennal scape about 4 times as long as wide; infuscation of forewing beneath stigmal vein well developed ---------- *Cerocephala rufa*

Distribution: Palearctic. Host: *Anobium punctatum.*

26 Antenna with 3 annular ring segments and 5 funicular segments ---------- 27
Antenna with 2 annular ring segments and 6 funicular segments ---------- 29

27 Mandibles asymmetrical, one with 4 teeth, the other with 3 ---------- *Meraporus requisitus*

Distribution: Nearctic. Host: *Sitophilus oryzae.*

Both mandibles with 4 teeth ---------- 28

28 Underside of forewing without long curved setae ---------- *Anisopteromalus*

Distribution: Worldwide. Hosts: Coleoptera, Lepidoptera.

Underside of forewing posterior to marginal vein with a row of long curved setae ---------- *Zatropis*

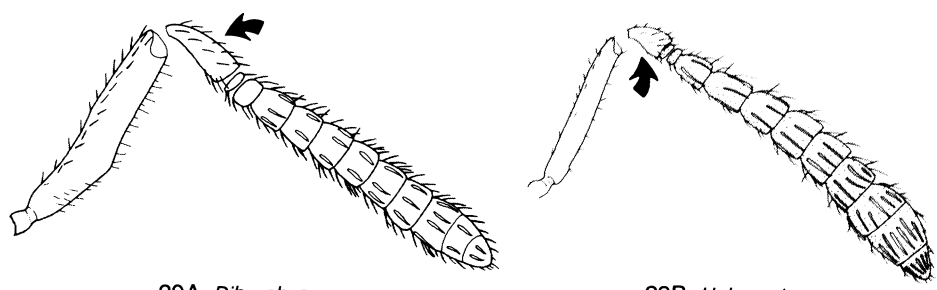
Distribution: Nearctic. Hosts: Coleoptera.

29 Pedicel unusually long (29A) ---------- *Dibrachys*

Forewing margin without cilia. Distribution: Worldwide. Hosts: Lepidoptera.

Pedicel not unusually long (similar to 29B) ---------- 30

Forewing margin usually with cilia (except *Tritneptis (Systellogaster) ovivora*).



29A *Dibrachys* 29B *Habrocytus*

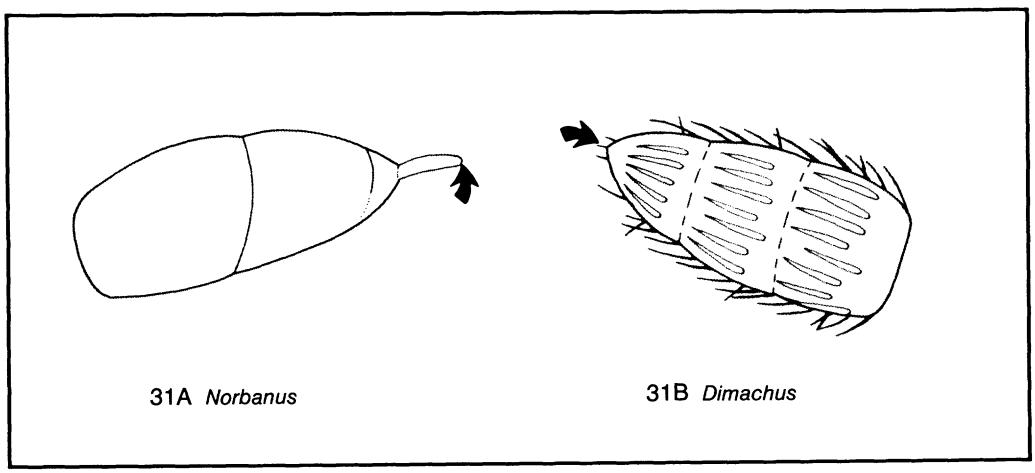
30 Tibia III with 2 apical spurs ---------- 31
Tibia III with 1 apical spur ---------- 32

31 Apex of antennal club with stylus (31A); pronotal collar sharp ---------- *Norbanus*

Distribution: Worldwide. Hosts: Cephidae.

Apex of antennal club without stylus (31B); pronotal collar rounded ---------- *Dimachus*

Distribution: Palearctic. Hosts: probably Anobiidae.



31A *Norbanus* 31B *Dimachus*

32 Forewing with infuscated band ---------- *Tritneptis (Systellogaster) ovivora*

Distribution: Nearctic. Hosts: Blattaria (oothecae).

Forewing hyaline ---------- 33

33 Pronotum sharply margined; clypeus deeply incised ---------- *Caenacis*

Distribution: Worldwide. Hosts: Hymenoptera.

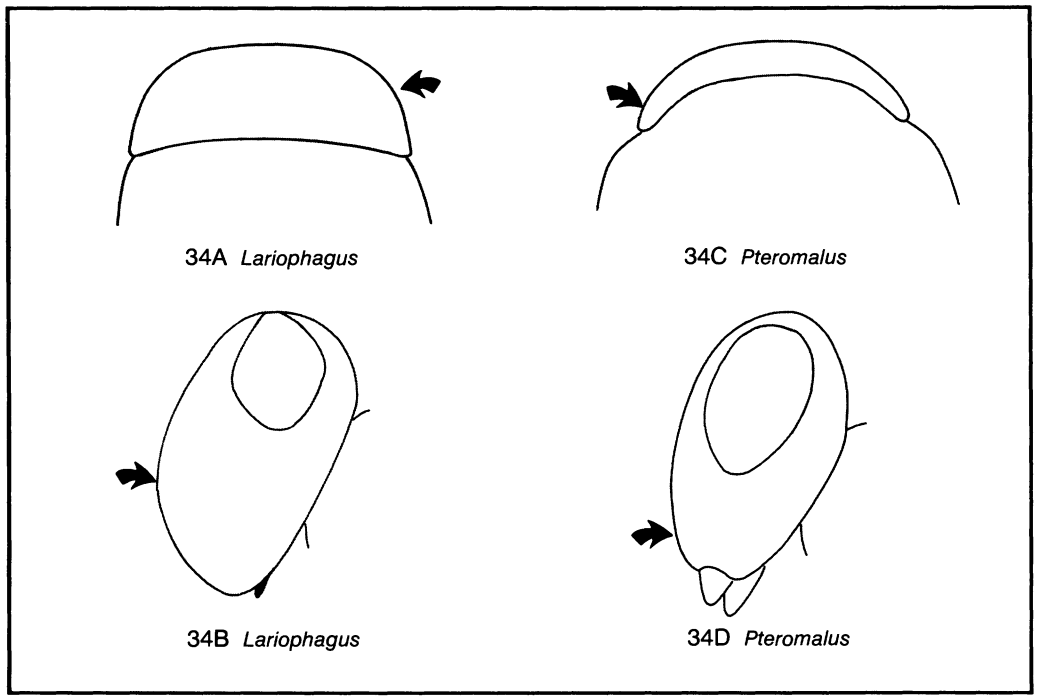
Pronotum not sharply margined; clypeus not deeply incised ---------- 34

34 Pronotum long, rounded (34A); face inflated (34B)----------*Lariophagus*

Distribution: Worldwide. Hosts: Coleoptera.

Pronotum short, transverse (34C); face not inflated (34D)----------*Pteromalus*

Distribution: Worldwide. Hosts: Coleoptera, Lepidoptera. See also 4B, 5E.

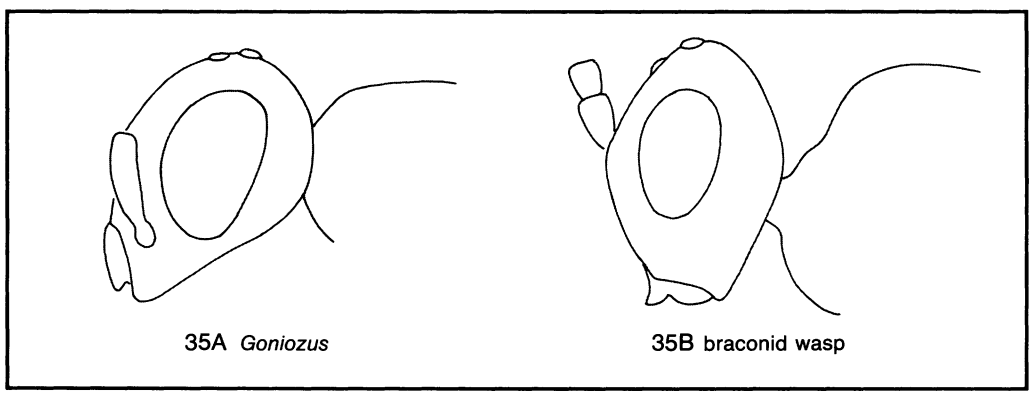


35 Head prognathous (35A); body depressed. Bethylidae (**bethylid wasps**)---------- 36

Body shining black; ovipositor modified as a sting.

Head hypognathous (35B); body not depressed. Ichneumonoidea (ichneumonoid parasitic wasps) ---------- 47

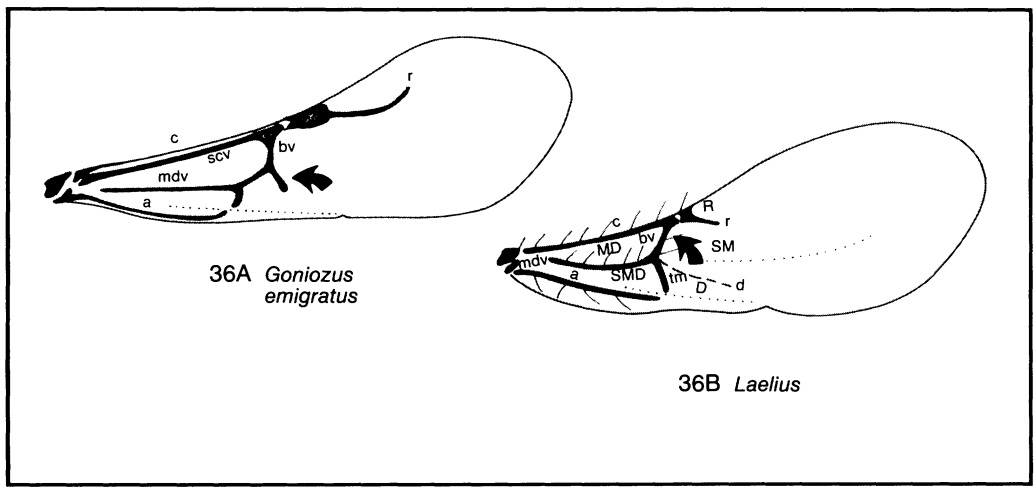
Body usually not shining black; ovipositor used as an egg-tube.



36 Wing with a vein or a stub of a vein arising from basal vein (36A) ---------- *Goniozus emigratus*

Distribution: Nearctic. Hosts: Larval Lepidoptera.

Predominantly wingless, but if winged, then with basal vein simple or absent, not giving rise to a vein or a stub of a vein (36B) ---------- 37



36A *Goniozus emigratus*

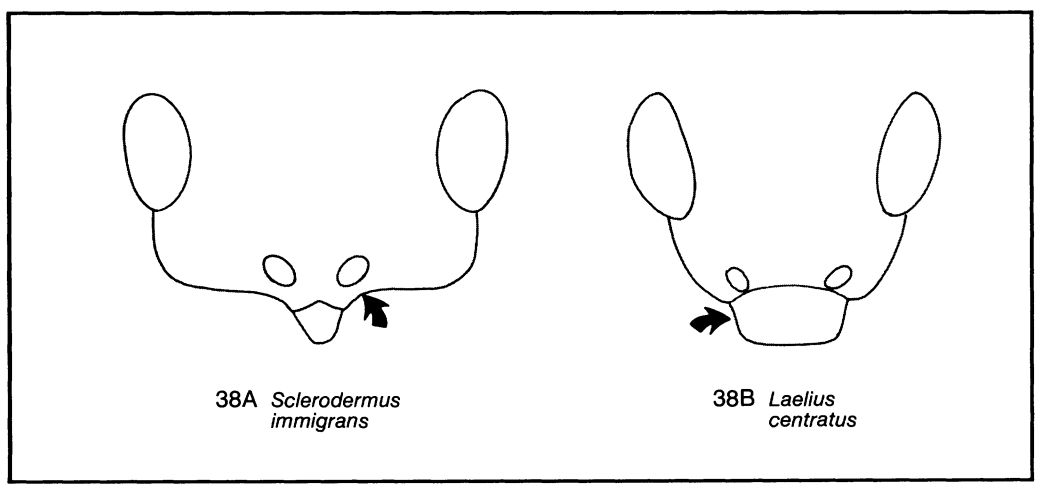
36B *Laelius*

37 Antenna with 13 segments (funicle segment I small in some species) ---------- 38
Antenna with 12 segments ---------- 42

38 Clypeus with median lobe short, truncate (38A) ---------- *Sclerodermus immigrans*

Distribution: Hawaii, Oriental. Host: *Caryedon serratus.*

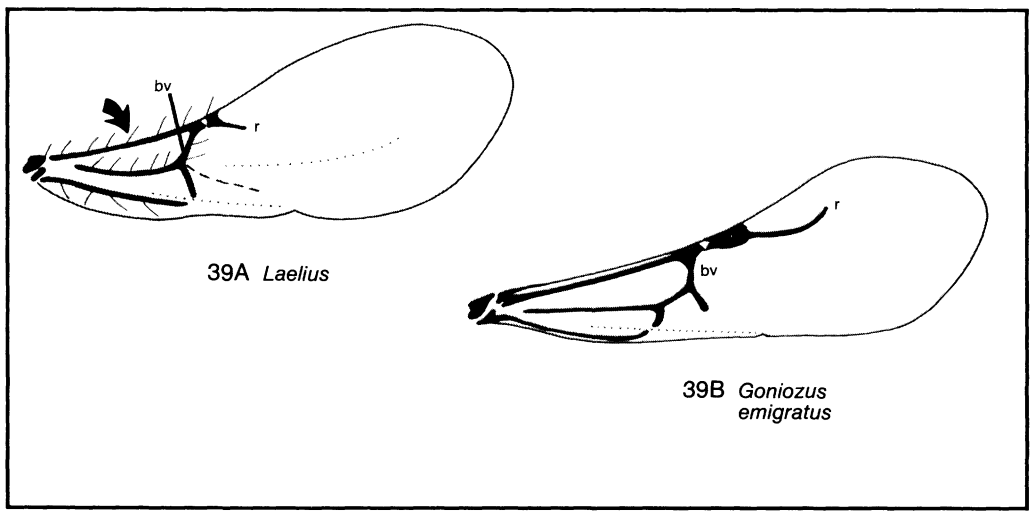
Clypeus with median lobe angularly or narrowly rounded (38B) ---------- 39



38A *Sclerodermus immigrans*

38B *Laelius centratus*

39 Veins with long, conspicuous setae; radial vein very short, at most slightly longer than basal vein (39A). Genus *Laelius* ---------- 40
Veins without long, conspicuous setae; radial vein much longer than basal vein (similar to 39B). Genus *Holepyris* ---------- 41



40 Wing hyaline ---------- *Laelius centratus*

Distribution: Nearctic. Hosts: *Trogoderma ornatum, T. simplex, T. variabile.* See 38B.

Wing slightly dusky (infuscated) ---------- *Laelius anthrenivorus*

Distribution: Oriental. Hosts: *Anthrenus* spp.

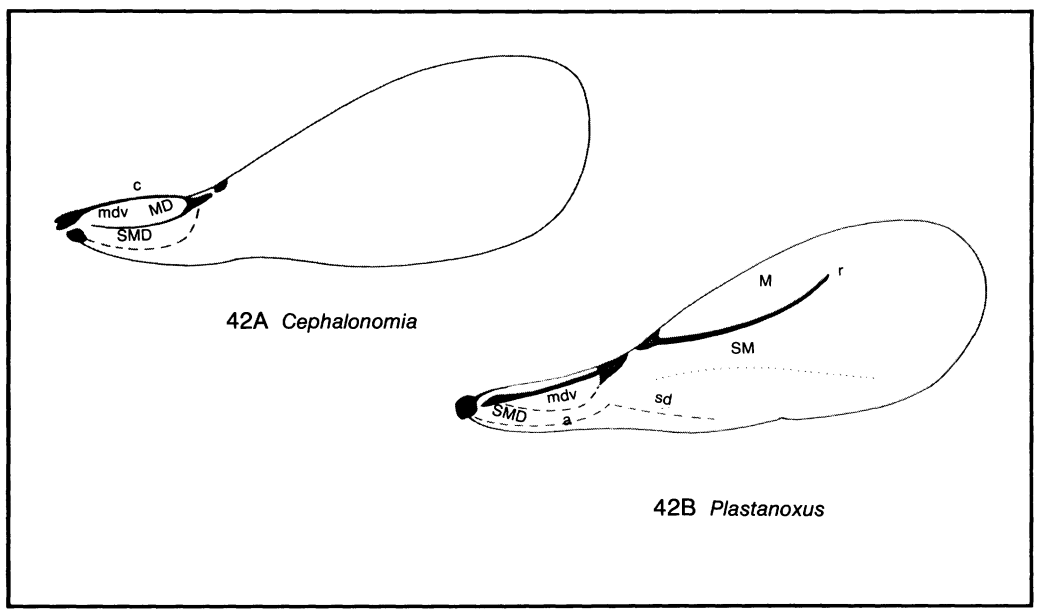
41 Eye setose ---------- *Holepyris sylvanidis*

Distribution: Worldwide. Hosts: *Oryzaephilus surinamensis, Sitophilus oryzae, Tribolium confusum.*

Eye without conspicuous vestiture of setae ---------- *Holepyris hawaiiensis*

Distribution: Worldwide. Host: *Ephestia elutella.*

42 Radial vein absent (42A) or wings absent. Genus *Cephalonomia* ---------- 43
Radial vein present (at least in part) (42B); wings fully developed. Genus *Plastanoxus* 46



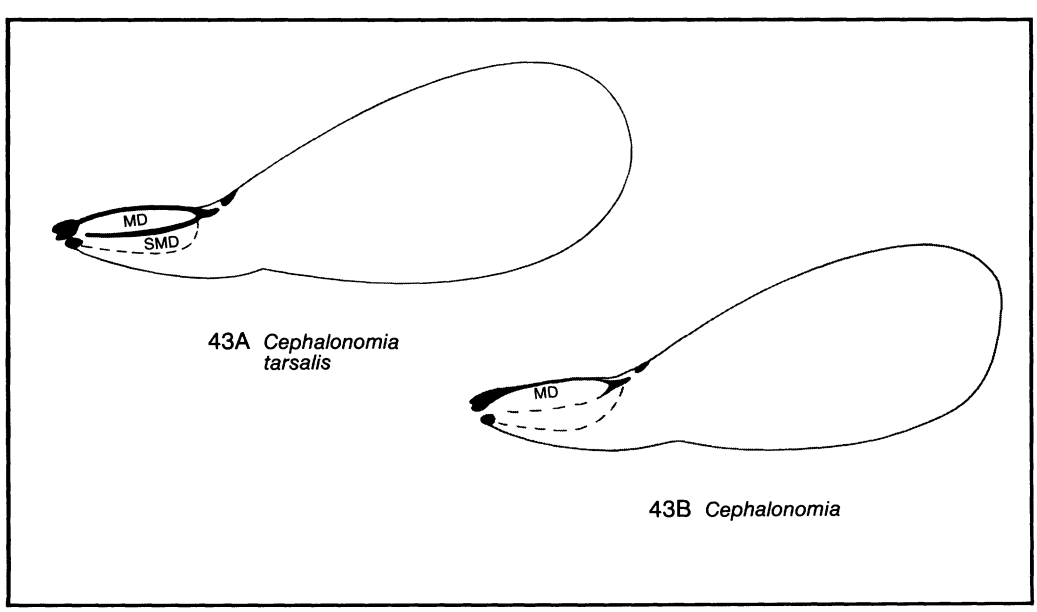
42A *Cephalonomia*

42B *Plastanoxus*

43 Forewing with a closed median cell (43A) ---------- *Cephalonomia tarsalis*

Distribution: Worldwide. Hosts: *Oryzaephilus surinamensis, Sitophilus oryzae.*

Forewing without a closed median cell (43B) ---------- 44



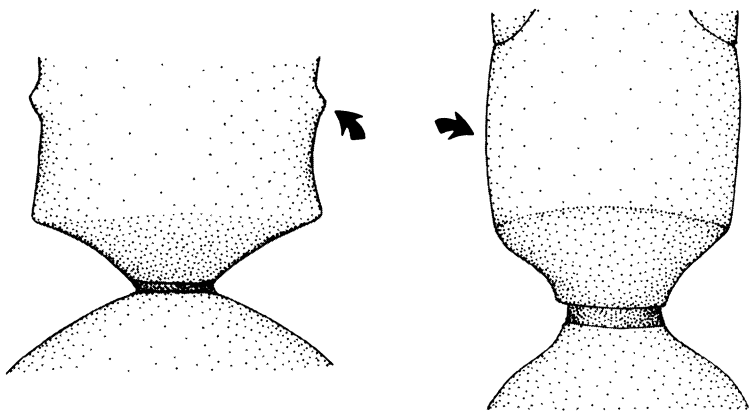
43A *Cephalonomia tarsalis*

43B *Cephalonomia*

44 Propodeum with a small dentiform process on each side (44A) ----*Cephalonomia gallicola*

Distribution: Worldwide. Hosts: Anobiidae, Ptinidae.

Propodeum without dentiform processes (44B)---------- 45



44A *Cephalonomia gallicola*

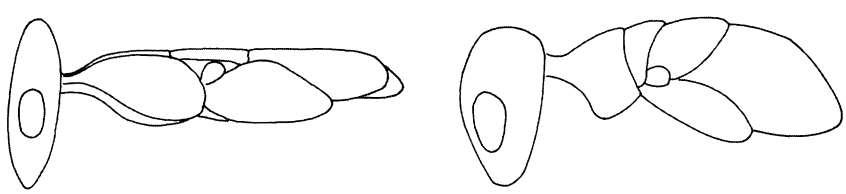
44B *Cephalonomia*

45 Thorax strongly depressed (45A) ----------**parasitic grain wasp,** *Cephalonomia waterstoni*

Distribution: Worldwide. Host: *Cryptolestes ferrugineus.*

Thorax not strongly depressed----------other *Cephalonomia*

Distribution: Worldwide. Hosts: Coleoptera.



45A *Cephalonomia waterstoni*

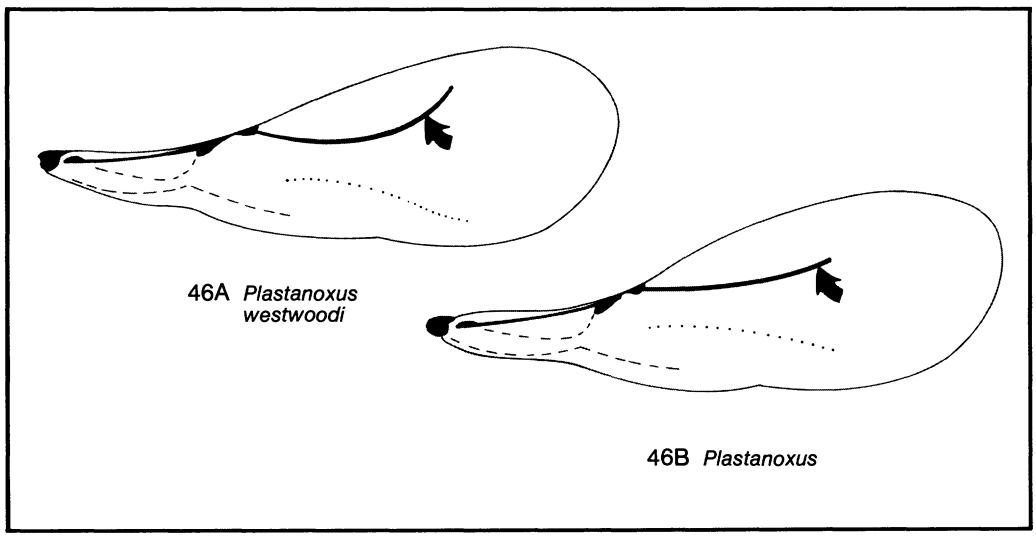
45B *Cephalonomia*

46 Radial vein gently curved (46A) ----------*Plastanoxus westwoodi*

Distribution: Worldwide. Host: *Cryptolestes pusillus.*

Radial vein straight distally (similar to 46B) ----------*Plastanoxus chittendenii*

Distribution: Holarctic. Hosts: *Cis* spp.

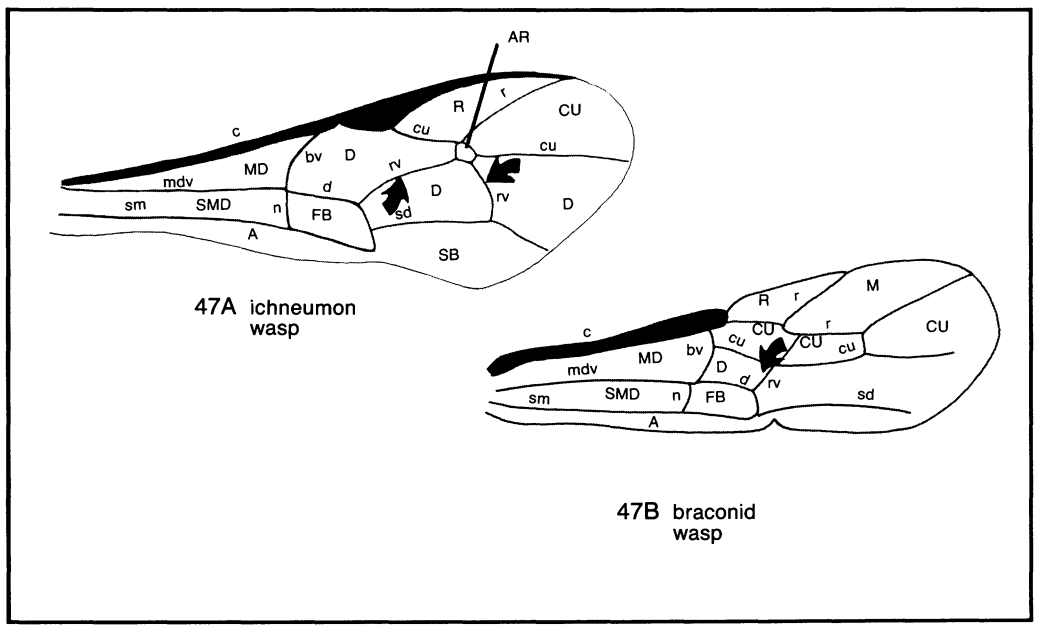


47 Forewing with 2 recurrent veins (47A). Ichneumonidae (**ichneumons**) ---------- 48

Areolet (AR) often present.

Forewing with 1 recurrent vein (47B). Braconidae (**braconid wasps**) ---------- 53

Aerolet absent



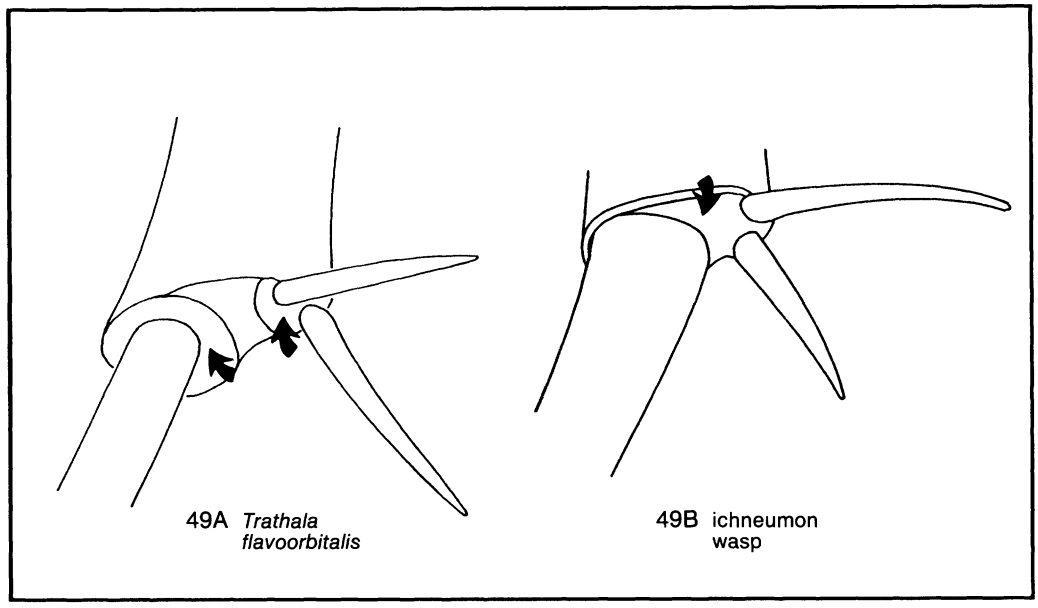
48 Gaster compressed; abdominal segments III and IV deeper than wide ---------- 49
Gaster depressed or cylindrical; abdominal segments III and IV wider than deep- 52

49 Tibial spurs inserted in an area separate from area of tarsal insertion (49A) ---------- *Trathala flavoorbitalis*

Clypeus separated from face by a groove; face usually more or less pale. Distribution: Indo-Australian, Oriental. Host: *Ostrinia nubilalis.*

Tibial spurs and tarsus inserted in a common area of tibia (49B)---------- 50

Clypeus usually confluent with face; face usually black.



50 Gastral segment I near its basal third circular or depressed oval in cross section ---------- *Venturia canescens*

Gastral tergum I never with a pit in front of spiracle. Distribution: Worldwide. Hosts: *Anagasta kuehniella, Cadra figulilella, Ephestia elutella, Galleria mellonella, Plodia interpunctella.*

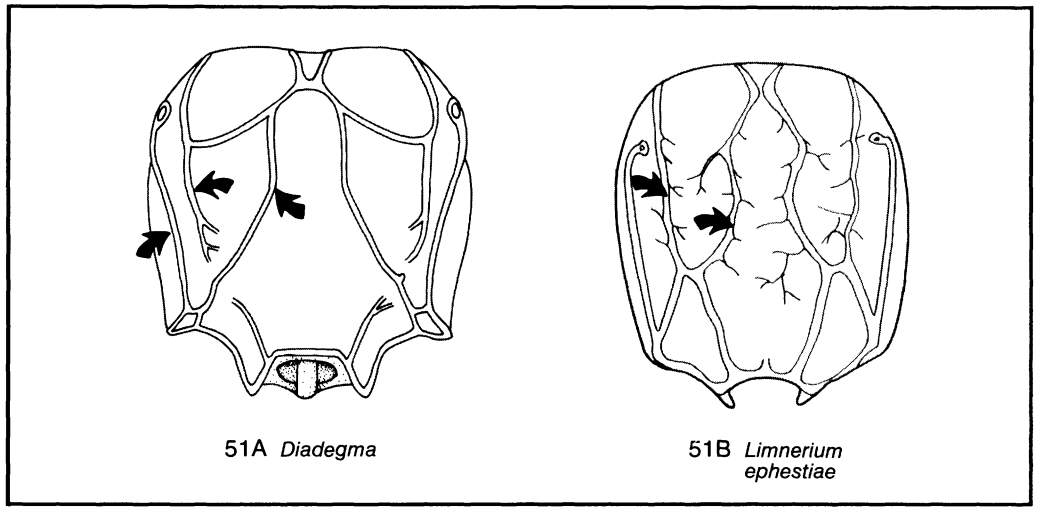
Gastral segment I near its basal third somewhat quadrate, trapezoidal, or triangular in cross section---------- 51

51 Propodeal carina usually strong (51A) ---------- *Diadegma*

Distribution: Worldwide. Hosts: Lepidoptera.

Propodeal carina usually weak (51B) ---------- *Limnerium ephestiae*

Distribution: Worldwide. Hosts: Pyraloidea.



51A *Diadegma*

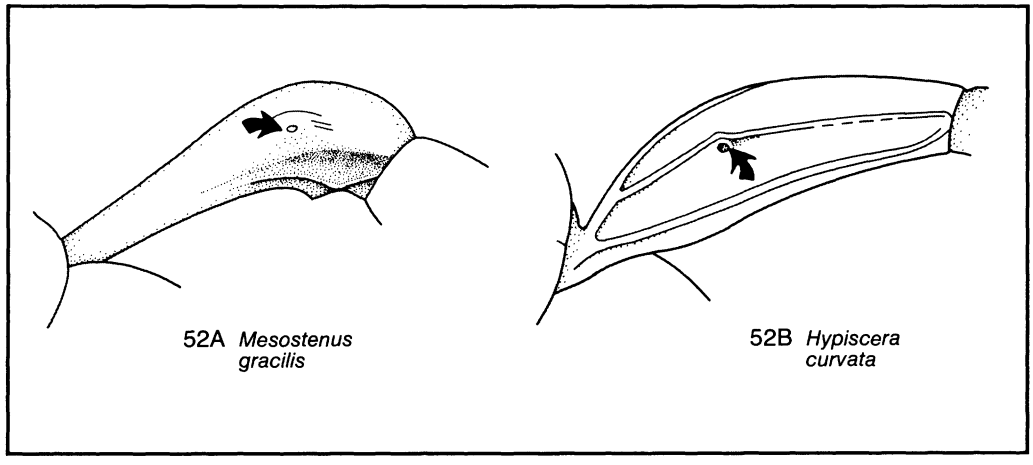
51B *Limnerium ephestiae*

52 Spiracle of gastral tergum I located somewhat behind midlength of tergum (52A) ---------- *Mesostenus gracilis*

Distribution: Worldwide. Hosts: *Anagasta kuehniella, Cadra figulilella, Ephestia elutella, Euzophera semifuneralis* (Walker), *Zophodia convolutella* (Hübner); also known from *Ozamia fuscomaculella clarefacta* Dyar.

Spiracle of gastral tergum I located near or in front of midlength of tergum (52B) ---------- *Hypiscera curvata*

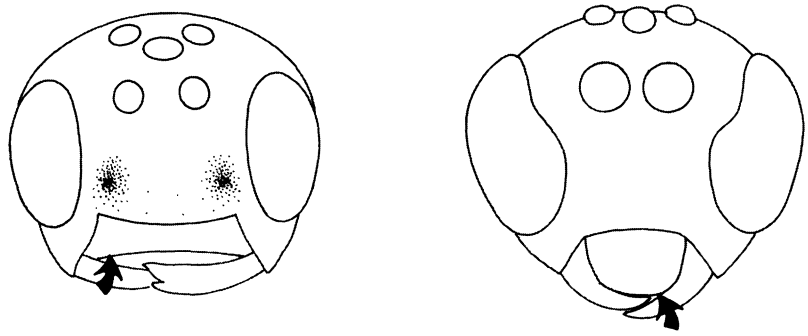
Distribution: Neotropical. Hosts: Lepidoptera.



52A *Mesostenus gracilis*

52B *Hypiscera curvata*

53 Clypeal margin concave (53A) ---------- 54
Clypeal margin arcuate (53B) ---------- 60



53A braconid wasp

53B *Apanteles*

54 Occipital and prepectal carinae absent; maxillary palpus 5-segmented. *Habrobracon* 55
Occipital and prepectal carinae usually present; maxillary palpus 6-segmented ---- 58

55 Gastral terga not shining ---------- *Habrobracon crassicornis*

Distribution: Palearctic. Hosts: *Anagasta kuehniella*; also known from *Sparganothis pilleriana* (Denis & Schiffermüller).

Gastral terga shining ---------- 56

56 Antenna 17 to 21 segmented, much longer than head and thorax combined ---------- *Habrobracon kitcheneri*

Distribution: Indo-Australian, Palearctic. Hosts: Lepidoptera.

Antenna 13 to 17 segmented, seldom longer than head and thorax combined ----- 57

57 Antenna 13 to 14 segmented, shorter than head and thorax combined ---------- *Habrobracon hebetor*

Distribution: Worldwide. Hosts: *Anagasta kuehniella, Cadra cautella, Ephestia elutella, Galleria mellonella, Plodia interpunctella, Sitotroga cerealella, Vitula edmandsii serratilineella*.

Antenna 15 to 17 segmented, slightly longer than head and thorax combined ---------- *Habrobracon brevicornis*

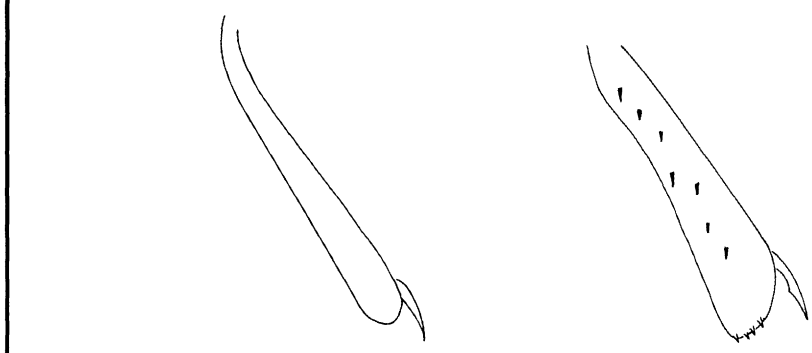
Distribution: Palearctic, probably Nearctic. Hosts: *Ostrinia nubilalis*; also known from *Dioryctria abietella* (Denis & Schiffermüller).

58 Tibia I without a row or cluster of stout spines or pegs on anterior surface (58A) ----------*Chremylus rubiginosus*

Prepectus sometimes margined. Distribution: Palearctic. Hosts: Lepidoptera.

Tibia I with a row or cluster of stout spines or pegs along anterior surface (58B) - 59

Prepectus always margined.



58A *Chremylus rubiginosus*

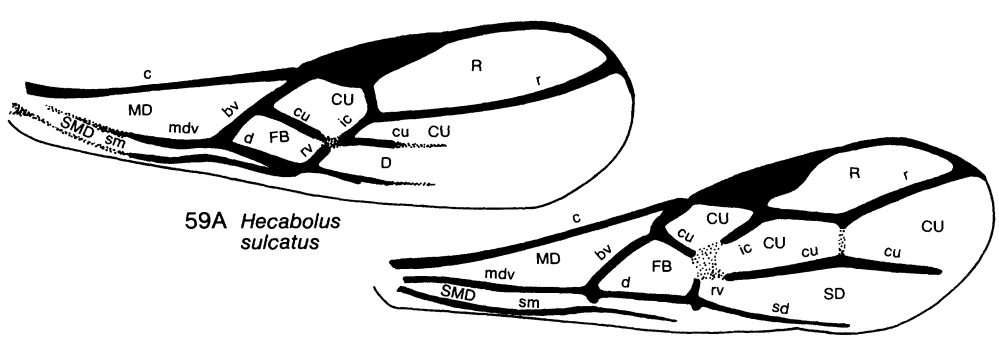
58B braconid wasp

59 Forewing with 2 cubital cells (59A) ----------*Hecabolus sulcatus*

Distribution: Palearctic. Hosts: *Anobium punctatum, Ptinus fur;* also reported from *Anobium rufipes* Fabricius, *A. thomsoni* Kraatz, *Hylesinus varius* Fabricius, *Ochina ptinoides* (Marsham), *Phloeosinus bicolor* (Brullé), *P. thuyae* Perris, *Ptilinus* spp., *Phymatodes alni* (L.).

Forewing with 3 cubital cells (59B) ----------*Spathius exarator*

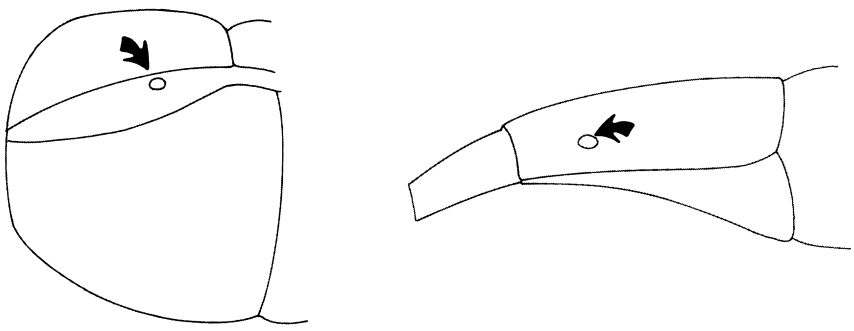
Distribution: Palearctic. Hosts: Coleoptera.



59A *Hecabolus sulcatus*

59B *Spathius exarator*

60 Occipital carina absent; spiracle of gastral tergum I situated on lateral membrane of tergum, removed from sclerotized median plate (60A). Genus *Apanteles*------- 61
Occipital carina present; spiracle of gastral tergum I situated on lateral margin of sclerotized median plate (60B)---------- 63



60A *Apanteles* 60B diagrammatic

61 Mesoscutum dull, strongly and rather coarsely punctate----------*Apanteles araeceri*

Distribution: Indo-Australian. Hosts: *Araecerus fasciculatus*; also reported from *Phalacris immarginatus* Champion.

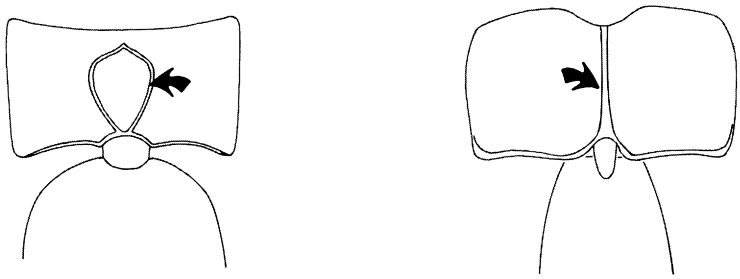
Mesoscutum somewhat shining, not coarsely punctate ---------- 62

62 Propodeum with a distinct areola, usually margined by a strong carina (62A)
----------*Apanteles carpatus*

Distribution: Nearctic. Hosts: *Tineola bisselliella*; also reported from *Phereoica uterella* (Walsingham), *Tinea pellionella* (L.), *Trichophaga tapetzella* (L.).

Propodeum without a distinct areola, but with a median carina from base to apex (62B)
----------*Apanteles nephoptericis*

Distribution: Nearctic. Hosts: *Anagasta kuehniella, Vitula edmandsii serratilineella*.



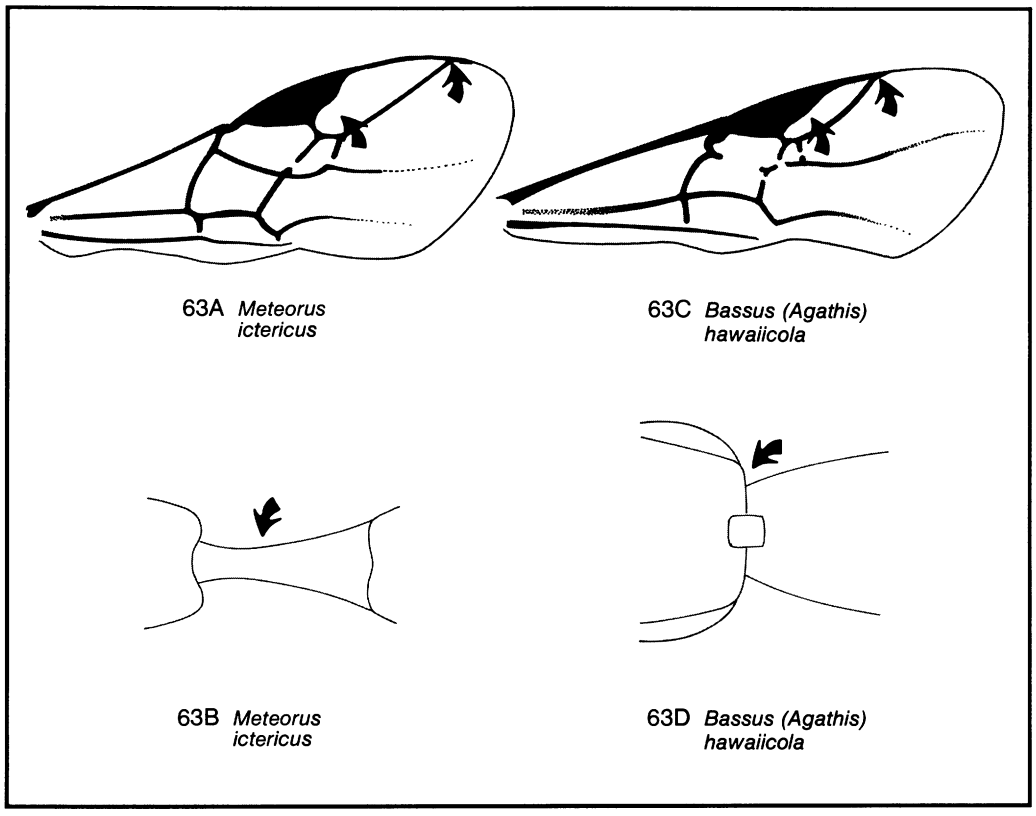
62A *Apanteles carpatus* 62B *Apanteles nephoptericis*

63 Radial cell long, radius nearly reaching wing apex (63A); gaster petiolate (63B) ---------- *Meteorus ictericus*

Distribution: Holarctic. Hosts: Lepidoptera.

Radial cell very narrow, radius meeting wing margin far from apex (63C); gaster sessile 63D)---------- *Bassus (Agathis) hawaiicola*

Distribution: Indo-Australian. Hosts: Lepidoptera.



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2 Graham, M.W.R. de V.
1969. The Pteromalidae of north-western Europe (Hymenoptera: Chalcidoidea). Bul. British Mus. (Nat. Hist.) Ent., suppl. 16, 908 p.

3 Michener, C.D.
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4 Townes, H.
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Notes and Sketches

Part 3

27 ILLUSTRATIONS OF MAJOR PEST SPECIES

Approximate body length measurements of insects are shown in millimeters in parentheses in the legend of each plate. The scientific illustrators are credited in the appropriate places on the following pages.

MITES (ACARI)

These illustrations, drawn by R.L. Smiley unless otherwise noted, are a continuation from part 1, chapter 1 (Mites), by R.L. Smiley. See figure 1.2 and couplet illustrations 8A, 8B, 11C, 47A, 48A, 48B, and 59A in chapter 1 for additional habitus illustrations of mites.

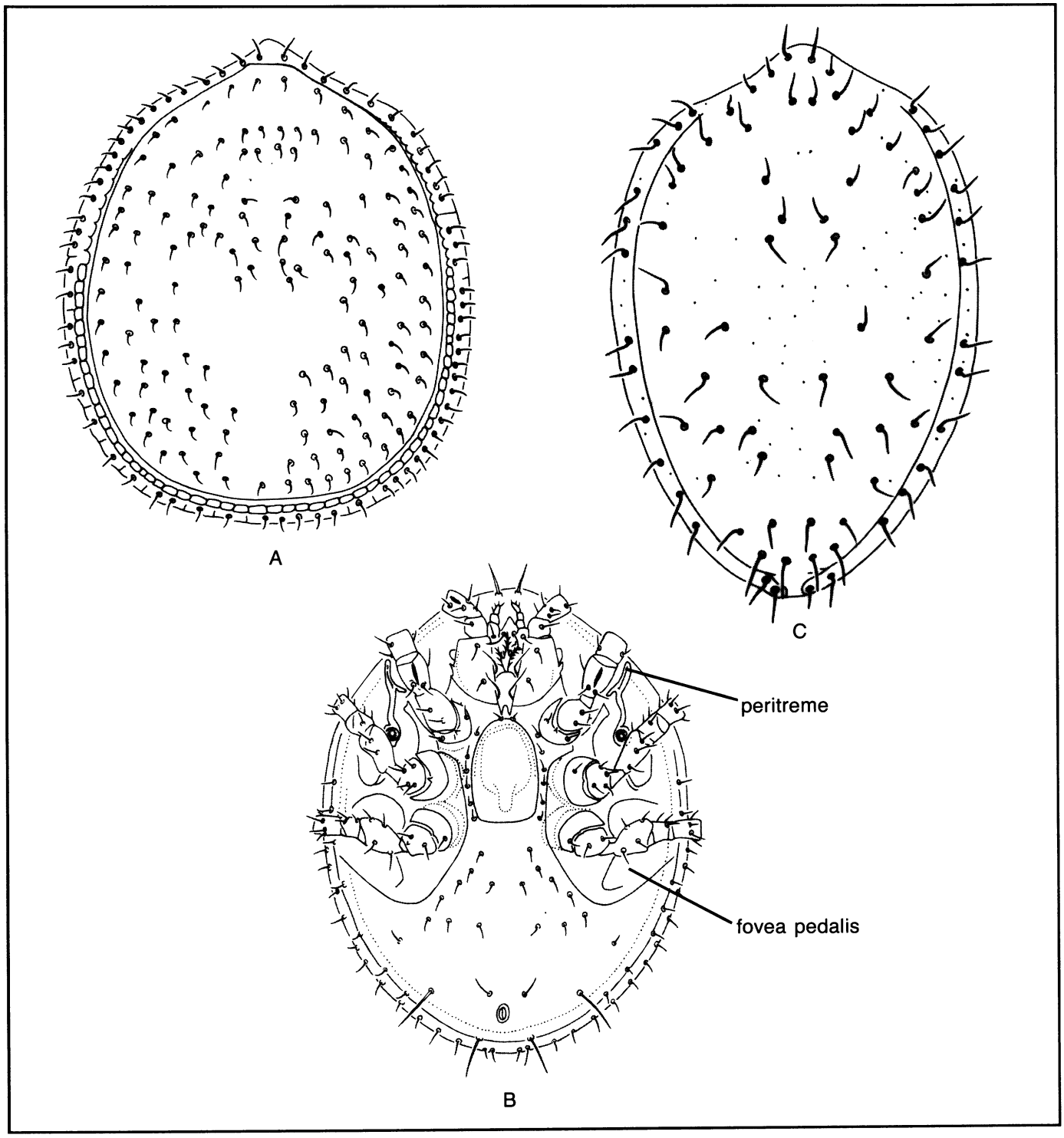


Plate 3. Uropodid mites (Uropodidae): A, *Leiodinychus krameri*, dorsal view of female; B, *Fuscuropoda* sp., ventral view of female; C, *Fuscuropoda marginata,* dorsal view of male.

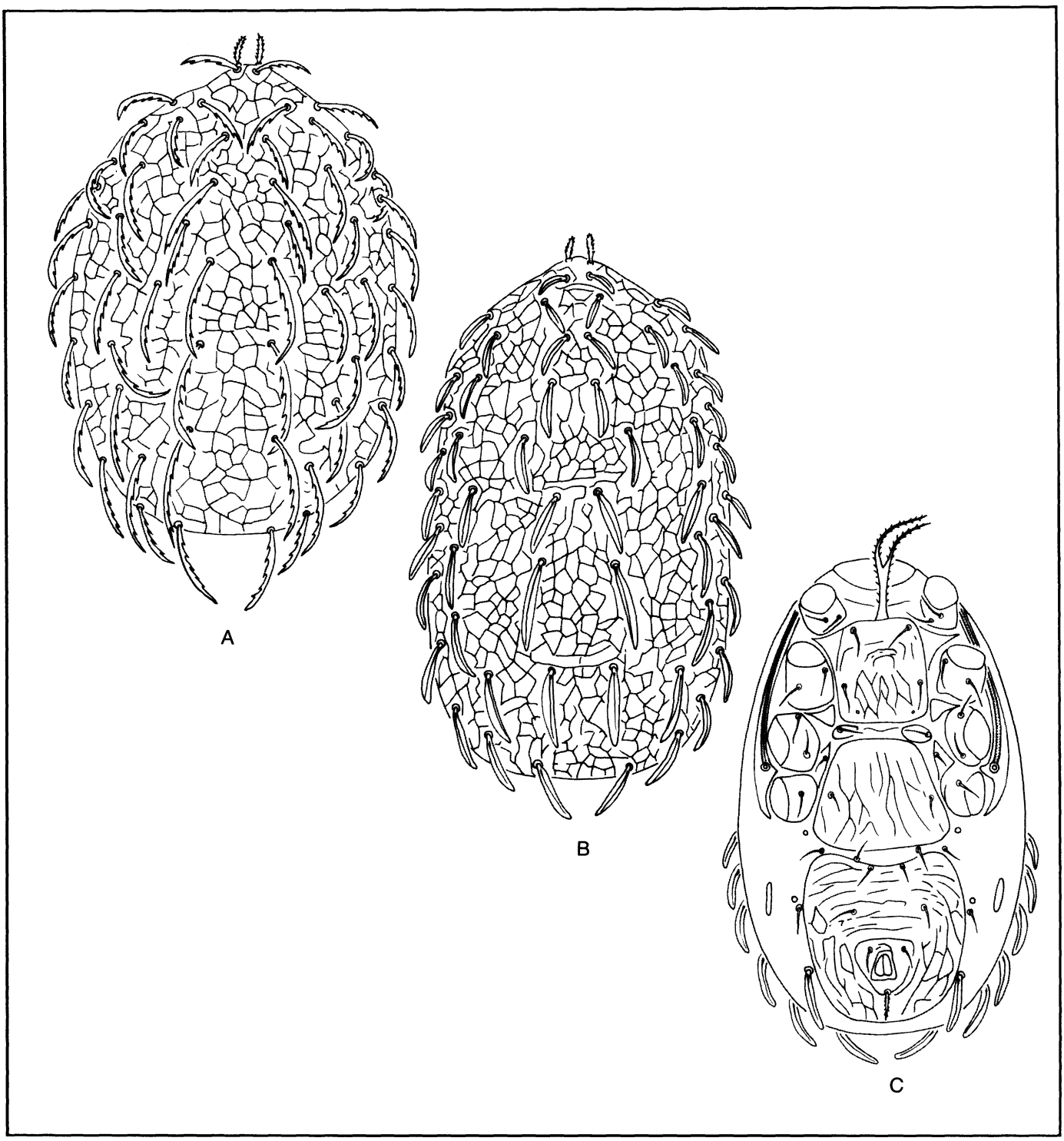


Plate 4. Ameroseiid mites (Ameroseiidae), females: A, *Kleemannia plumigera,* dorsal view; B, *Kleemannia plumosa,* dorsal view; C, same, ventral view.

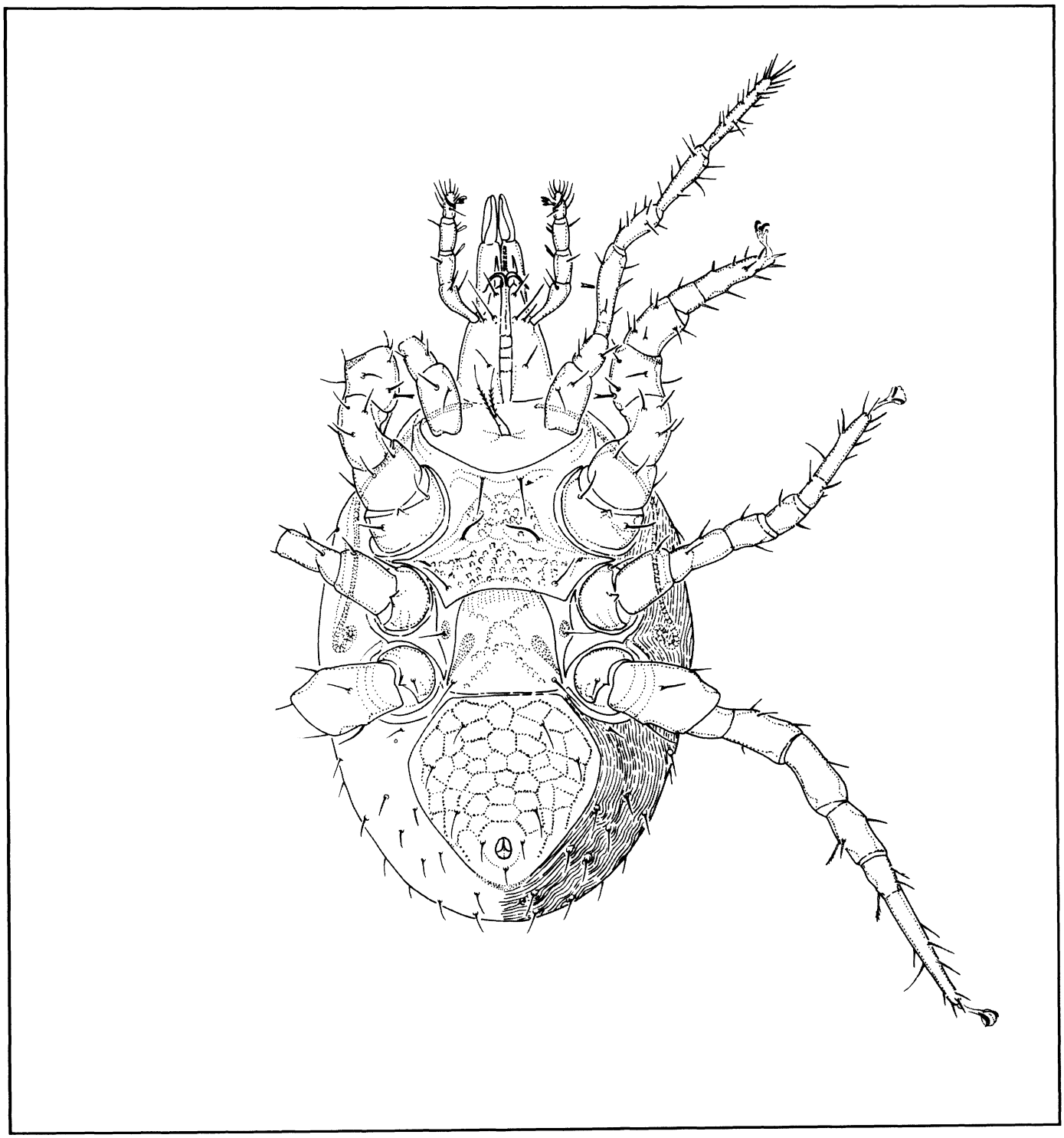


Plate 5. House fly mite, *Macrocheles muscaedomesticae* (Macrochelidae), ventral view of female. (Redrawn from *3* by C. Feller).

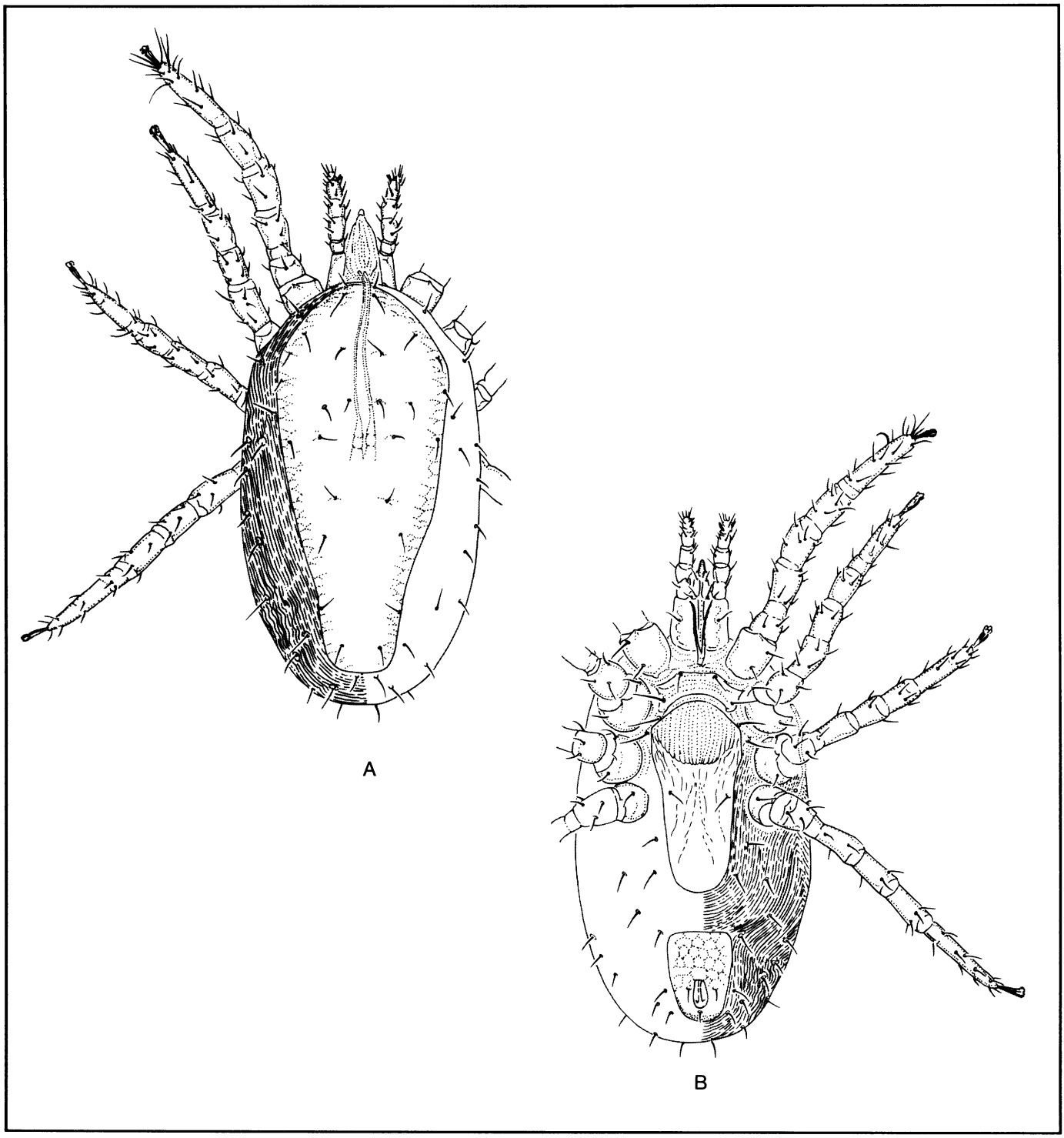


Plate 6. **Chicken mite,** *Dermanyssus gallinae* (Dermanyssidae), female: A, dorsal view; B, ventral view. (Redrawn from *3* by C. Feller.)

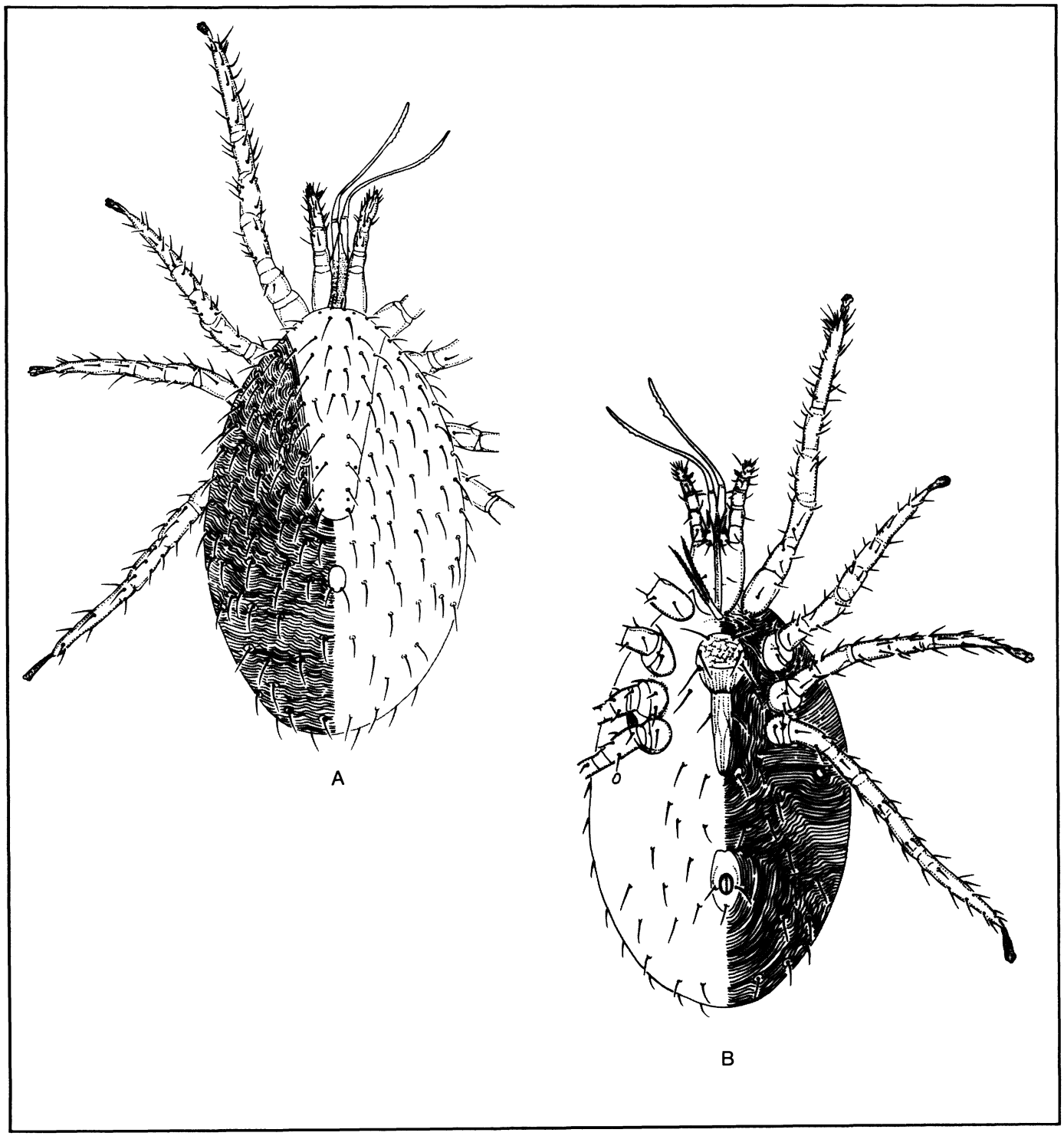


Plate 7. **House mouse mite,** *Liponyssoides sanguineus* (Macronyssidae), female: A, dorsal view; B, ventral view. (Redrawn from *3* by C. Feller.)

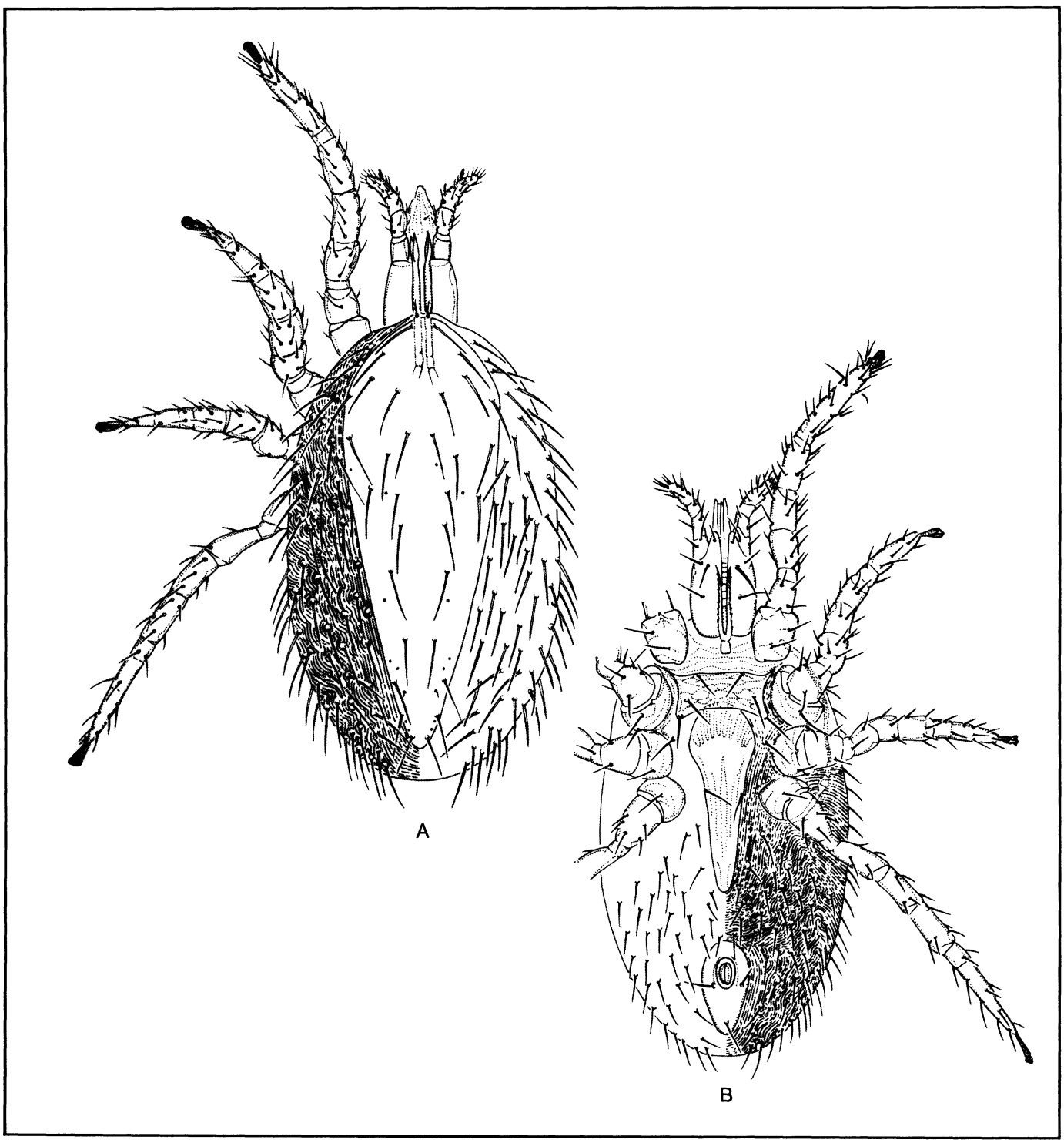


Plate 8. **Tropical rat mite**, *Ornithonyssus bacoti* (Macronyssidae), female: A, dorsal view; B, ventral view. (Redrawn from *3* by C. Feller.) (For the gravid female of *Ornithonyssus sylviarum*, see couplet illustration 11C.)

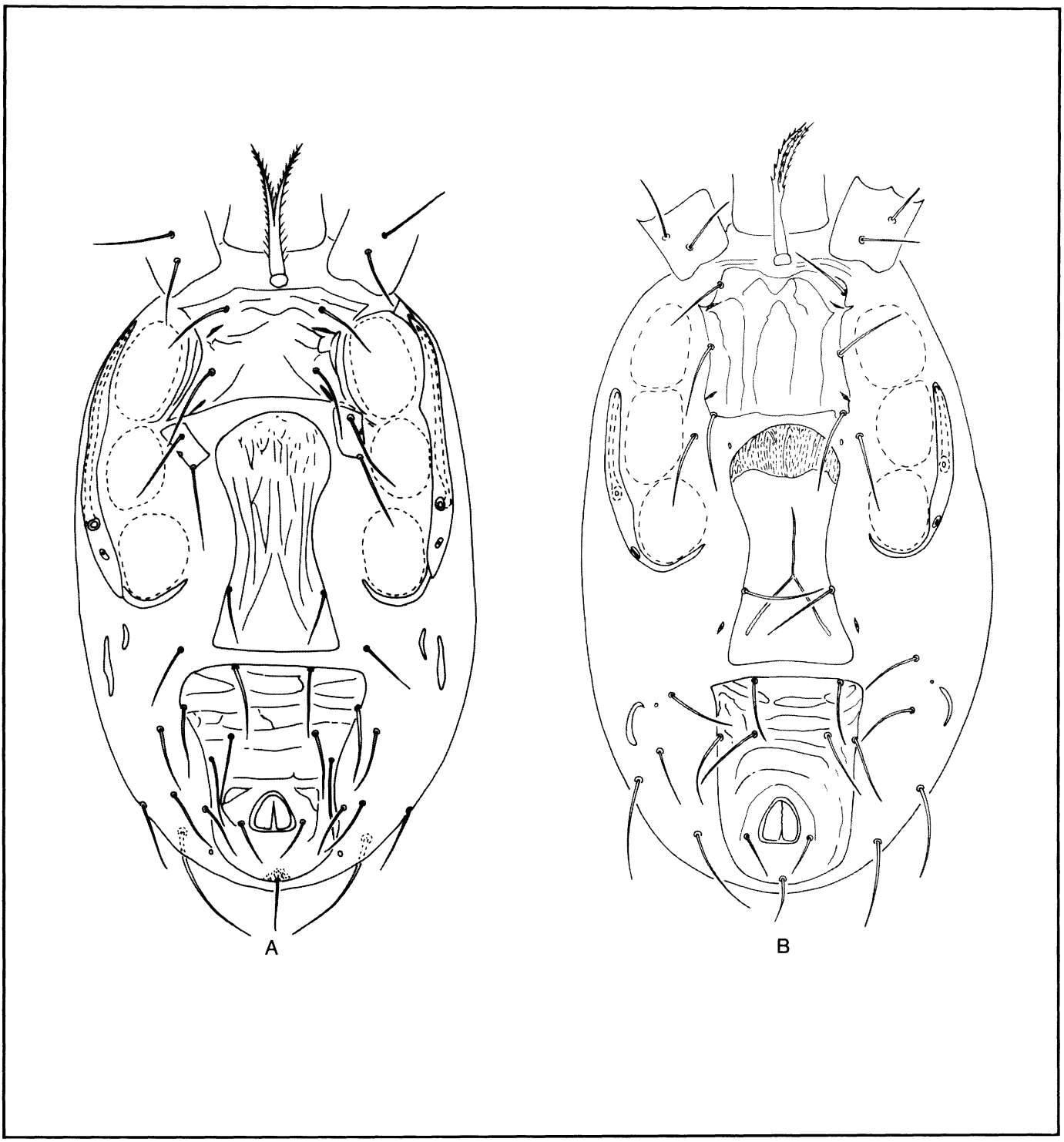


Plate 9. Ascid mites (Ascidae), females, ventral views: A, *Blattisocius dentriticus* (for dorsal view, see couplet illustration 8B); B, *Blattisocius tarsalis*.

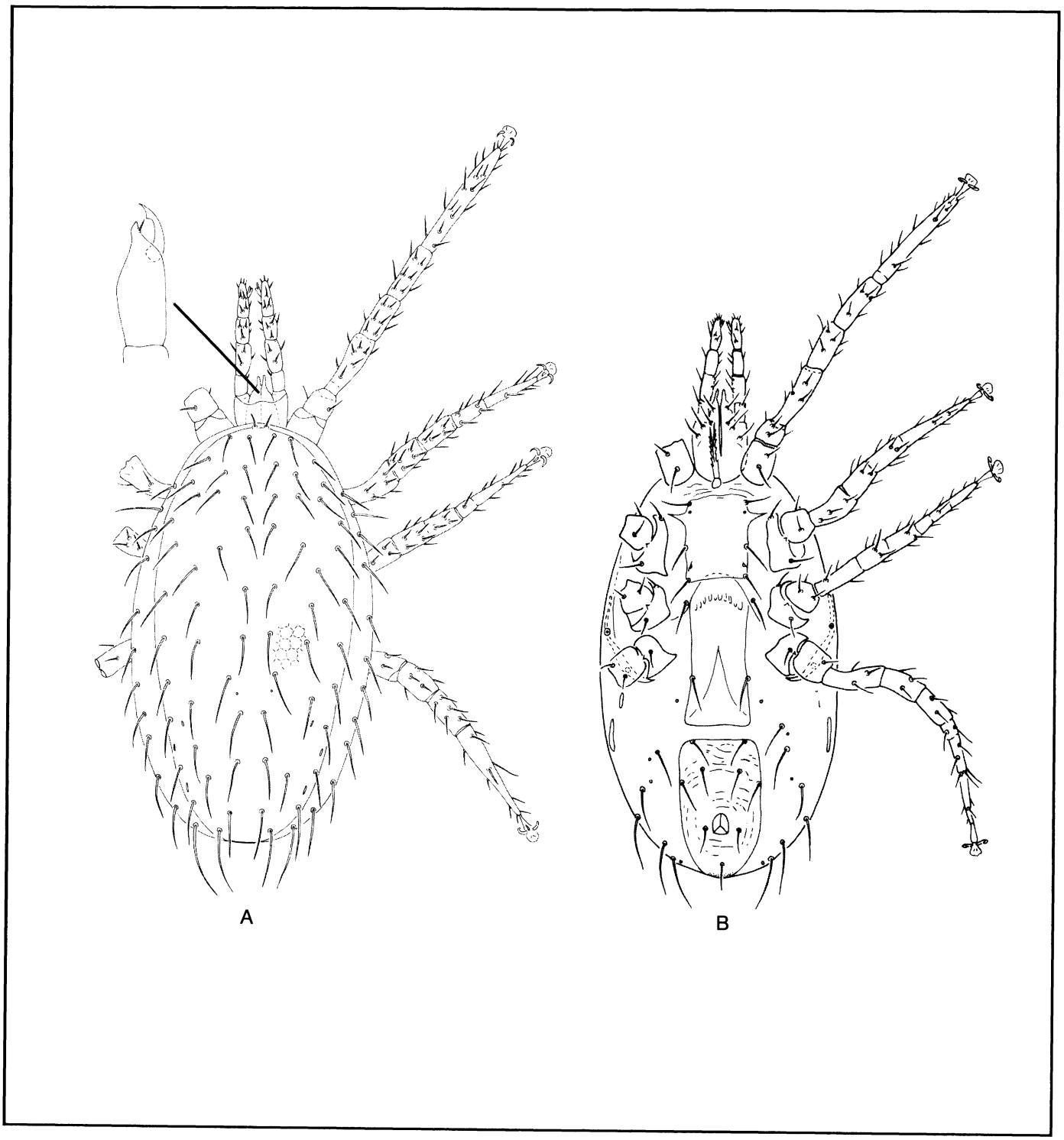


Plate 10. *Blattisocius keegani* (Ascidae), female:
A, dorsal view; B, ventral view.

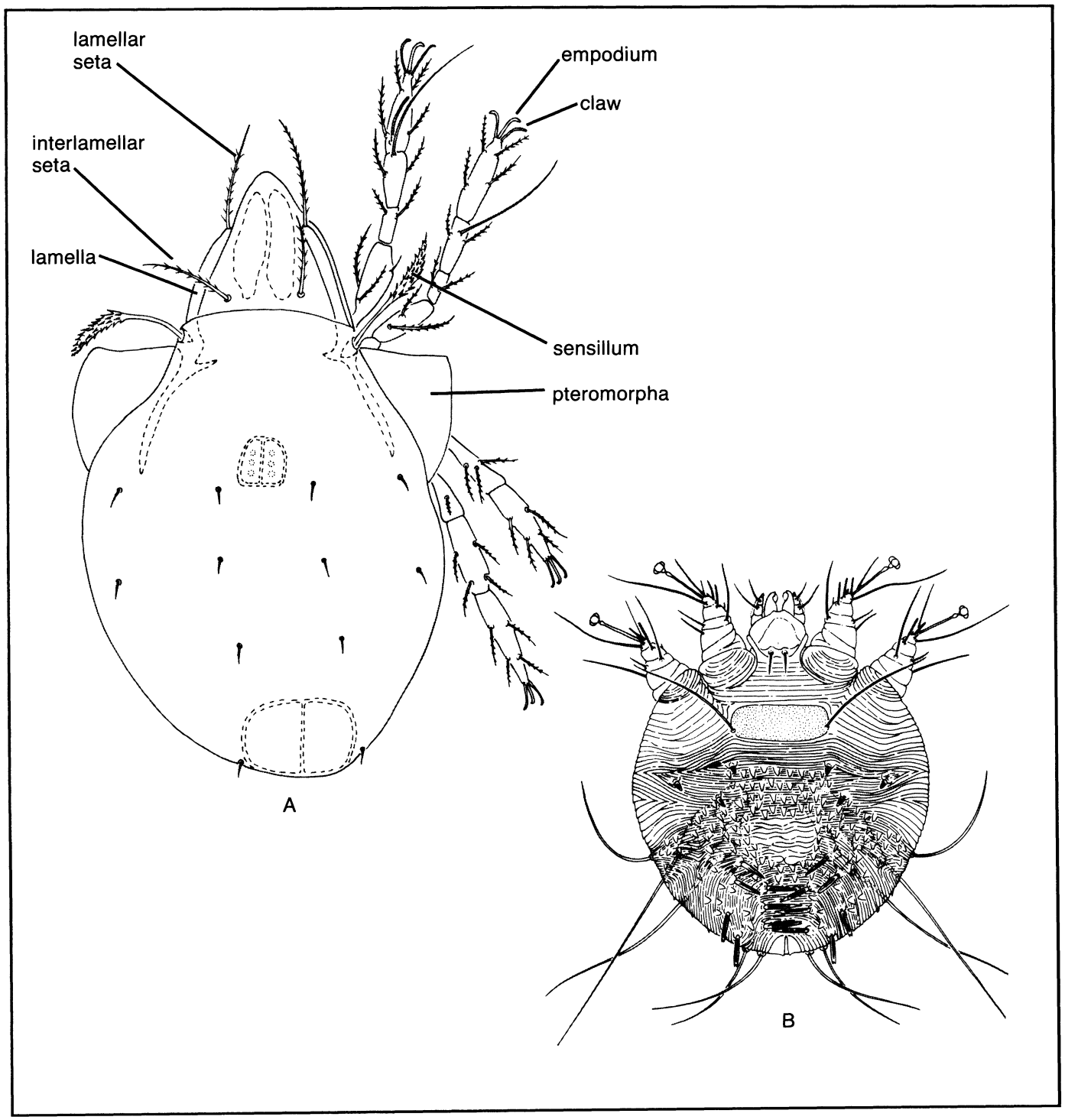


Plate 11. Acariform mites (Acariformes), females, dorsal views: A, a beetle mite, *Scheloribates* sp. (Oribatulidae); B, **itch mite,** *Sarcoptes scabiei* (Sarcoptidae) (redrawn from *3* by C. Feller).

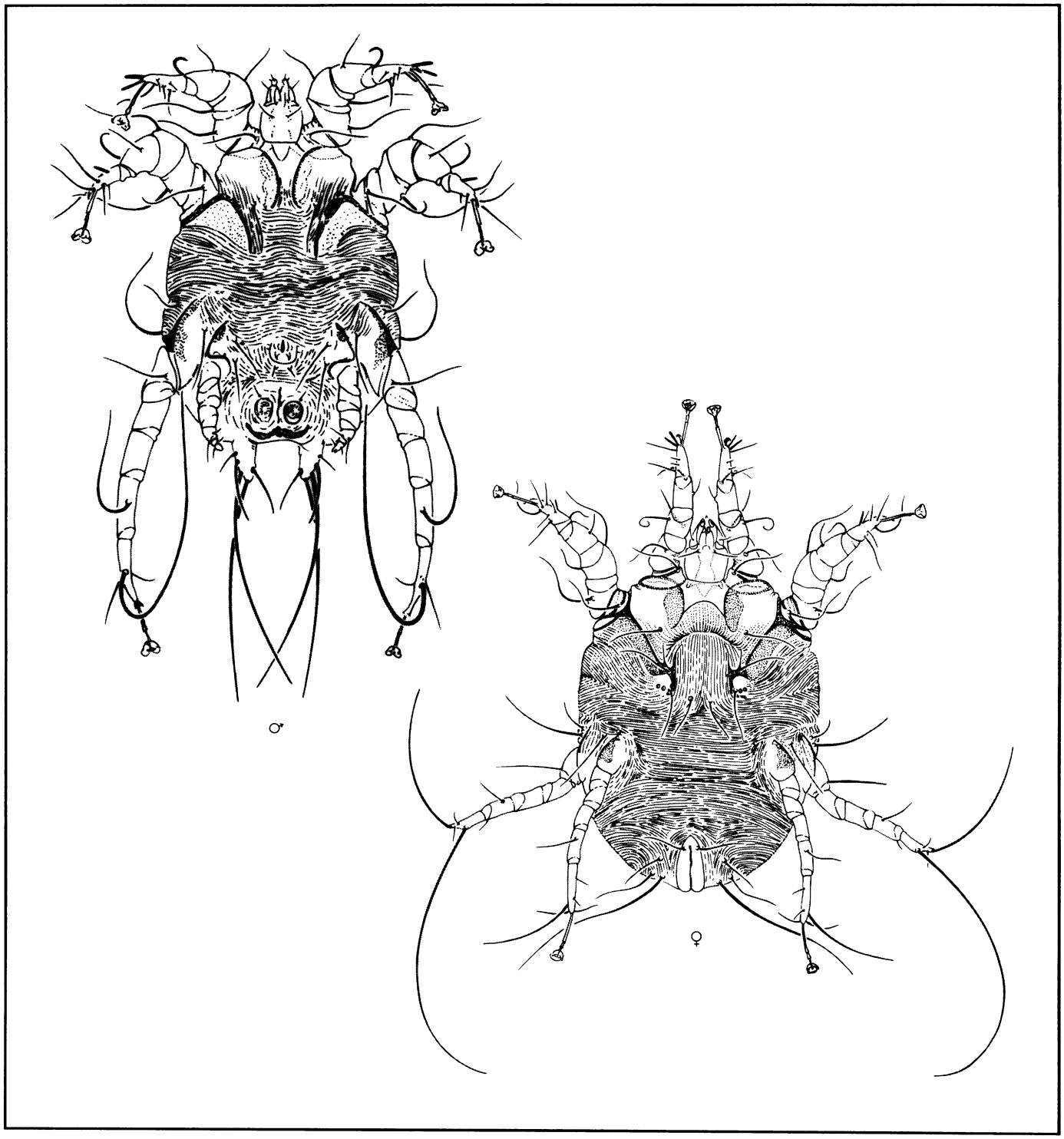


Plate 12. **Scab mite,** *Psoroptes equi* (Psoroptidae), ventral views. (Redrawn from *3* by C. Feller.)

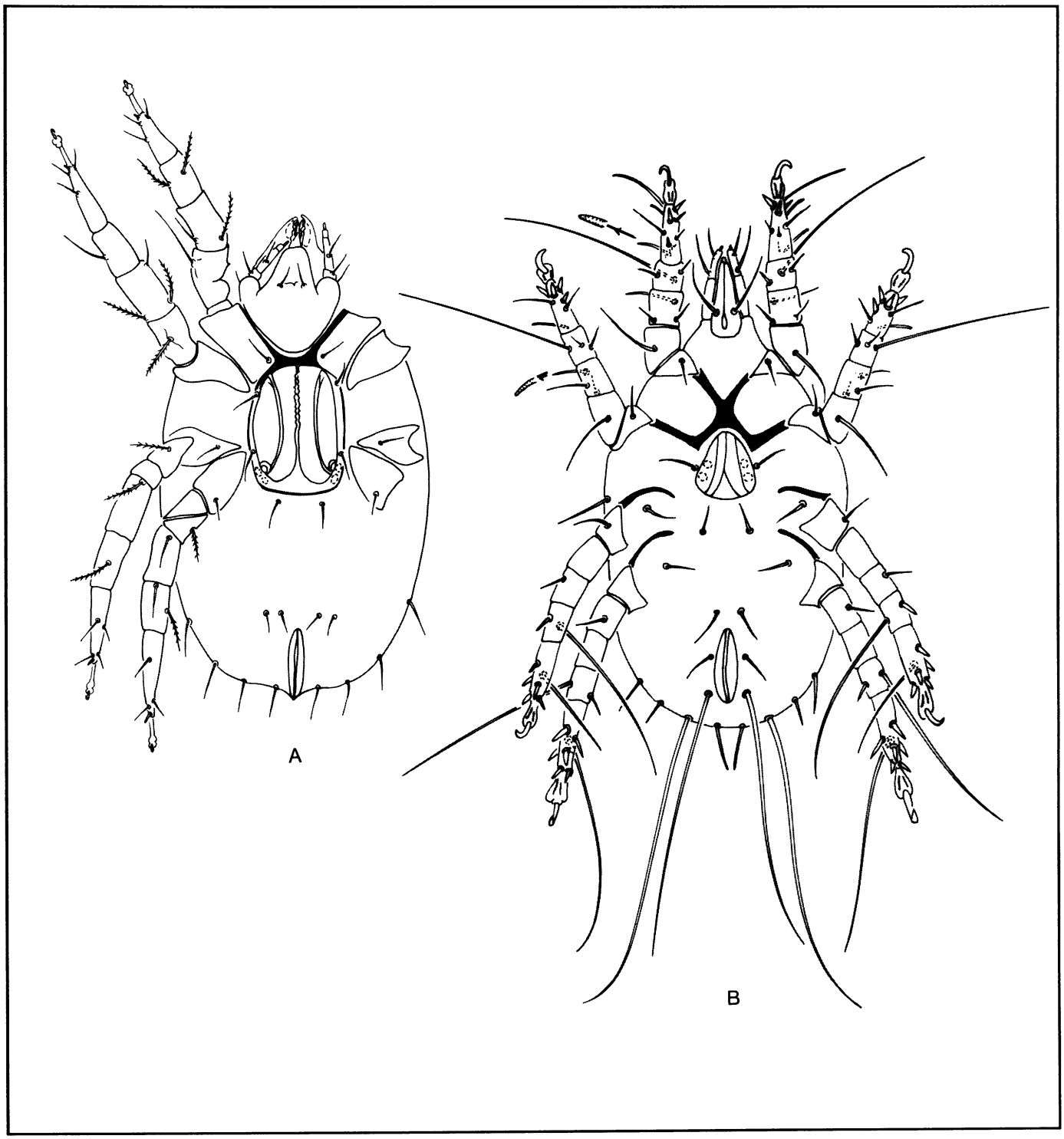


Plate 13. Astigmatid mites (Astigmata), females, ventral views: A, **brown flour mite,** *Gohieria fusca* (Glycyphagidae); B, **driedfruit mite,** *Carpoglyphus lactis* (Carpoglyphidae).

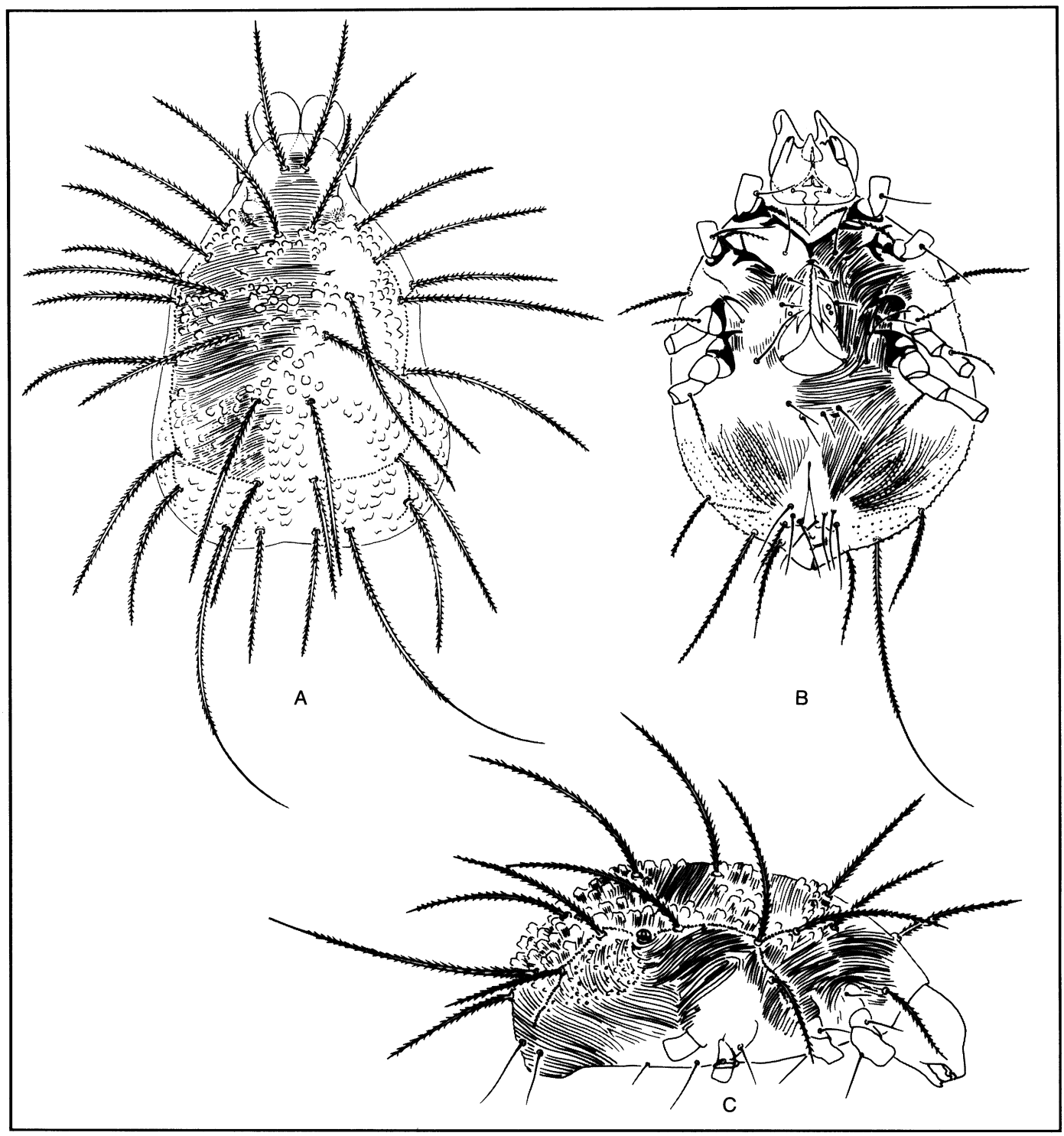


Plate 14. **Warty grain mite**, *Aeroglyphus robustus* (Glycyphagidae), female: A, dorsal view; B, ventral view; C, lateral view. (Redrawn from *2* by C. Feller.)

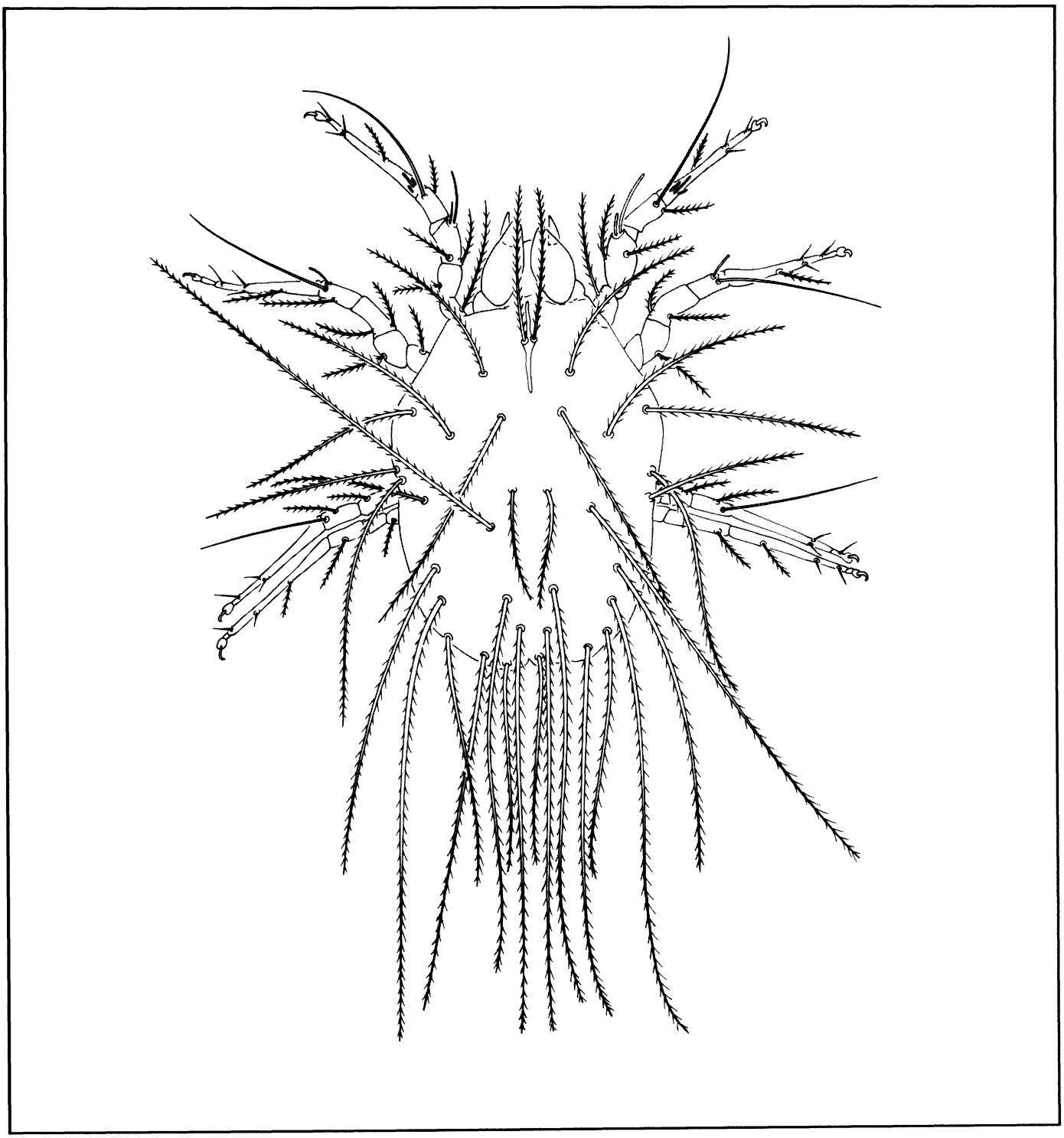


Plate 15. **House mite,** *Glycyphagus domesticus* (Glycyphagidae), male, dorsal view.

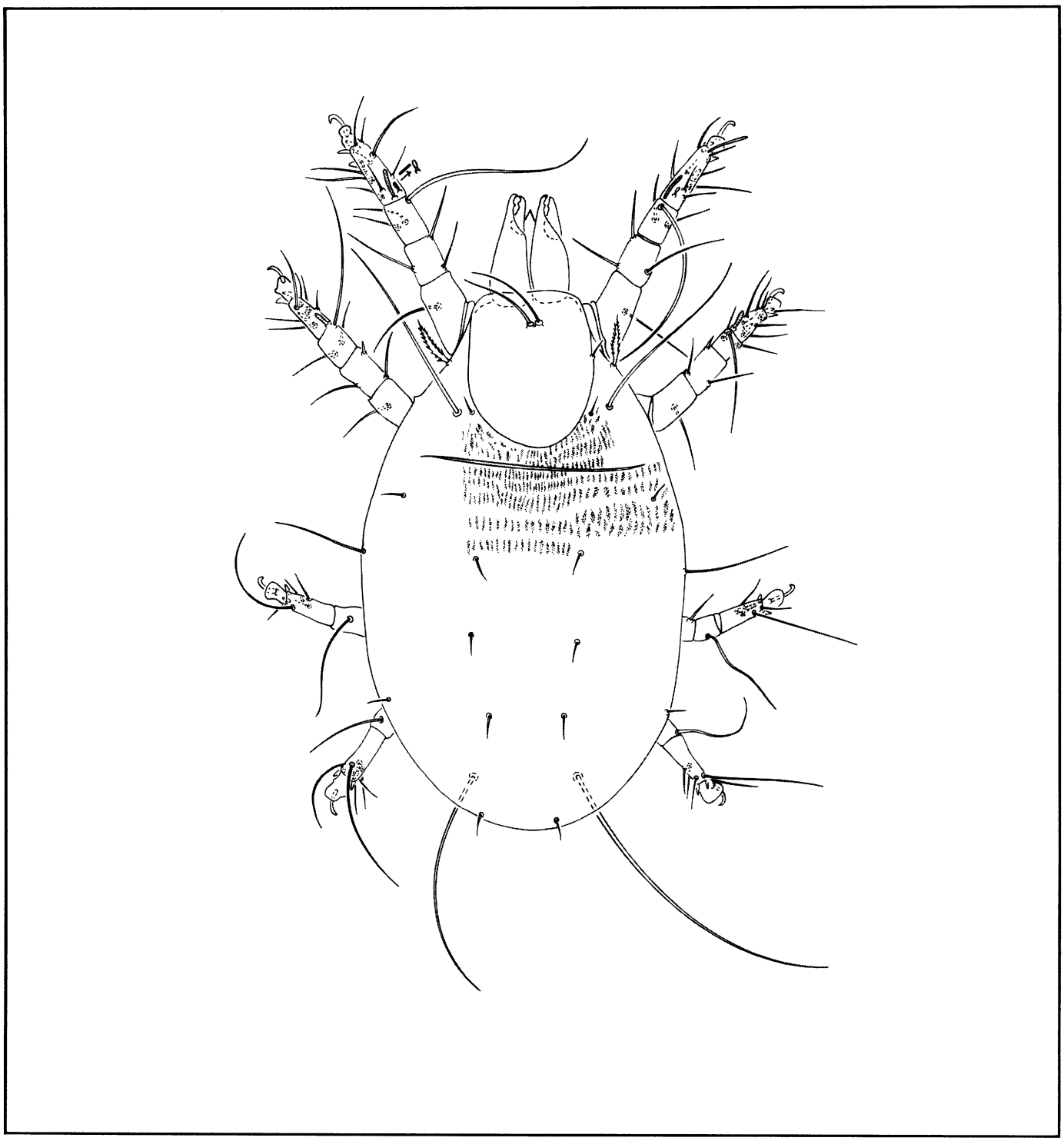


Plate 16. **Scaly grain mite,** *Suidasia nesbitti* (Acaridae), female, dorsal view.

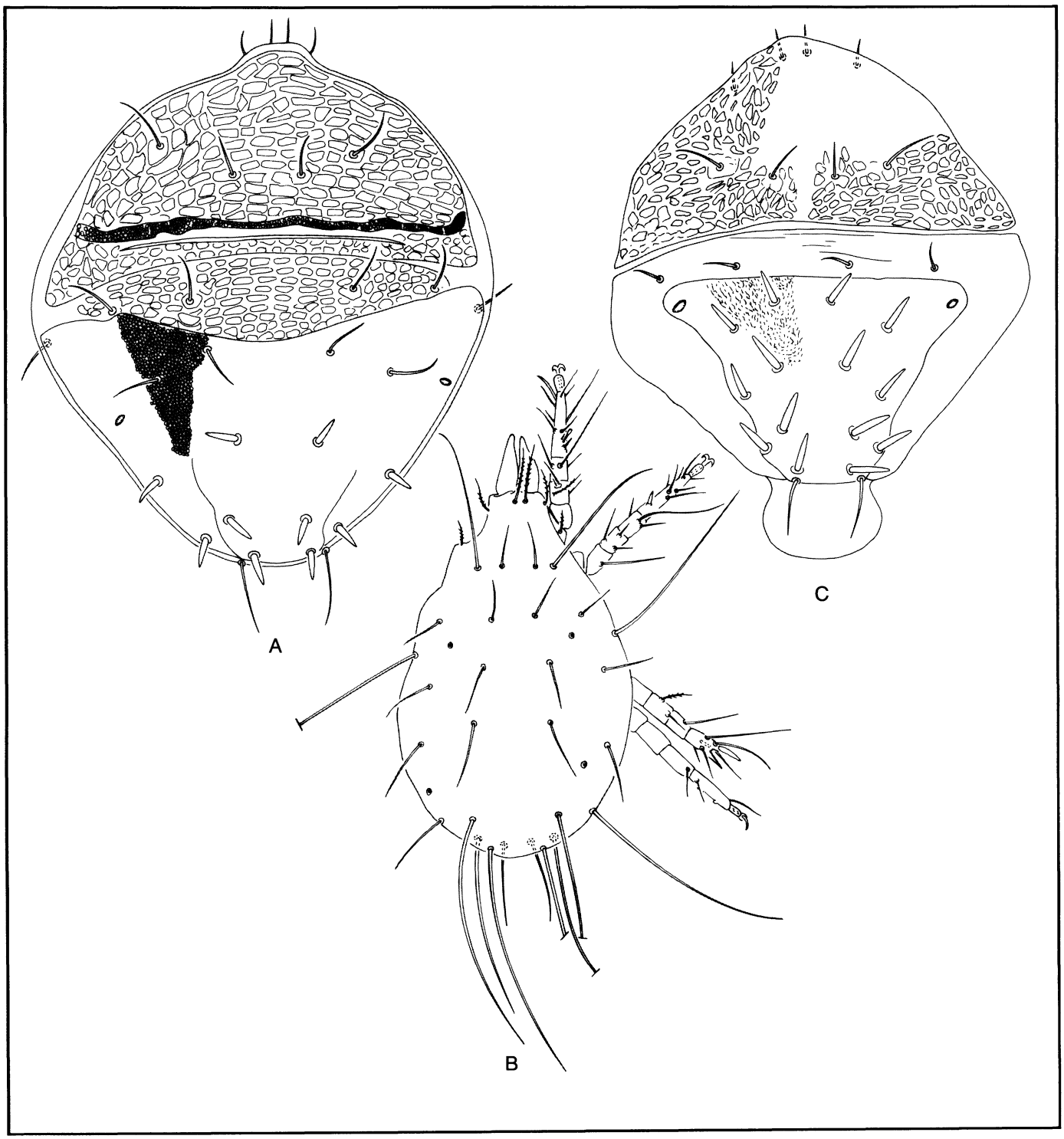


Plate 17. Lardoglyphid mites (Lardoglyphidae), dorsal views: A, *Lardoglyphus zacheri,* hypopus; B, same, male; C, *Lardoglyphus konoi,* hypopus.

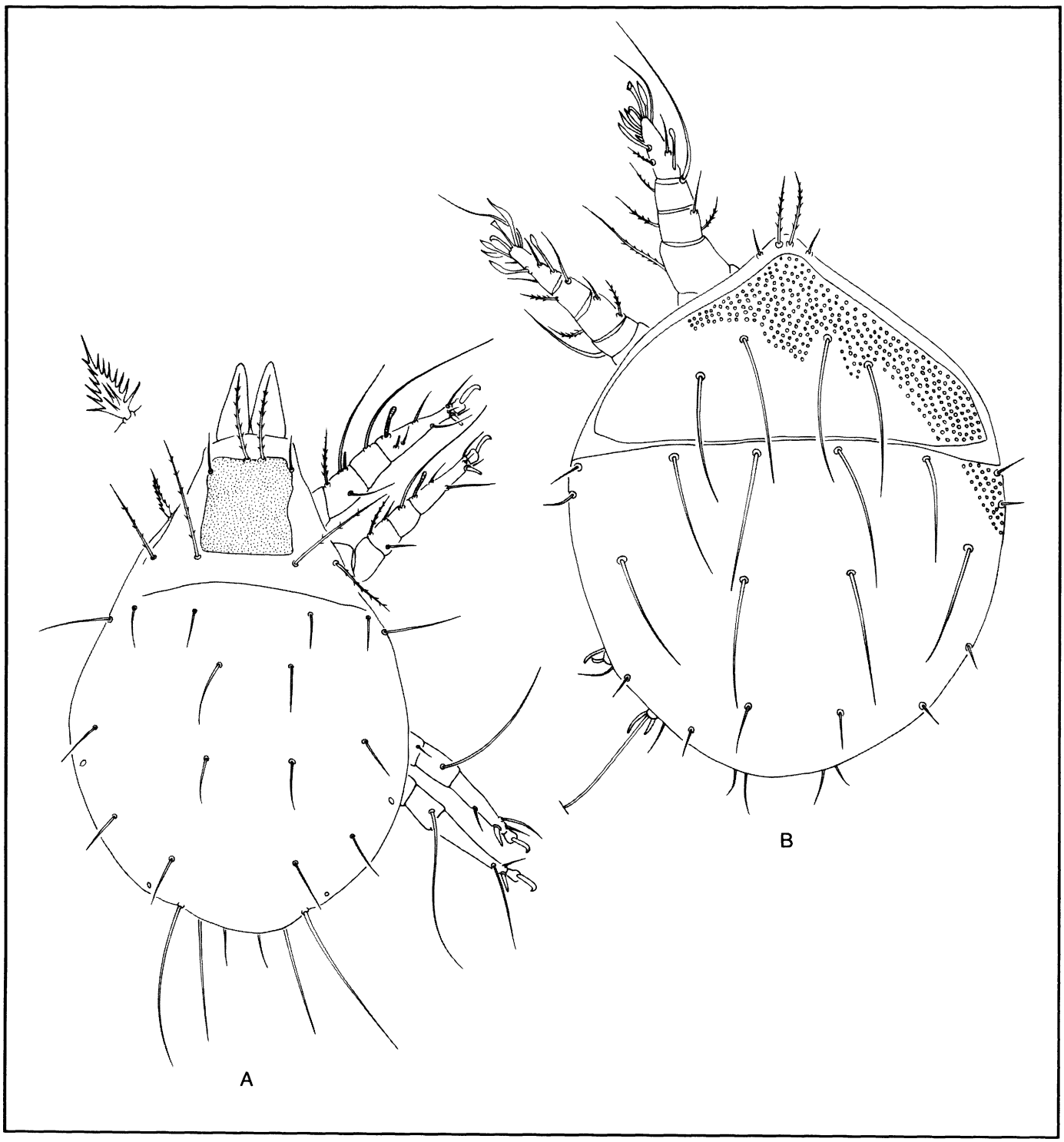


Plate 18. **Grain mite**, *Acarus siro* (Acaridae), dorsal views: A, female; B, hypopus.

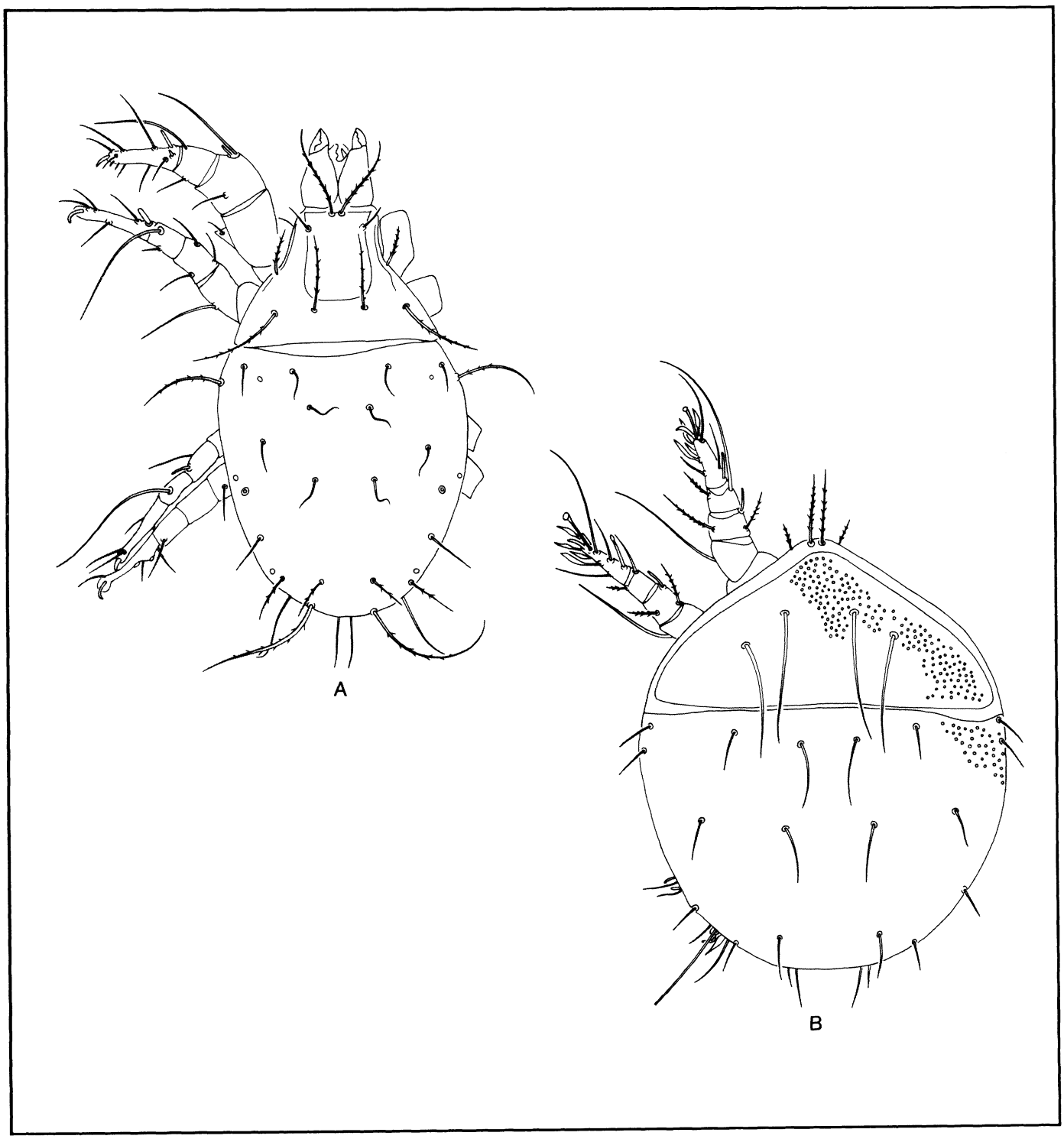


Plate 19. *Acarus farris* (Acaridae), dorsal views:
A, male; B, hypopus.

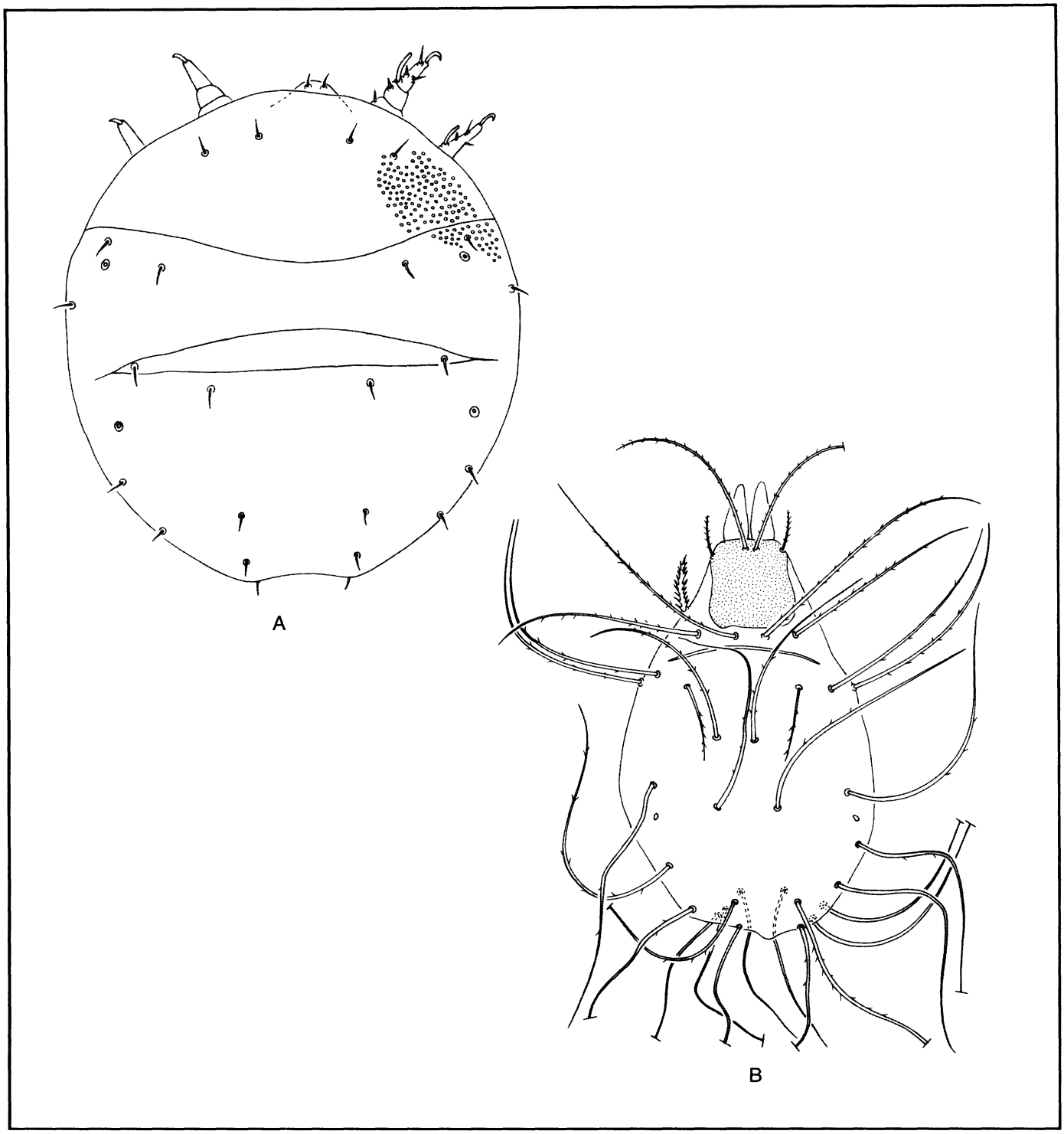


Plate 20. **Acarid mites** (Acaridae), dorsal views: A, *Acarus immobilis,* hypopus; B, **cheese mite,** *Tyrolichus casei,* female.

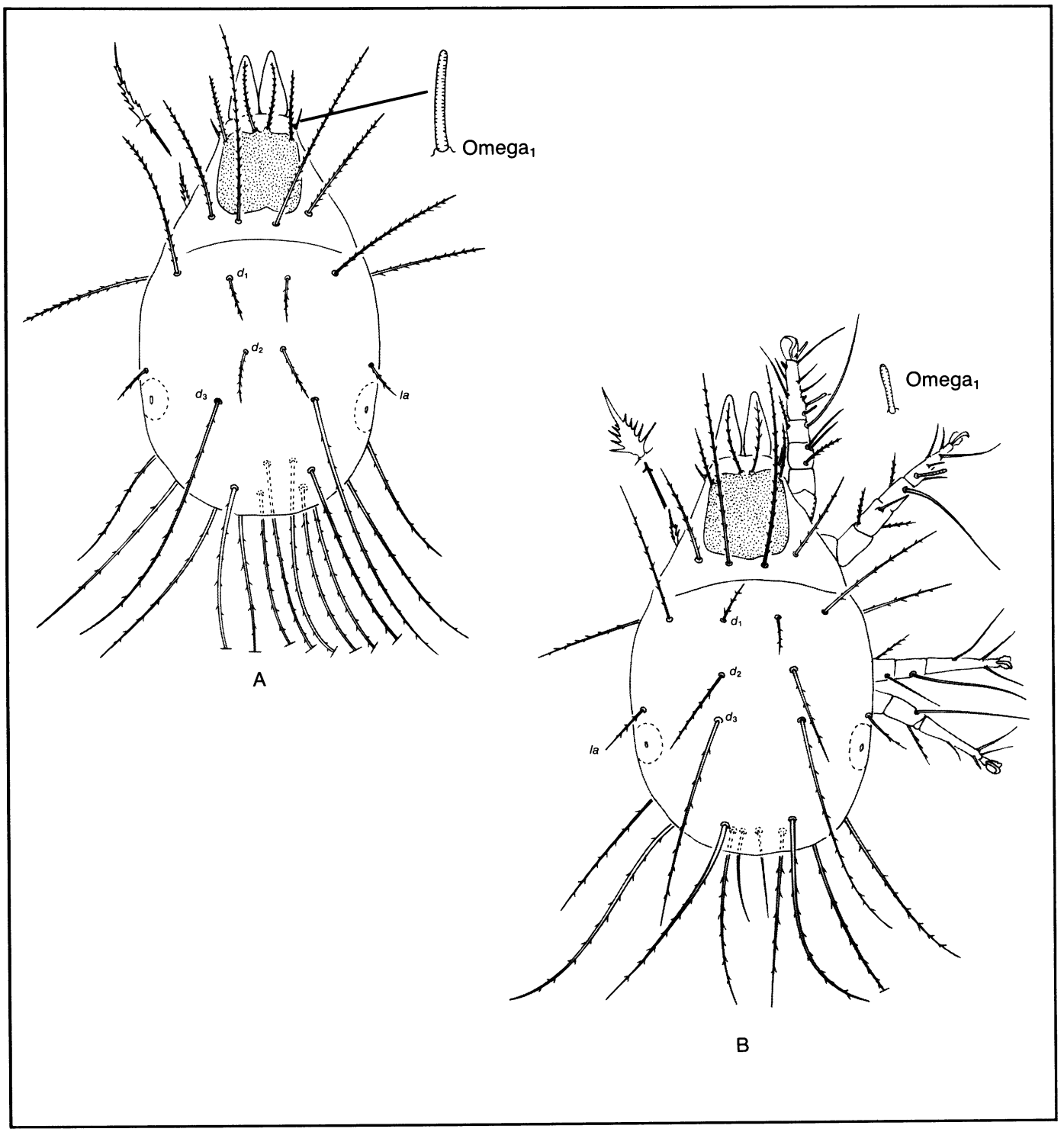


Plate 21. **Acarid mites** (Acaridae), dorsal views of females: A, *Tyrophagus longior;* B, **mold mite,** *Tyrophagus putrescentiae.*

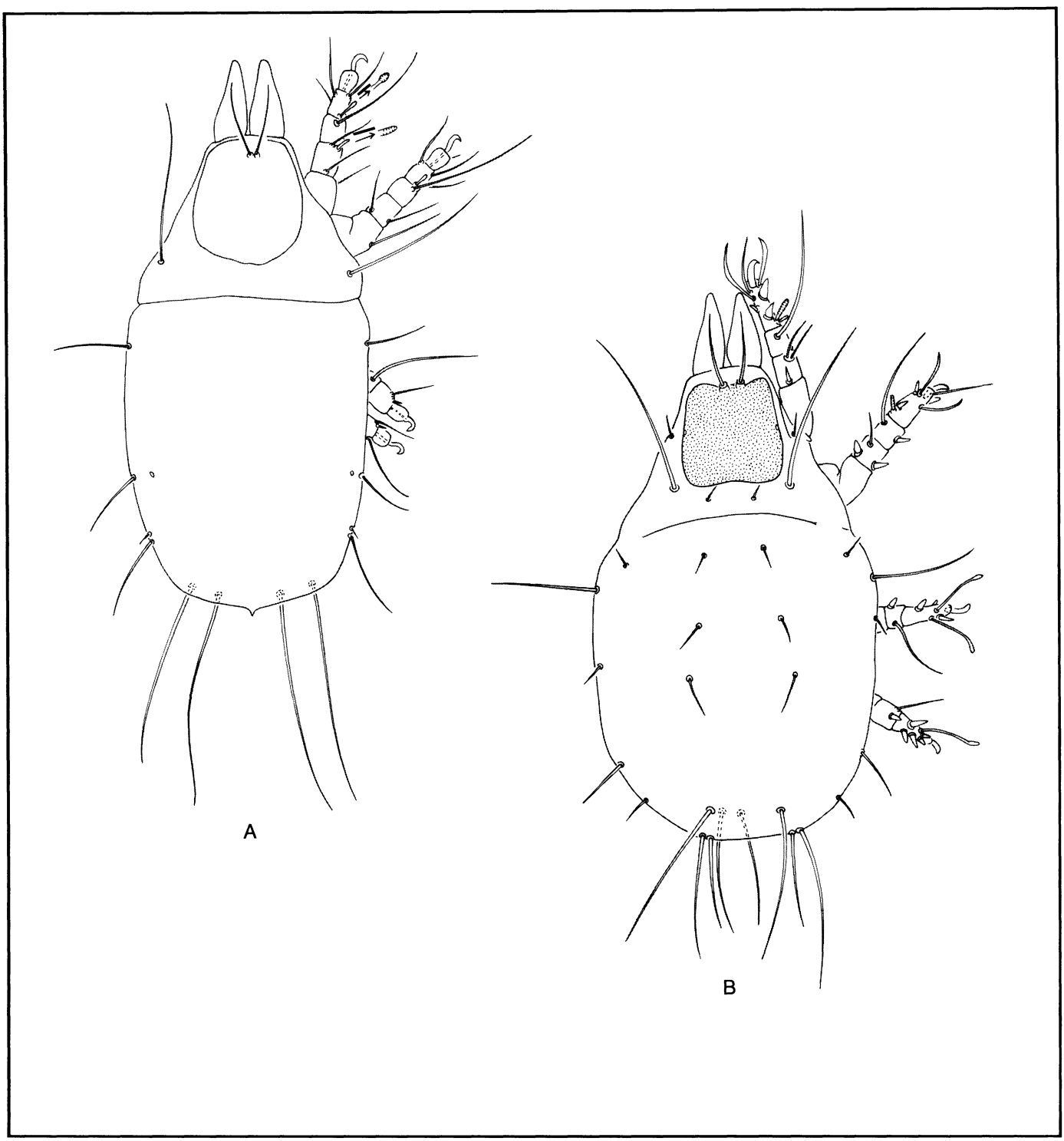


Plate 22. **Acarid mites** (Acaridae), dorsal views of females: A, *Thyreophagus entomophagus;* B, *Rhizoglyphus robini* (see also pl. 23).

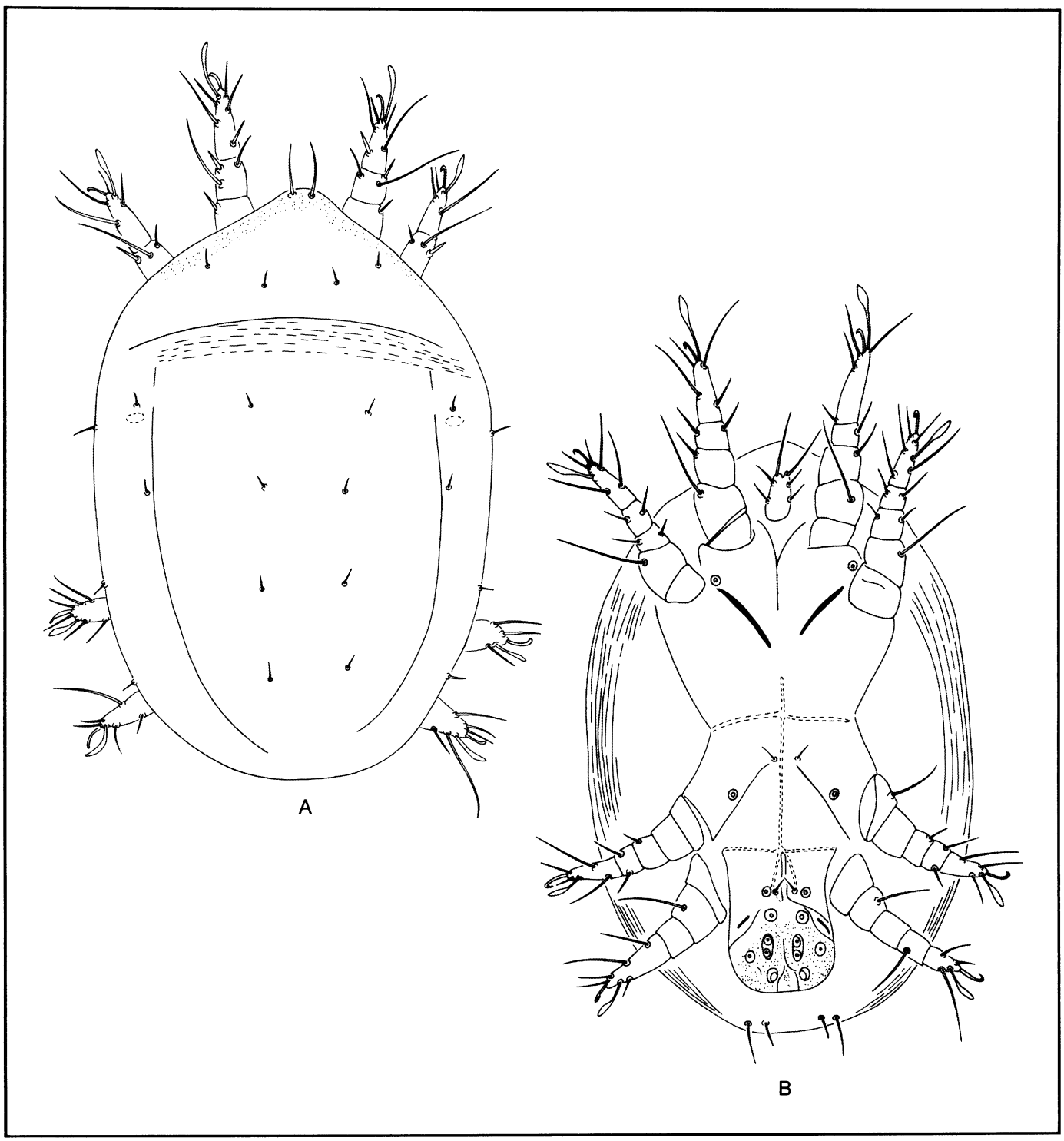


Plate 23. *Rhizoglyphus robini* (Acaridae), hypopus: A, dorsal view; B, ventral view. (See also pl. 22B.)

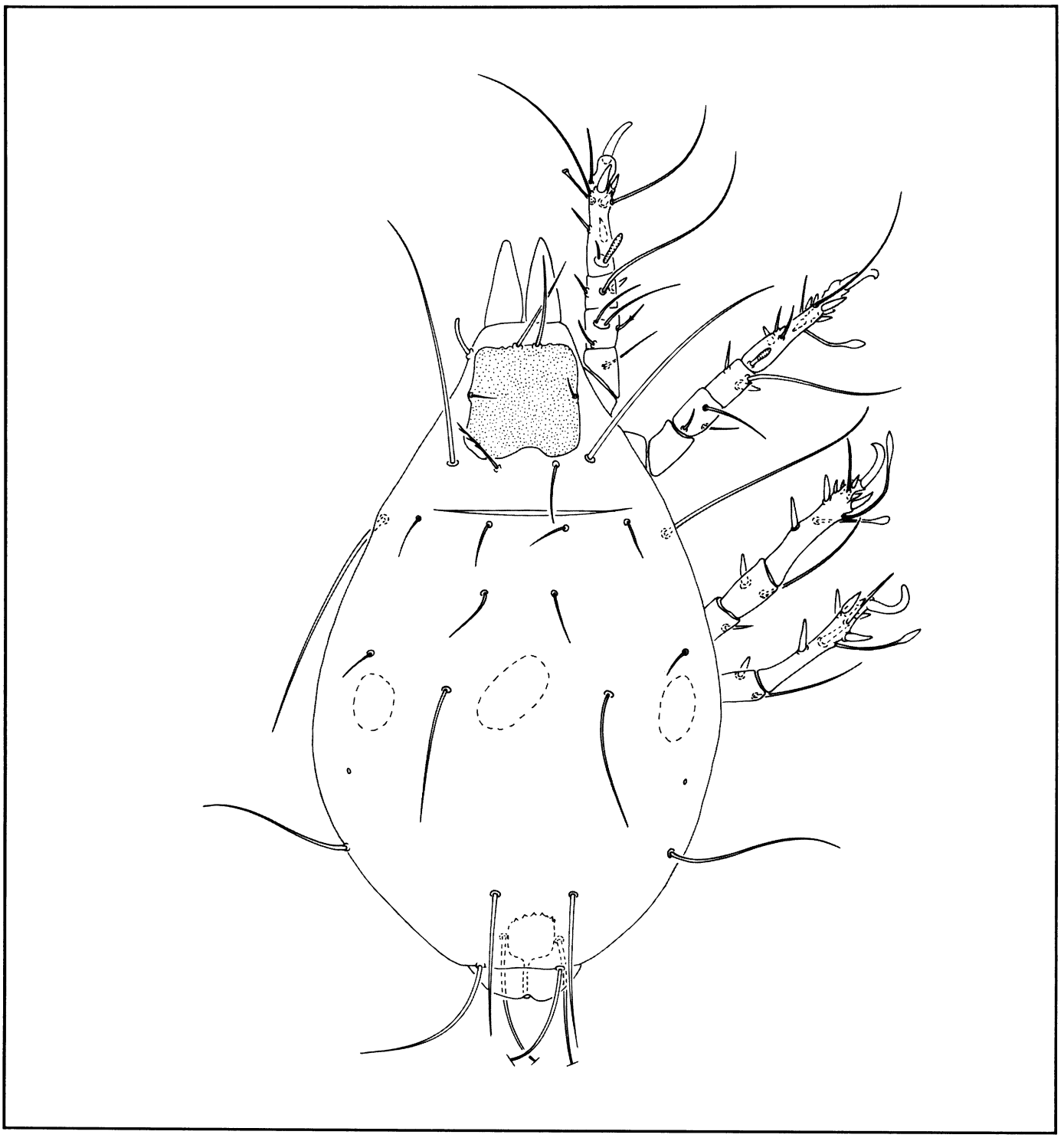


Plate 24. *Caloglyphus berlesei* (Acaridae), dorsal view of gravid female.

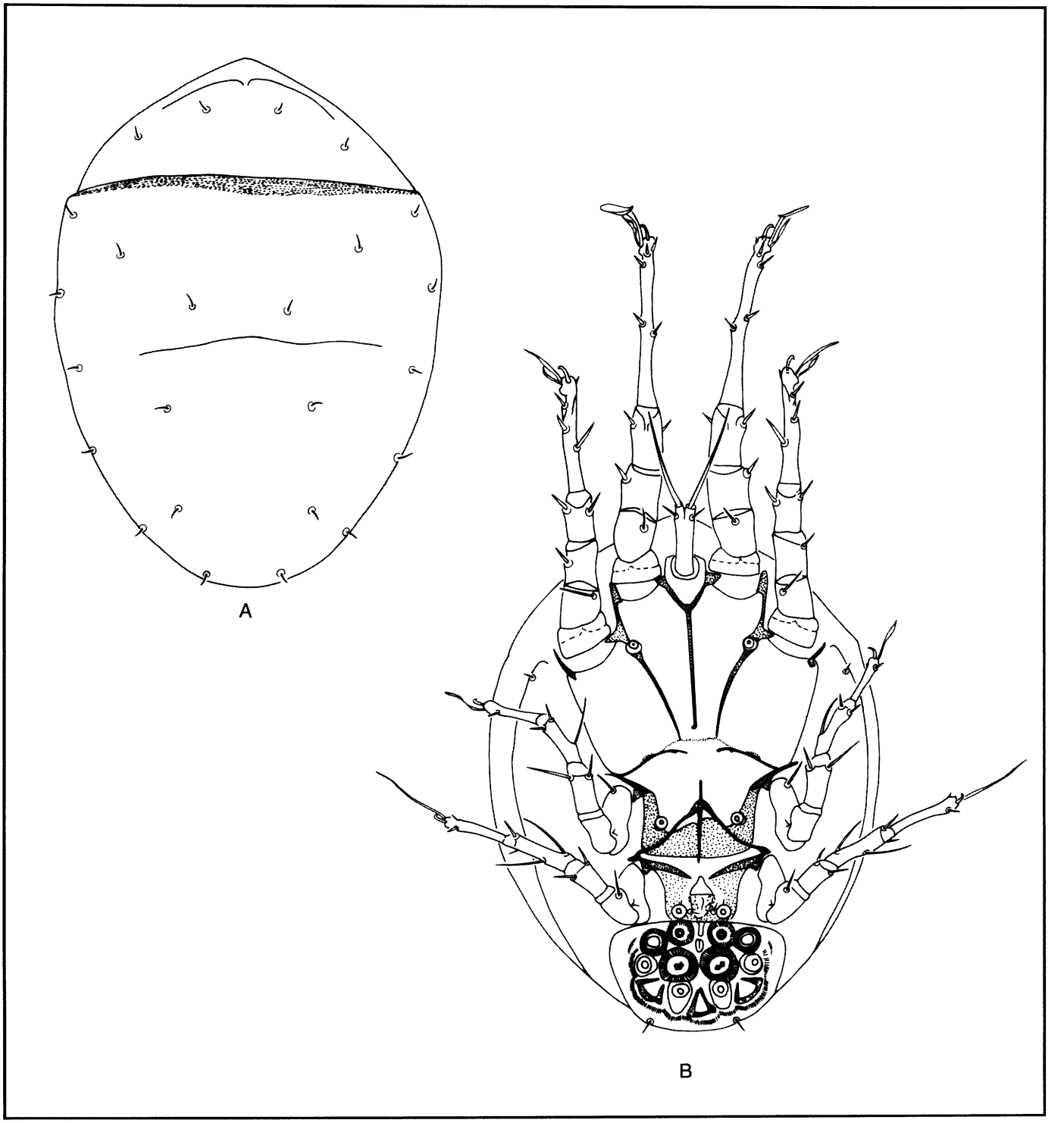


Plate 25. *Histiostoma heinemanni* (Histiostomatidae), hypopus: A, dorsal view; B, ventral view. (See also pl. 26 and 27.) (Redrawn from *15* by C. Feller.)

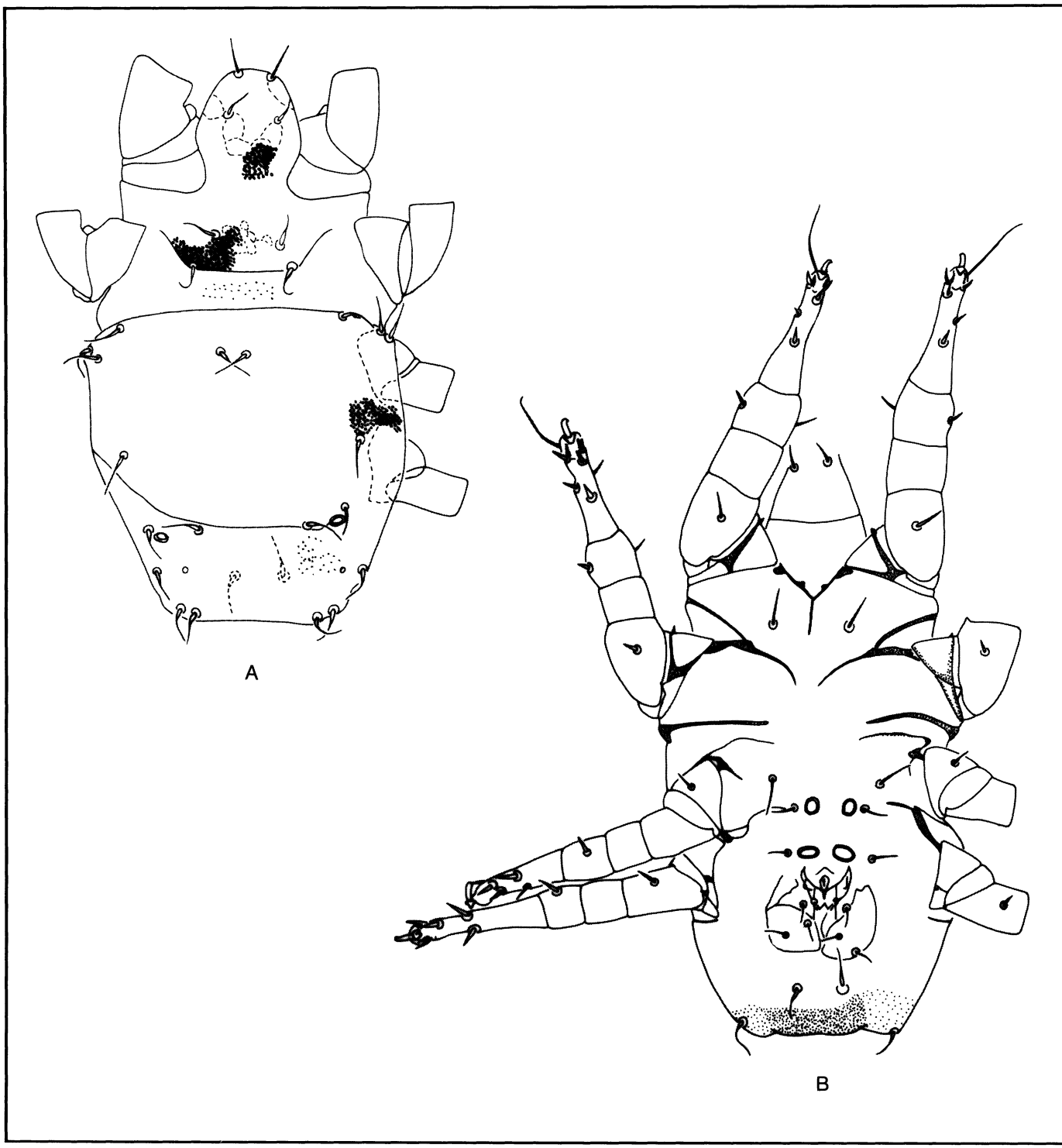


Plate 26. *Histiostoma heinemanni* (Histiostomatidae), male: A, dorsal view; B, ventral view. (See also pl. 25 and 27.) (Redrawn from *15* by C. Feller.)

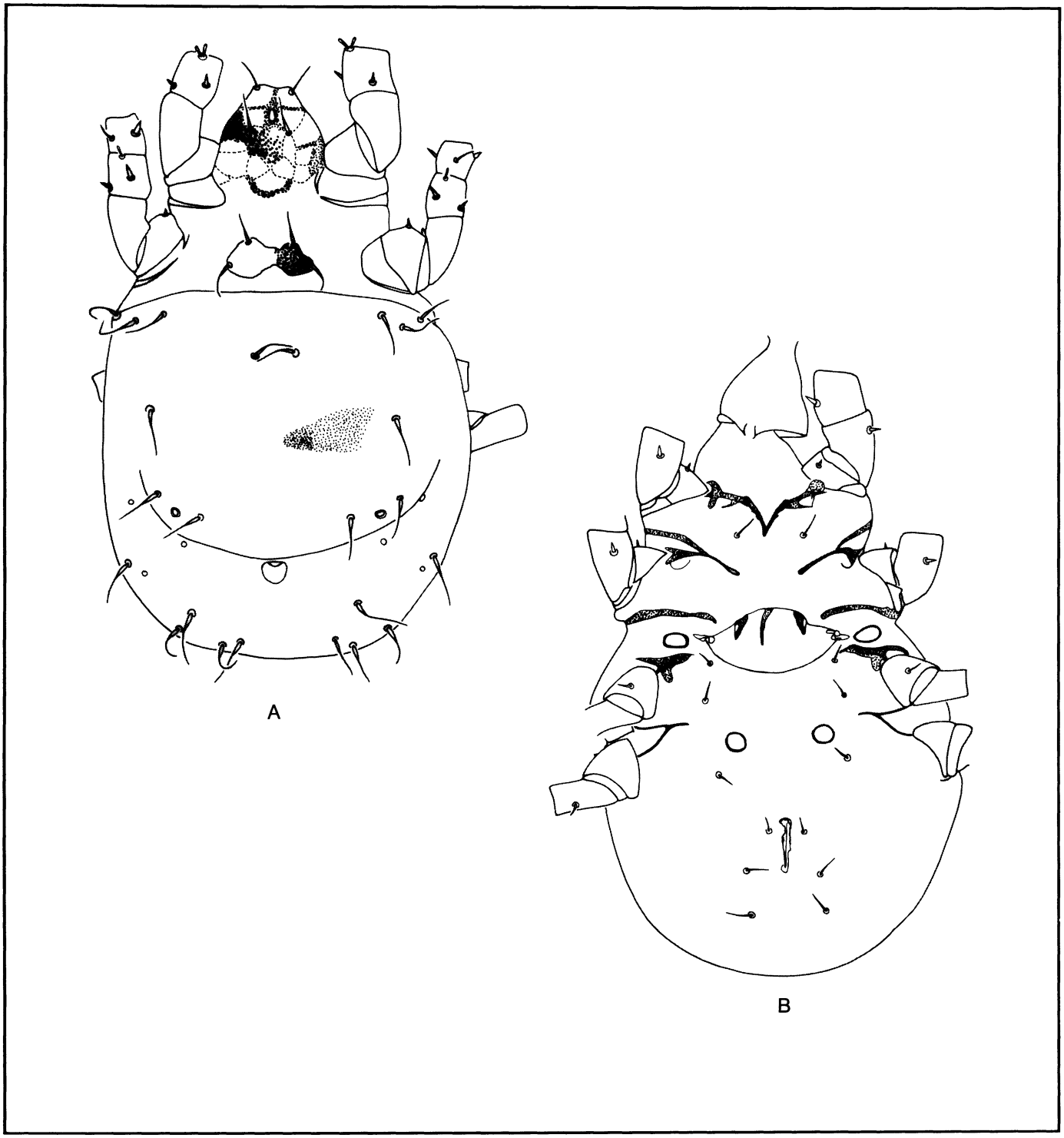


Plate 27. *Histiostoma heinemanni* (Histiostomatidae), female: A, dorsal view; B, ventral view. (See also pl. 25 and 26.) (Redrawn from *15* by C. Feller.)

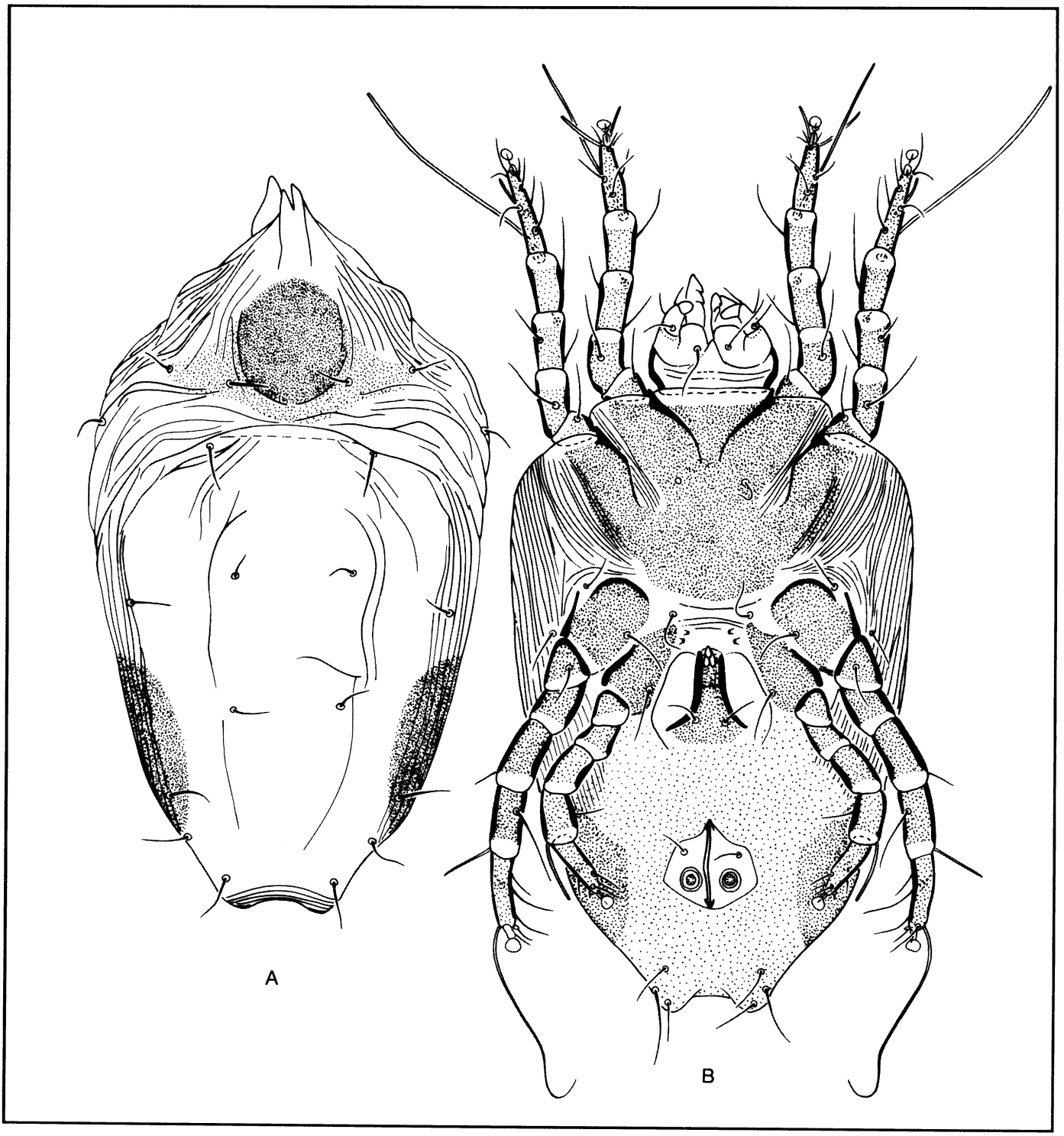


Plate 28. *Euroglyphus longior* (Pyroglyphidae), male: A, dorsal view; B, ventral view. (See also pl. 29.) (Redrawn from *10* by C. Feller.)

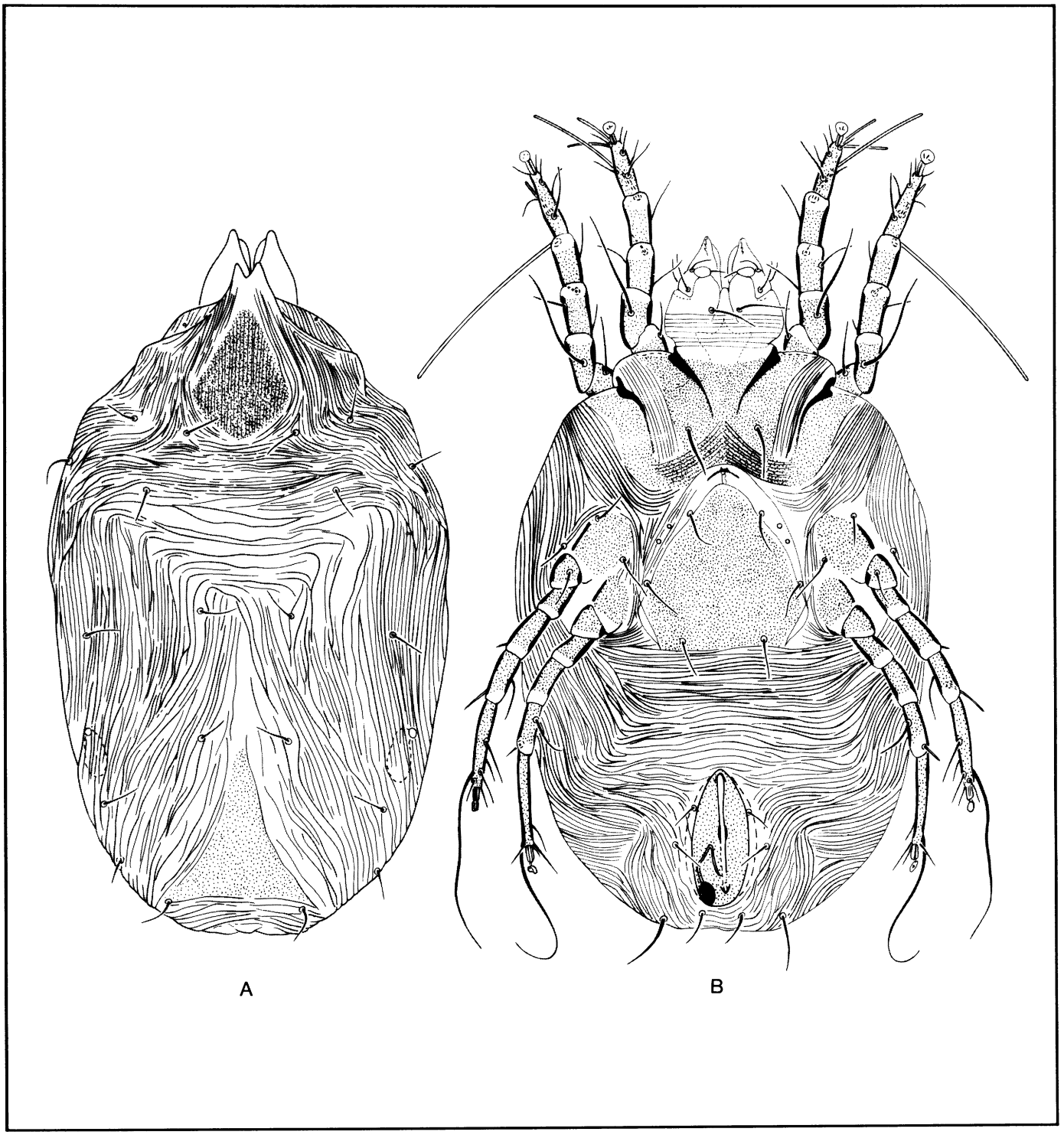


Plate 29. *Euroglyphus longior* (Pyroglyphidae), female: A, dorsal view; B, ventral view. (See also pl. 28.) (Redrawn from *10* by C. Feller.)

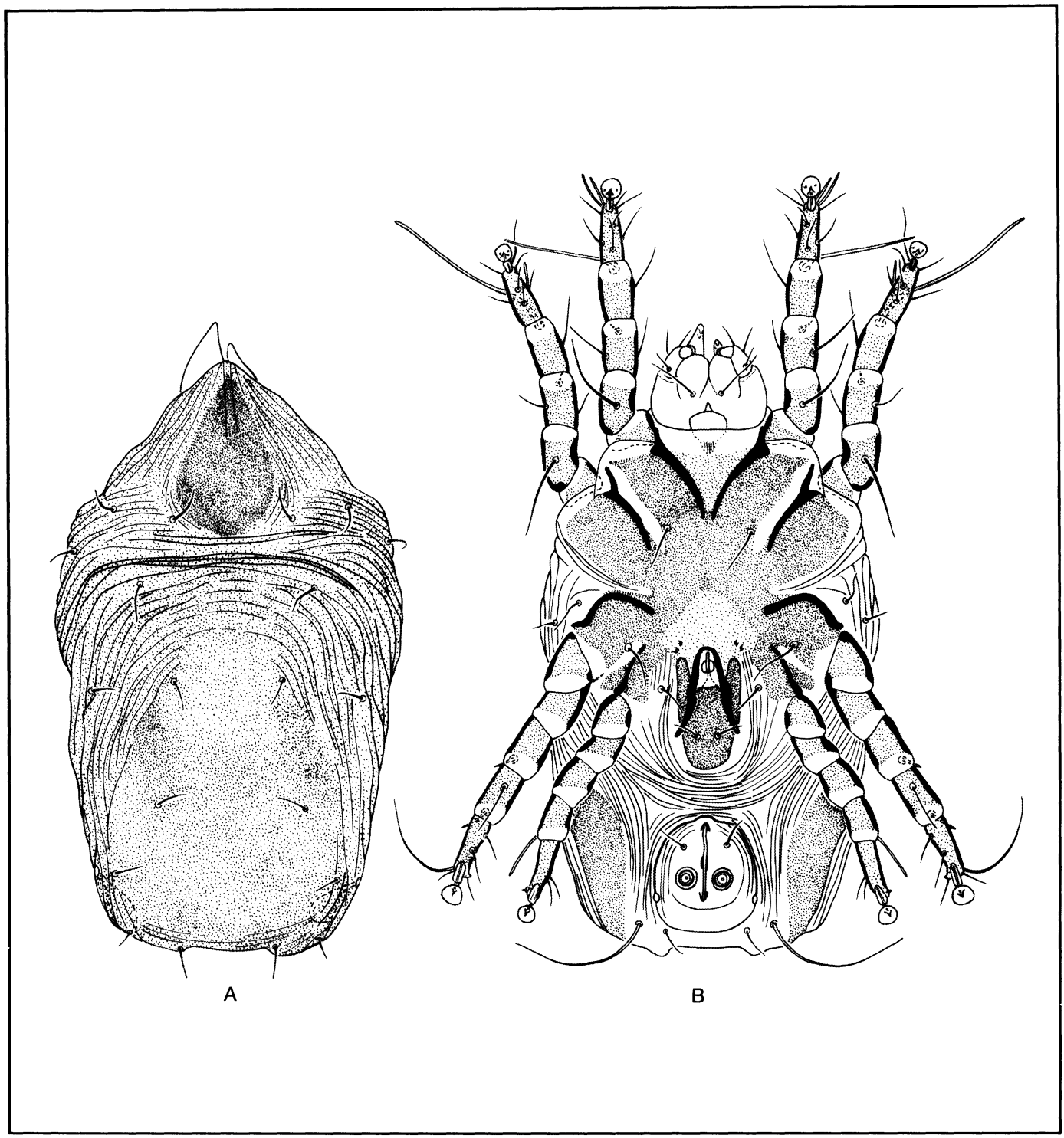


Plate 30. *Euroglyphus maynei* (Pyroglyphidae), male: A, dorsal view; B, ventral view. (See also pl. 31.) (Redrawn from *10* by C. Feller.)

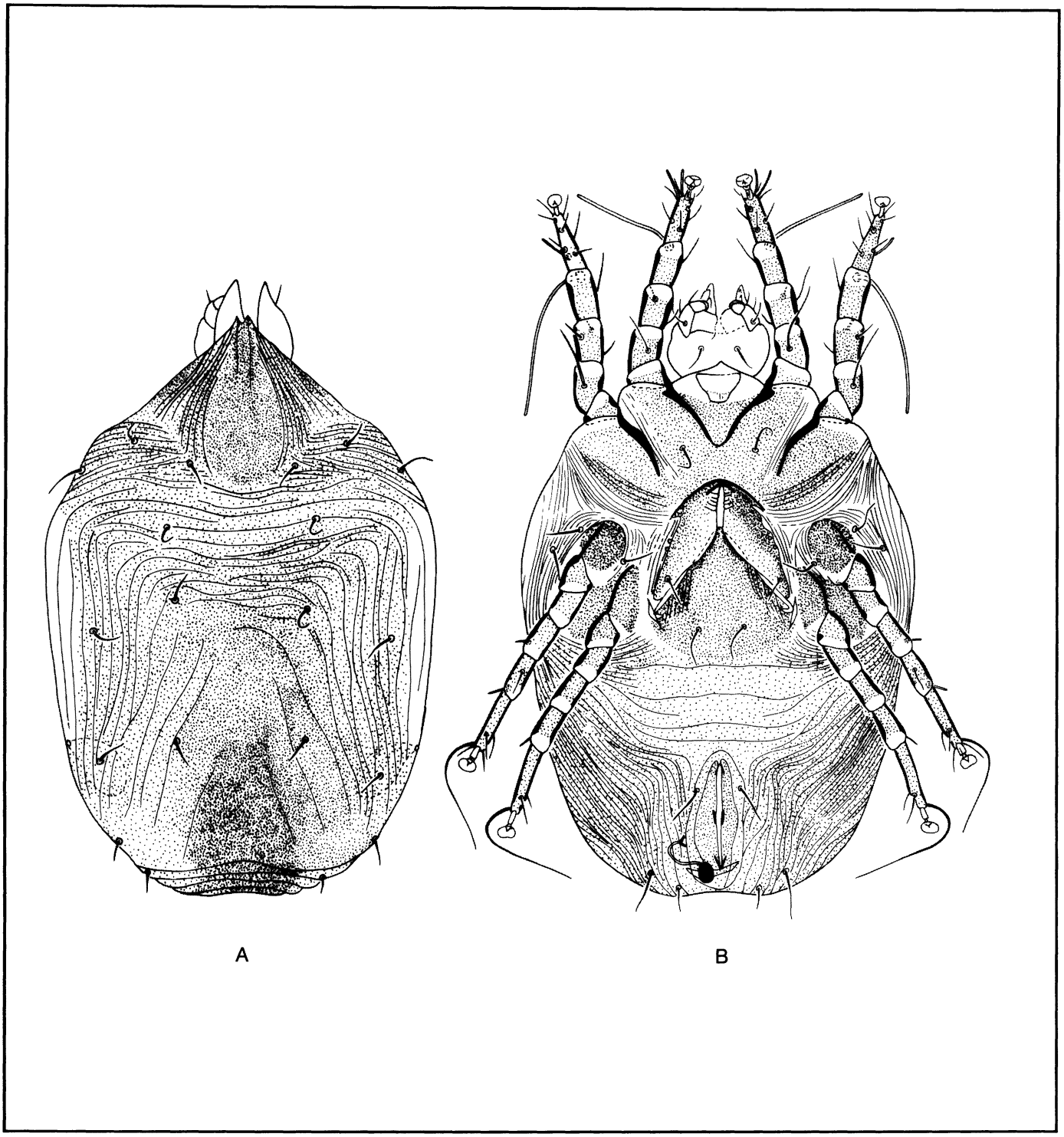


Plate 31. *Euroglyphus maynei* (Pyroglyphidae), female: A, dorsal view; B, ventral view. (See also pl. 30.) (Redrawn from *10* by C. Feller.)

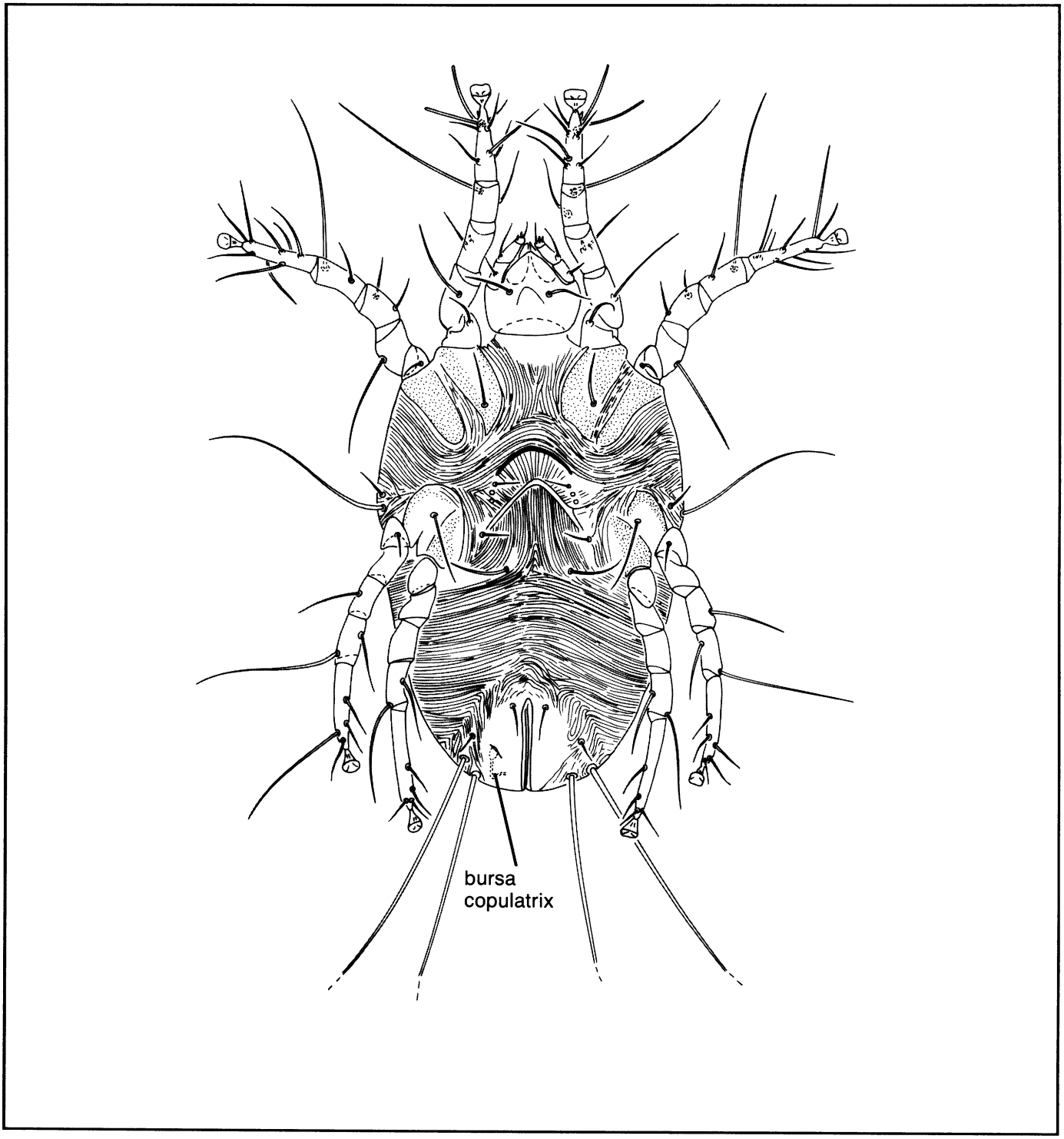


Plate 32. **American house dust mite,** *Dermatophagoides farinae* (Pyroglyphidae), ventral view of female.

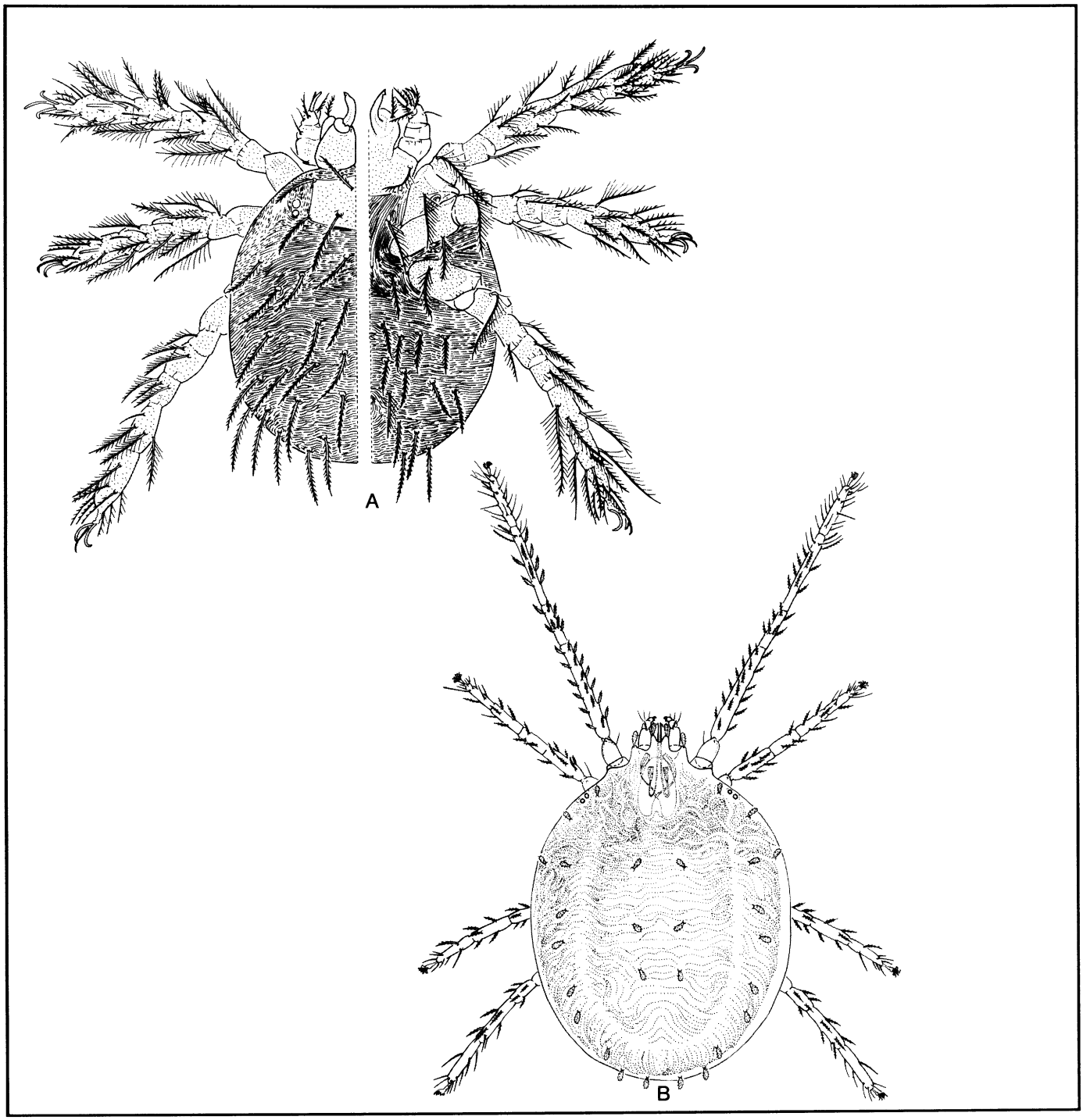


Plate 33. Prostigmatid mites (Prostigmata): A, *Leptotrombidium akamushi* (Trombiculidae), dorsal (left) and ventral (right) views of larva (chigger); B, **clover mite,** *Bryobia praetiosa* (Tetranychidae), dorsal view of female. (Figs. redrawn from *3* by C. Feller.)

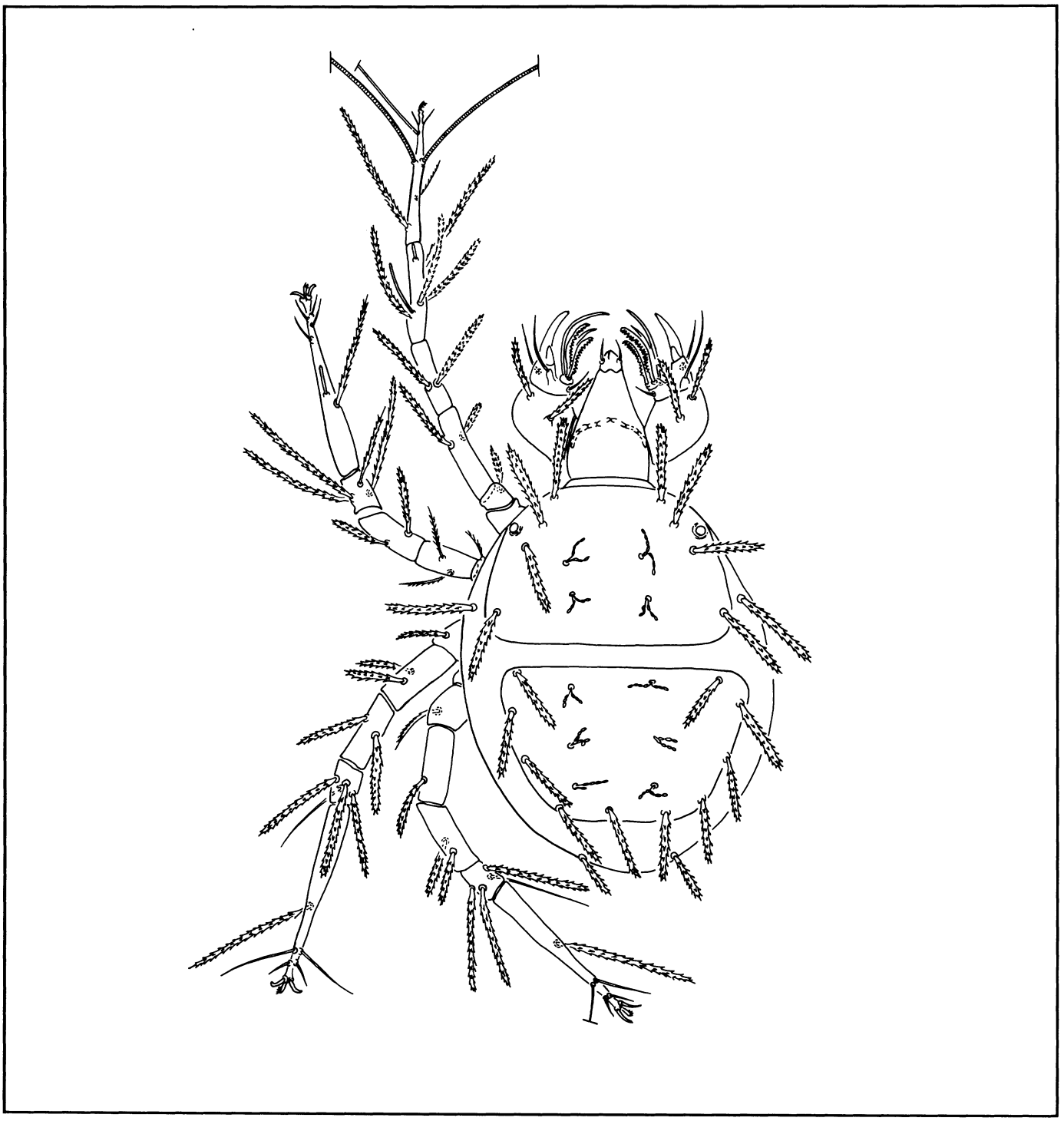


Plate 34. *Cheletomorpha lepidopterorum* (Cheyletidae), dorsal view of female (integumental striations not shown). (See couplets 51–53 for illustrations of other cheyletids.)

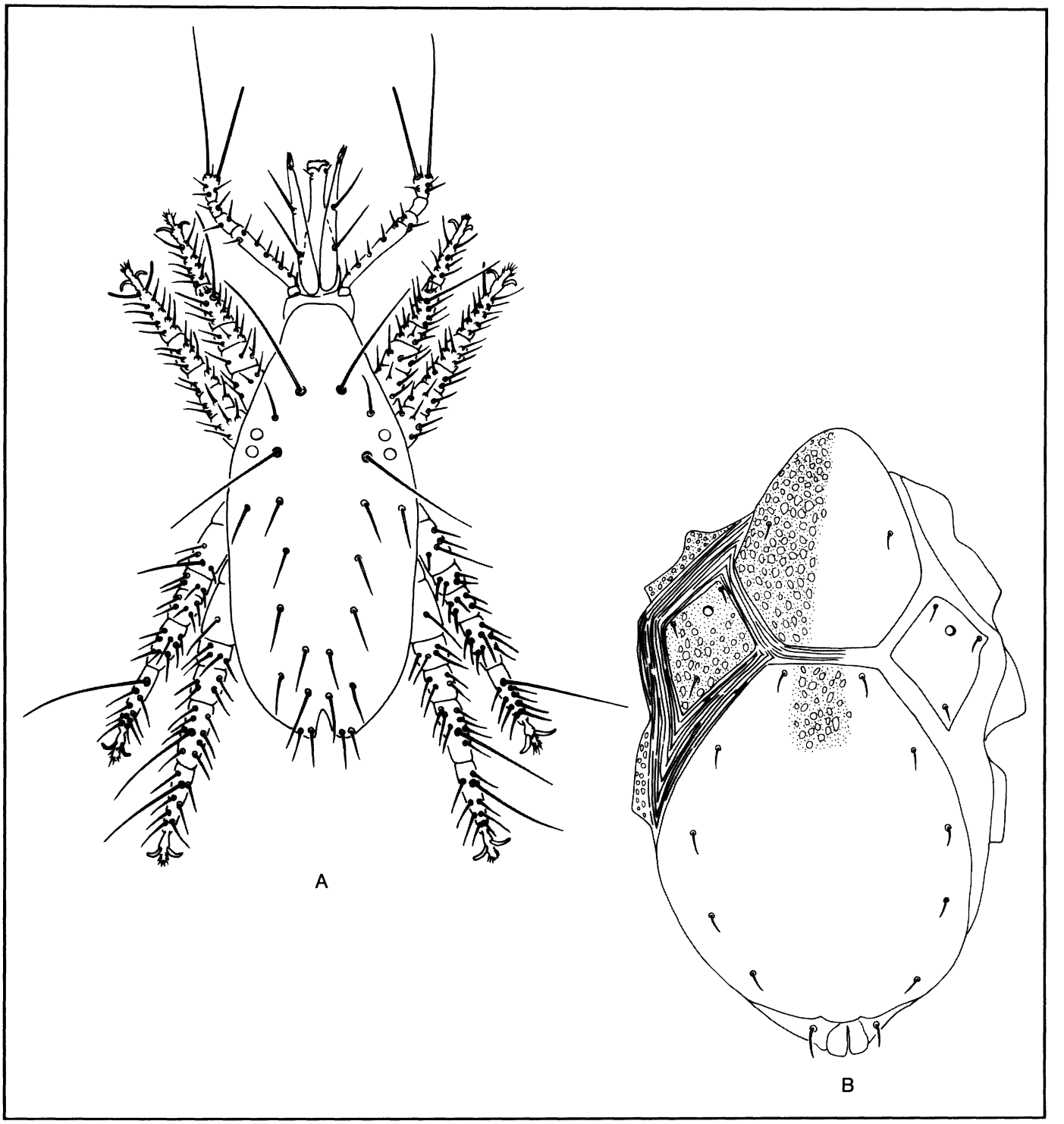


Plate 35. Prostigmatid mites (Prostigmata), dorsal views of females: A, *Spinibdella bifurcata* (Bdellidae); B, *Rhombognathides seahami* (Halacaridae).

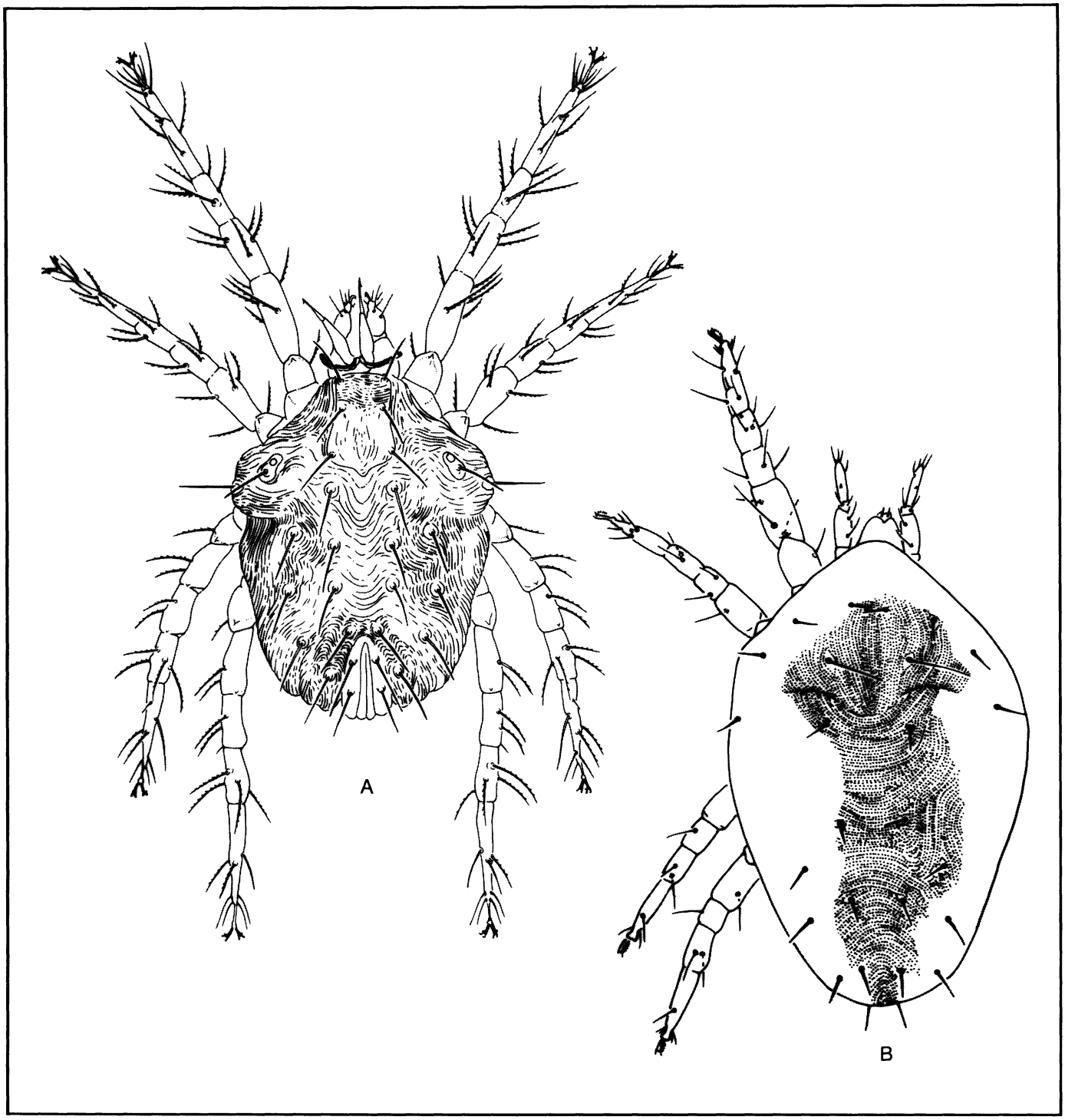


Plate 36. Prostigmatid mites (Prostigmata), females, dorsal views: A, cockroach mite, *Pimeliaphilus cunliffei* (Pterygosomatidae) (redrawn from *1* by C. Feller); B, *Tydeus* sp. (Tydeidae) (redrawn by C. Feller from original by E.W. Baker).

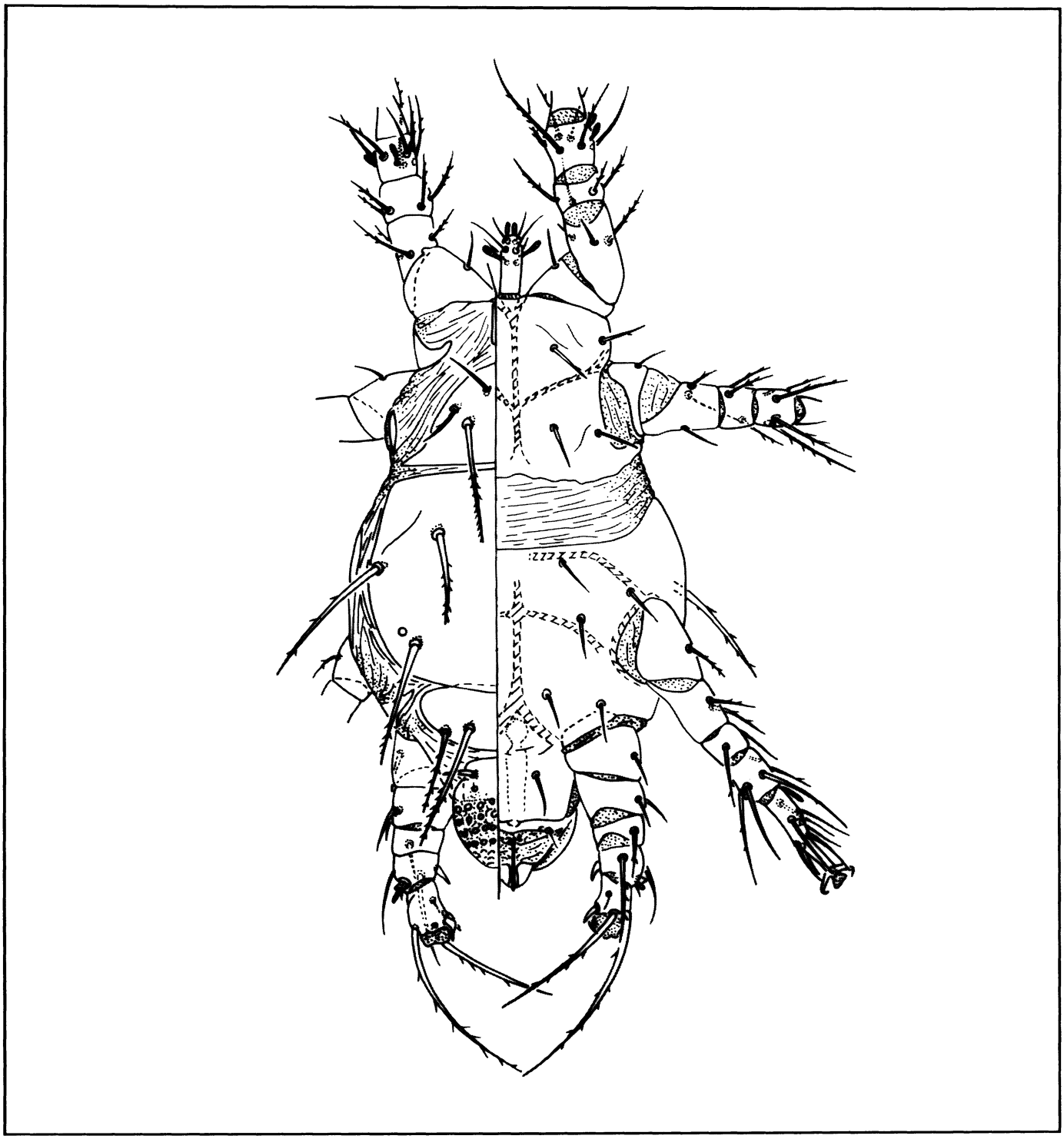


Plate 37. *Scutacarus baculitarsus agaricus* (Scutacaridae), male, dorsal (left) and ventral (right) views. (See also pl. 38.) (Redrawn from *22* by C. Feller.)

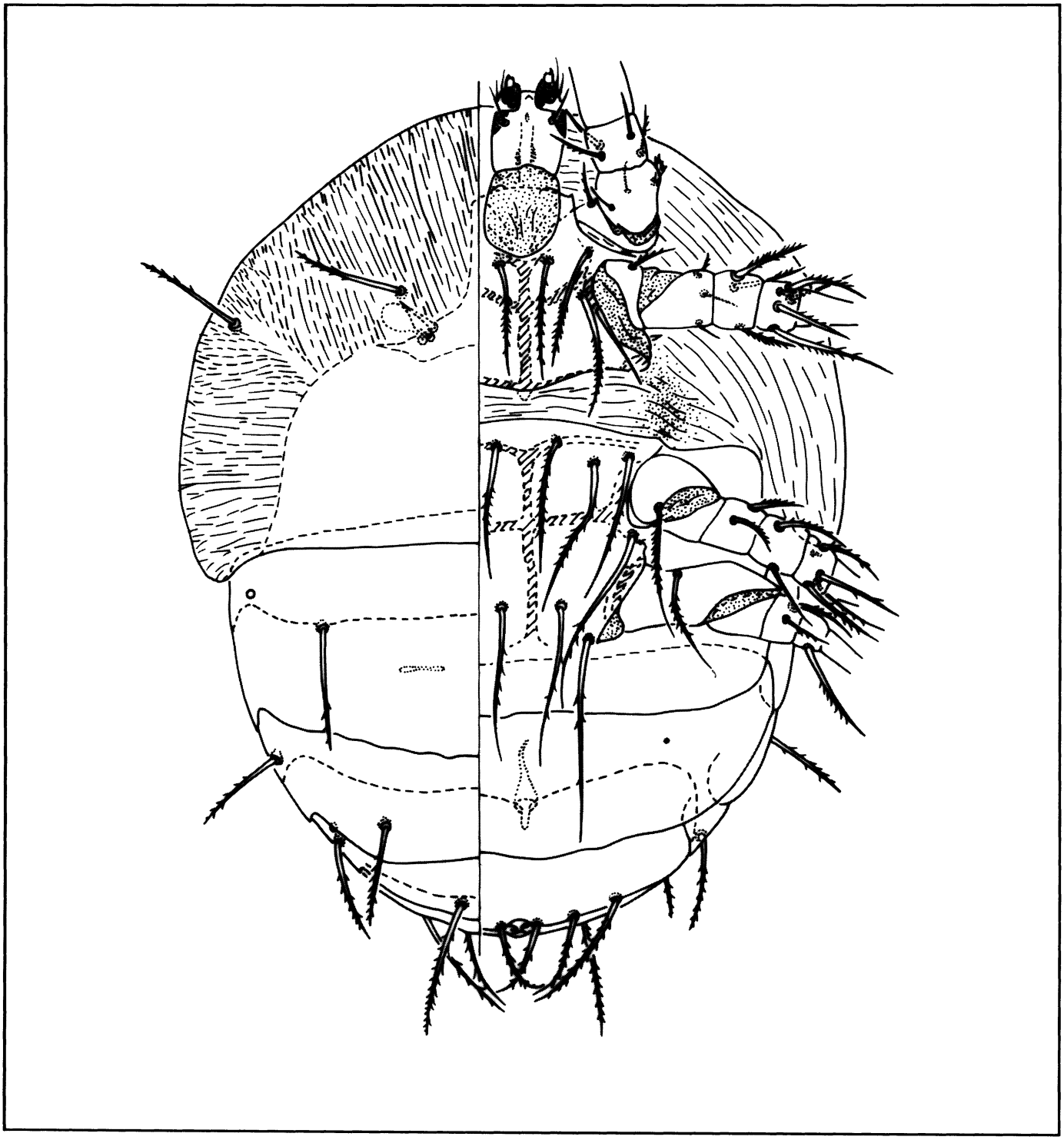


Plate 38. *Scutacarus baculitarsus agaricus* (Scutacaridae), female, dorsal (left) and ventral (right) views. (See also pl. 37.) (Redrawn from *22* by C. Feller).

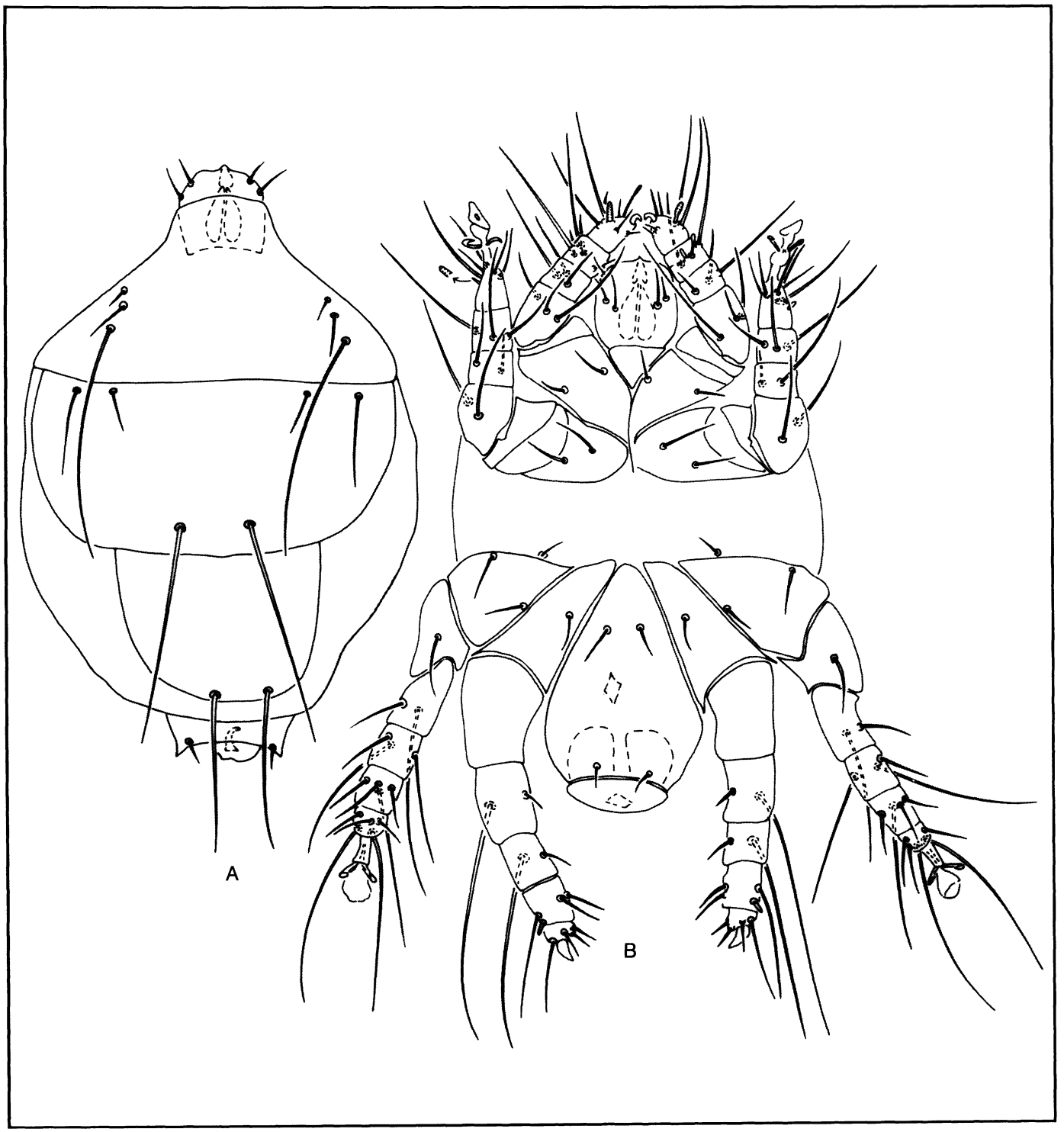


Plate 39. **Straw itch mite,** *Pyemotes tritici* (Pyemotidae), male: A, dorsal view; B, ventral view. (See also pl. 40.)

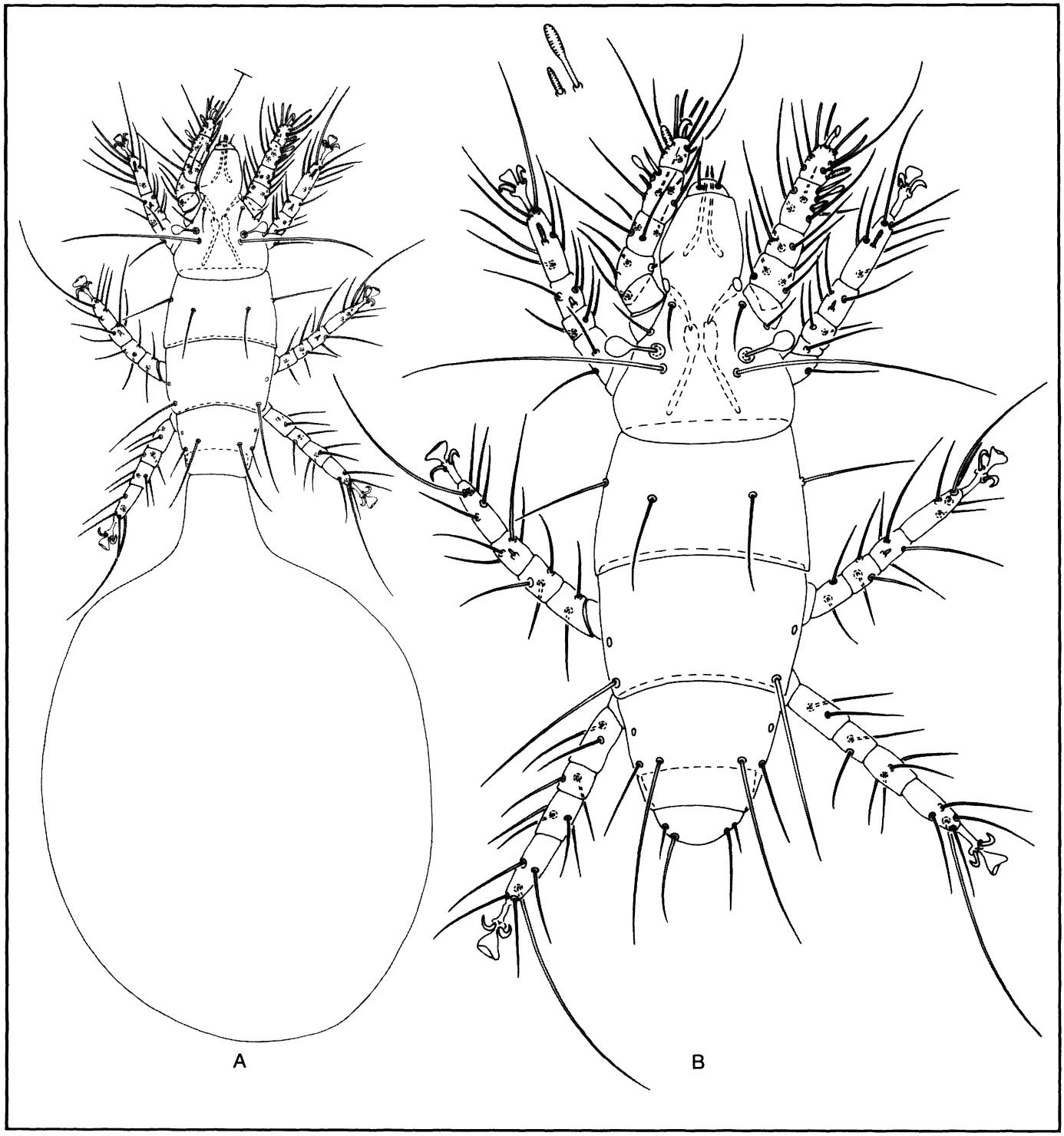


Plate 40. **Straw itch mite,** *Pyemotes tritici* (Pyemotidae), dorsal views of females: A, gravid; B, nongravid. (See also pl. 39.)

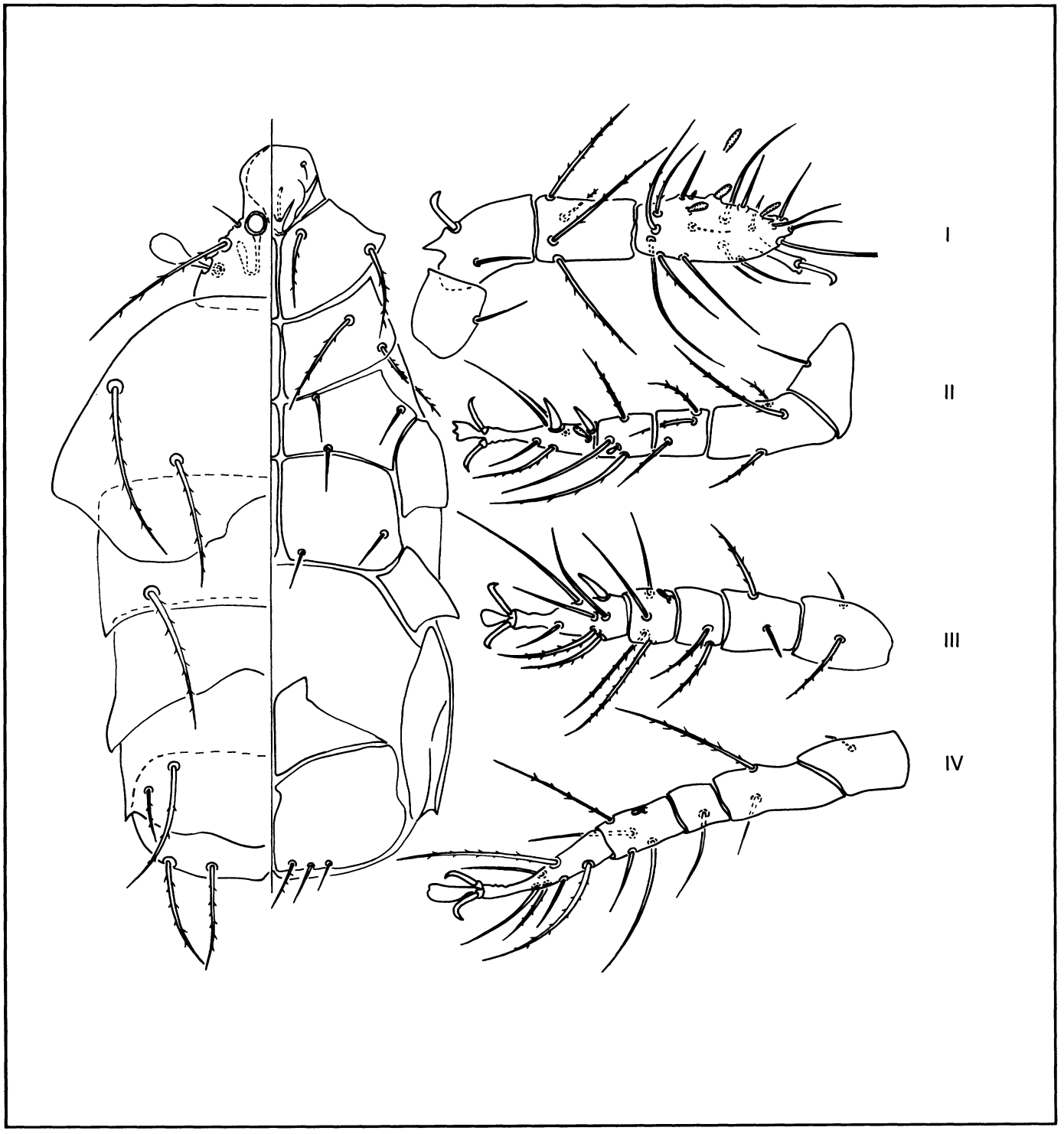


Plate 41. *Pygmephorus sellnicki* (Pygmephoridae), female, dorsal (left) and ventral (right) views; legs I-IV (redrawn from *25* by C. Feller).

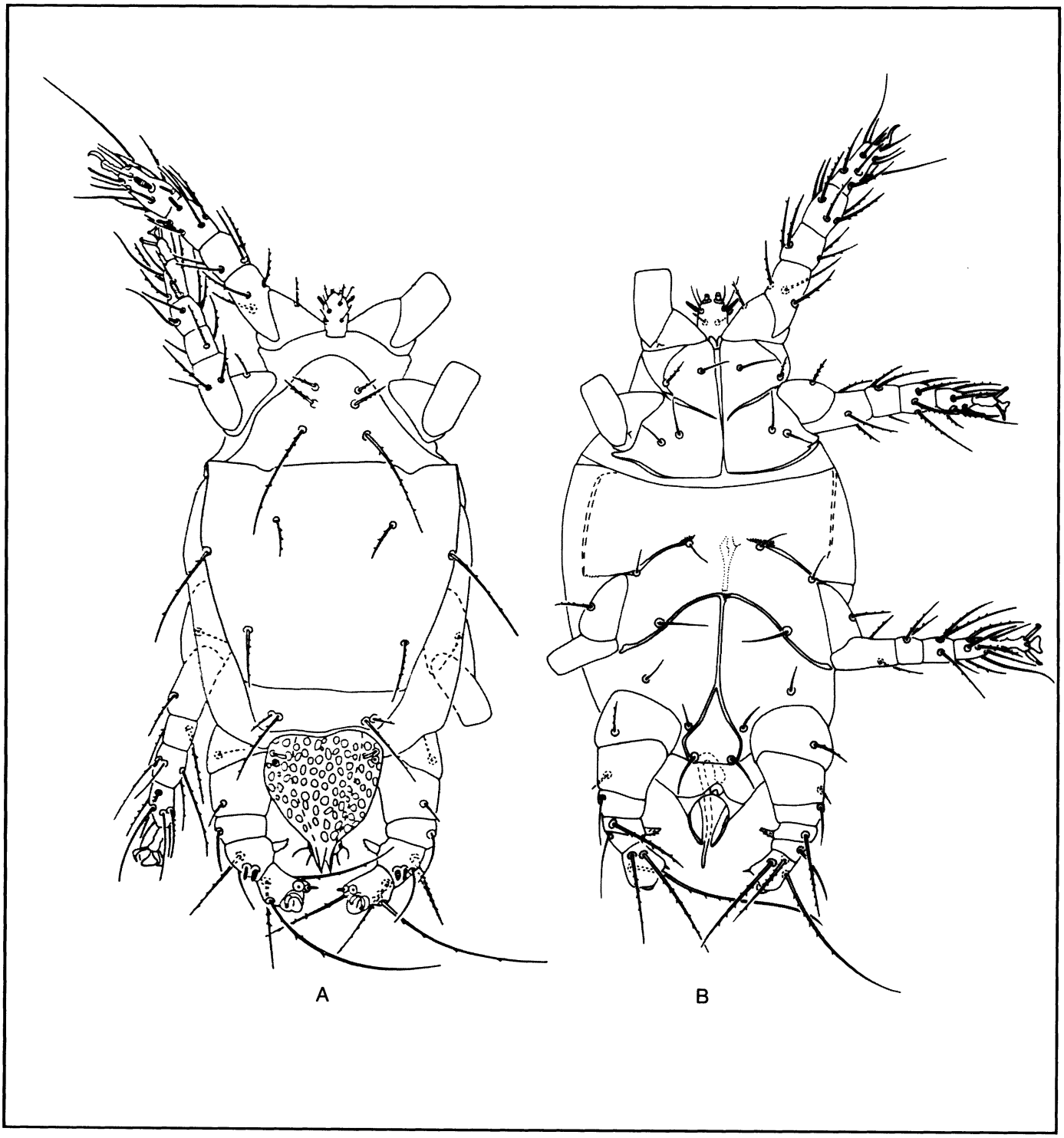


Plate 42. *Pseudopygmephorus smileyi* (Pygmephoridae), male: A, dorsal view; B, ventral view. (See also pl. 43.) (Redrawn from *17* by C. Feller.)

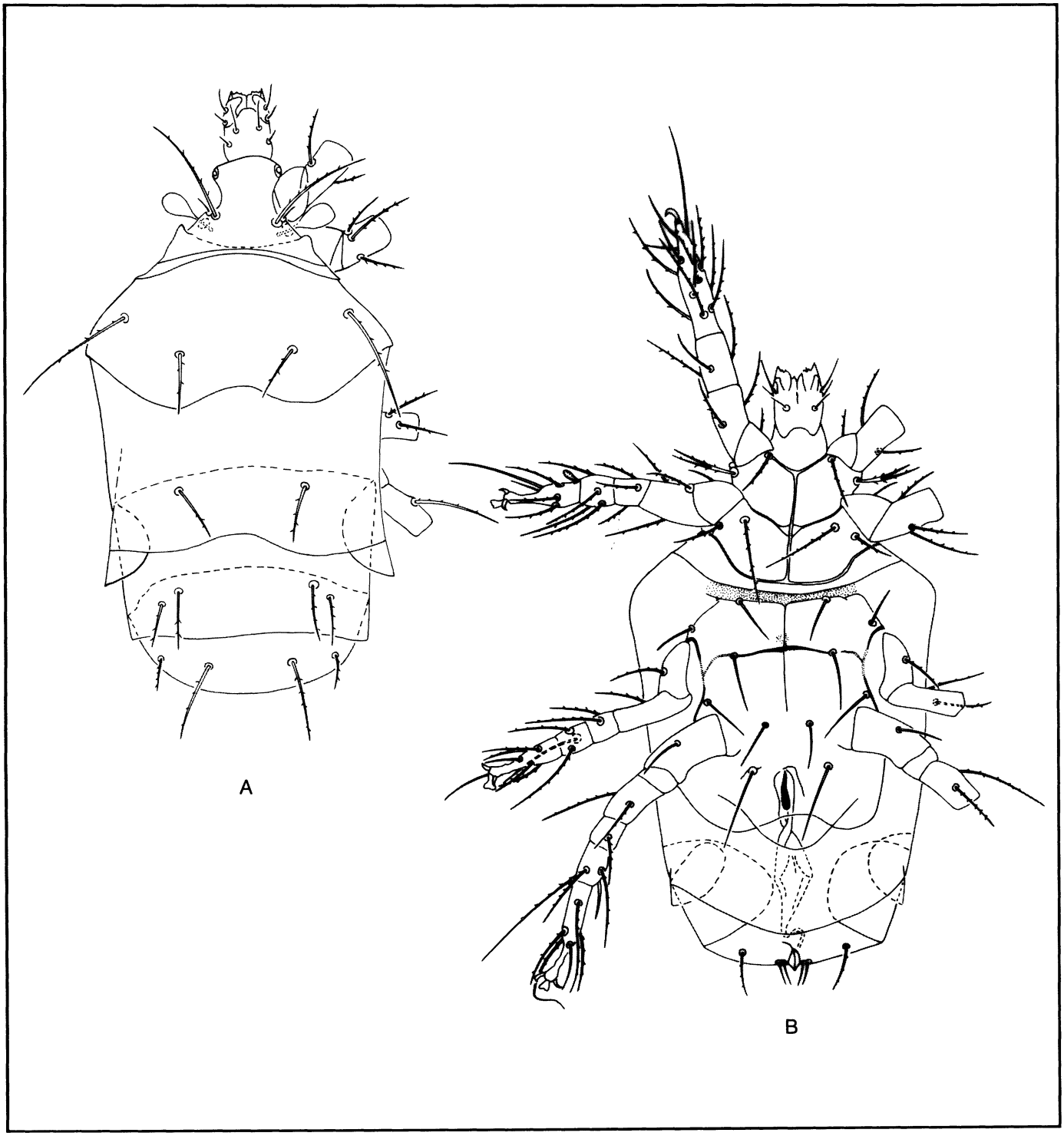


Plate 43. *Pseudopygmephorus smileyi* (Pygmephoridae), female: A, dorsal view; B, ventral view. (See also pl. 42.) (Redrawn from *17* by C. Feller.)

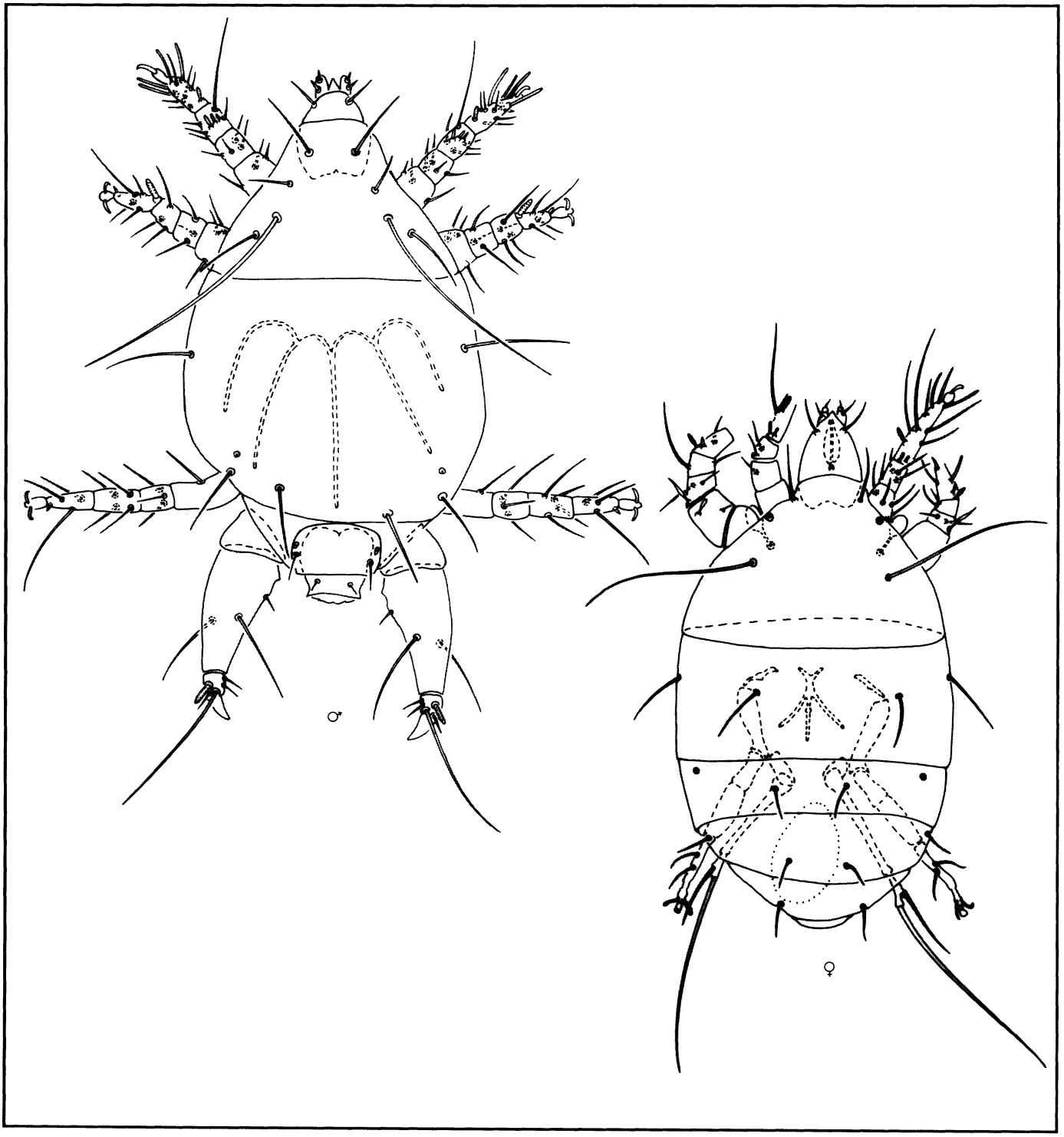


Plate 44. *Tarsonemus scaurus* (Tarsonemidae), dorsal views.

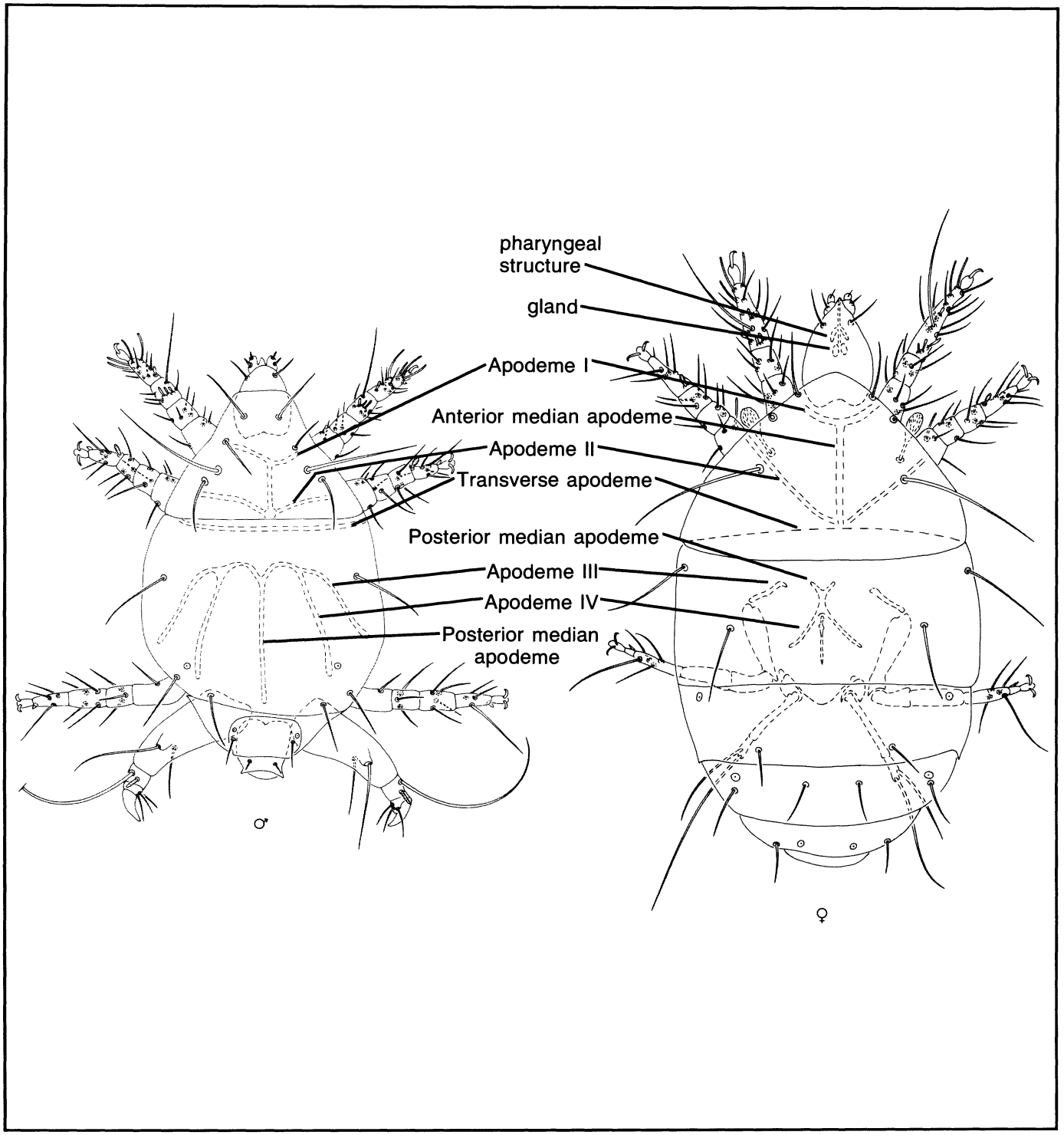


Plate 45. *Tarsonemus granarius* (Tarsonemidae), dorsal views.

COCKROACHES (BLATTARIA)

These illustrations, drawn by A.D. Cushman unless otherwise indicated, are a continuation from part 1, chapter 2 (Cockroaches), by A.B. Gurney and F.W. Fisk.

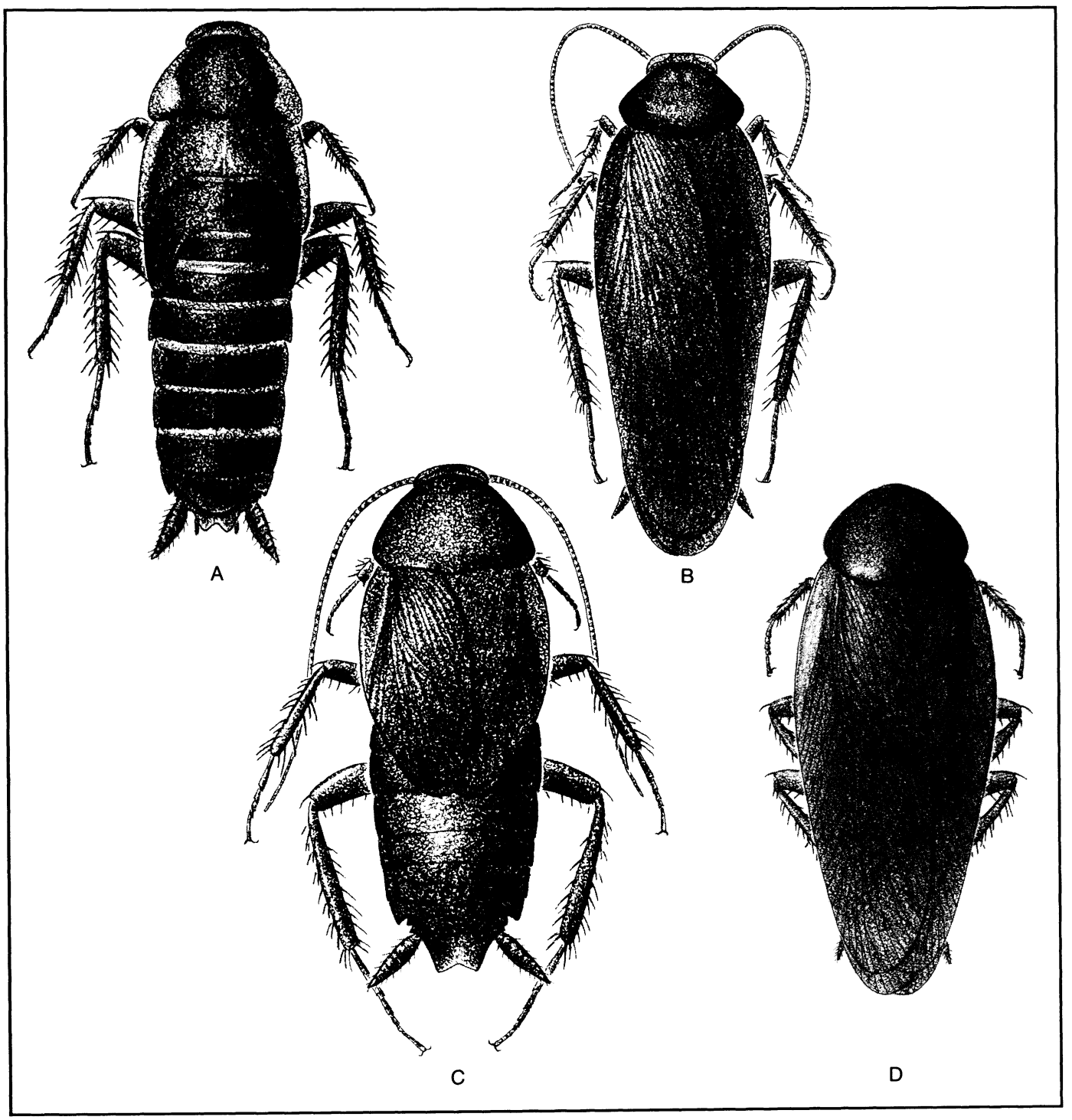


Plate 46. Blattid cockroaches (Blattidae), dorsal views (drawings by C. Feller): A, *Periplaneta japonica,* nymph; B, same, male (31-35); C, same, female (31-35); D, **smokybrown cockroach,** *Periplaneta fuliginosa* (31-35).

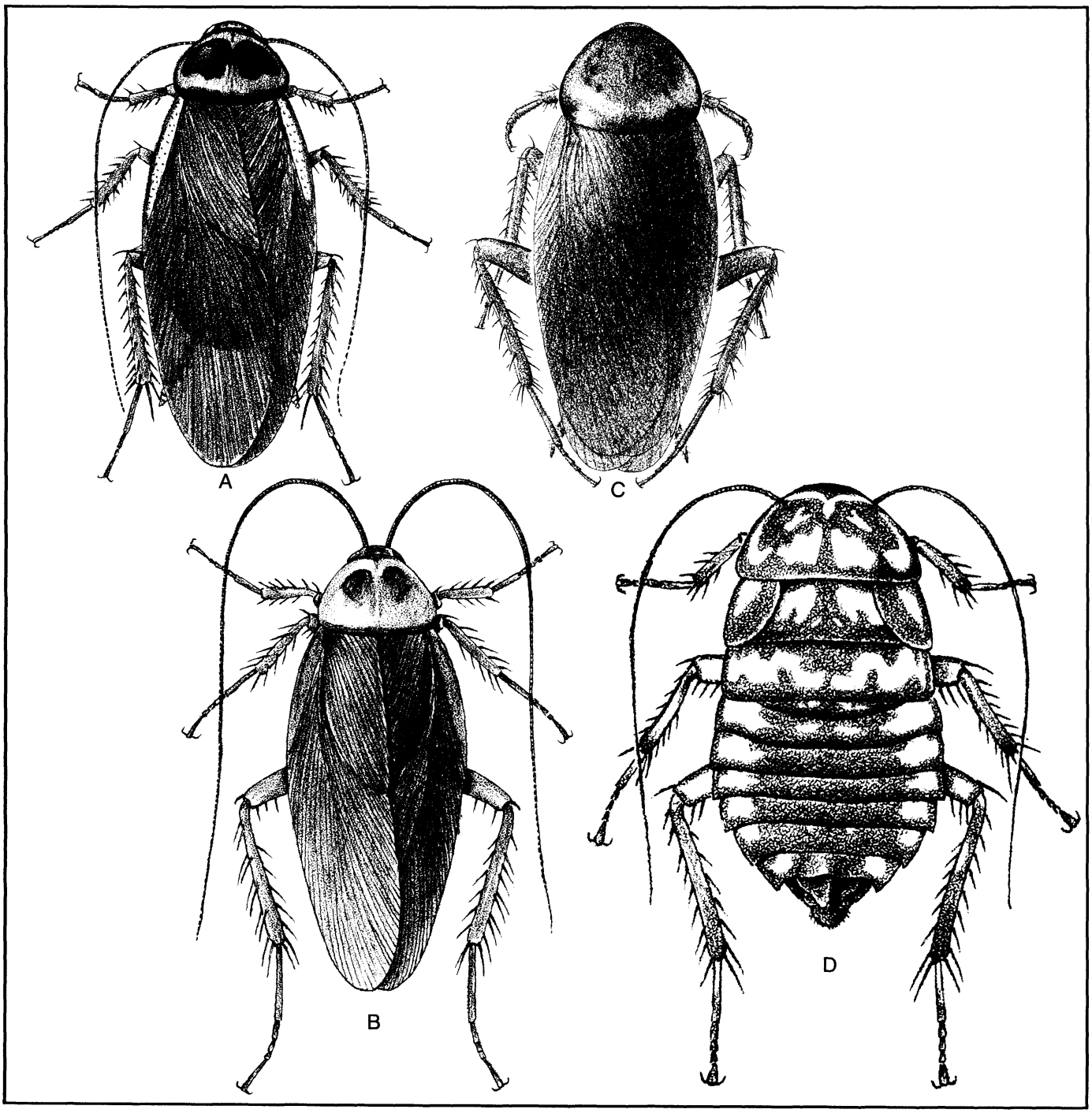


Plate 47. Blattid cockroaches (Blattidae), dorsal views: A, **Australian cockroach,** *Periplaneta australasiae* (27-33); B, **American cockroach,** *Periplaneta americana* (35-40); C, **brown cockroach,** *Periplaneta brunnea* (31-37) (drawing by C. Feller); D, **harlequin cockroach,** *Neostylopyga rhombifolia,* female (20-25).

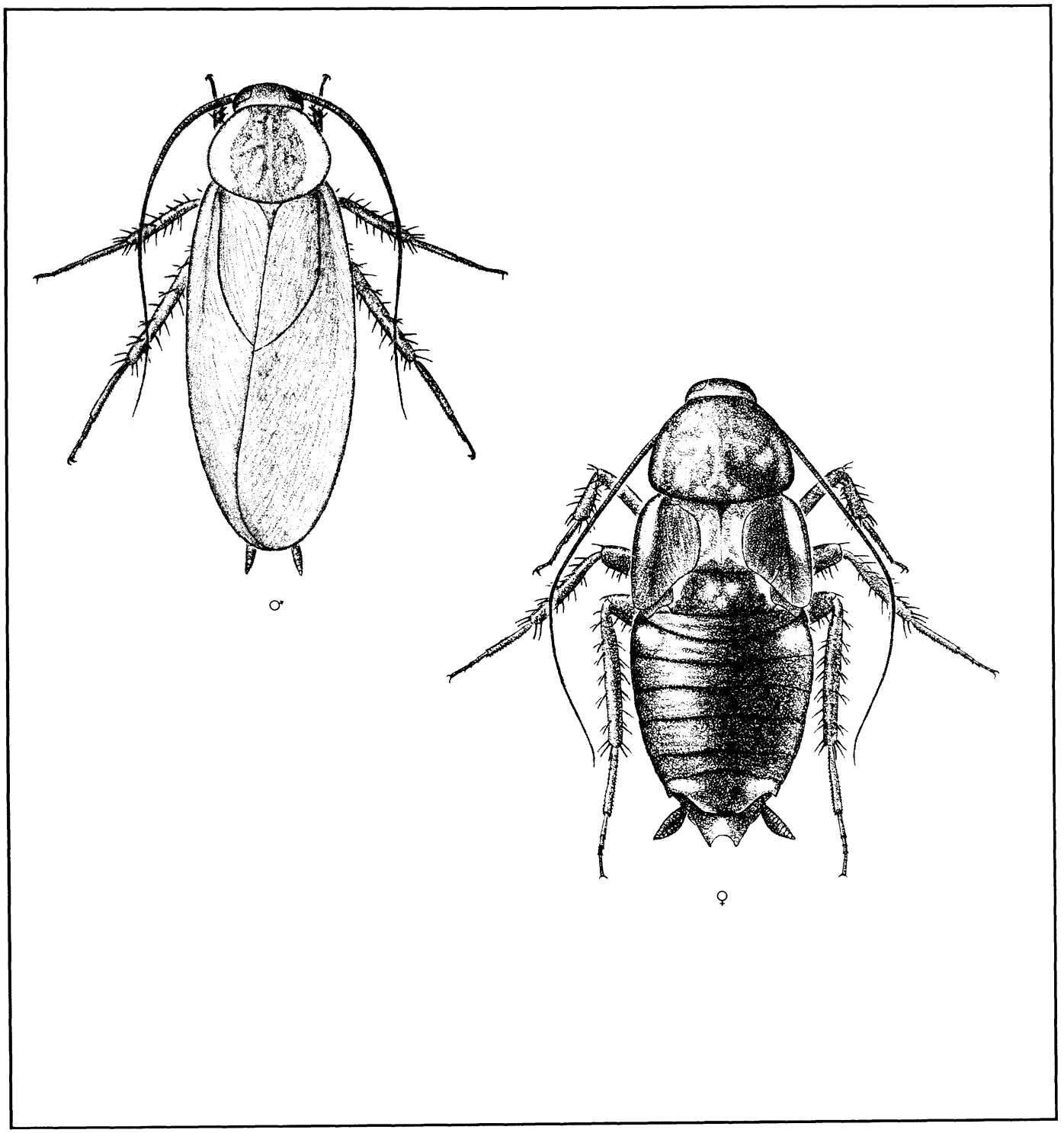


Plate 48. **Turkestan cockroach,** *Blatta lateralis* (Blattidae), dorsal views (male, 19-23; female, 22-25) (drawings by C. Feller).

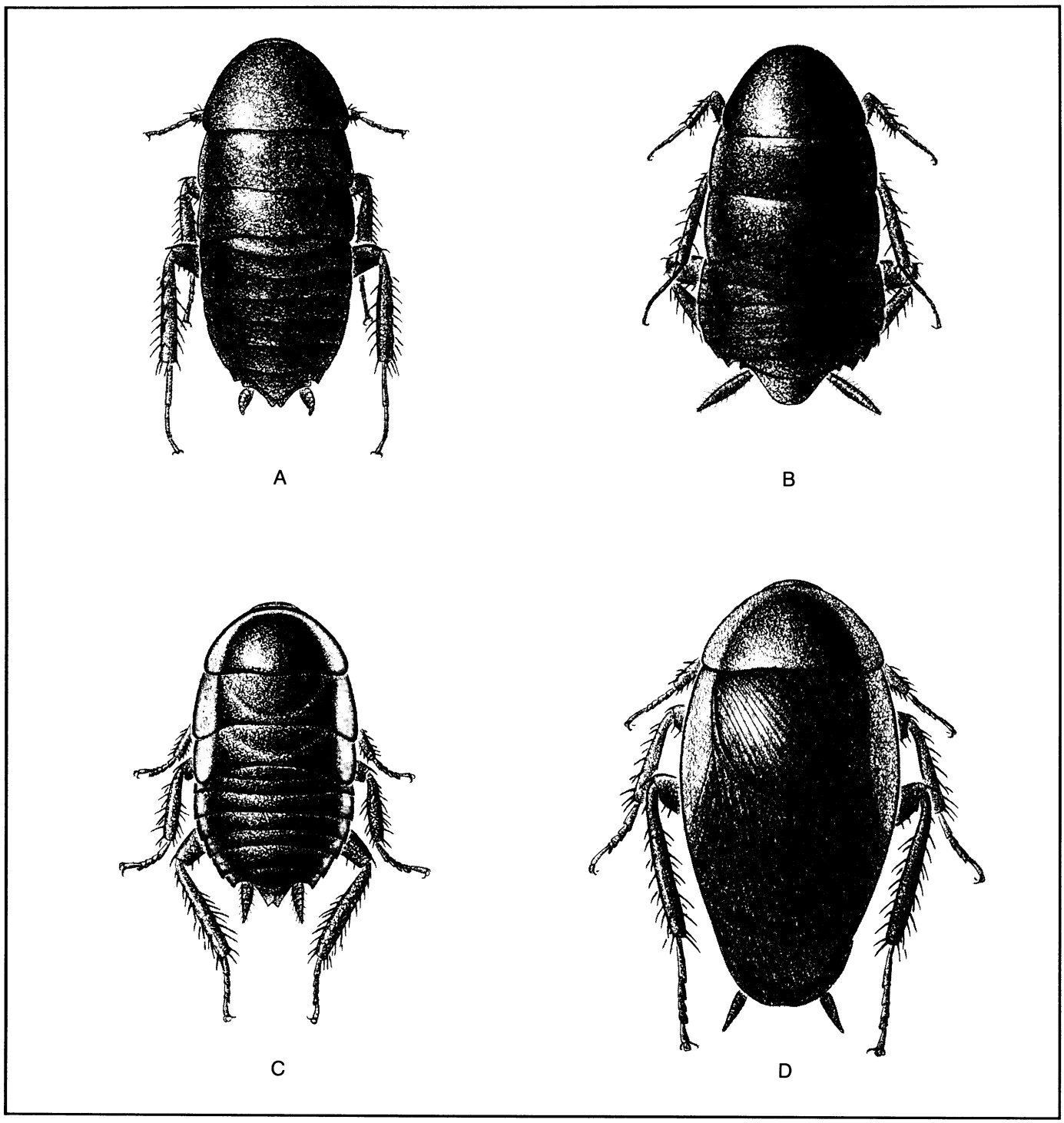


Plate 49. Blattid cockroaches (Blattidae), dorsal views (drawings by C. Feller): A, *Lamproblatta* sp., nymph; B, same, female (16-19); C, *Methana marginalis,* nymph; D, same, adult (28.2).

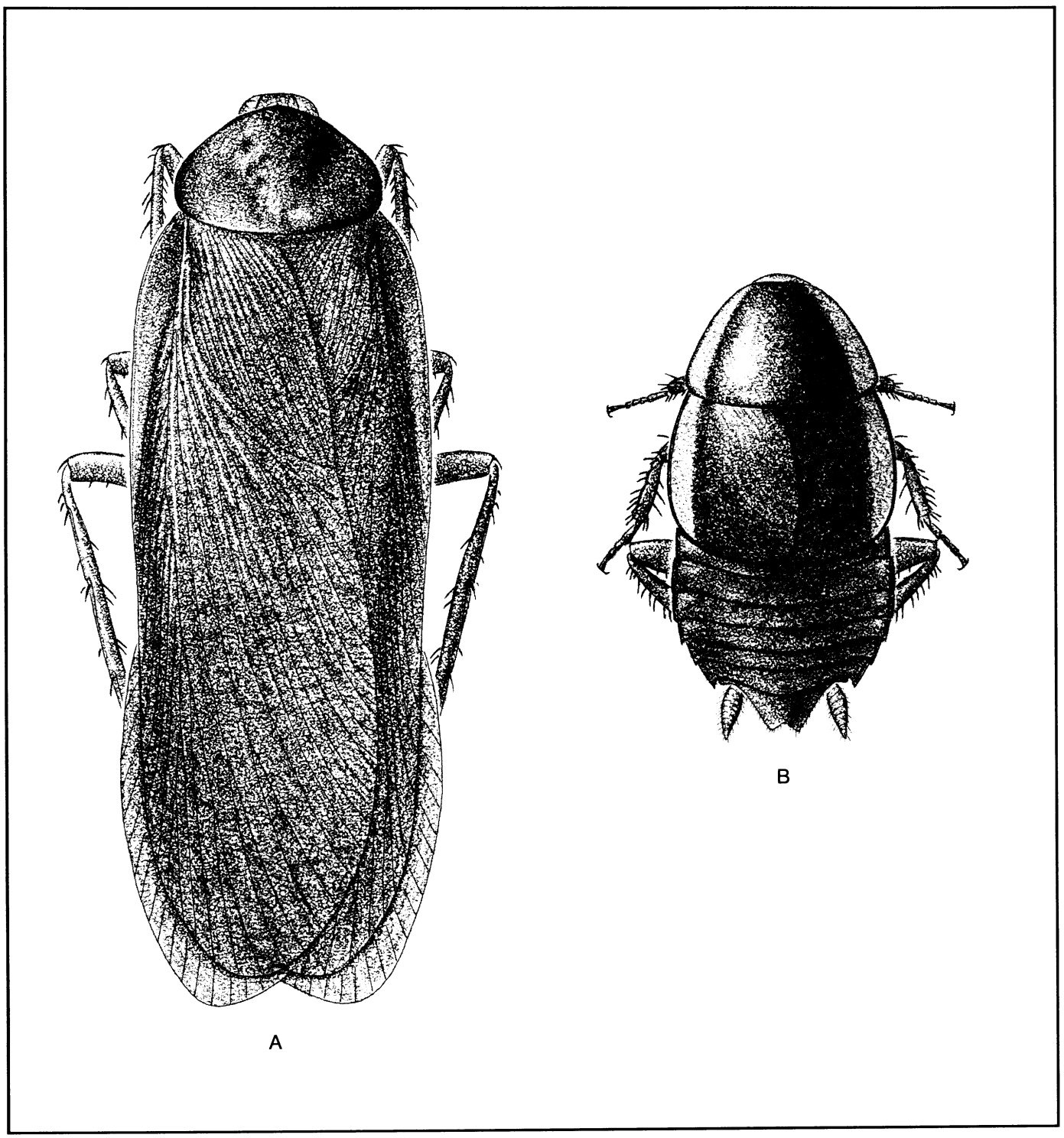


Plate 50. Blattid cockroaches (Blattidae), dorsal views (drawings by C. Feller): A, *Deropeltis erythrocephala,* male (36-40); B, *Pelmatosilpha* sp., female (17-21).

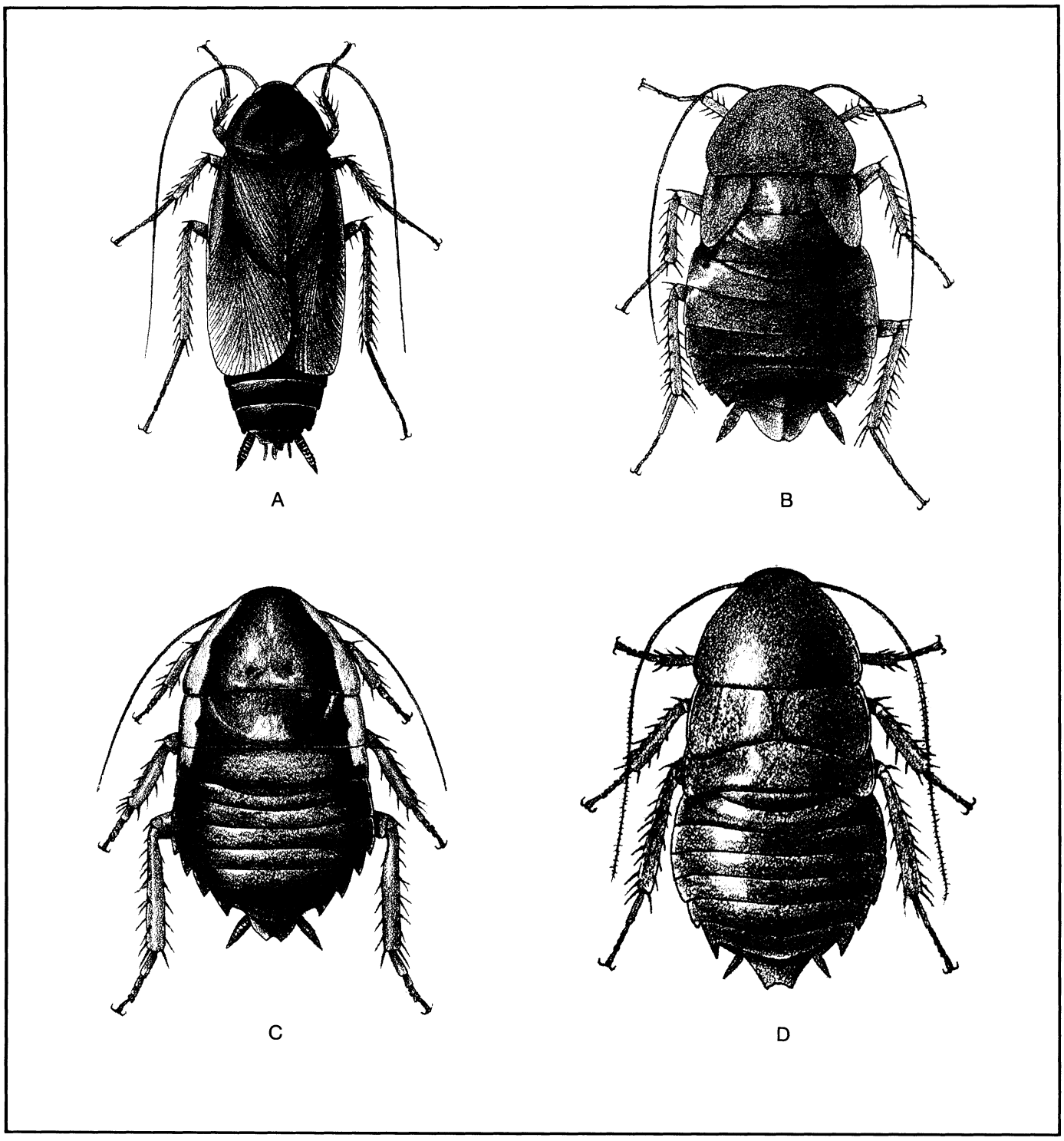


Plate 51. Blattid cockroaches (Blattidae), dorsal views: A, **oriental cockroach,** *Blatta orientalis,* male (20-27); B, same, female (20-27); C, Florida stinkroach, *Eurycotis floridana,* nymph; D, same, adult (30-40).

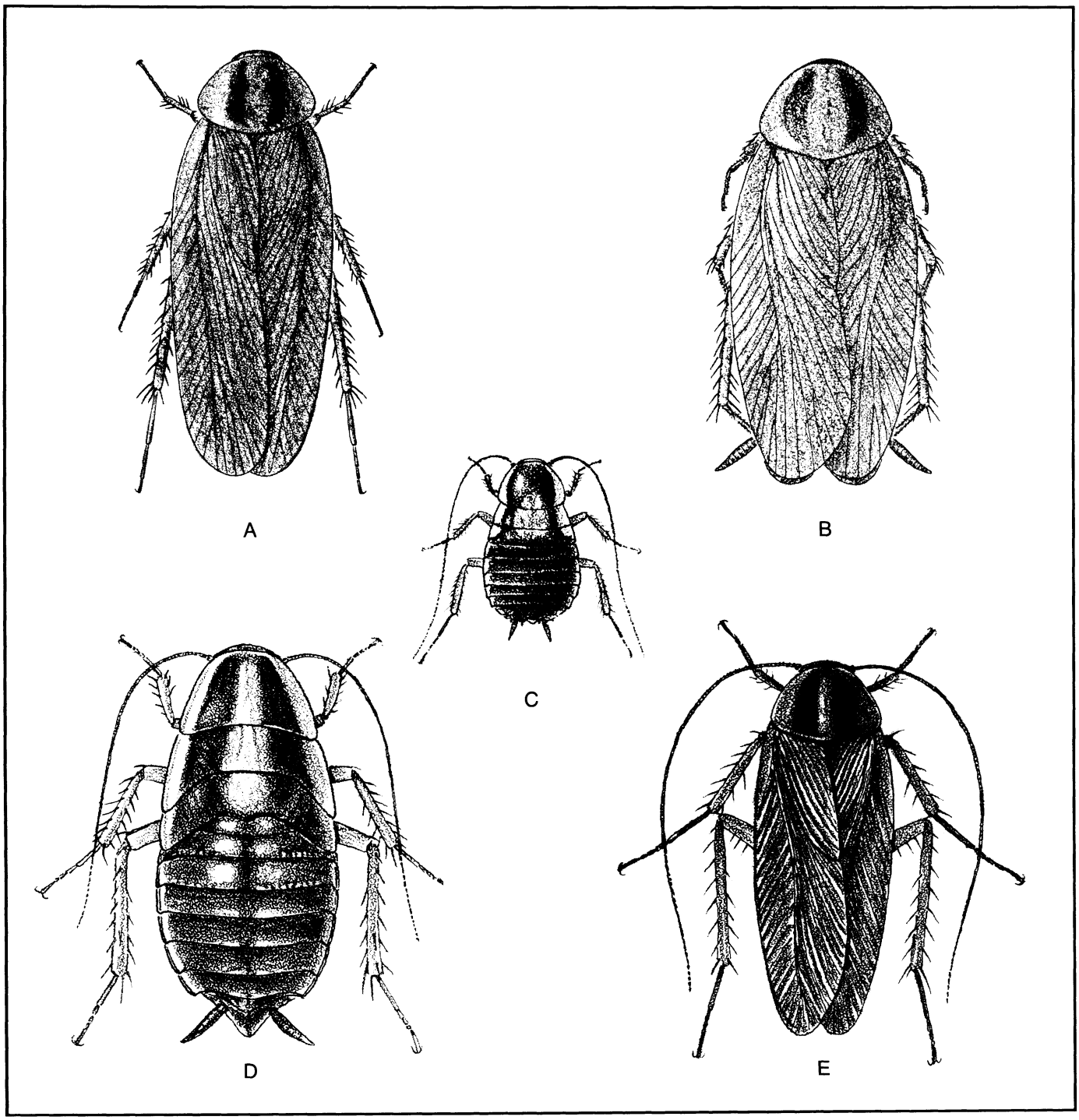


Plate 52. Blattellid cockroaches (Blattellidae), dorsal views: A, **false German cockroach,** *Blattella lituricollis* (11-12); B, field cockroach, *Blattella vaga* (10-15) (drawings A&B by C. Feller); C, **German cockroach,** *Blattella germanica,* nymph; D, same, nymph; E, same, adult (10-15).

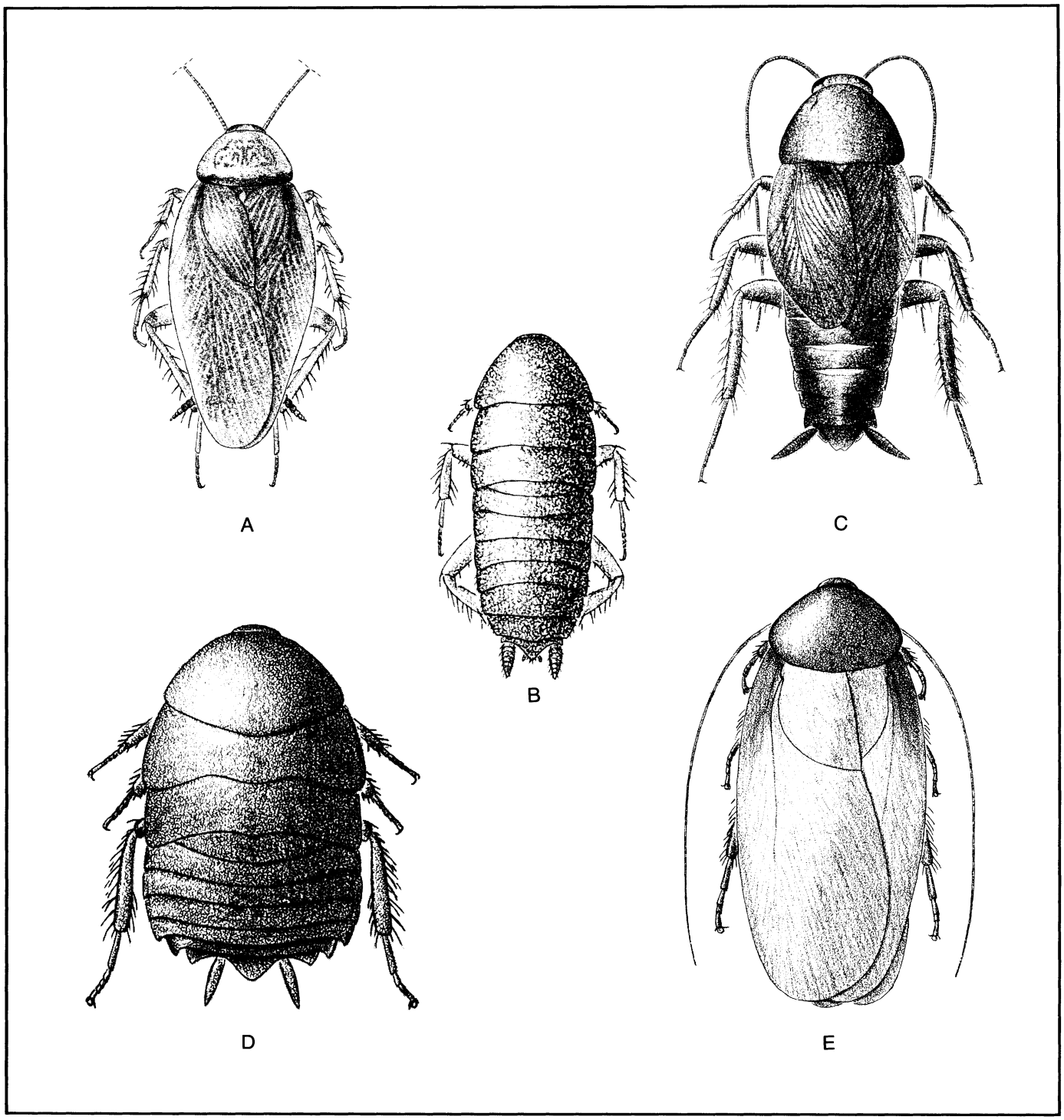


Plate 53. Blattellid cockroaches (Blattellidae), dorsal views (drawings by C. Feller): A, *Lupparia* sp. (10-12); B, *Shawella couloniana,* nymph; C, same, adult (15-22); D, banana cockroach, *Nyctibora noctivaga,* nymph; E, same, adult (33-35).

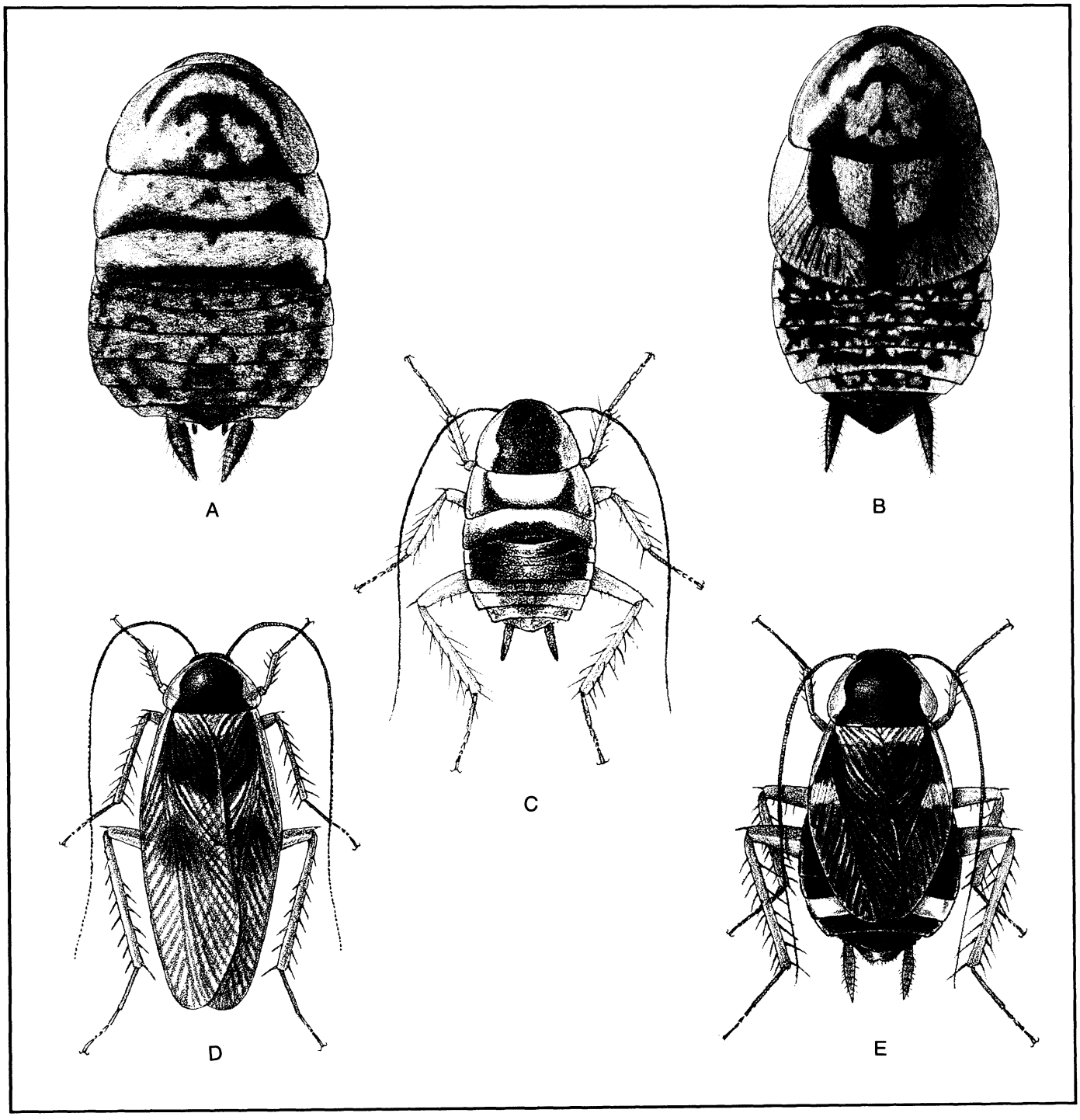


Plate 54. Blattellid cockroaches (Blattellidae), dorsal views: A, little gem cockroach, *Aglaopteryx gemma,* nymph; B, same, adult (7.5-9.3) (drawings A&B by C. Feller); C, **brownbanded cockroach,** *Supella longipalpa,* nymph; D, same, male (10-14); E, same, female (10-14).

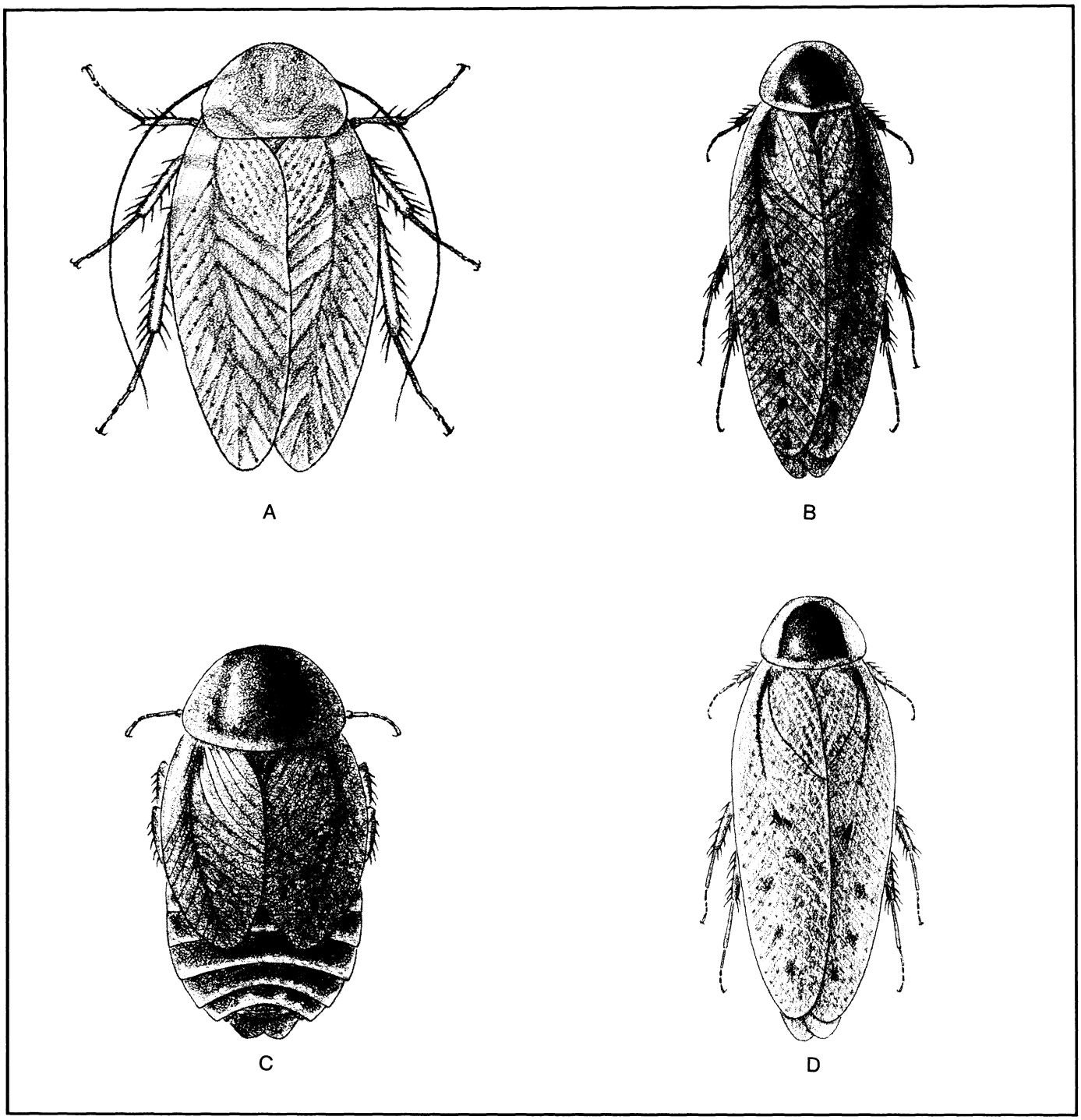


Plate 55. Blattellid cockroaches (Blattellidae), dorsal views: A, **spotted Mediterranean cockroach,** *Ectobius pallidus* (8-9.3); B, dusky cockroach, *Ectobius lapponicus,* male (9.5-11.3); C, same, female (6.8-7.9); D, forest cockroach, *Ectobius sylvestris,* male (7.8-8.5). (Drawings B-D by C. Feller.)

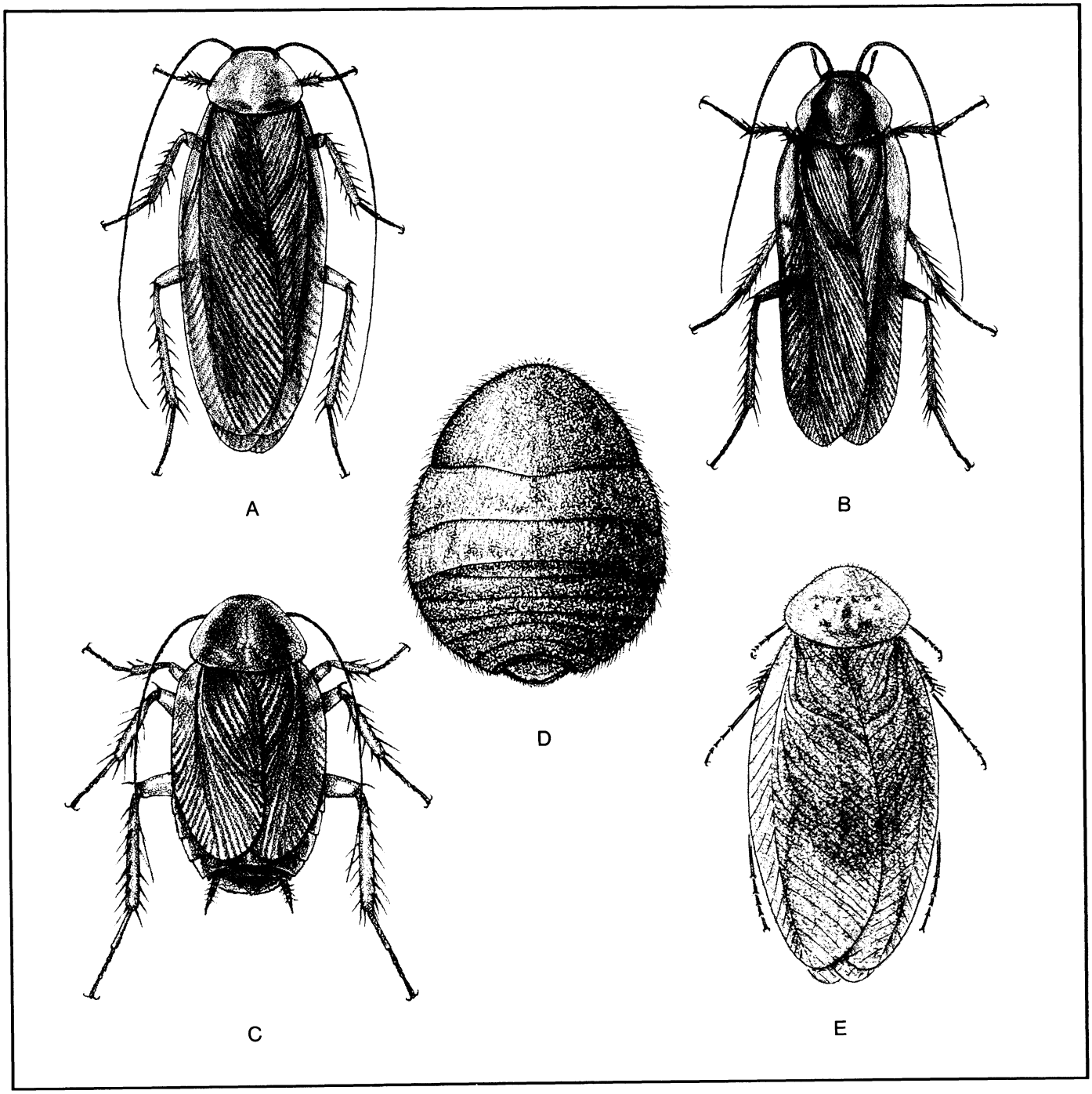


Plate 56. Blattellid and polyphagid cockroaches, dorsal views, A-C, wood cockroaches (Blattellidae): A, Virginia woodroach, *Parcoblatta virginica,* male (11.5-14.2); B, Pennsylvania woodroach, *Parcoblatta pennsylvanica,* male (22-30); C, same, female (13-20); D, sand cockroach, *Arenivaga* sp. (Polyphagidae), nymph; E, same, male (10.5-23.8) (drawings D&E by C. Feller).

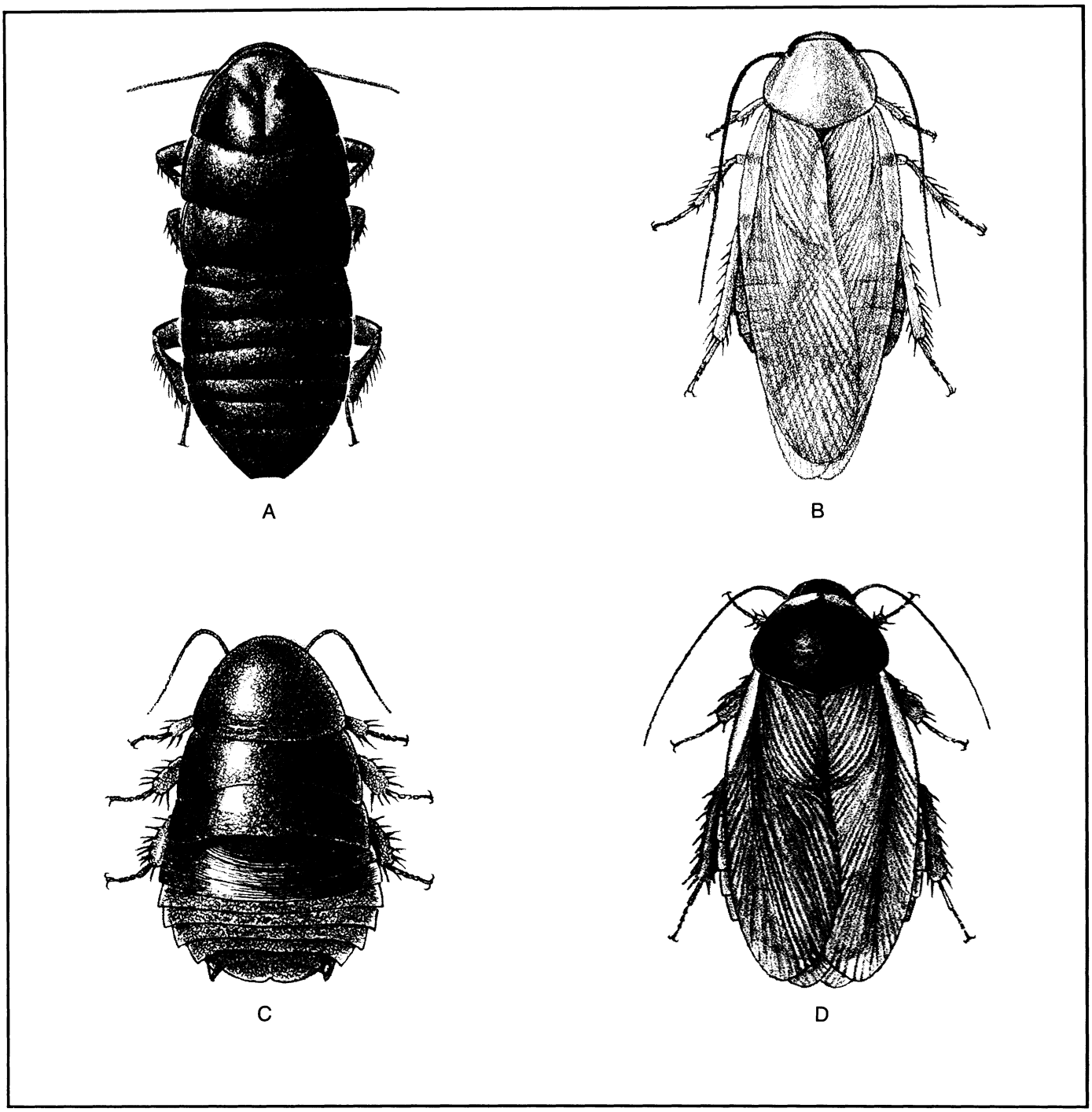


Plate 57. Cryptocercid and blaberid cockroaches, dorsal views: A, brownhooded cockroach, *Cryptocercus punctulatus* (23-29) (Cryptocercidae) (drawing by C. Feller); B-D, Blaberidae; B, **Cuban cockroach,** *Panchlora nivea* (15-20); C, **Surinam cockroach,** *Pycnoscelus surinamensis,* nymph; D, same, female (18-24).

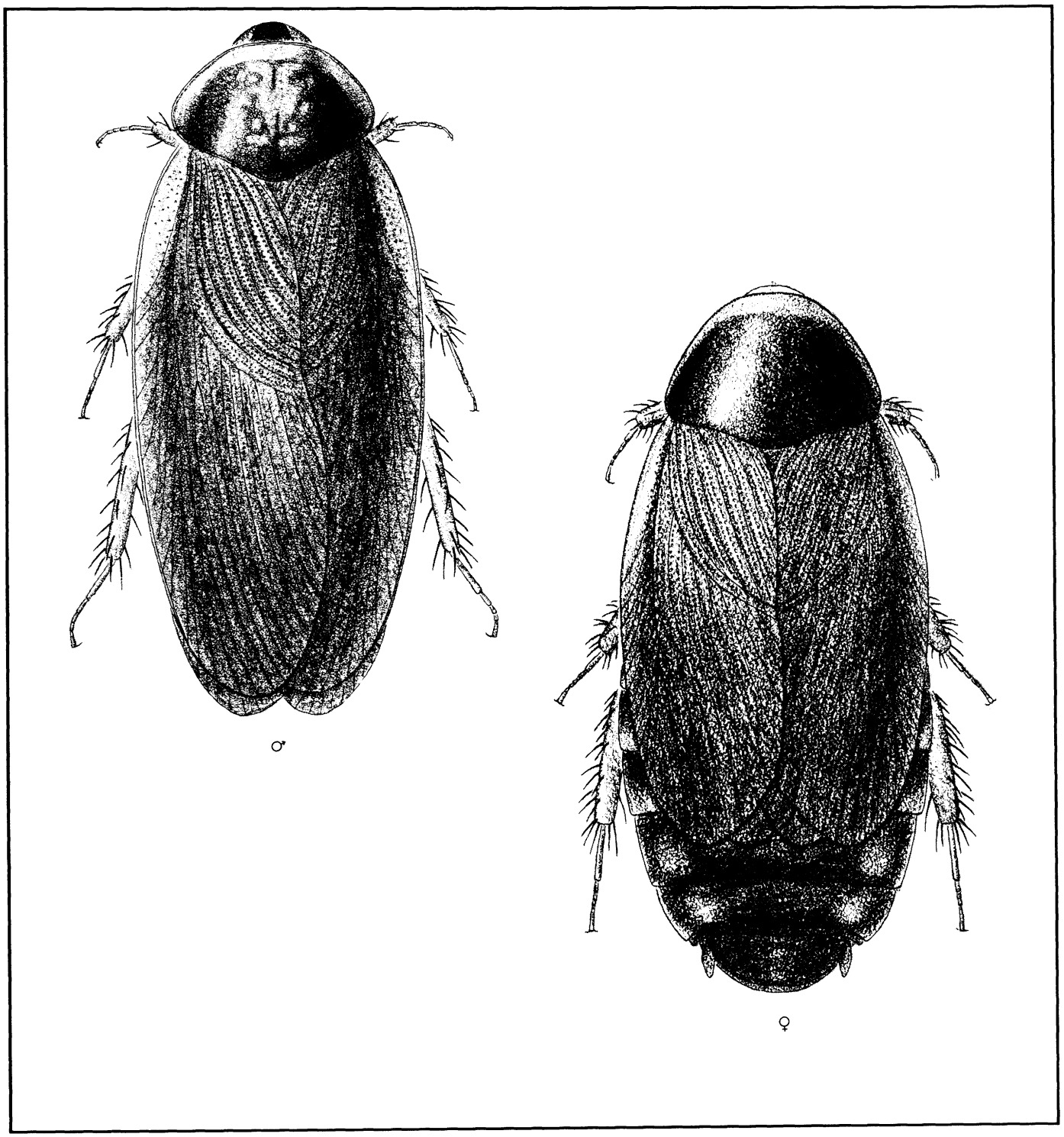


Plate 58. Indian cockroach, *Pycnoscelus indicus* (17-18) (Blaberidae), dorsal views (drawings by C. Feller).

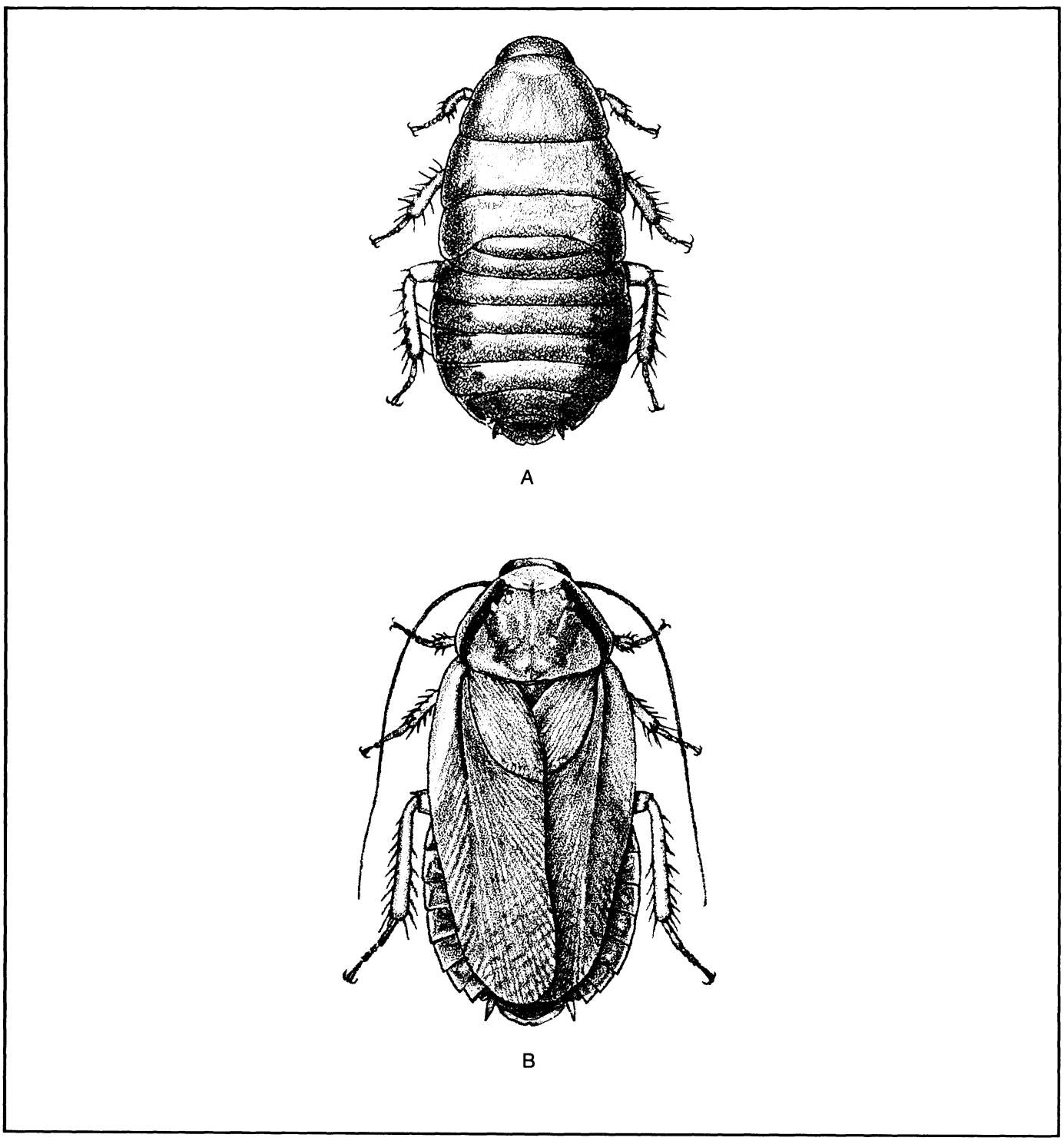


Plate 59. **Cinereous cockroach,** *Nauphoeta cinerea* (Blaberidae): A, nymph; B, adult (25-29).

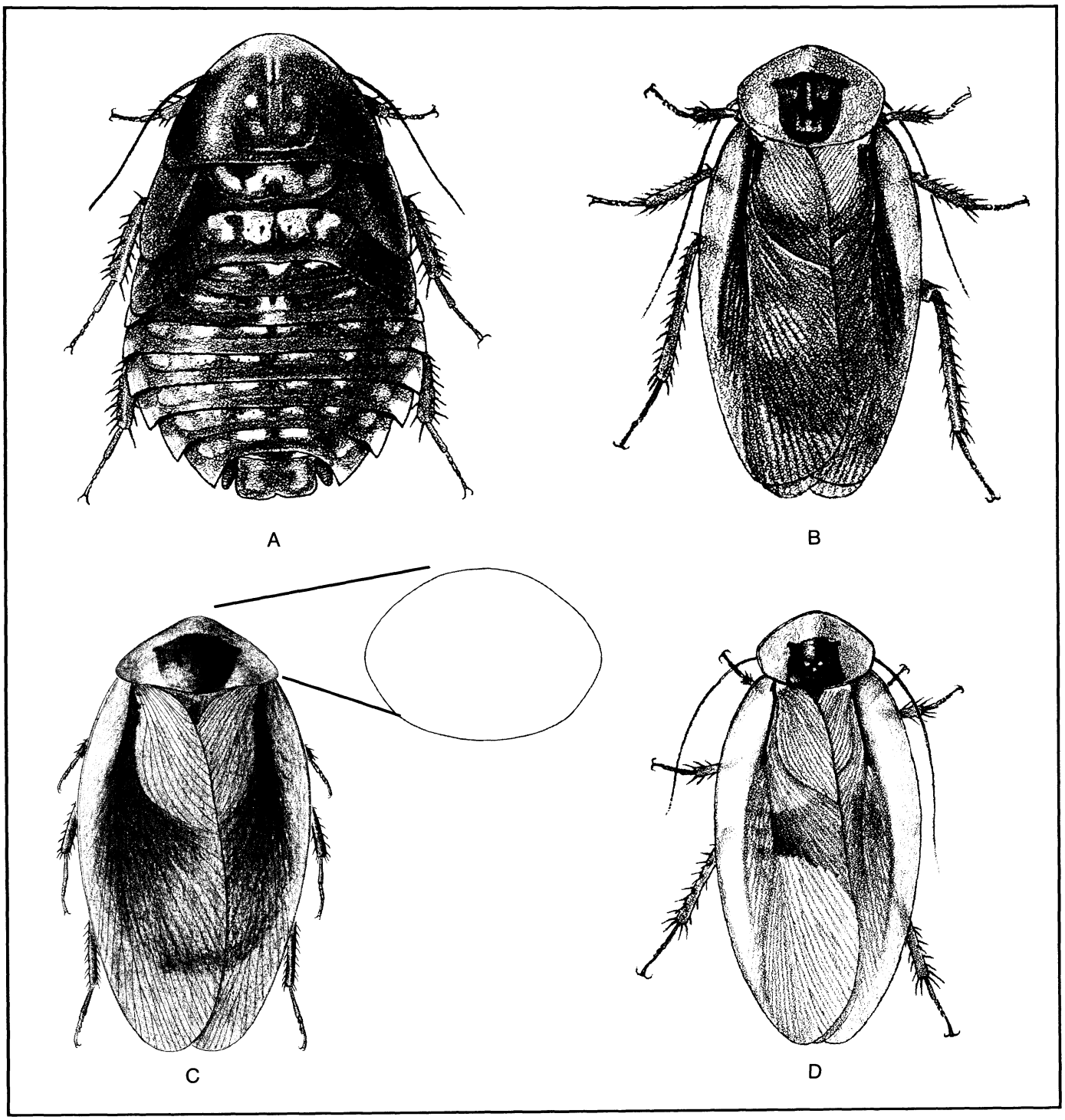
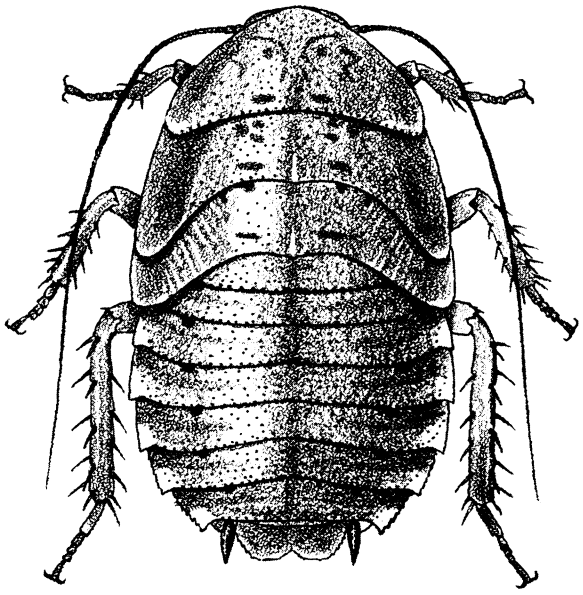
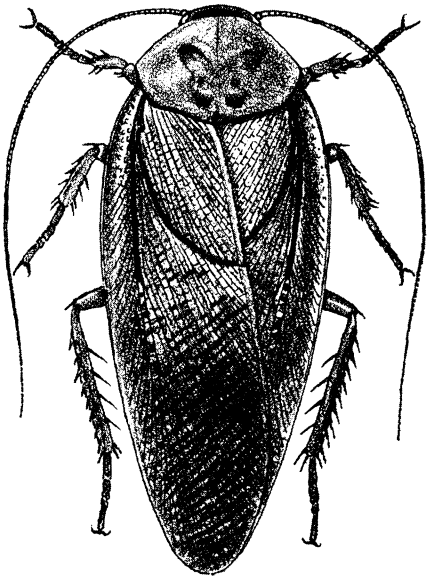


Plate 60. Giant cockroaches, *Blaberus* spp. (Blaberidae), dorsal views: A, *Blaberus craniifer,* nymph; B, same, adult (60-70); C, *Blaberus discoidalis* (49) (inset shows shape of pronotum in full dorsal view) (drawings by C. Feller); D, *Blaberus giganteus* (70-80).



A



B

Plate 61. **Madeira cockroach,** *Leucophaea maderae* (Blaberidae): A, nymph; B, adult (40-50).

Notes and Sketches

ADULT AND LARVAL BEETLES

This series of illustrations, drawn by A.D. Cushman unless otherwise indicated, is a continuation from part 1, chapters entitled "Adult Beetles (Coleoptera)," by J.M. Kingsolver and "Larval Beetles (Coleoptera)," by D.M. Anderson.

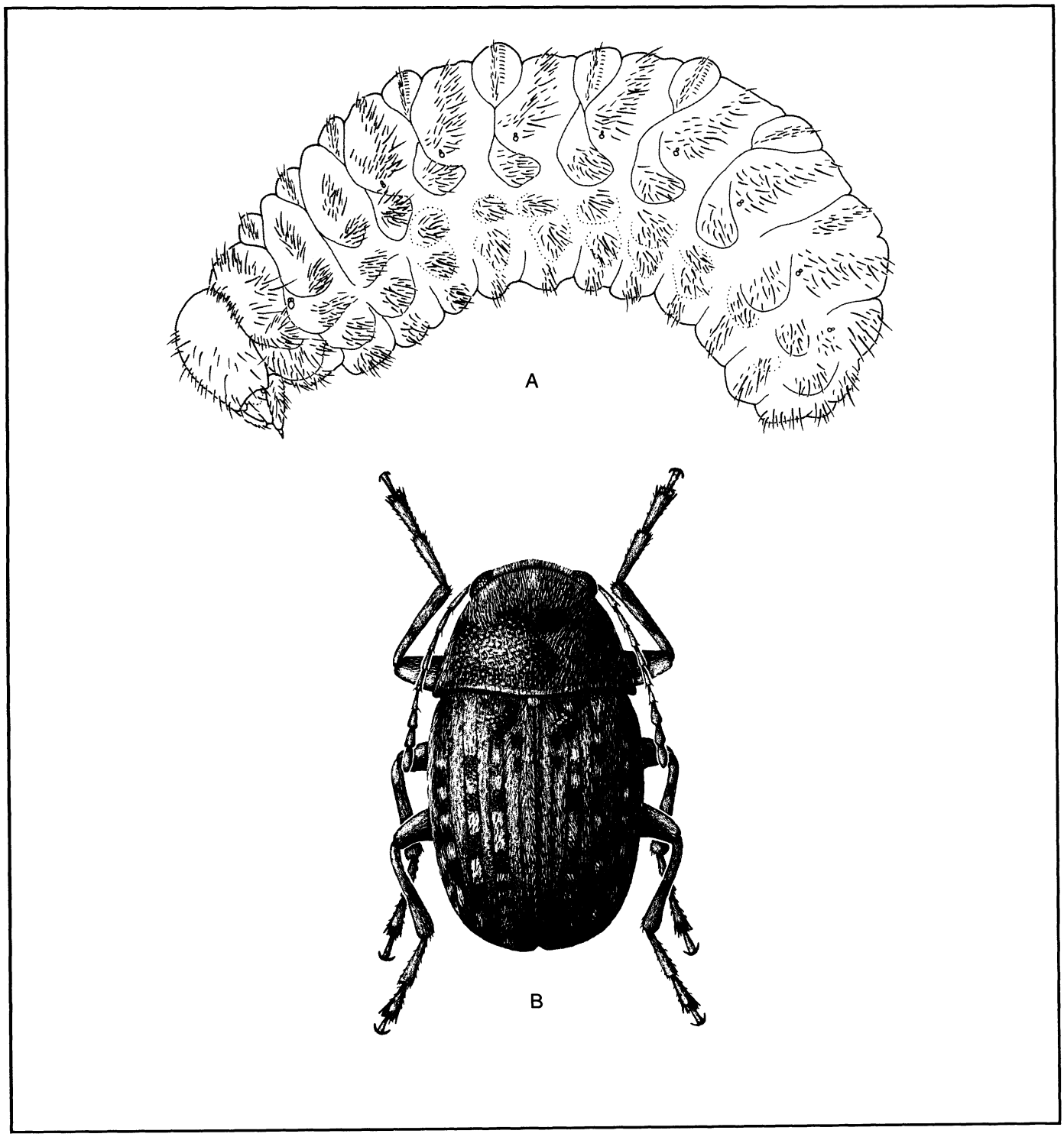


Plate 62. **Coffee bean weevil,** *Araecerus fasciculatus* (Anthribidae): A, larva (4.5-6) (drawing by M. Ryan); B, adult (2-4.5) (drawing by R. White).

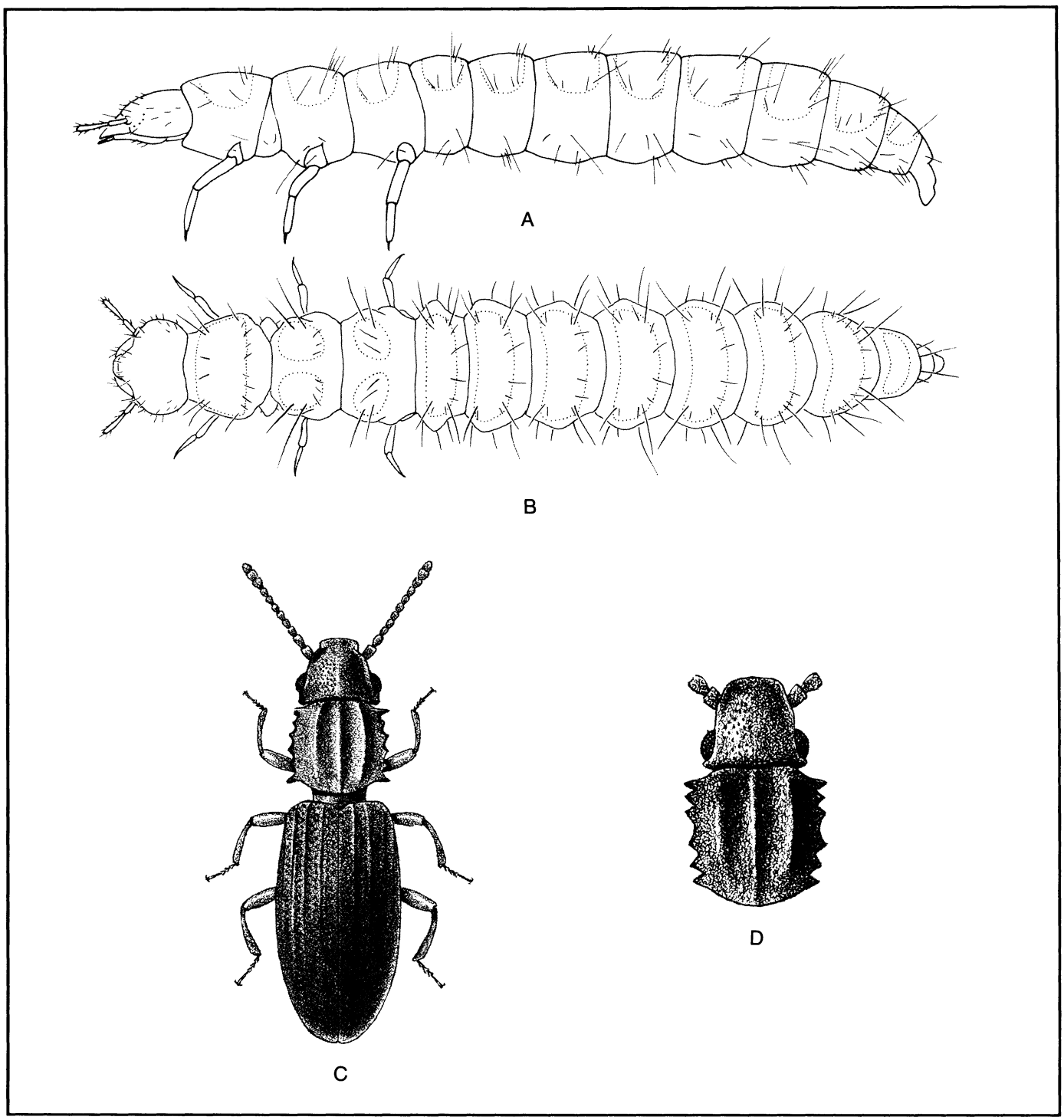


Plate 63. Grain beetles, *Oryzaephilus* (Cucujidae): A-C, **sawtoothed grain beetle**, *O. surinamensis*; A&B, larva (3) (drawings by C. Feller); C, same, adult (1.8-3.5); D, **merchant grain beetle**, *O. mercator* (2.2-3.5).

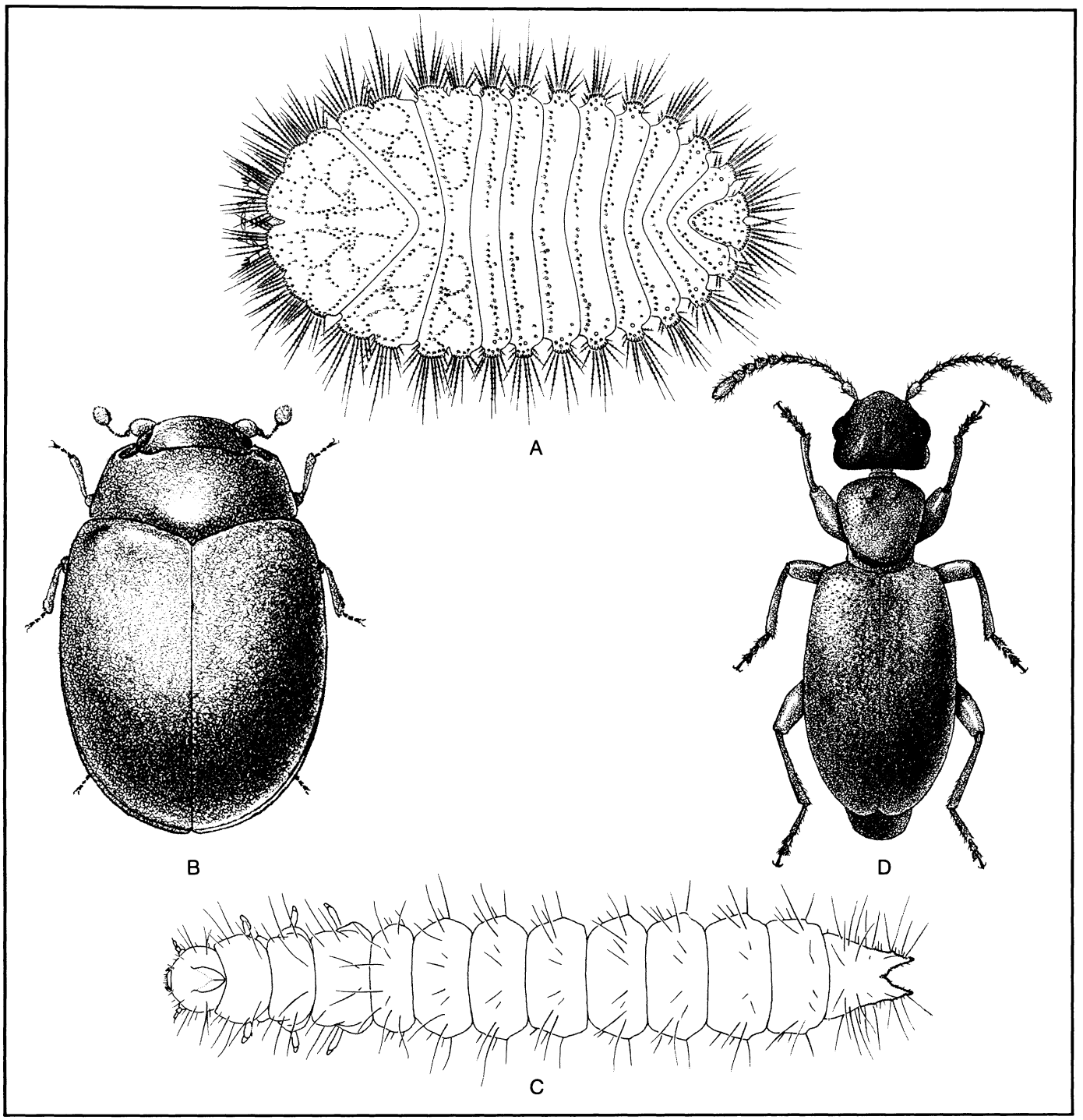


Plate 64. Cerylonid and anthicid beetles: A, oval grain beetle, *Murmidius ovalis* (Cerylonidae), larva (1.9) (drawing by C. Feller); B, same, adult (1.2-1.4); C, *Anthicus* sp. (Anthicidae), larva (5) (drawing by C. Feller); D, **narrownecked grain beetle,** *A. floralis,* adult (2.7-3.5).

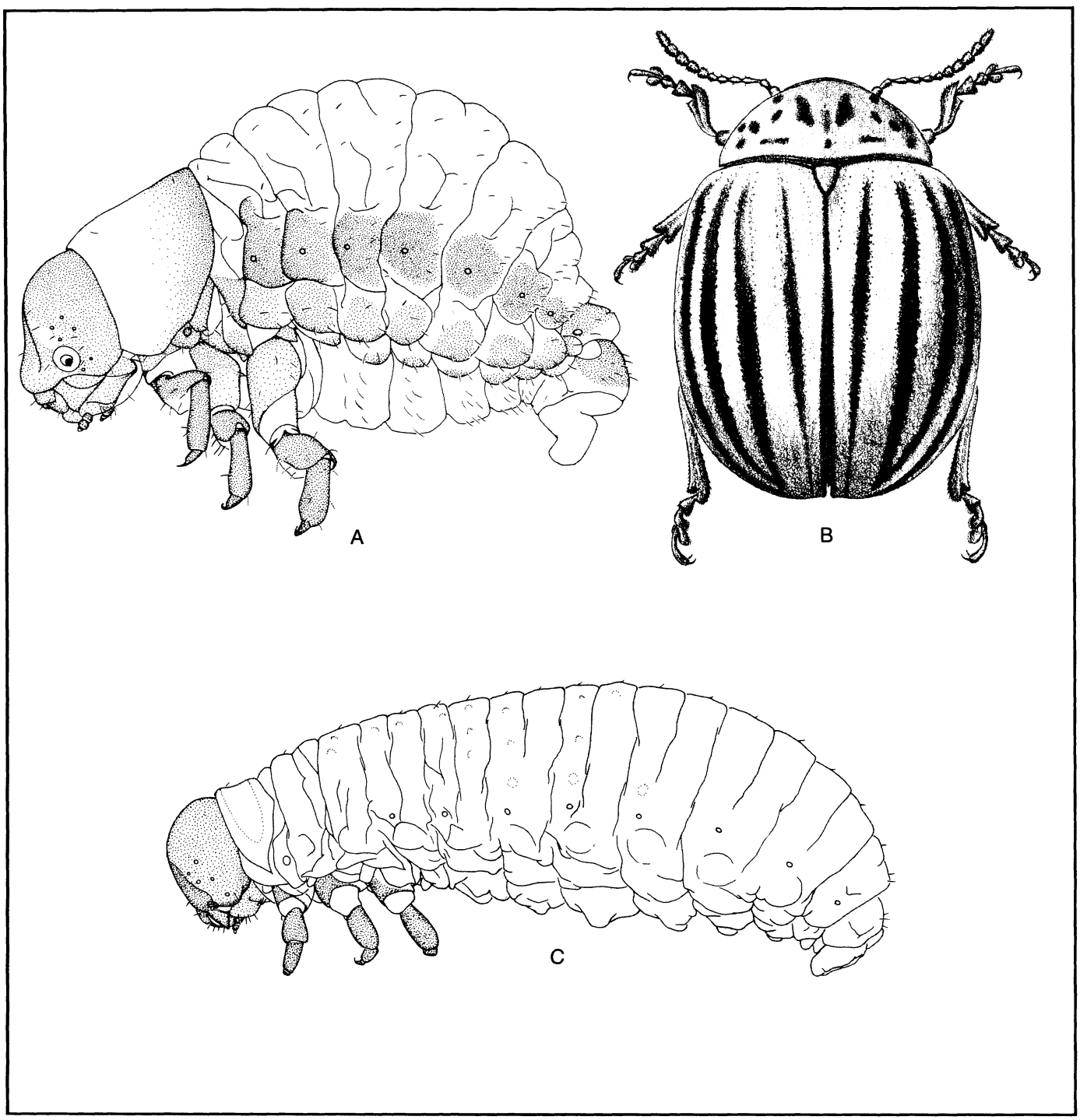


Plate 65. **Leaf beetles** (Chrysomelidae) (drawings by C. Feller): A, **Colorado potato beetle,** *Leptinotarsa decemlineata,* larva (15); B, same, adult (7-10.5); C, **asparagus beetle,** *Crioceris asparagi,* larva (9) (for adults of *C. duodecimpunctata* and *C. asparagi,* see pl. 1N&O).

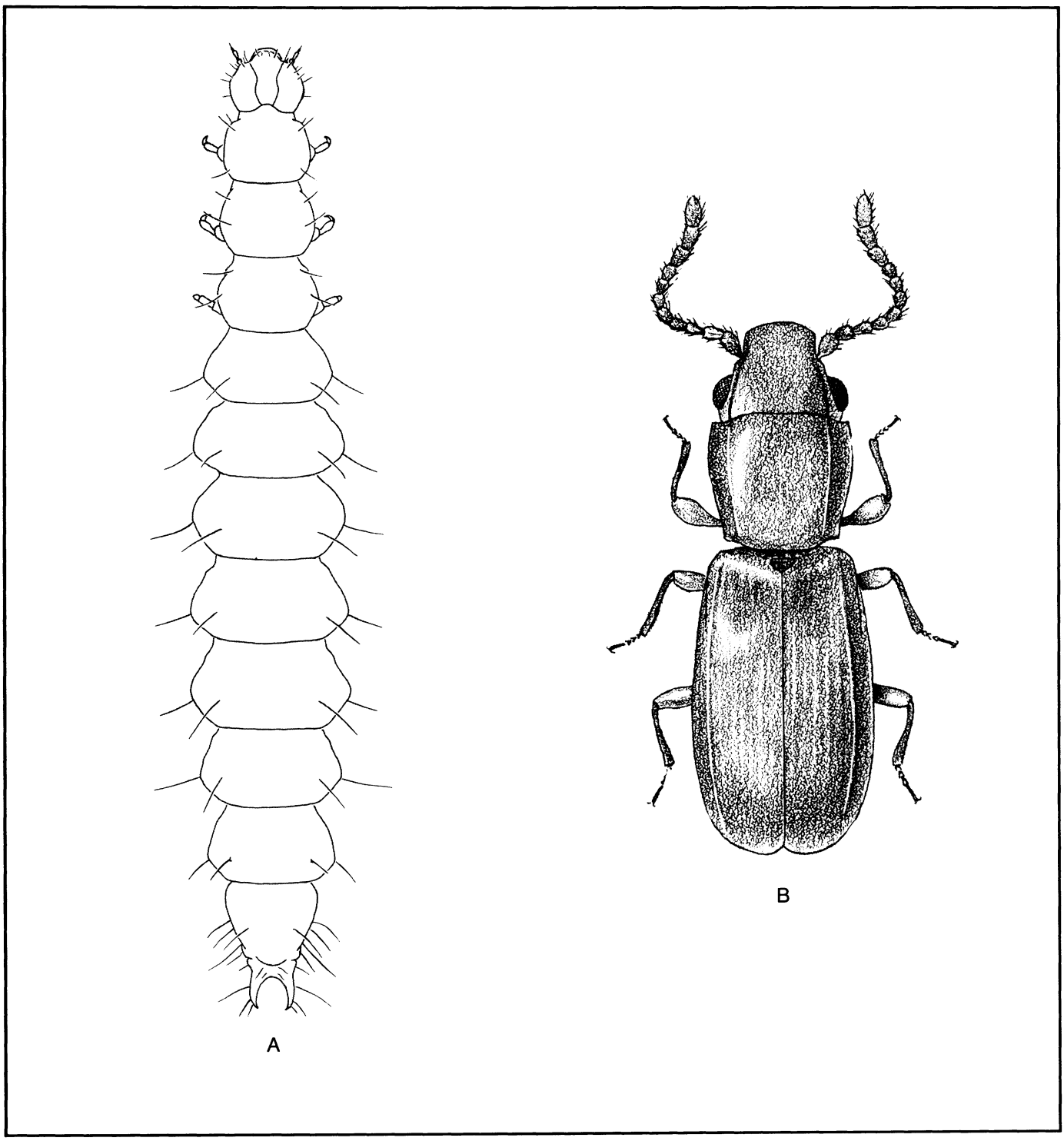


Plate 66. Grain beetles, *Cryptolestes* spp. (Cucujidae) (drawings by C. Feller): A, *Cryptolestes* sp., larva (3.5); B, **flat grain beetle,** *C. pusillus,* adult (1.4-1.9).

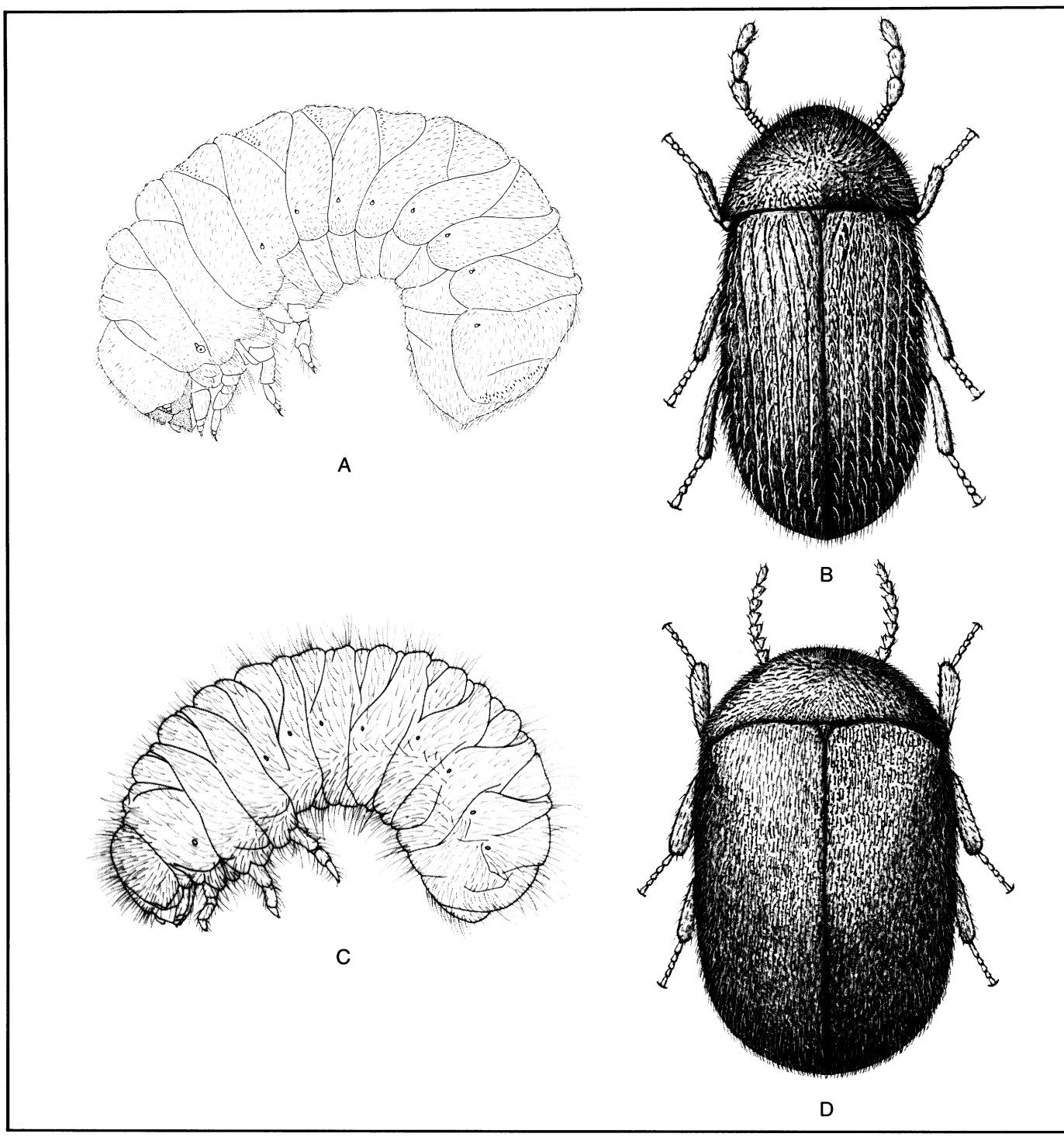


Plate 67. Anobiid beetles (Anobiidae): A, **drugstore beetle,** *Stegobium paniceum,* larva (3-4); B, same, adult (2.2-3.7); C, **cigarette beetle,** *Lasioderma serricorne,* larva (3-4) (drawings A&C by C. Feller); D, same, adult (1.8-3) (drawings B&D by R. White).

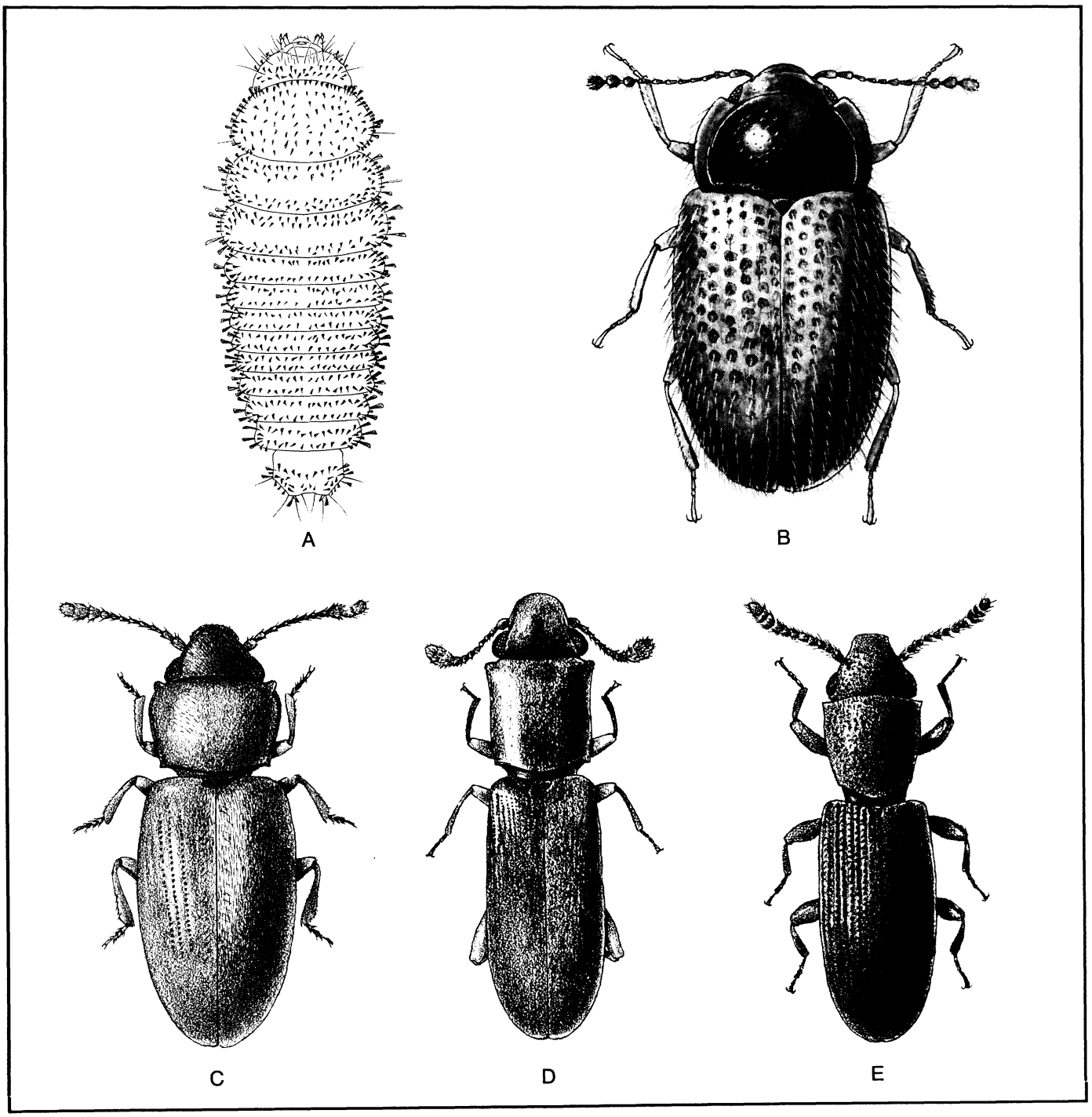
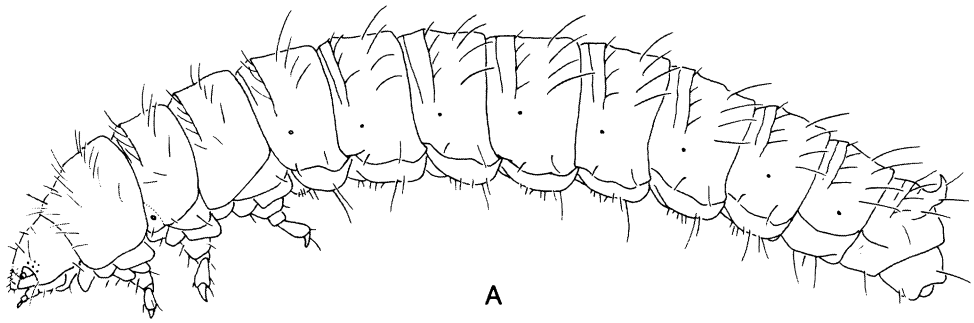
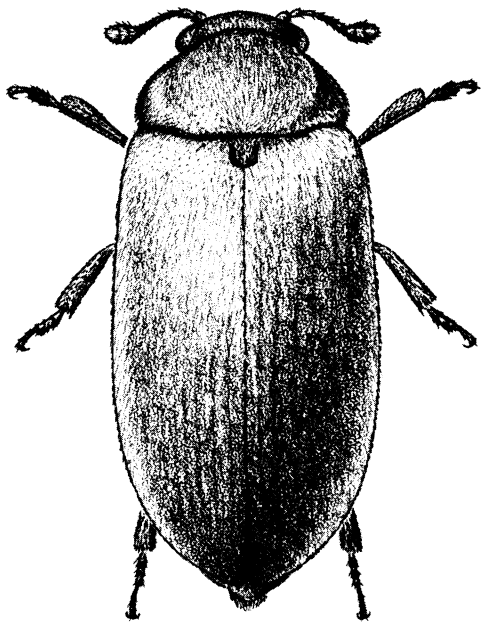


Plate 68. Endomychid and cucujid beetles: A, hairy cellar beetle, *Mycetaea subterranea* (Endomychidae), larva (2.2-2.5) (drawing by C. Feller); B, same, adult (1.5-1.8); C, **foreign grain beetle,** *Ahasverus advena* (Cucujidae), adult (2-3); D, **squarenecked grain beetle,** *Cathartus quadricollis* (Cucujidae), adult (2-2.7); E, *Silvanus planatus* (Cucujidae), adult (2.7-2.9).



A



B

Plate 69. **Raspberry fruitworm**, *Byturus unicolor* (Byturidae): A, larva (6) (drawing by C. Feller); B, adult, (3.8-4).

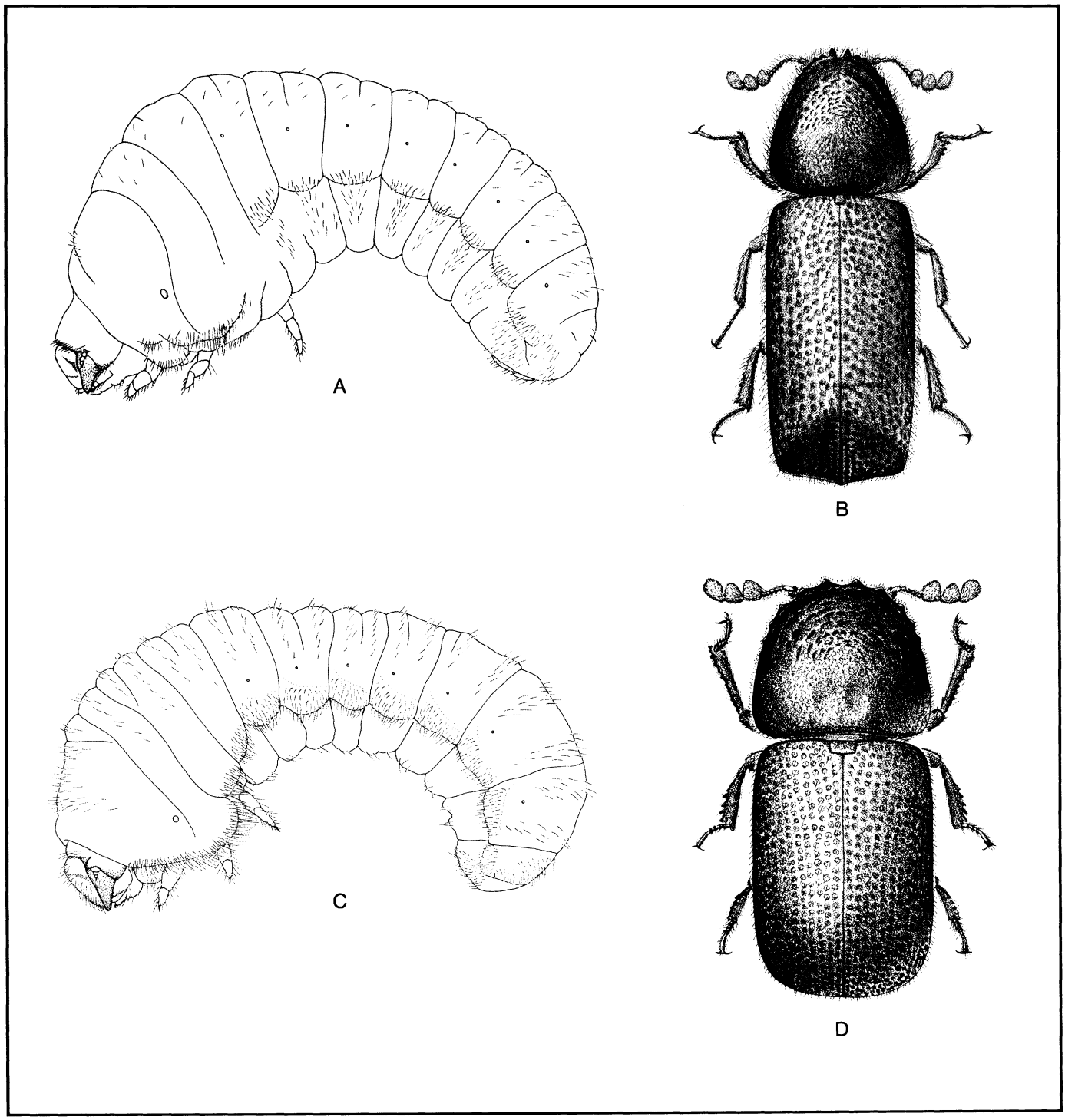


Plate 70. **False powderpost beetles** (Bostrichidae) (drawings by C. Feller): A, **larger grain borer,** *Prostephanus truncatus,* larva (3.6); B, same, adult (3.3-4.5); C, **bamboo powderpost beetle,** *Dinoderus minutus,* larva (3); D, same, adult (2.6-3.5).

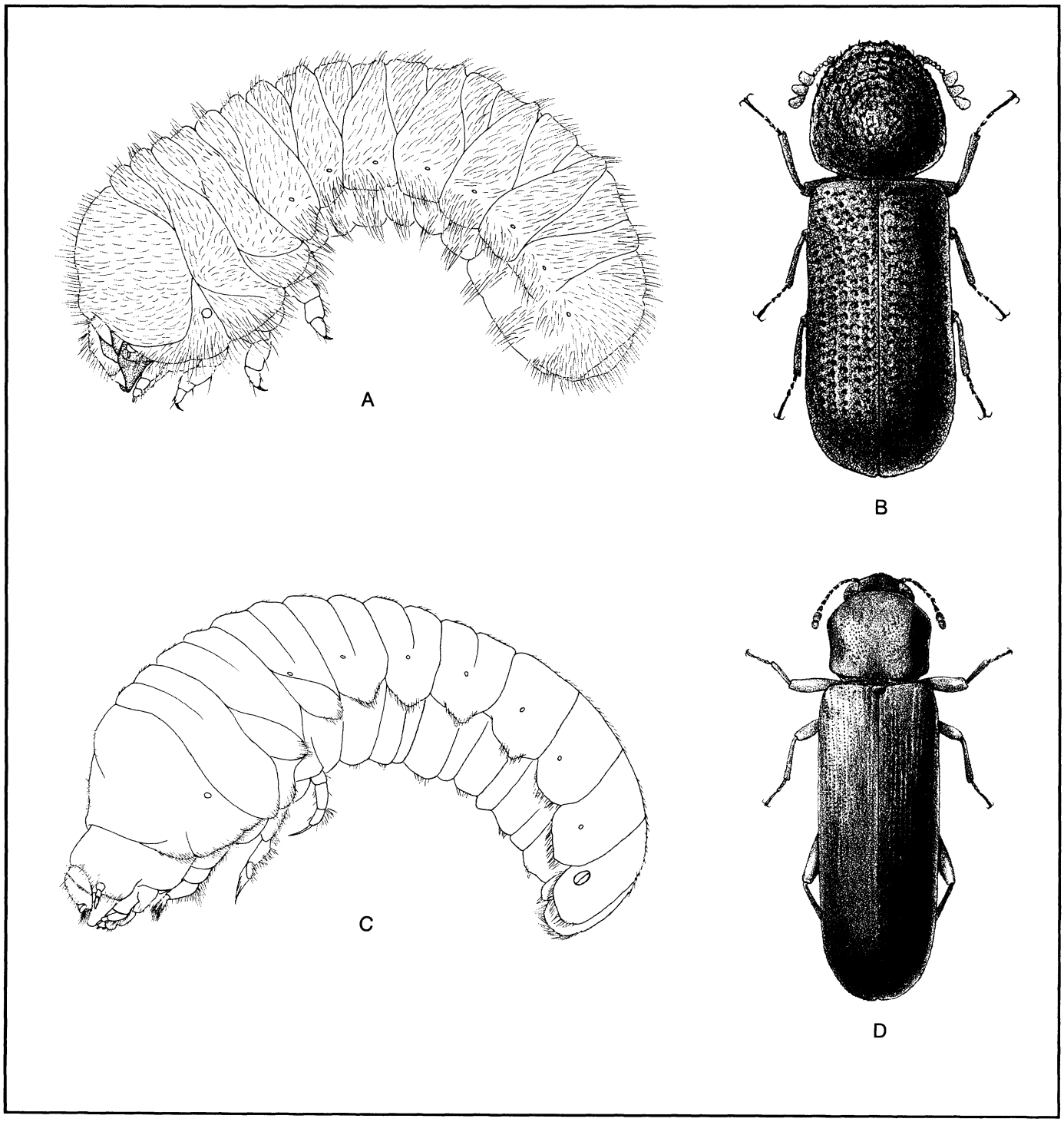


Plate 71. Wood-boring beetles: A, **lesser grain borer**, *Rhyzopertha dominica* (Bostrichidae), larva (3-3.1); B, same, adult (2-3); C, brown powderpost beetle, *Lyctus brunneus* (Lyctidae), larva (6) (drawings A & C by C. Feller); D, same, adult (2-2.7).

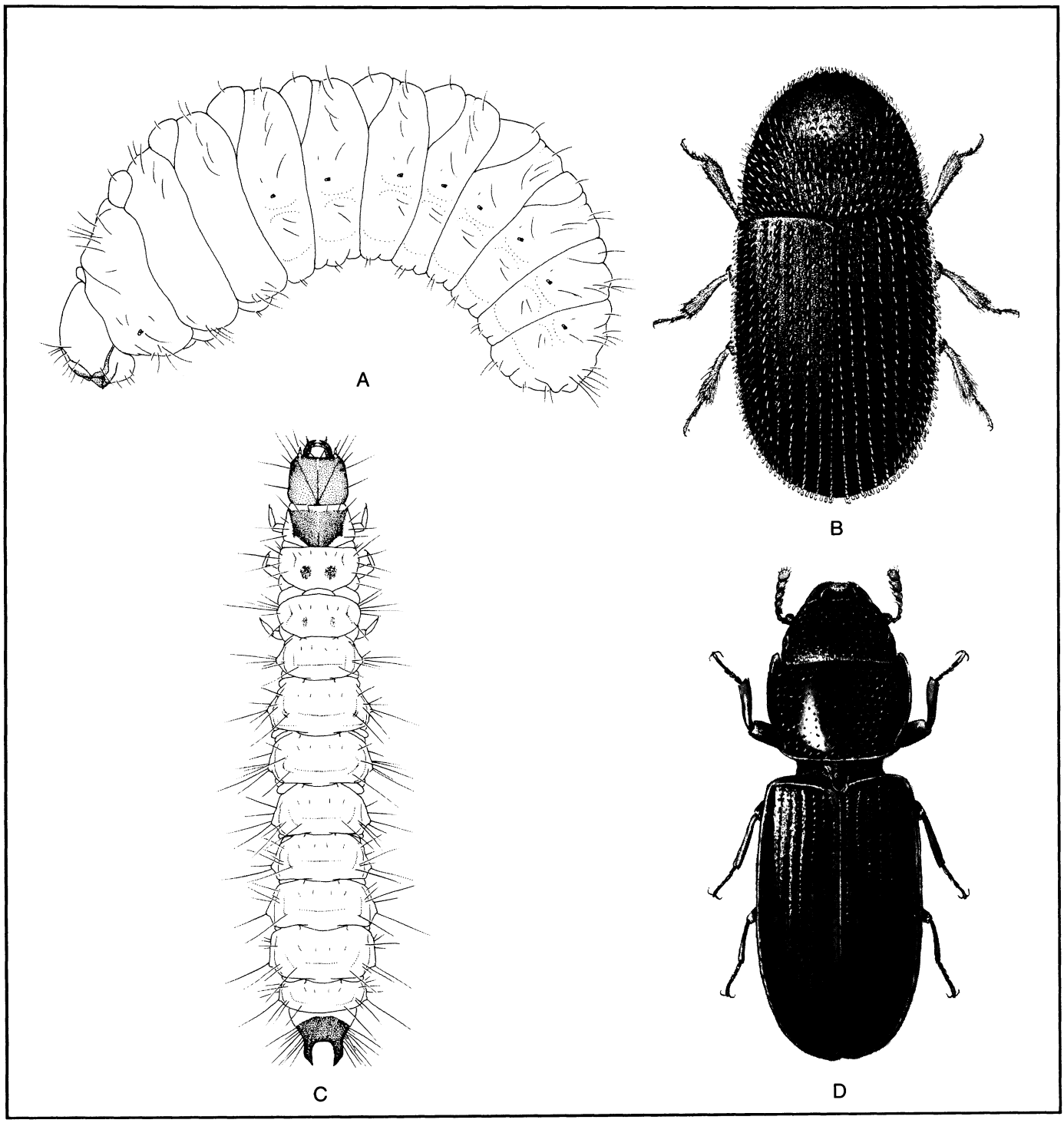


Plate 72. Scolytid and trogositid beetles: A, **coffee berry borer**, *Hypothenemus hampei* (Scolytidae), larva (2); B, same, adult (1.5-1.7); C, **cadelle,** *Tenebroides mauritanicus* (Trogositidae), larva (18-19) (drawings A-C by C. Feller); D, same, adult (5-11).

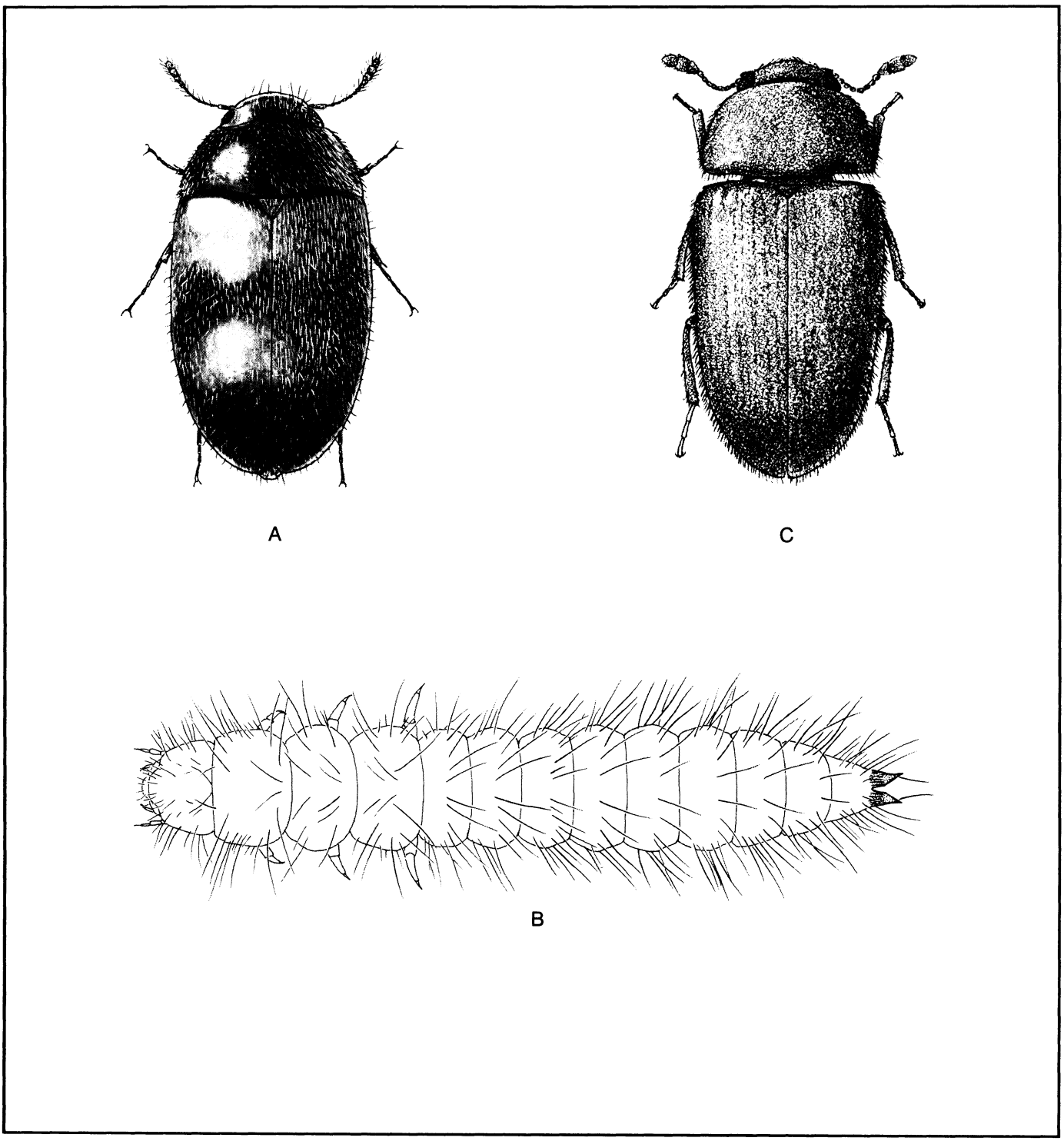


Plate 73. **Hairy fungus beetles** (Mycetophagidae): A, *Litargus balteatus,* adult (1.7-1.9); B, **hairy fungus beetle,** *Typhaea stercorea,* larva (4-4.5) (drawing by C. Feller); C, same, adult (2-2.3).

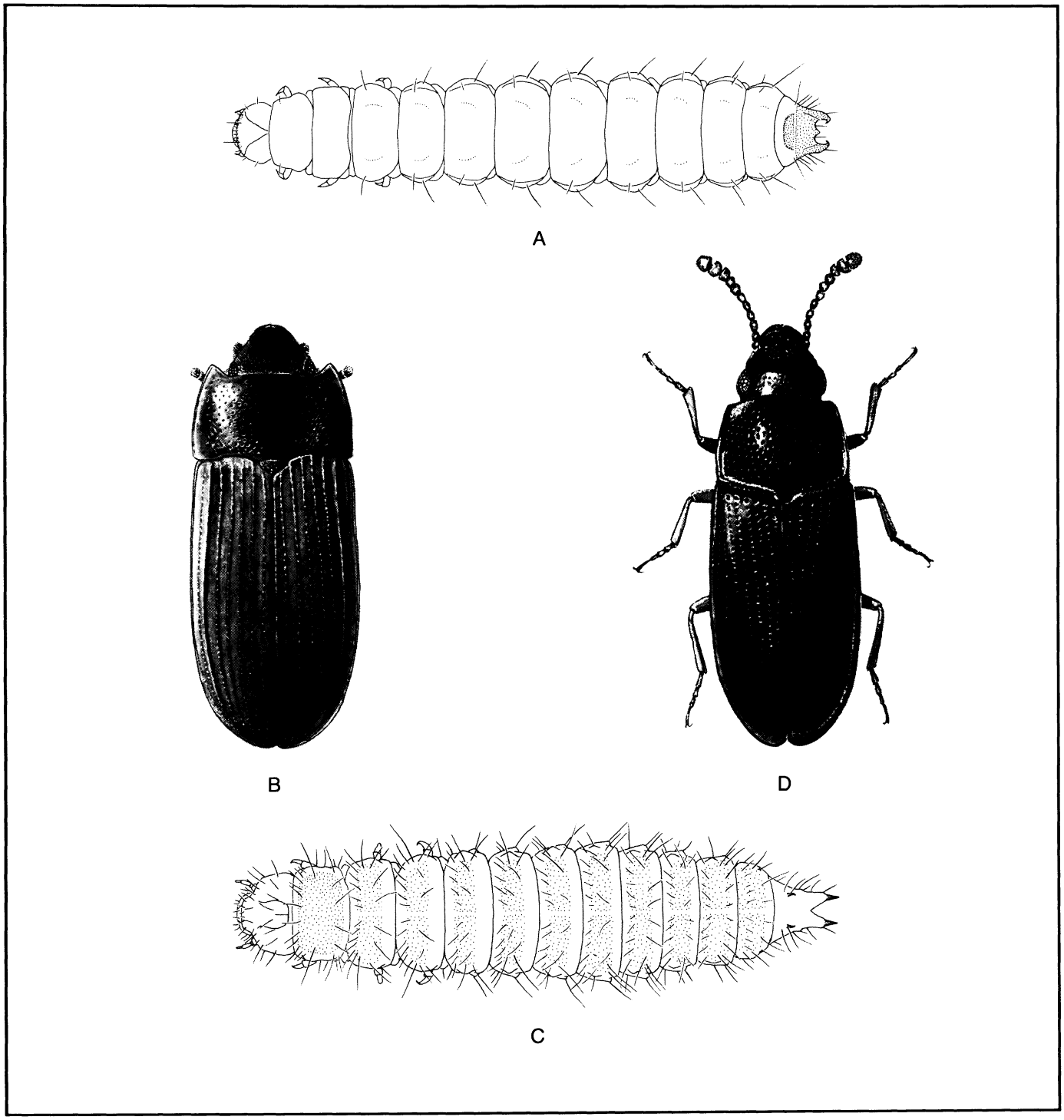


Plate 74. Grain beetles: A, Siamese grain beetle, *Lophocateres pusillus* (Trogositidae), larva (5.4); B, same, adult (2.6-3.2); C, Mexican grain beetle, *Pharaxonotha kirschi* (Languriidae), larva (8.5) (drawings A&C by C. Feller); D, same, adult (4-4.5).

DERMESTID BEETLES (DERMESTIDAE)

This series of illustrations, drawn by A.D. Cushman (unless otherwise noted), is a continuation from part 1, chapter 5 (Dermestid Beetles), by J.M. Kingsolver.

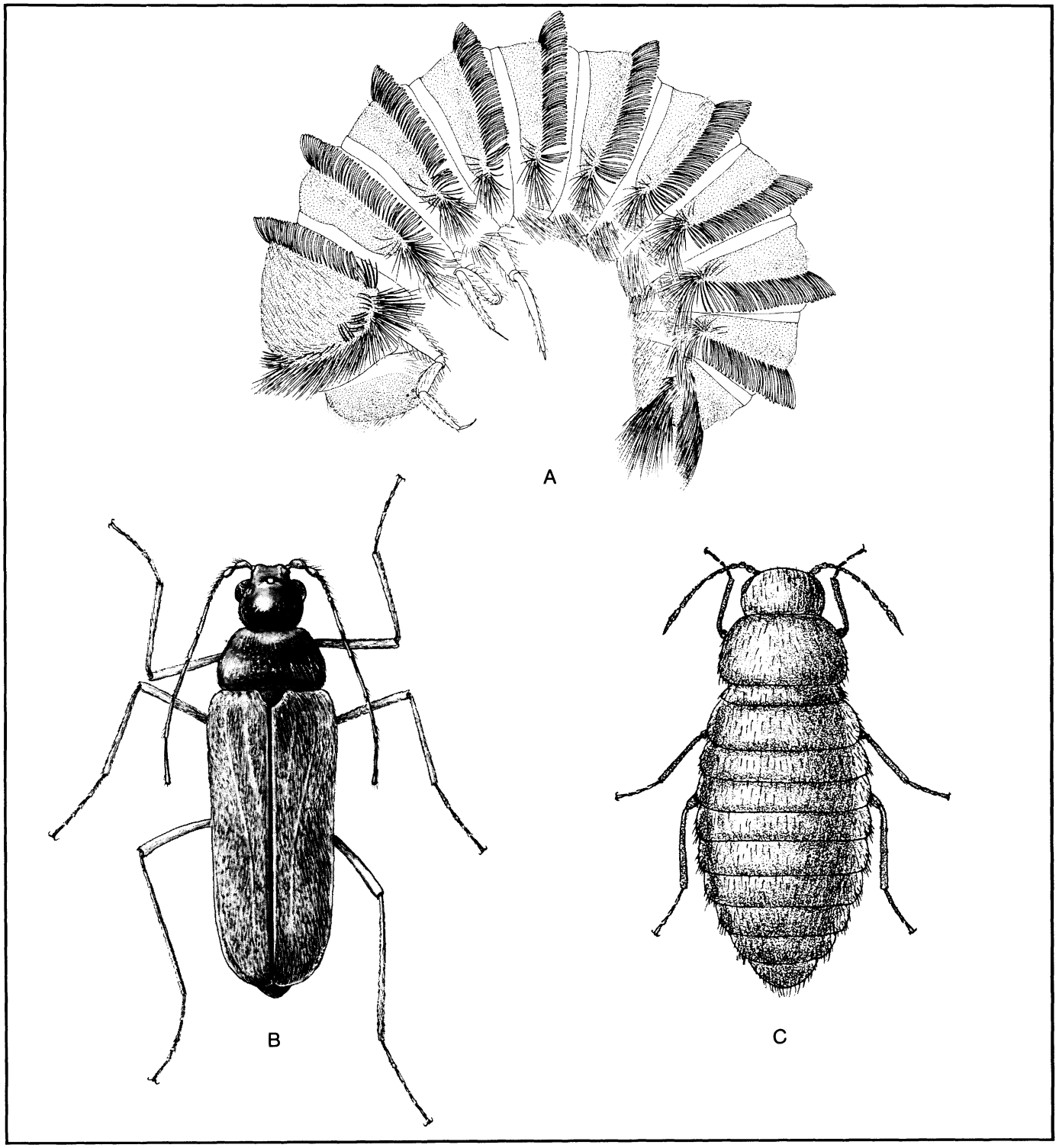


Plate 75. **Odd beetle,** *Thylodrias contractus* (Dermestidae): A, larva (4-4.8) (drawing by C. Feller); B, male (2.3-3); C, female (3.7-4.4).

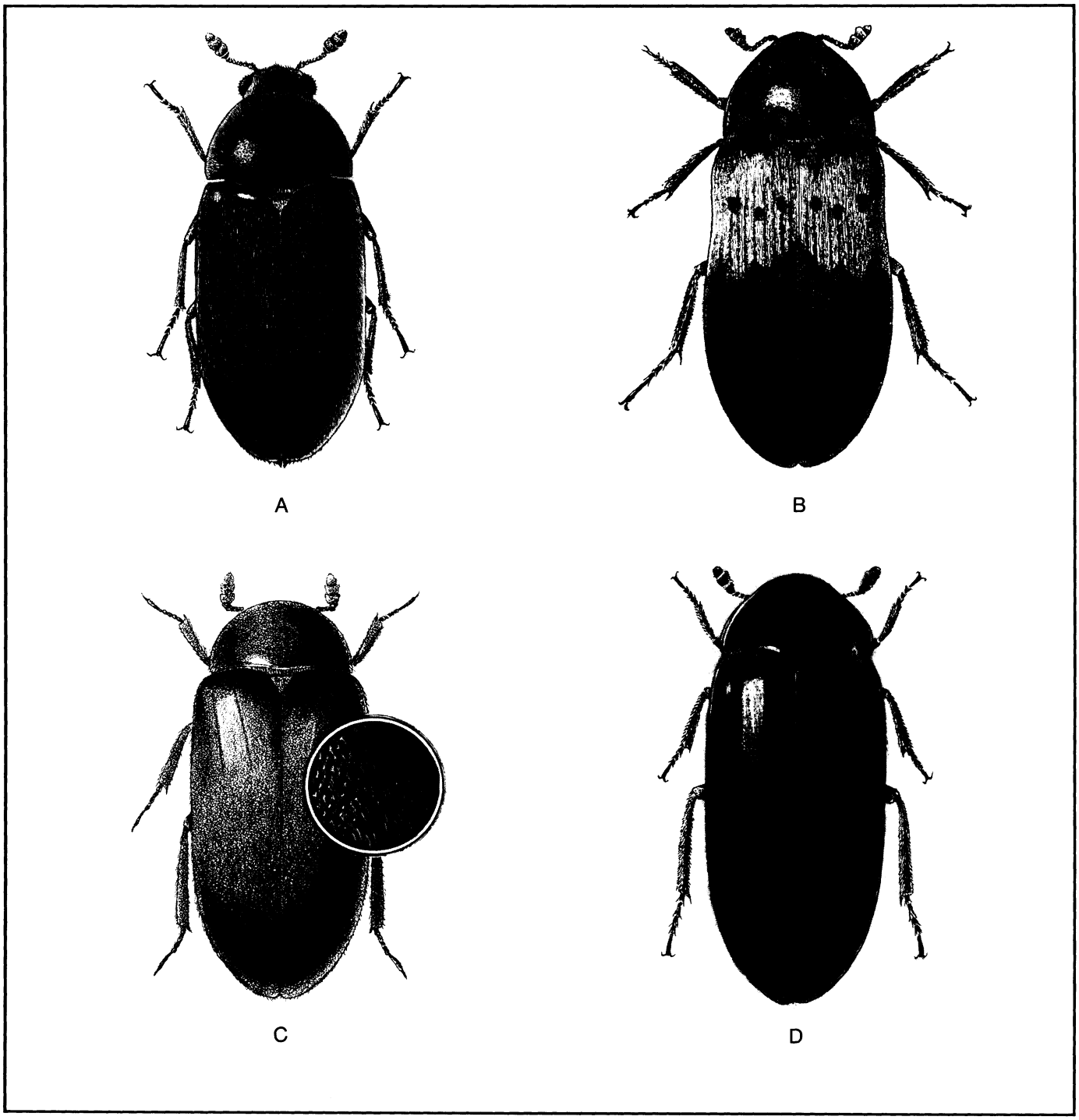


Plate 76. **Dermestid beetles** (Dermestidae): A, **hide beetle,** *Dermestes maculatus* (5.5-10); B, **larder beetle,** *Dermestes lardarius* (7-9); C, *Dermestes haemorrhoidalis* (male, 6.9; female, 7.7); D, Peruvian larder beetle, *Dermestes peruvianus* (male, 8.5; female, 9.6).

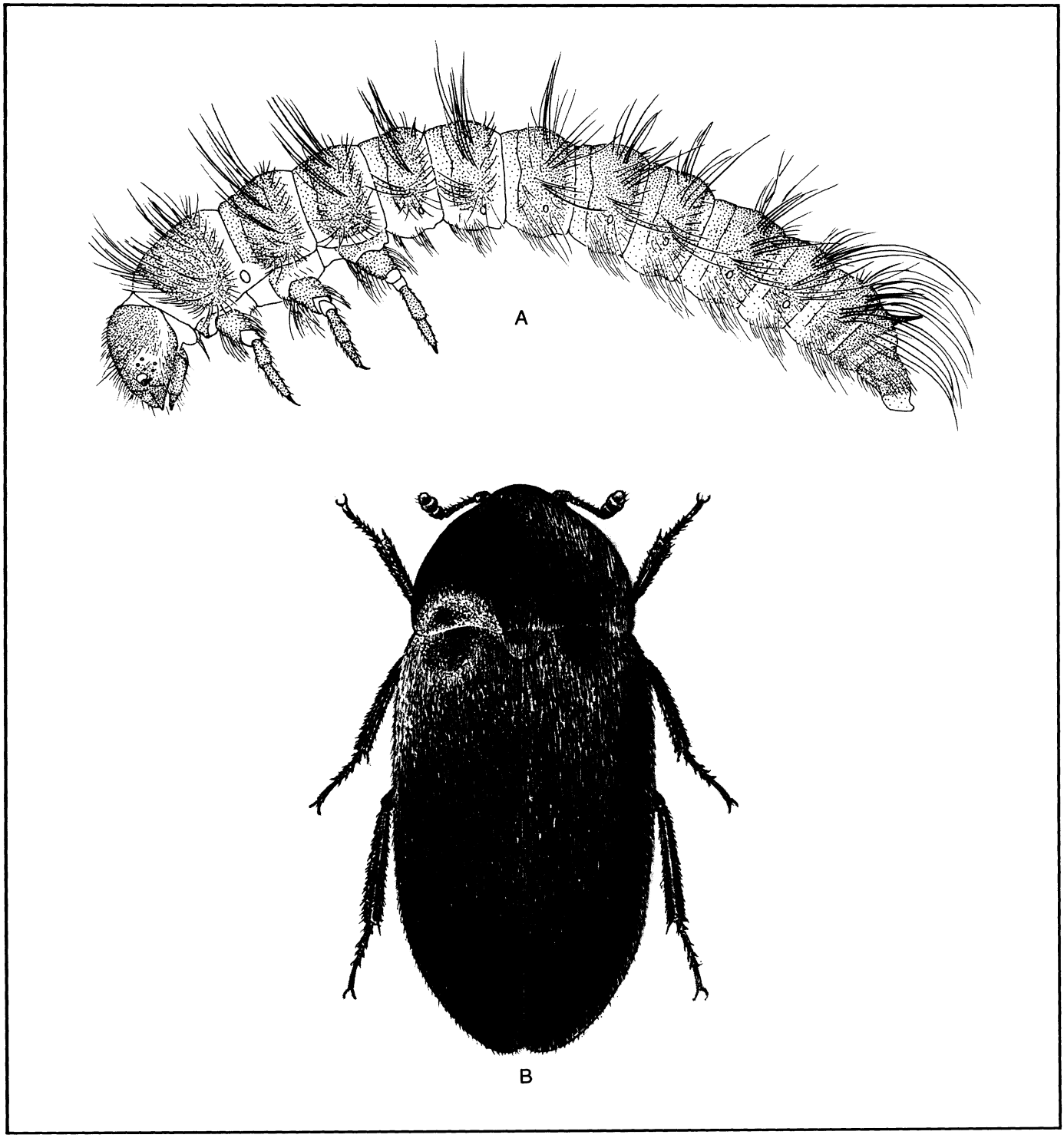


Plate 77. **Black larder beetle,** *Dermestes ater* (Dermestidae): A, larva (15-17) (drawing by C. Feller); B, adult (7-9.5).

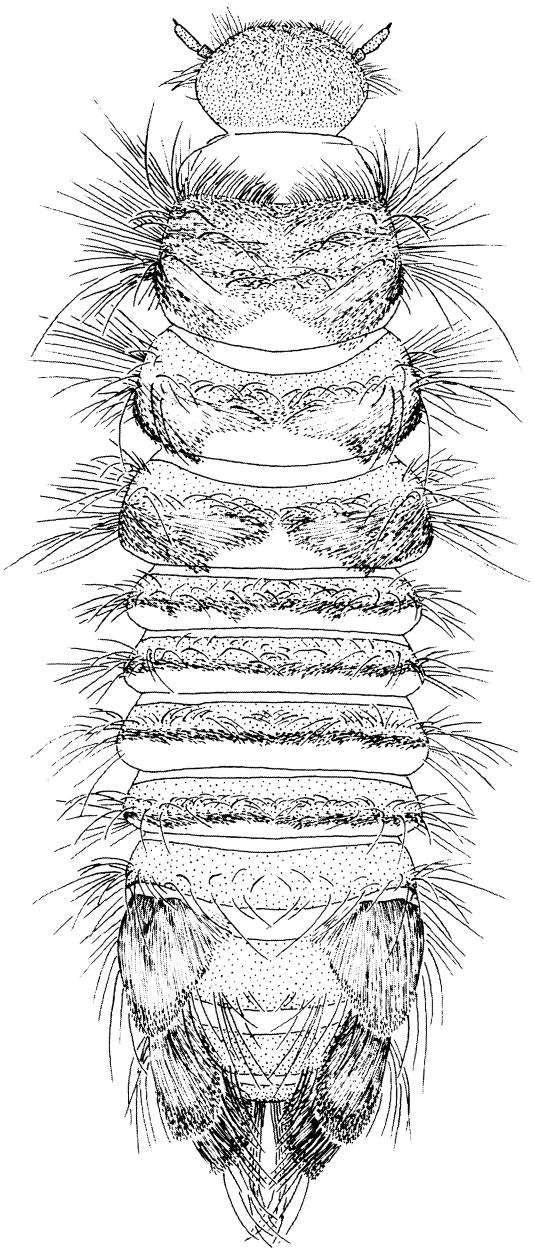


Plate 78. **Varied carpet beetle,** *Anthrenus verbasci* (Dermestidae), larva (4-4.5) (drawing by C. Feller); adult (1.7-3.2) is figured in plate 1A.

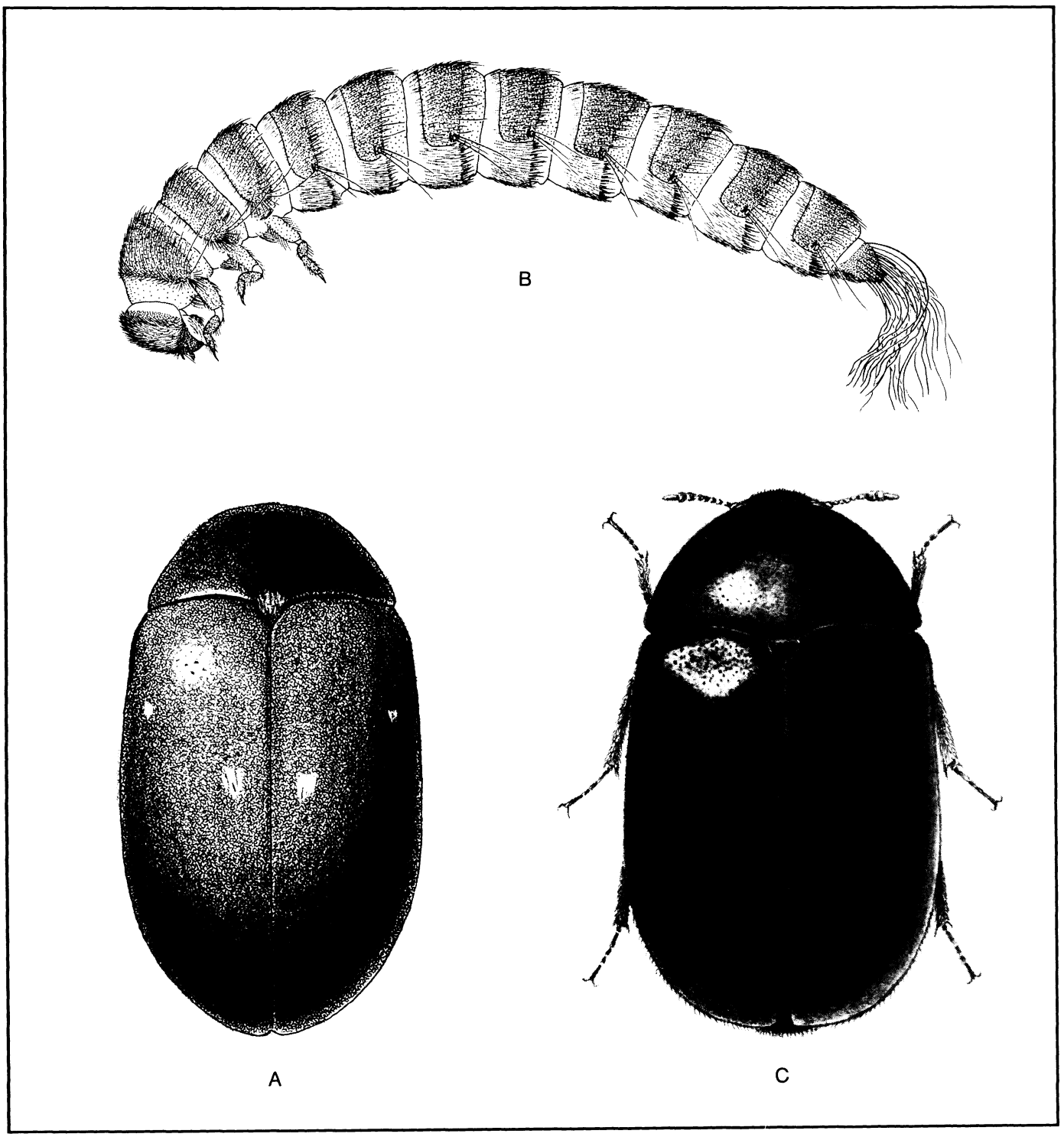


Plate 79. **Dermestid beetles** (Dermestidae): A, *Attagenus pellio* (3.6-5.7); B, **black carpet beetle,** *Attagenus unicolor,* larva (6-8.2) (drawing by C. Feller); C, same, adult (2.8-5).

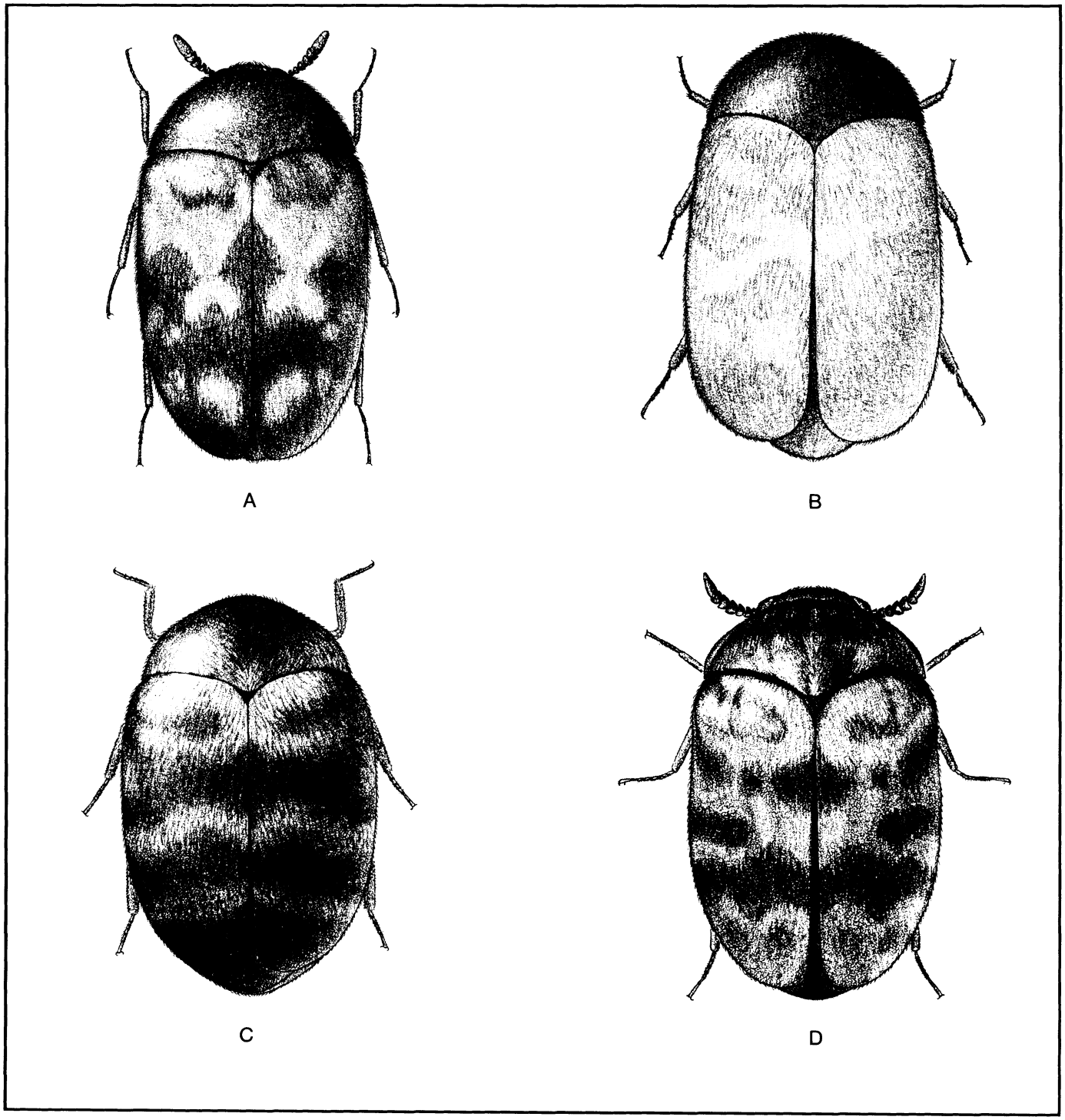


Plate 80. **Dermestid beetles** (Dermestidae) (drawings by C. Feller): A, *Trogoderma simplex* (2.2-4.4); B, **khapra beetle,** *Trogoderma granarium* (1.5-3); C, glabrous cabinet beetle, *Trogoderma glabrum* (2-3.9); D, European larger cabinet beetle, *Trogoderma versicolor* (1.8-4.2).

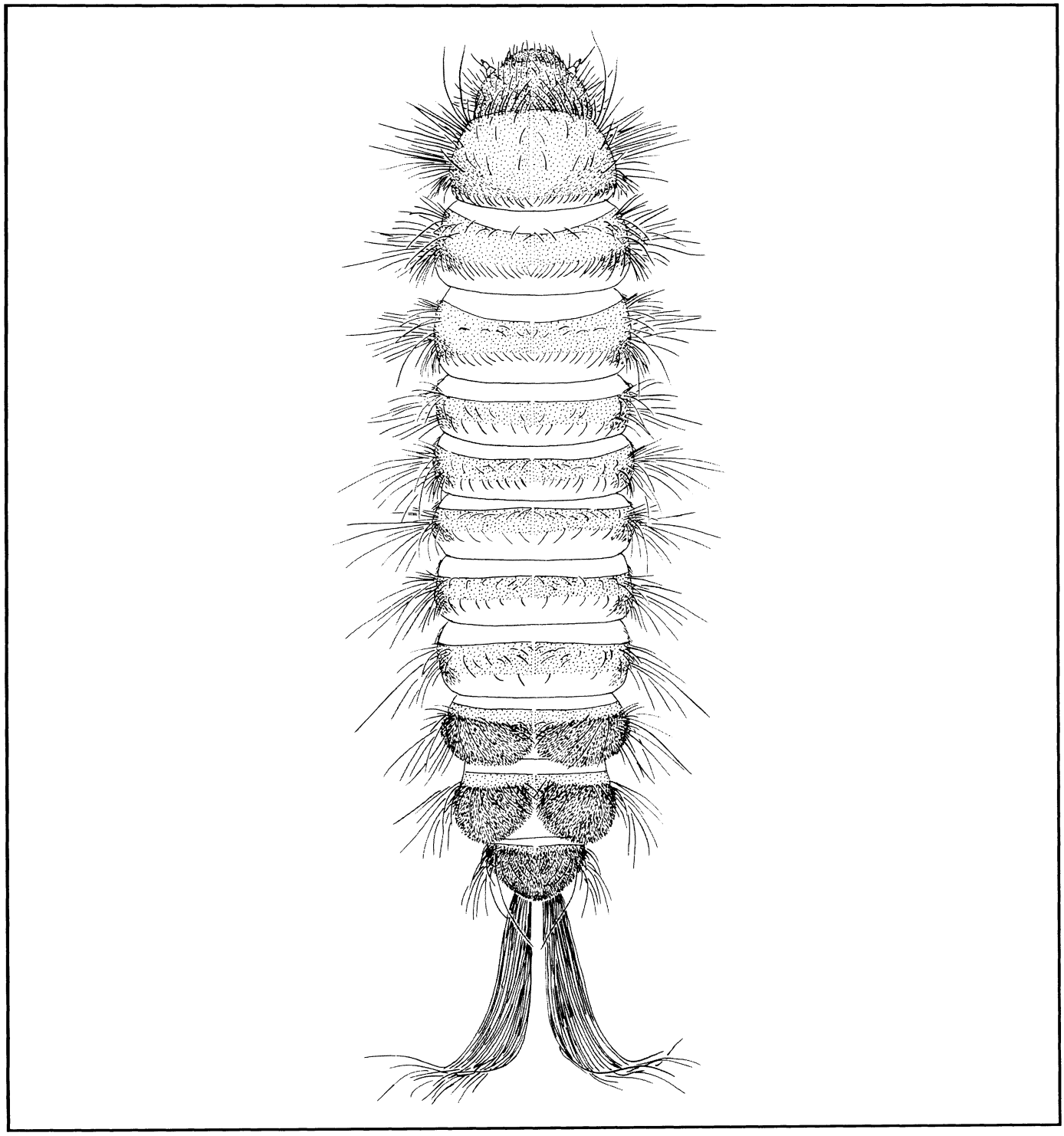


Plate 81. **Warehouse beetle,** *Trogoderma variabile* (Dermestidae), larva (5-6.5) (drawing by C. Feller); adult (2.7-3.5) is figured in plate 1C.

SPIDER BEETLES (PTINIDAE)

This series of illustrations, drawn by A.D. Cushman unless otherwise indicated, is a continuation from part I, chapter 6, by T.J. Spilman.

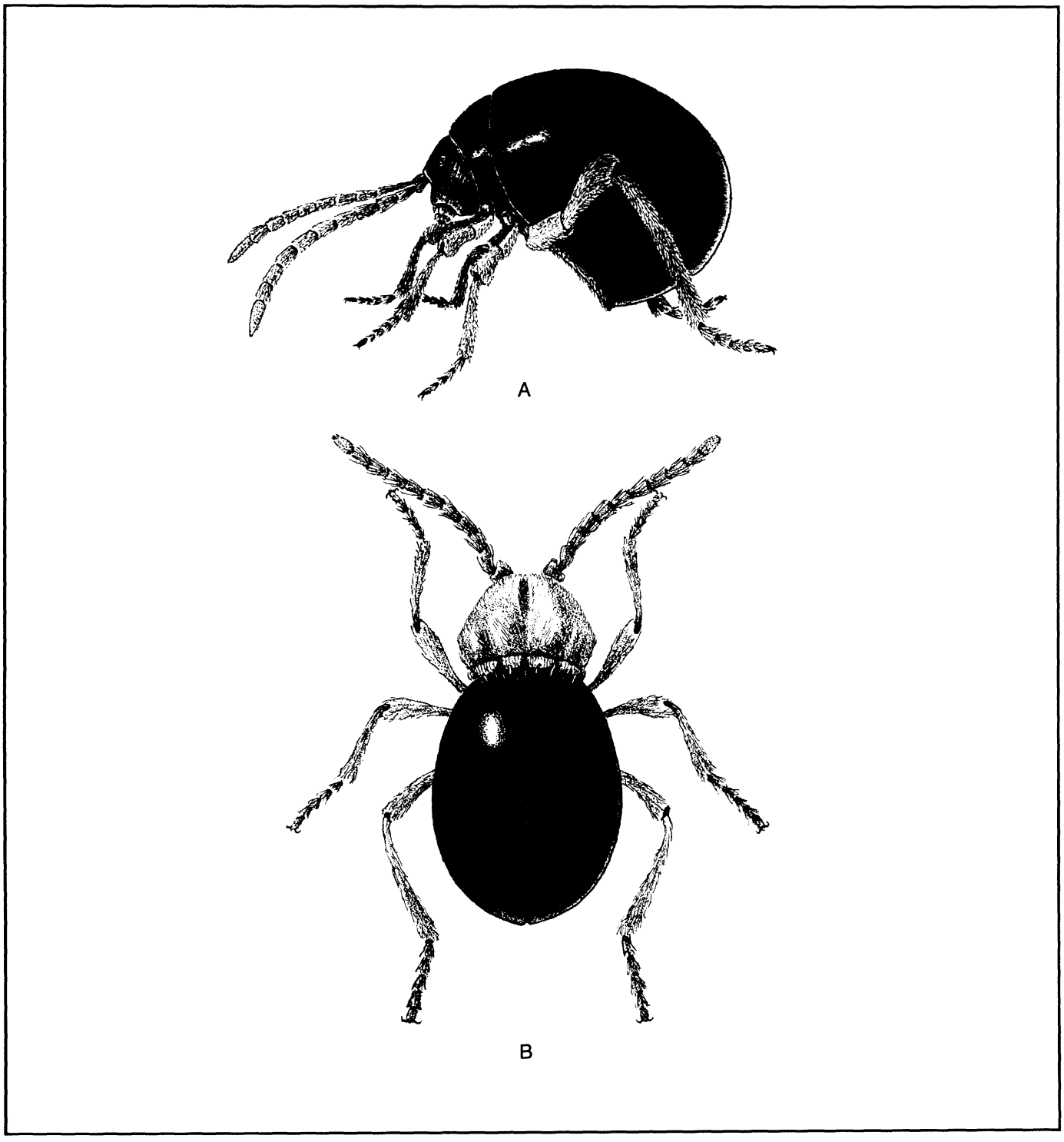


Plate 82. **Spider beetles** (Ptinidae): A, hump beetle, *Gibbium psylloides* (1.7-3.2); B, **American spider beetle,** *Mezium americanum* (1.5-3.5).

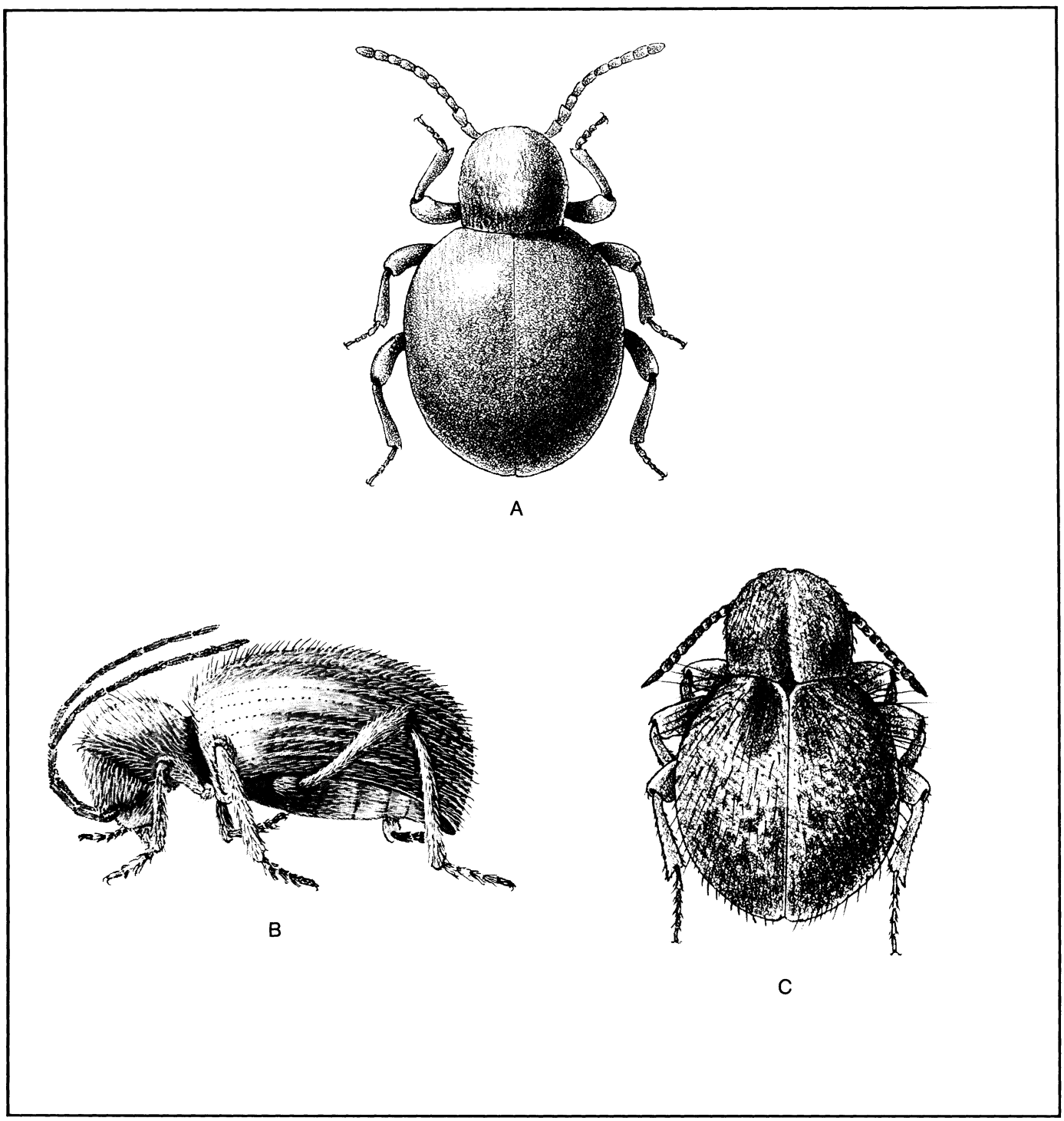


Plate 83. **Spider beetles** (Ptinidae): A, humpbacked spider beetle, *Sphaericus gibboides* (1.6-2.8); B, **golden spider beetle**, *Niptus holoeucus* (3-4.5); C, **globular spider beetle**, *Trigonogenius globulum* (2-4).

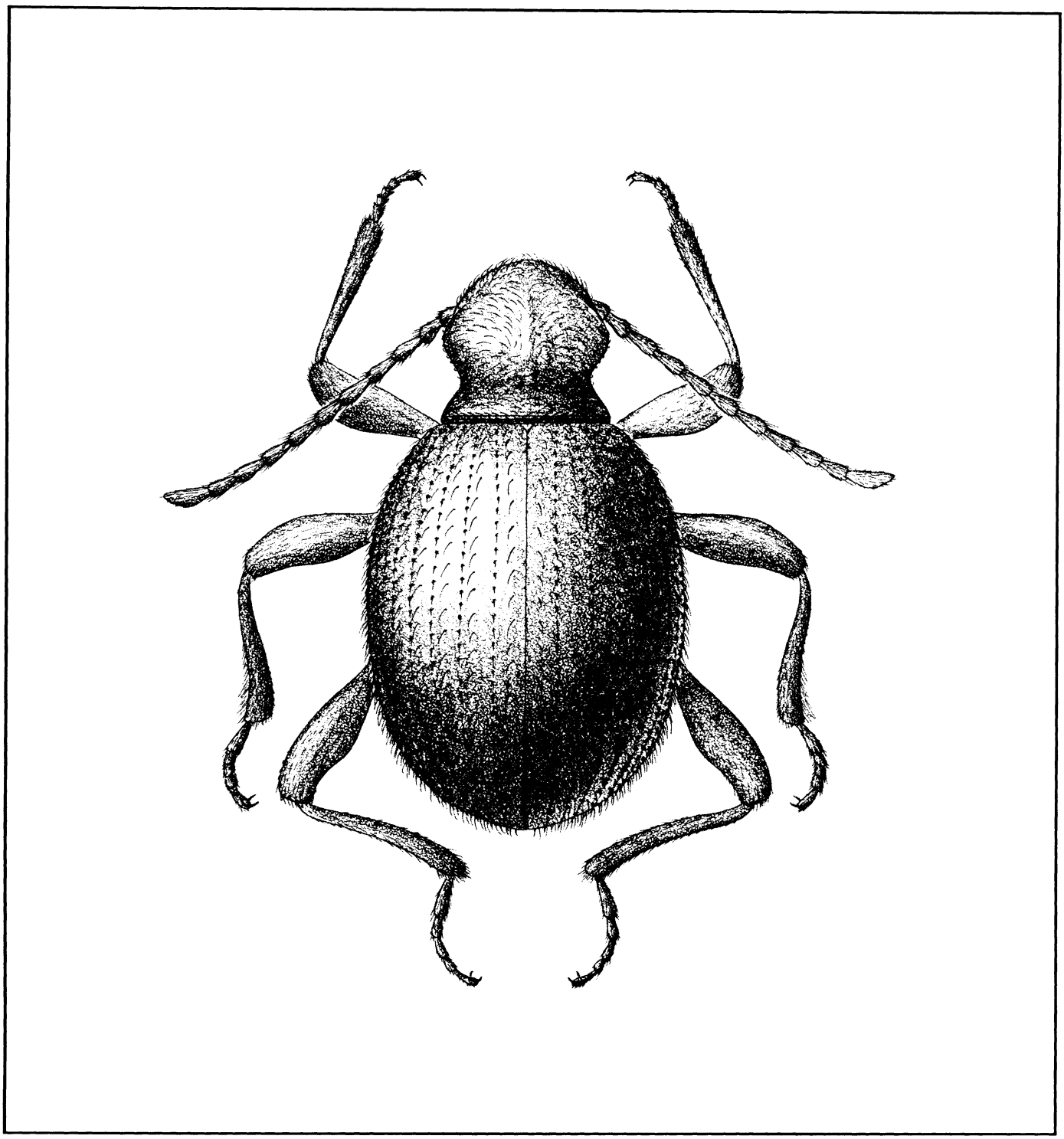


Plate 84. A spider beetle, *Pseudeurostus hilleri* (Ptinidae) (1.9-2.8). (Drawing by C. Feller.)

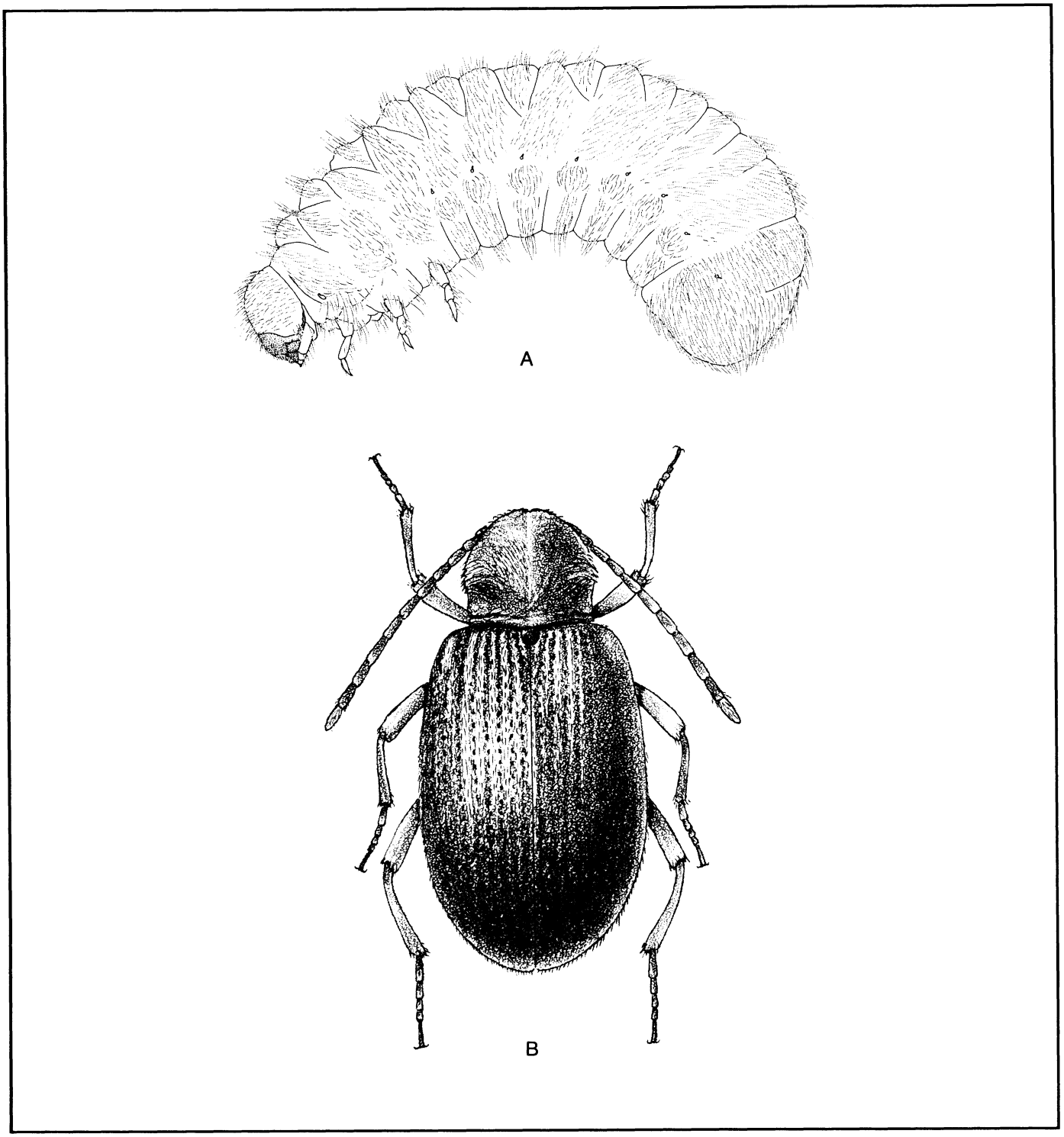


Plate 85. **Spider beetles** (Ptinidae): A, *Ptinus* sp., larva (3-5) (drawing by C. Feller); B, **Australian spider beetle,** *Ptinus ocellus,* adult (2.5-4.5).

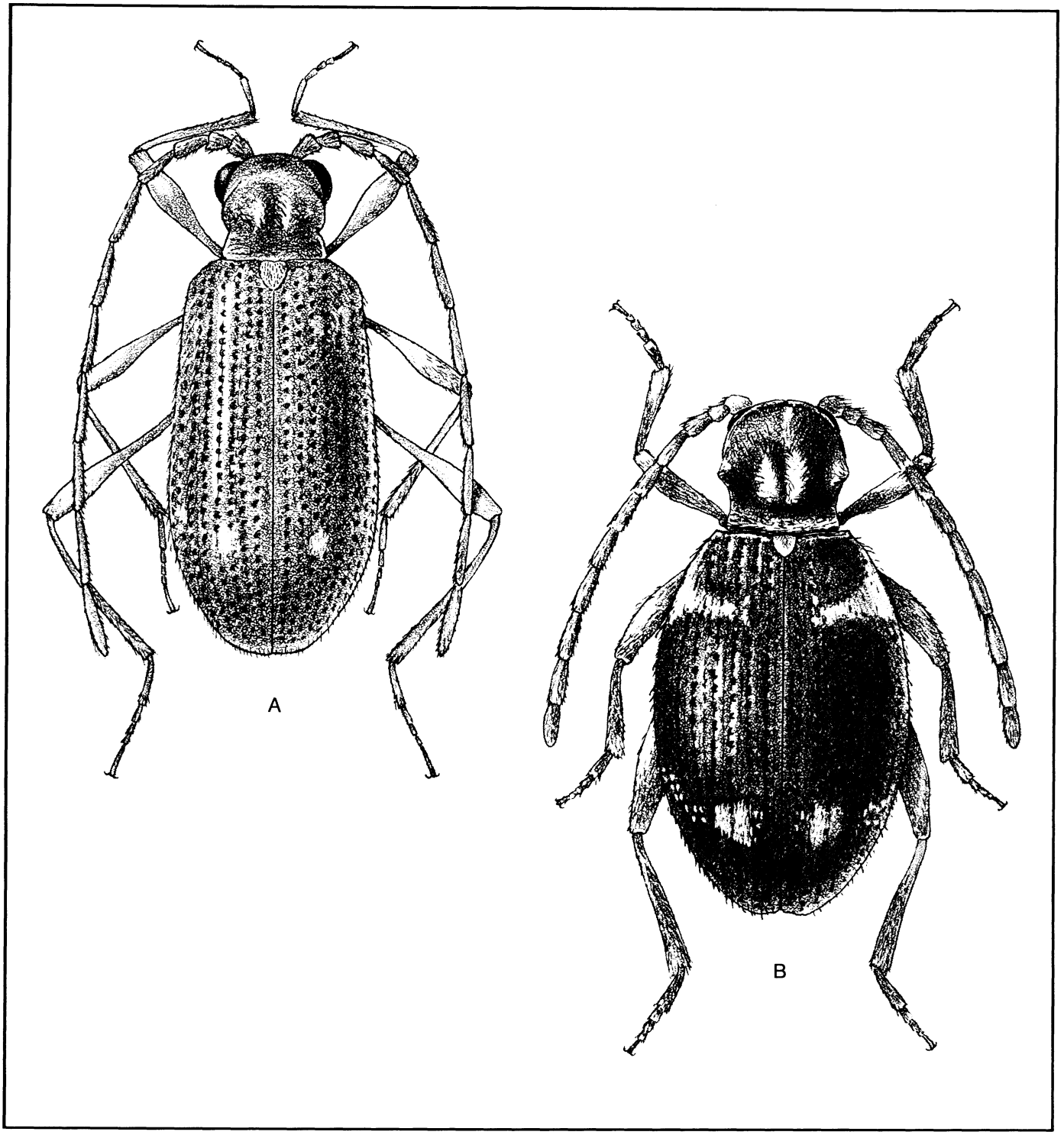
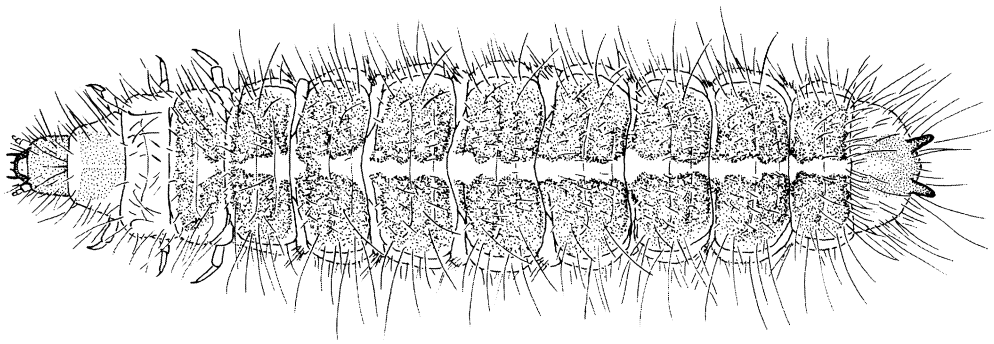


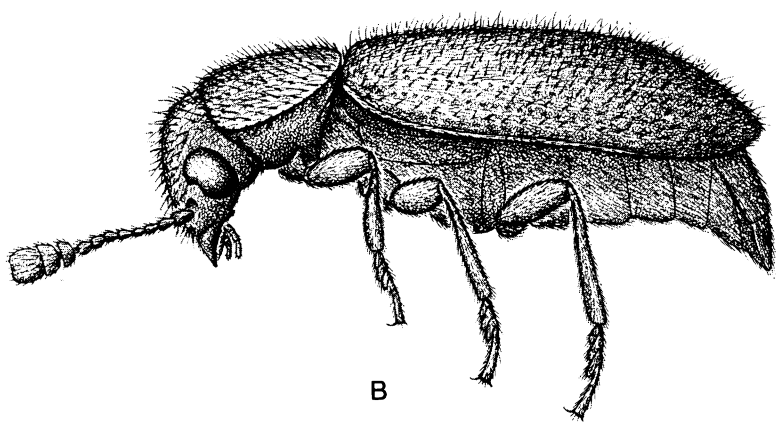
Plate 86. **Whitemarked spider beetle,** *Ptinus fur* (Ptinidae) (2-4.3): A, male; B, female.

CHECKERED BEETLES (CLERIDAE)

This plate, drawn by C. Feller, is a continuation from part 1, chapter 4, by D.M. Anderson and chapter 7, by J.M. Kingsolver.



A



B

Plate 87. **Redlegged ham beetle,** *Necrobia rufipes* (Cleridae): A, larva (9-10); B, adult (4-5).

SAP BEETLES (NITIDULIDAE)

This series of illustrations, drawn by C. Feller, is a continuation from part 1, chapter 4 (Larval Beetles), by D.M. Anderson and chapter 8 (Sap Beetles), by W.A. Connell.

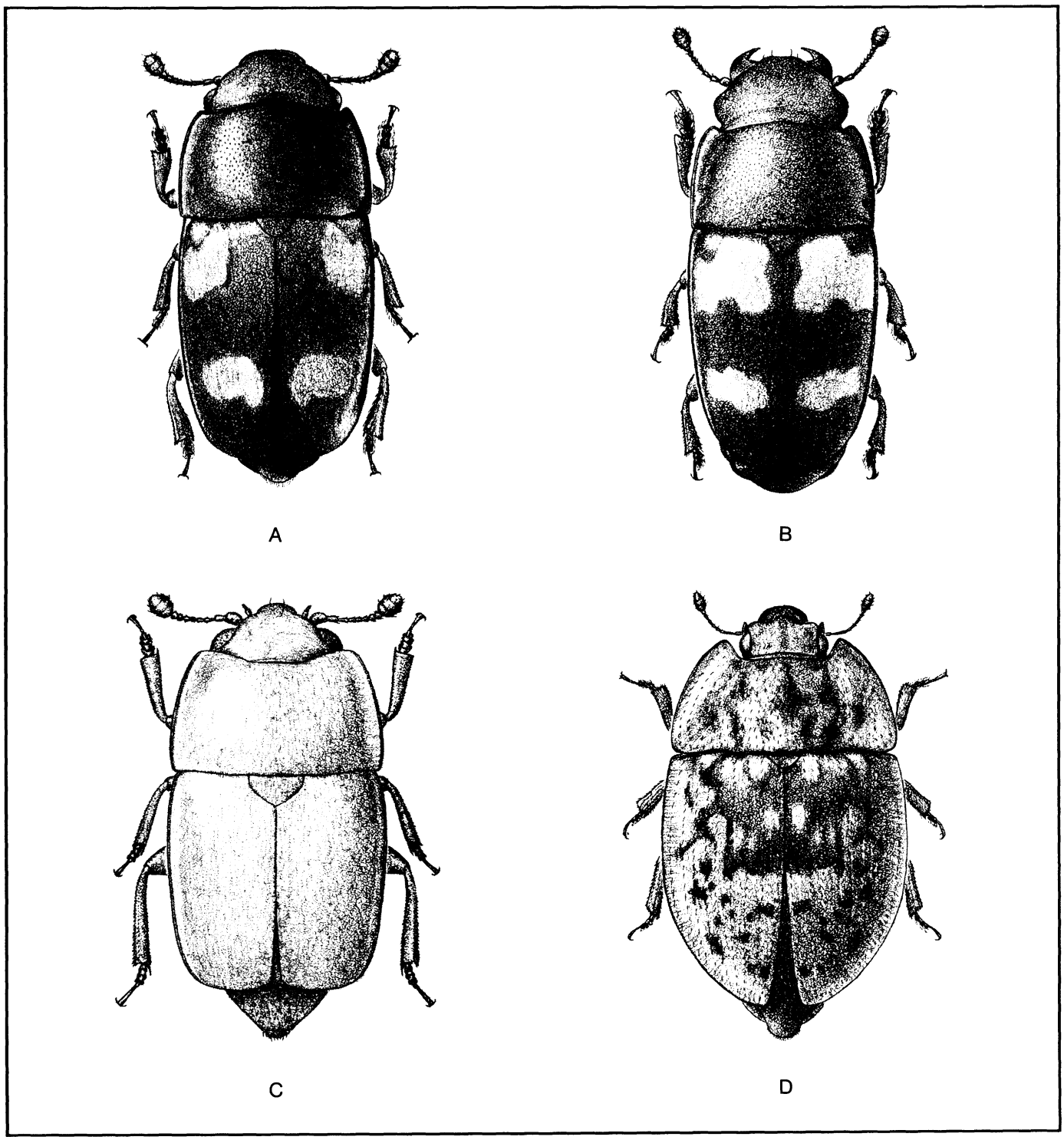


Plate 88. **Sap beetles** (Nitidulidae): A, *Glischrochilus quadrisignatus* (4-7); B, *Glischrochilus fasciatus* (4-7); C, yellowbrown sap beetle, *Haptoncus luteolus* (1.7-2.8); D, *Lobiopa insularis* (4.5-8).

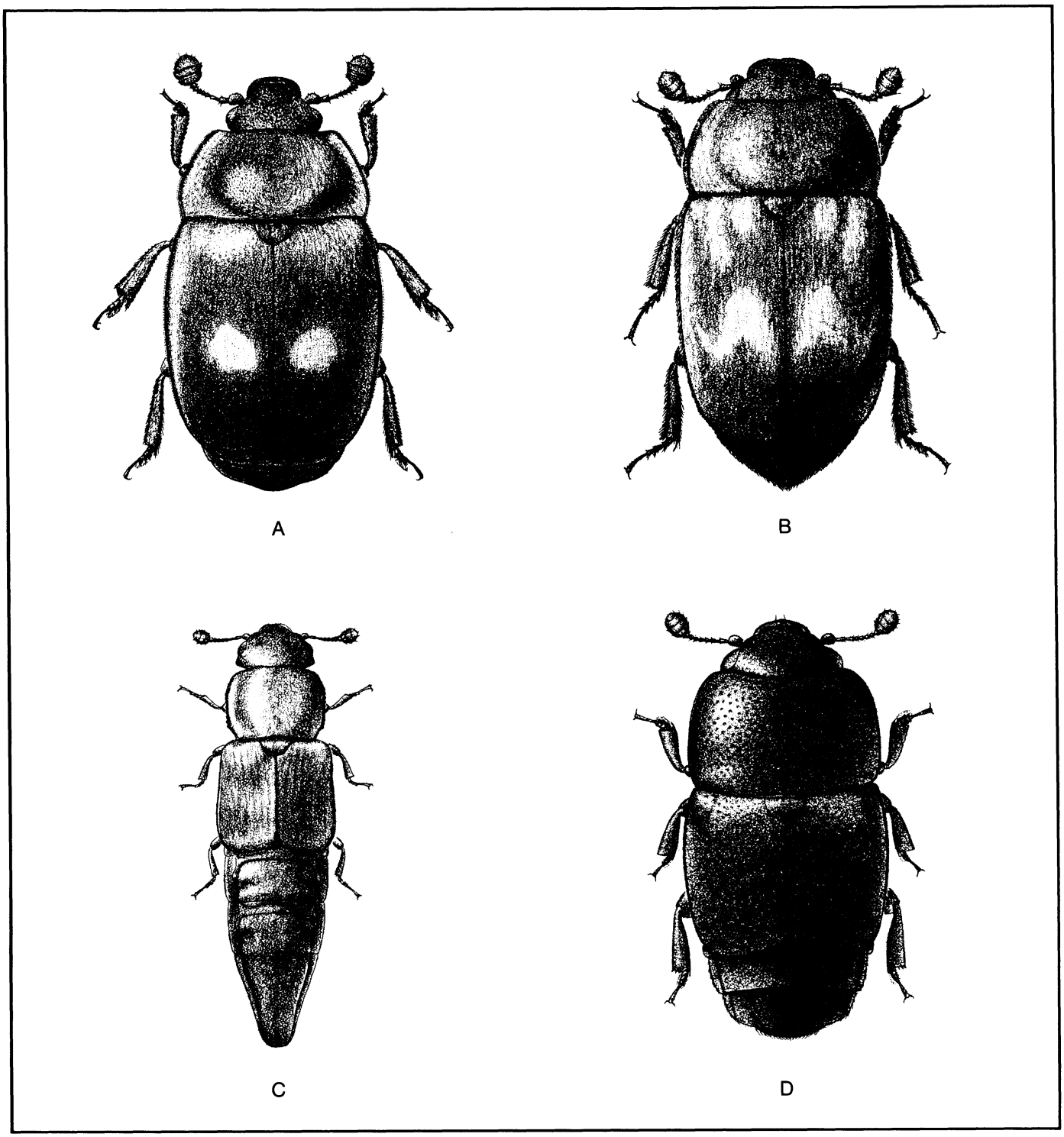


Plate 89. **Sap beetles** (Nitidulidae): A, *Nitidula bipunctata* (3-5); B, *Nitidula ziczac* (3-5); C, *Conotelus stenoides* (3.5-4); D, pineapple sap beetle, *Carpophilus humeralis* (3-4.2).

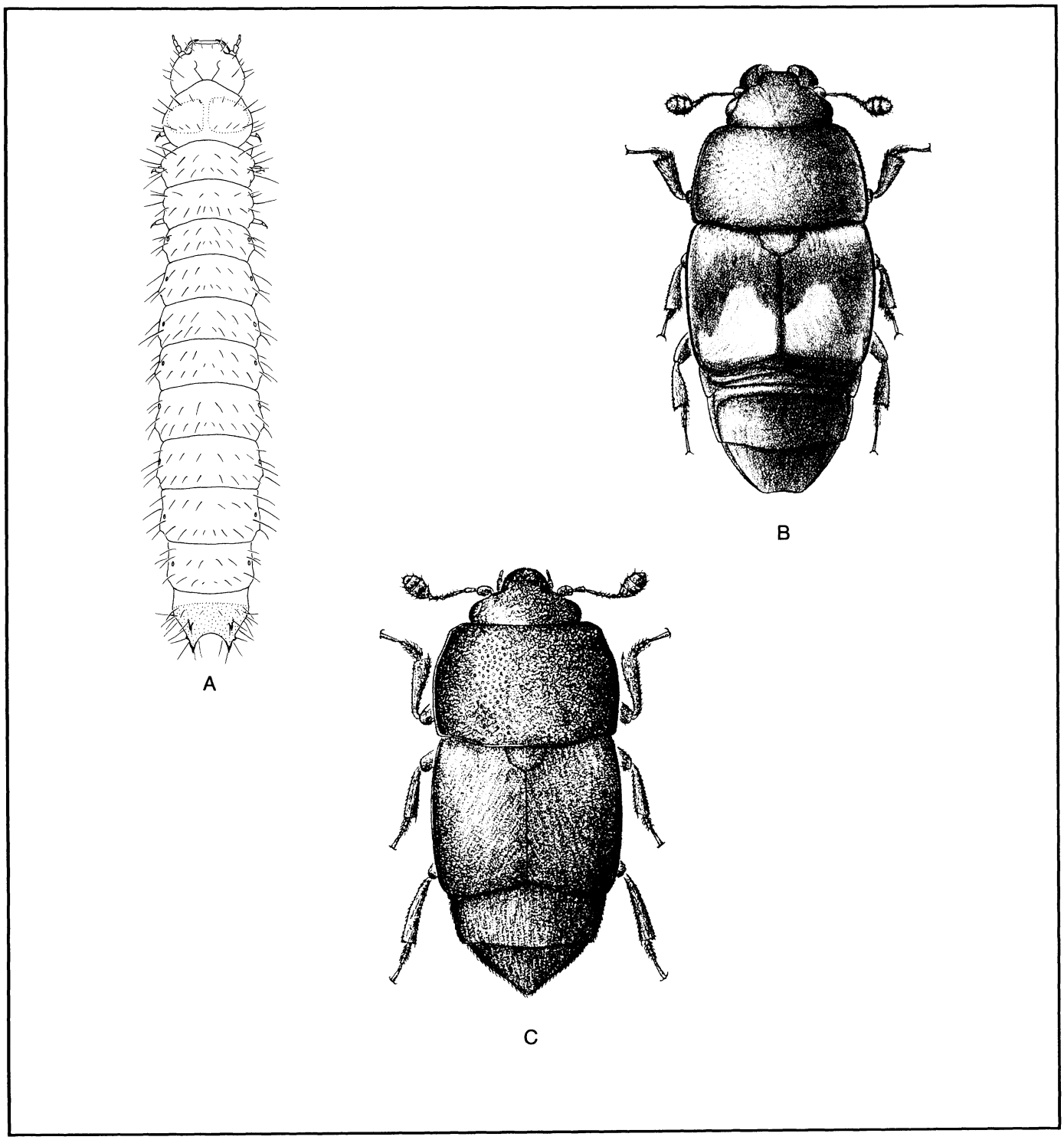


Plate 90. **Sap beetles** (Nitidulidae): A, **driedfruit beetle,** *Carpophilus hemipterus,* larva (6-9); B, same, adult (2-4); C, *Carpophilus obsoletus* (2.5-4).

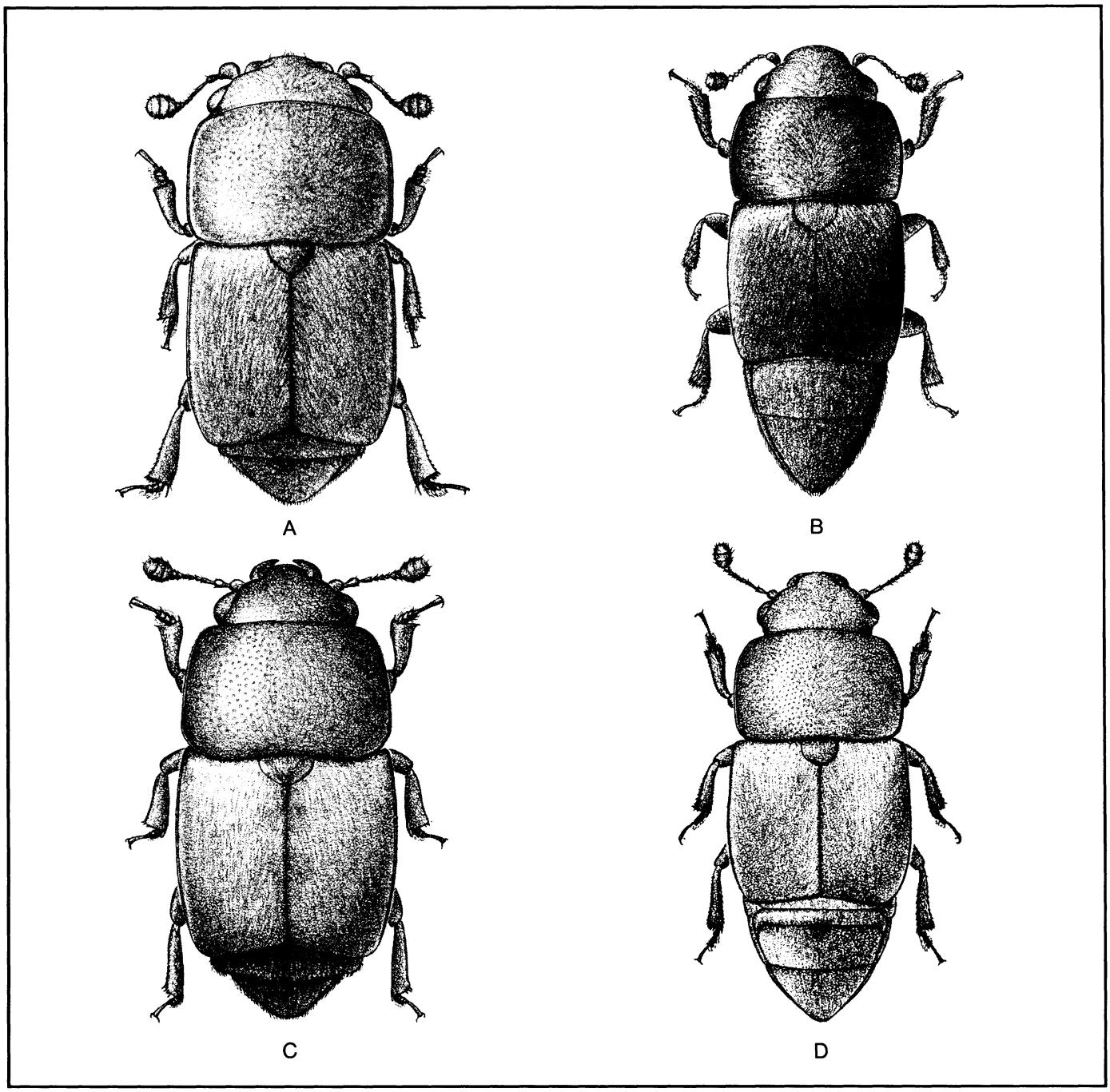
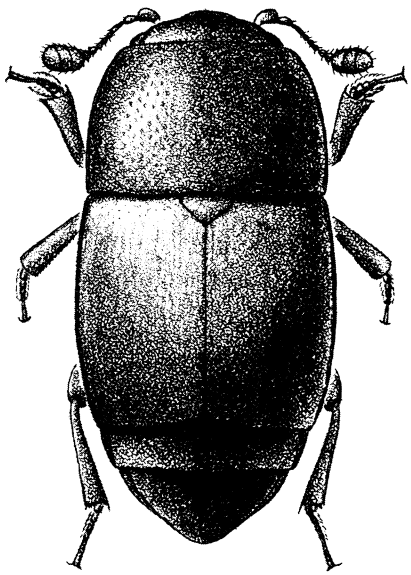
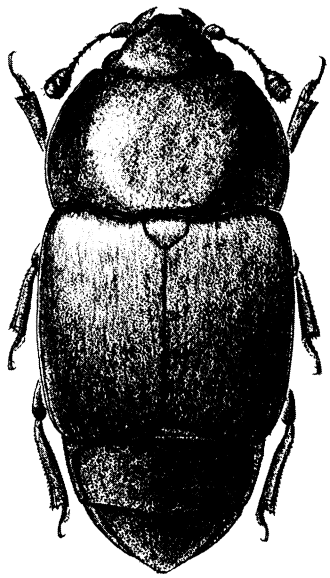


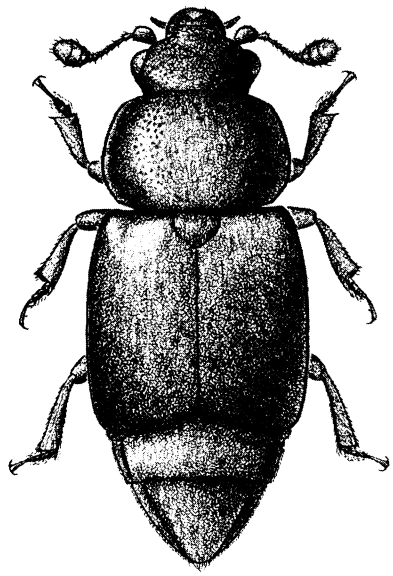
Plate 91. Habitus types (A-D) in the *Carpophilus dimidiatus* group (**sap beetles,** Nitidulidae). All the types and intermediates occur in each species. B and D are illustrated with distended abdomens. The complex consists of *Carpophilus dimidiatus* (2.2-3.2), *Carpophilus freemani* (1.9-2.9), *Carpophilus fumatus* (2.3-3.6), *Carpophilus maculatus* (2.5-3.4), *Carpophilus mutilatus* (2-3.4), and *Carpophilus pilosellus* (1.5-2.5).



A



B

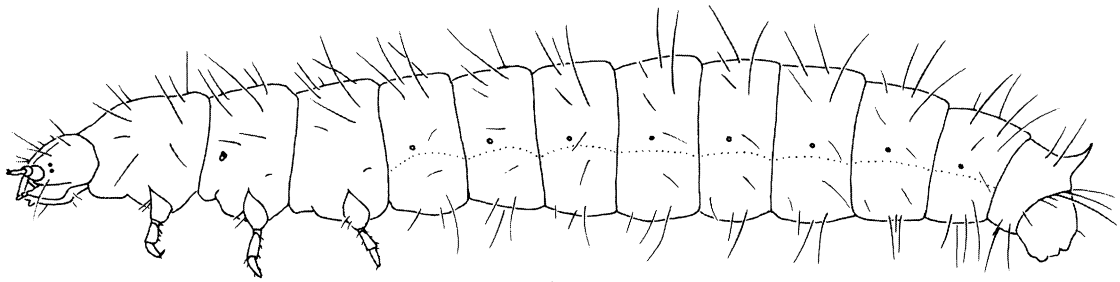


C

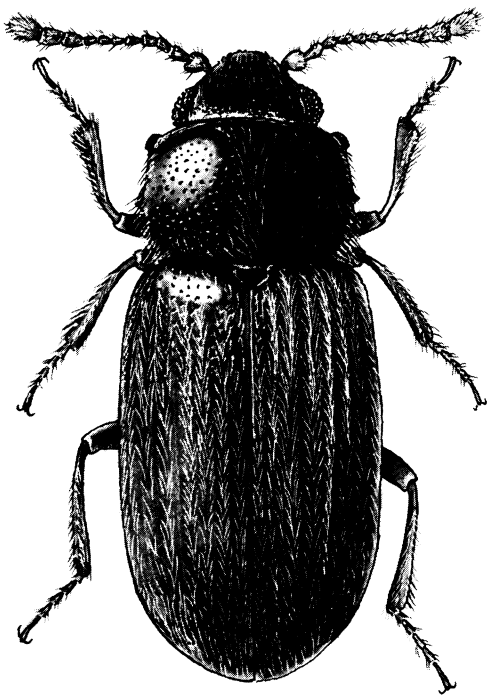
Plate 92. **Sap beetles** (Nitidulidae): A, *Carpophilus marginellus* (2.7-3.5); B, **dusky sap beetle,** *Carpophilus lugubris* (3-4.5); C, *Carpophilus ligneus* (2.5-3.2).

CRYPTOPHAGID BEETLES (CRYPTOPHAGIDAE)

These illustrations are a continuation from Part 1, chapter 4 (Larval Beetles), by D.M. Anderson and chapter 9 (Cryptophagid Beetles), by J.M. Kingsolver.



A



B

Plate 93. **Silken fungus beetles** (Cryptophagidae): A, *Cryptophagus laticollis,* larva (2.5-3.3) (drawing by C. Feller); B, cellar beetle, *Cryptophagus cellaris,* adult (2.2-2.7) (drawing by A.D. Cushman).

MINUTE BROWN SCAVENGER BEETLES (LATHRIDIIDAE)

These illustrations, drawn by C. Feller, are a continuation from part 1, chapter 3 (Larval Beetles), by D.M. Anderson and chapter 10 (Lathridiid Beetles), by J.M. Kingsolver and F.G. Andrews.

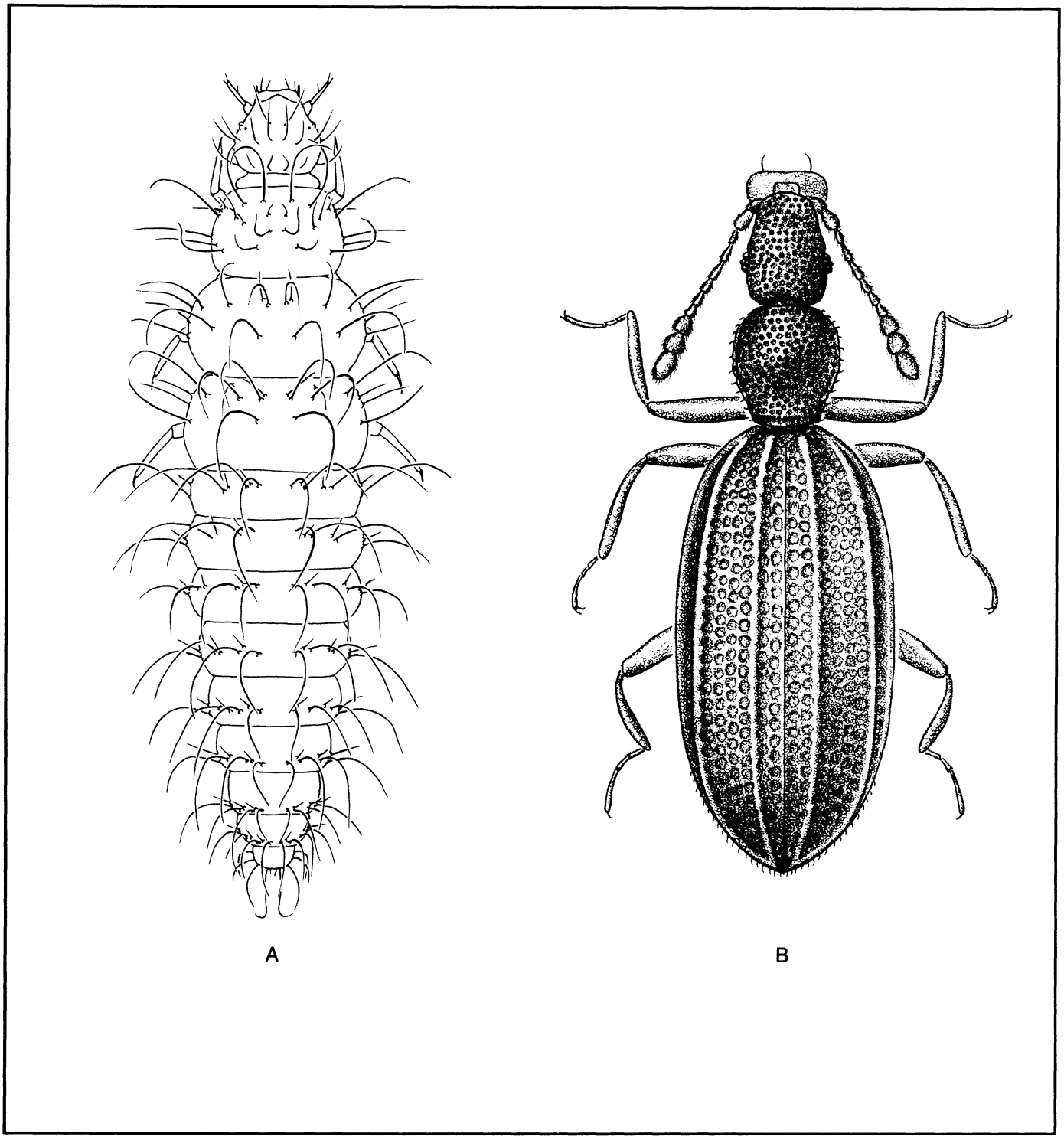


Plate 94. **Minute brown scavenger beetles** (Lathridiidae): A, *Aridius nodifer,* larva (2.4); B, *Adistemia watsoni,* adult (1.2-1.7).

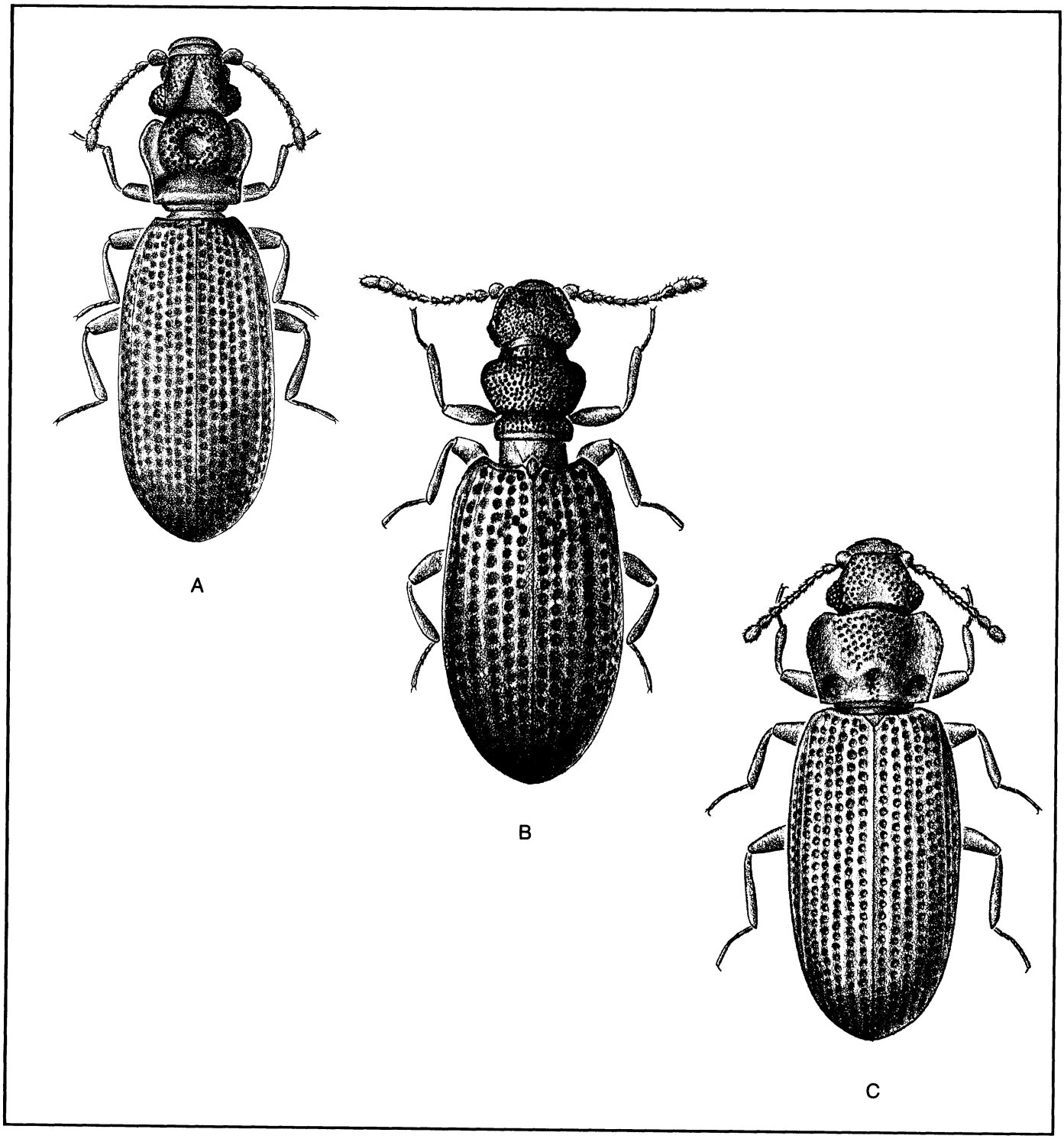


Plate 95. **Minute brown scavenger beetles** (Lathridiidae): A, *Dienerella filum* (1.2-1.6); B, *Dienerella ruficollis* (1-1.2); C, *Dienerella arga* (1.3-1.4).

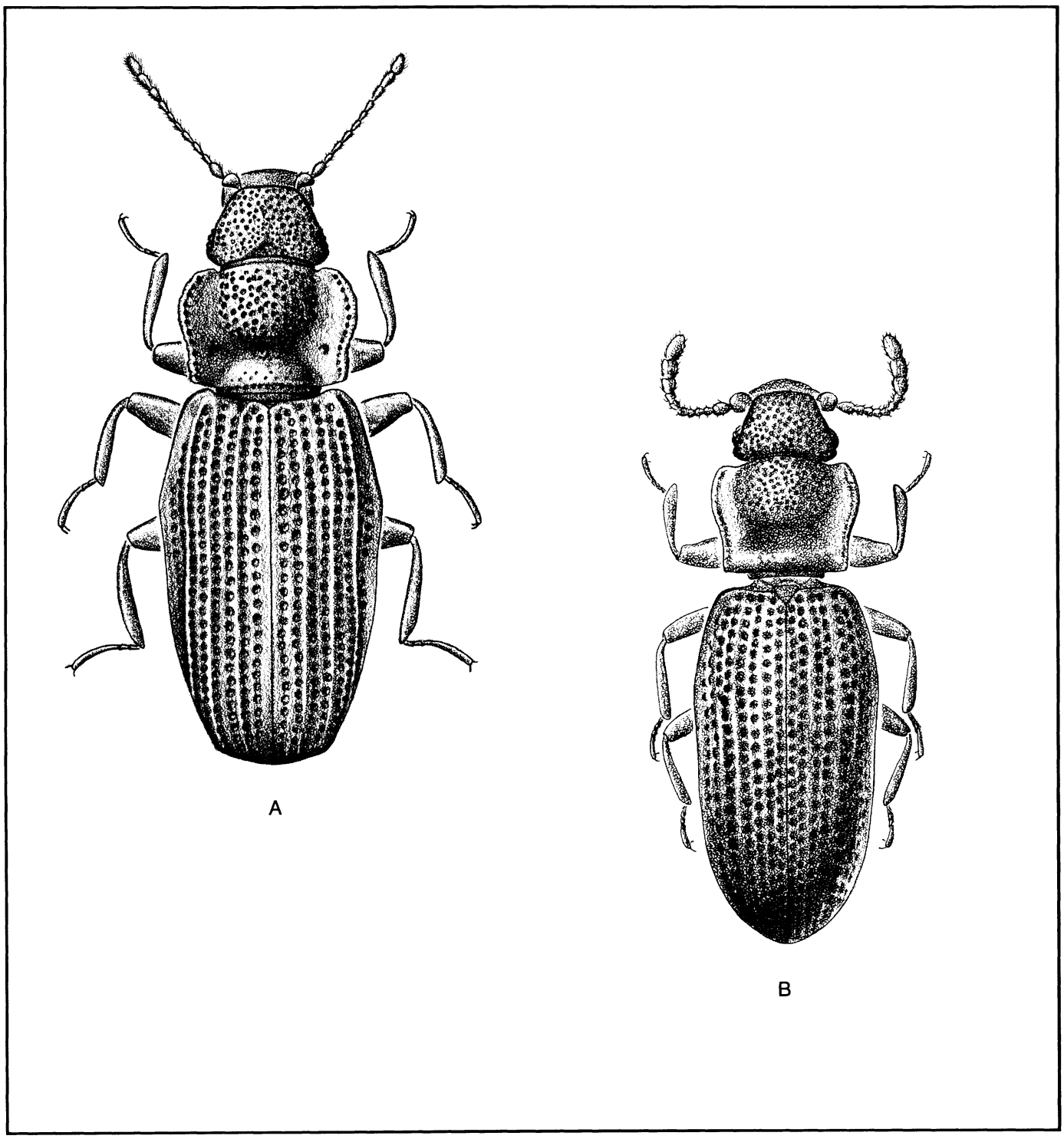


Plate 96. **Minute brown scavenger beetles** (Lathridiidae): A, *Dienerella costulata* (1-1.5); B, *Dienerella filiformis* (1.2-1.4).

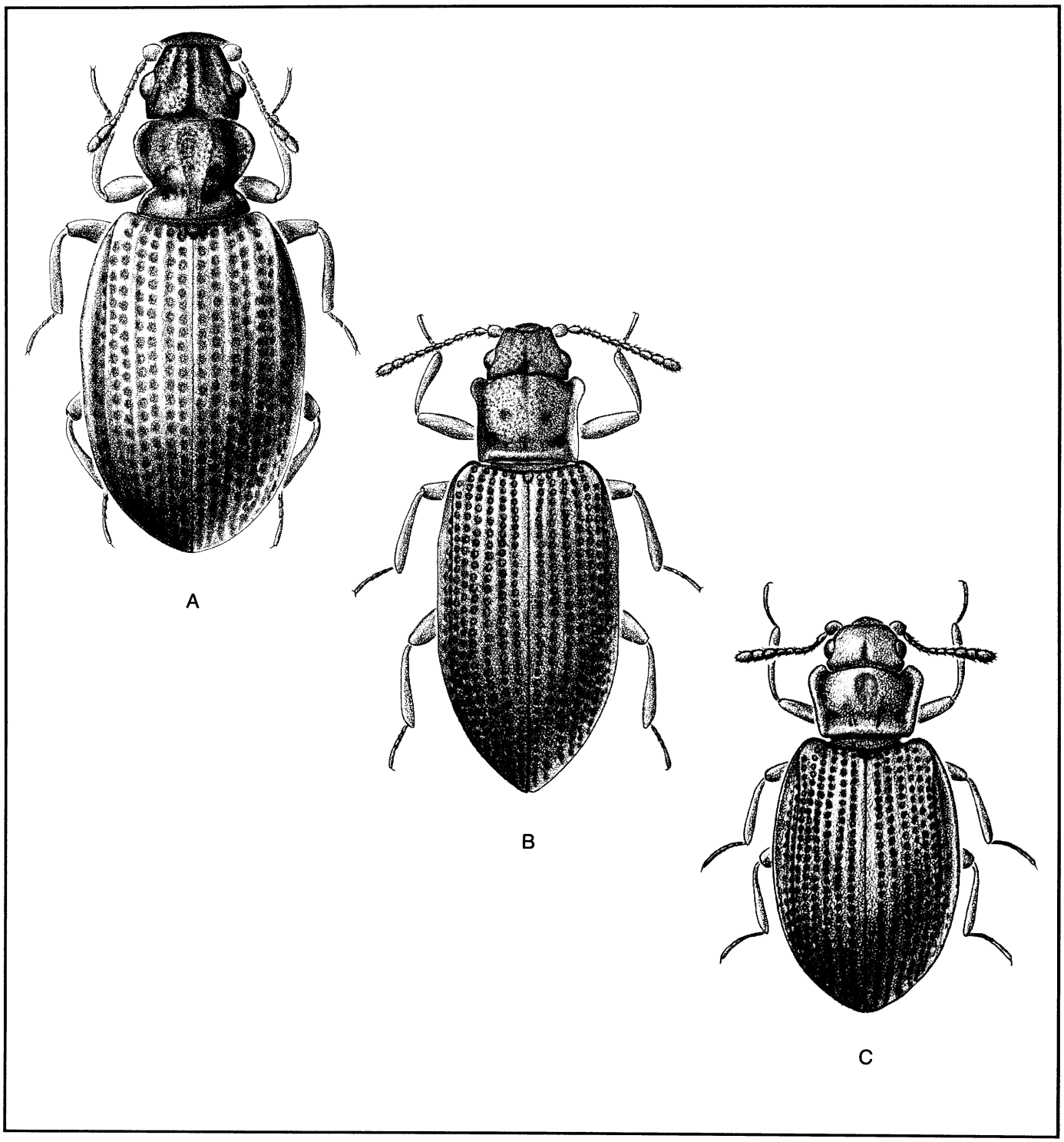


Plate 97. **Minute brown scavenger beetles** (Lathridiidae): A, **plaster beetle,** *Cartodere constricta* (1.2-1.7); B, *Lathridius protensicollis* (2.4-2.6); C, **squarenosed fungus beetle,** *Lathridius minutus* (1.2-2.4).

Notes and Sketches

DARKLING BEETLES (TENEBRIONIDAE)

These illustrations, drawn by A.D. Cushman unless otherwise noted, are a continuation from part 1, chapter 3 (Larval Beetles), by D.M. Anderson and chapter 11 (Darkling Beetles), by T.J. Spilman.

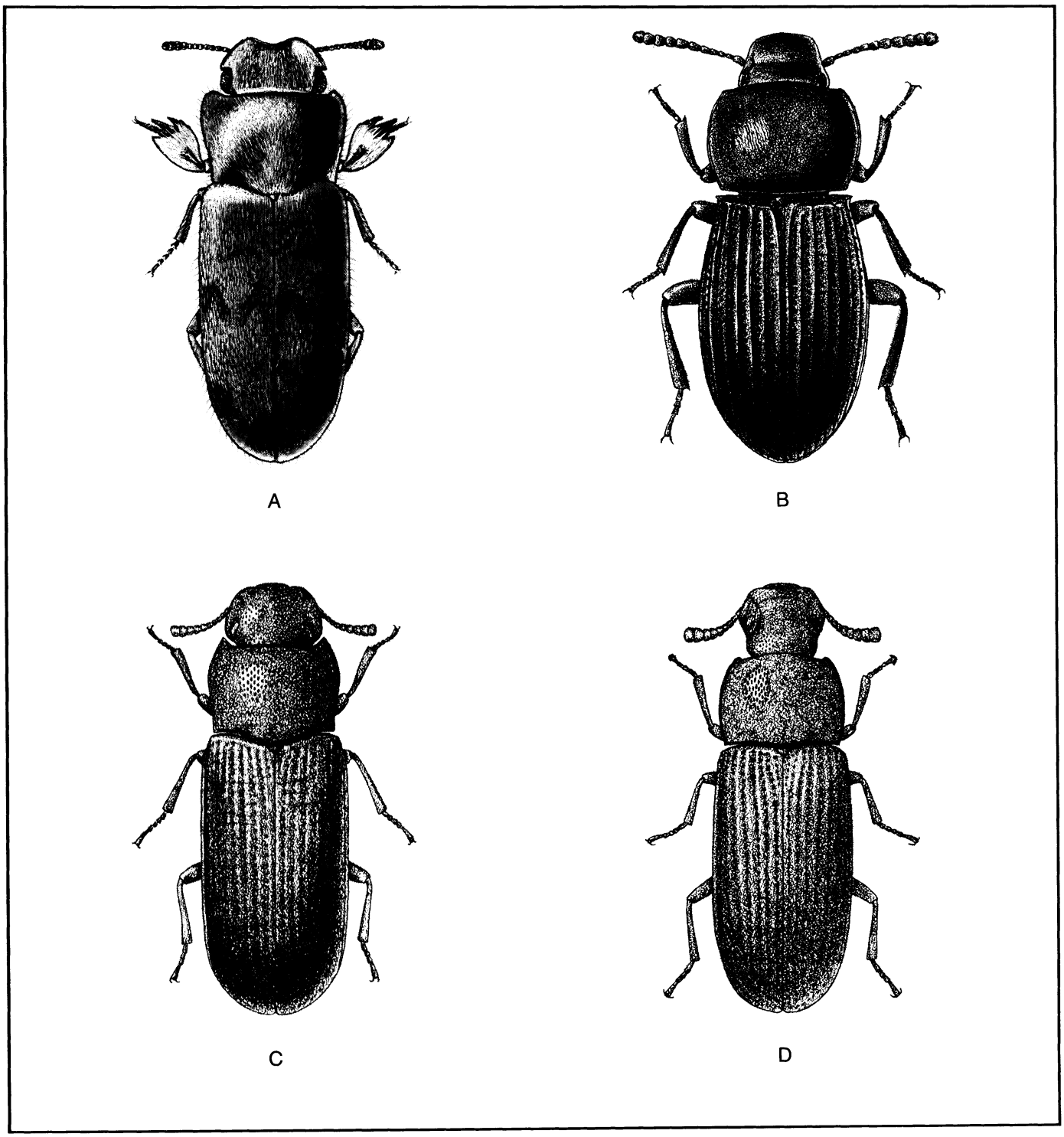
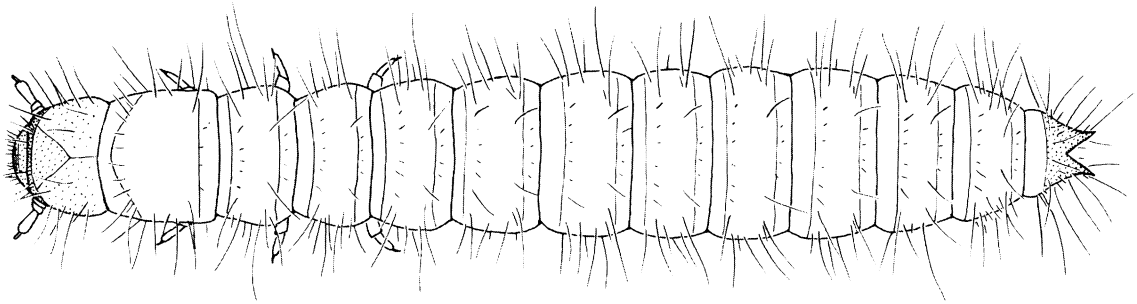
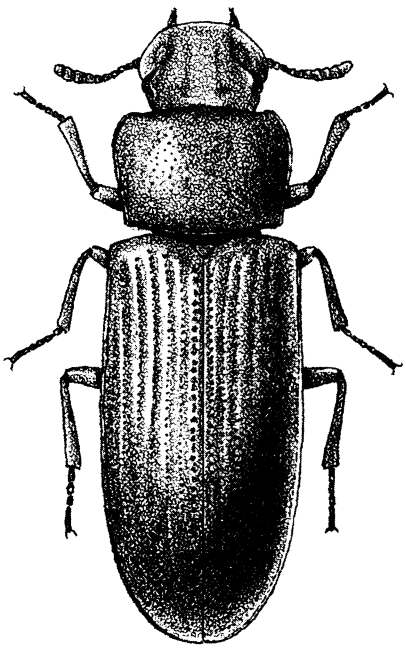


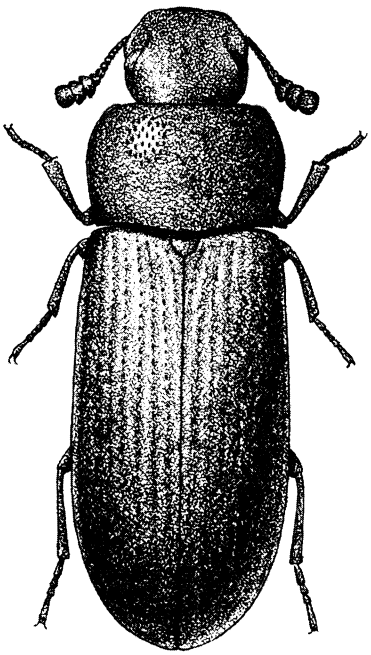
Plate 98. Tenebrionid beetles (Tenebrionidae): A, *Lepidocnemeplatia sericea* (2.6-4.4); B, fig engraver beetle, *Apsena rufipes* (4.2-7); C, giant flour beetle, *Tribolium brevicorne* (5-7); D, false black flour beetle, *Tribolium destructor* (4.5-5.7).



A



B



C

Plate 99. Flour beetles (Tenebrionidae): A, **confused flour beetle,** *Tribolium confusum,* larva (6-7) (drawing by C. Feller); B, same, adult (2.6-4.4); C, **red flour beetle,** *Tribolium castaneum* (2.3-4.4).

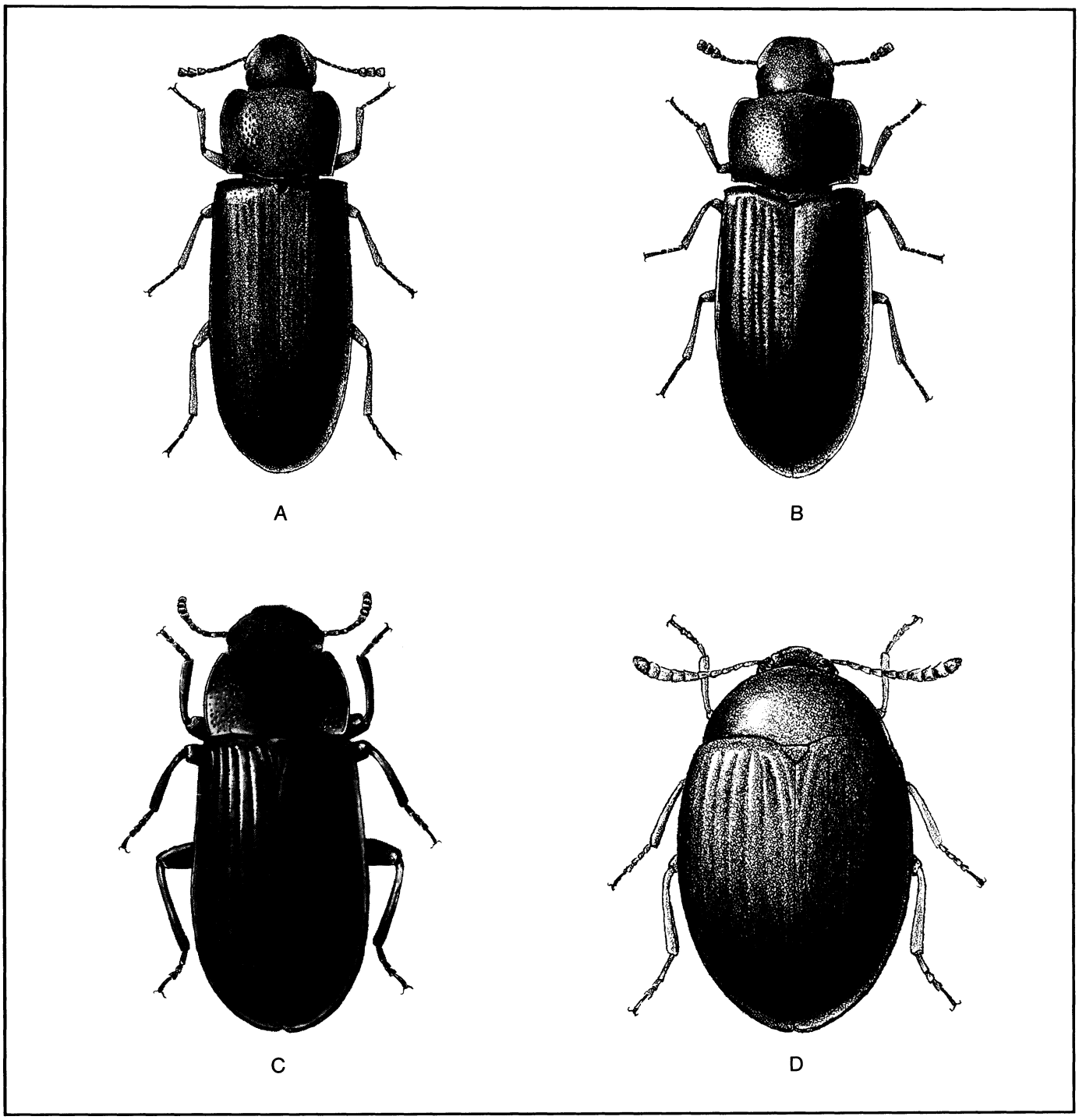


Plate 100. Tenebrionid beetles (Tenebrionidae): A, **American black flour beetle,** *Tribolium audax* (2.8-4.5); B, black flour beetle, *Tribolium madens* (3.9-5.1); C, *Neatus tenebrioides* (10.5-14.5); D, redhorned grain beetle, *Platydema ruficorne* (3.5-5.8).

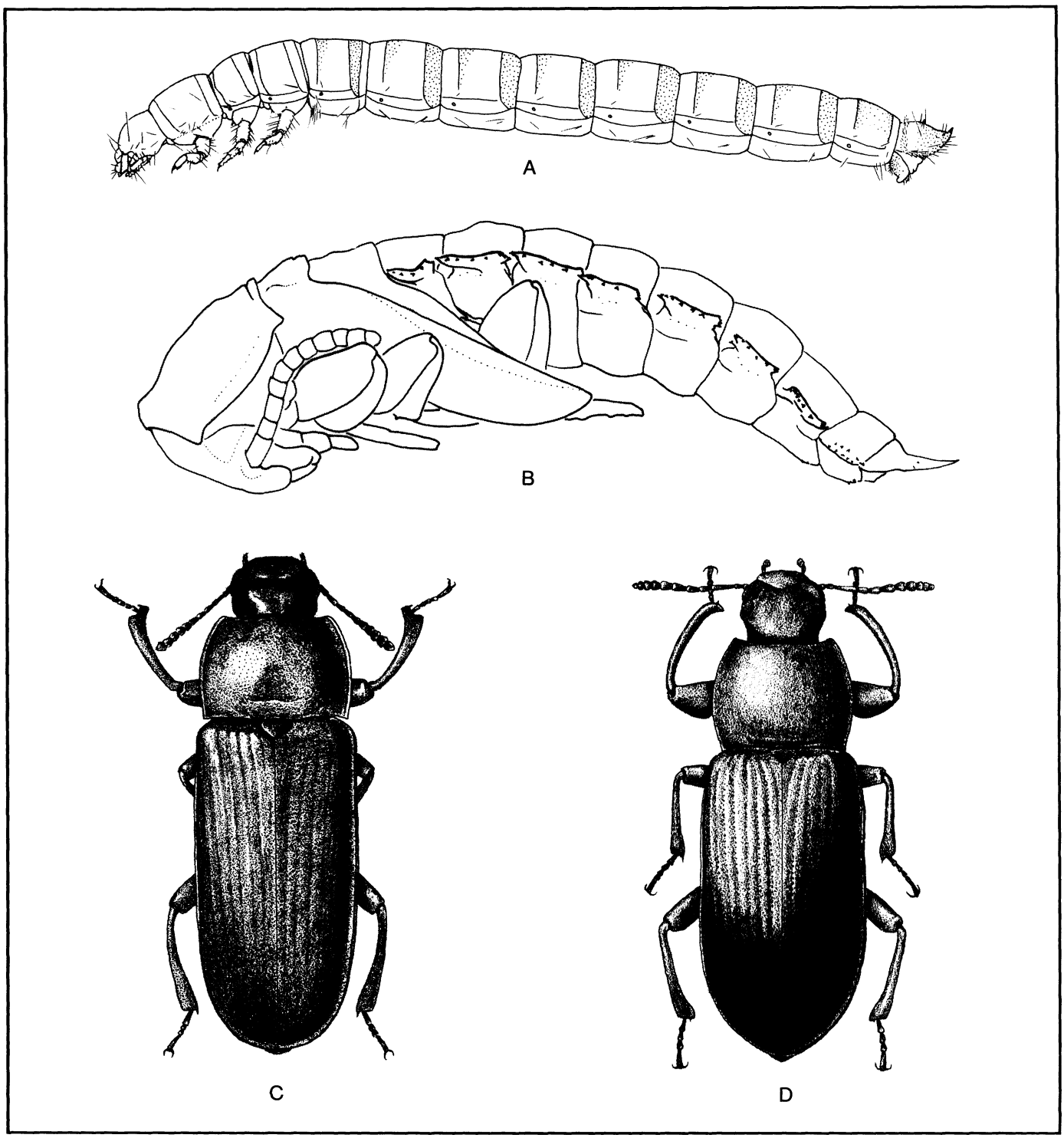


Plate 101. Mealworms (Tenebrionidae): A, **yellow mealworm,** *Tenebrio molitor,* larva (12-32); B, same, pupa (drawings A&B by C. Feller); C, same, adult (15); D, **dark mealworm,** *Tenebrio obscurus* (13.5-18).

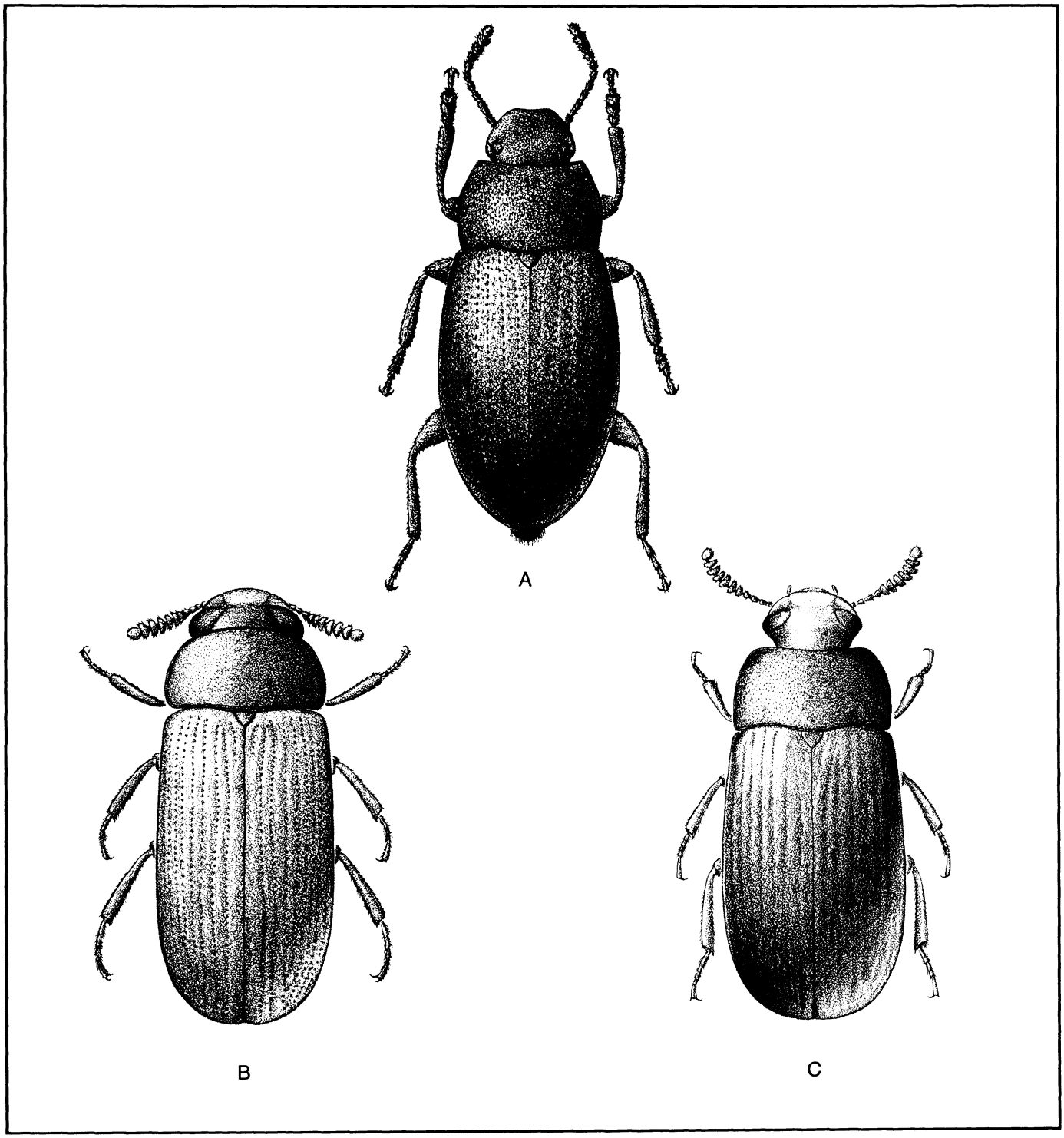


Plate 102. **Darkling beetles** (Tenebrionidae) (drawings by C. Feller): A, fig darkling beetle, *Blapstinus discolor* (4.1-7); B, *Palembus ocularis* (3.5-4.3); C, *Palembus dermestoides* (5.7-6.2).

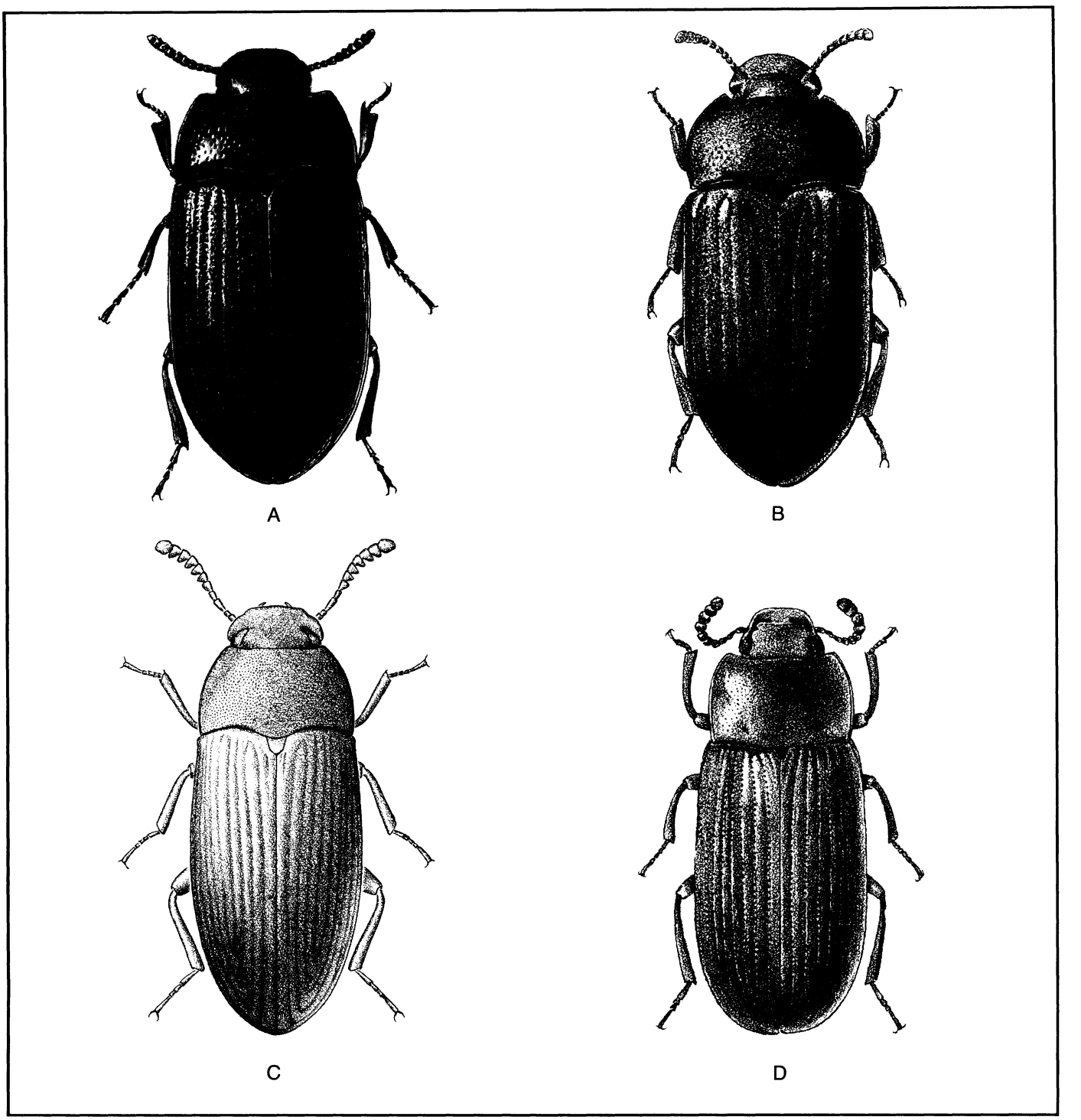


Plate 103. Tenebrionid beetles (Tenebrionidae): A, **lesser mealworm,** *Alphitobius diaperinus* (5.5-7); B, **black fungus beetle,** *Alphitobius laevigatus* (4.5-6.7); C, *Alphitobius viator* (5.5-6.6) (drawing by C. Feller); D, **larger black flour beetle,** *Cynaeus angustus* (4.5-6.1).

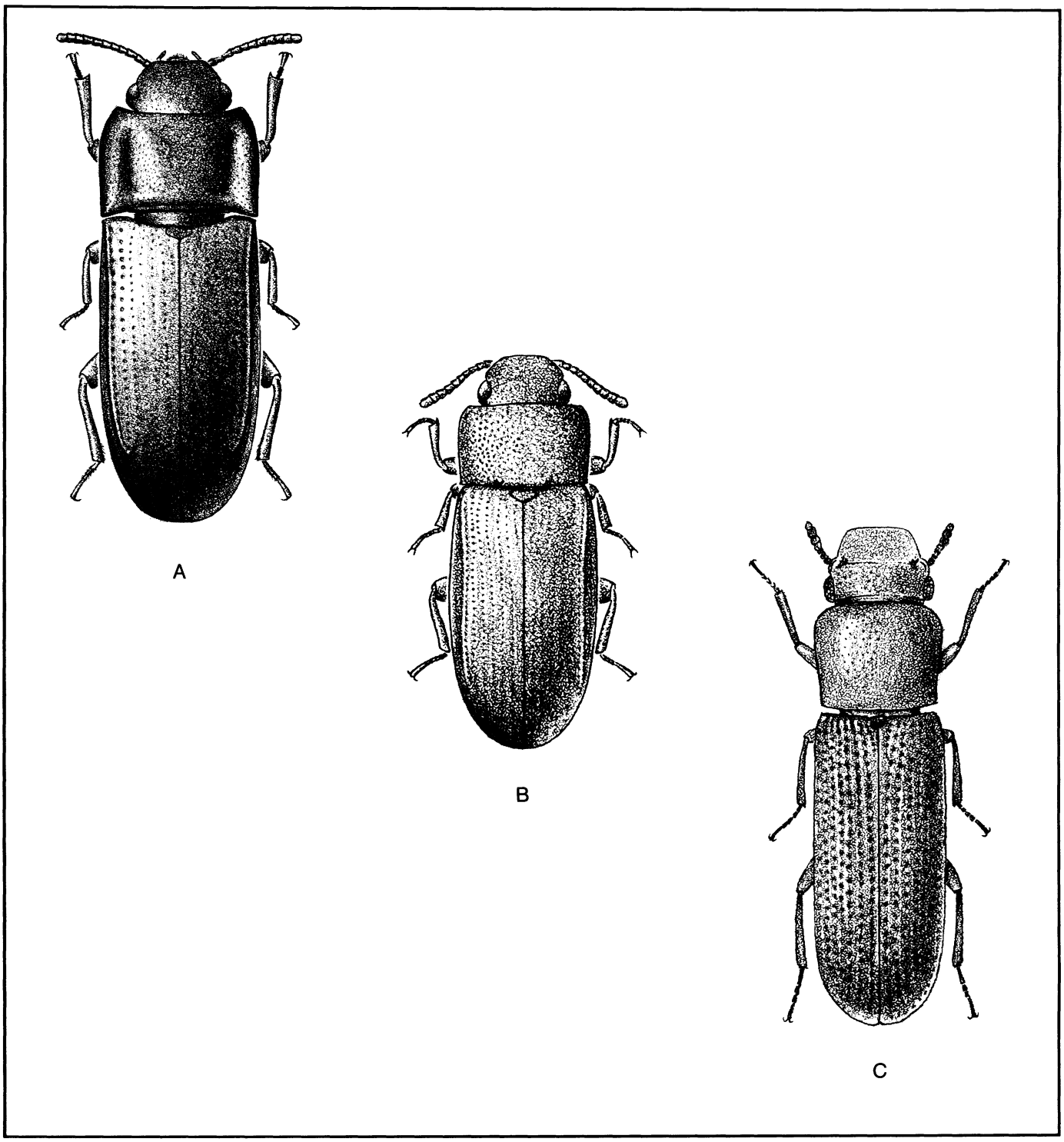


Plate 104. **Darkling beetles** (Tenebrionidae): A, *Coelopalorus foveicollis* (3.6-4.3); B, *Coelopalorus carinatus* (1.9-2.6) (drawings A&B by C. Feller); C, **longheaded flour beetle,** *Latheticus oryzae* (2.3-5.7).

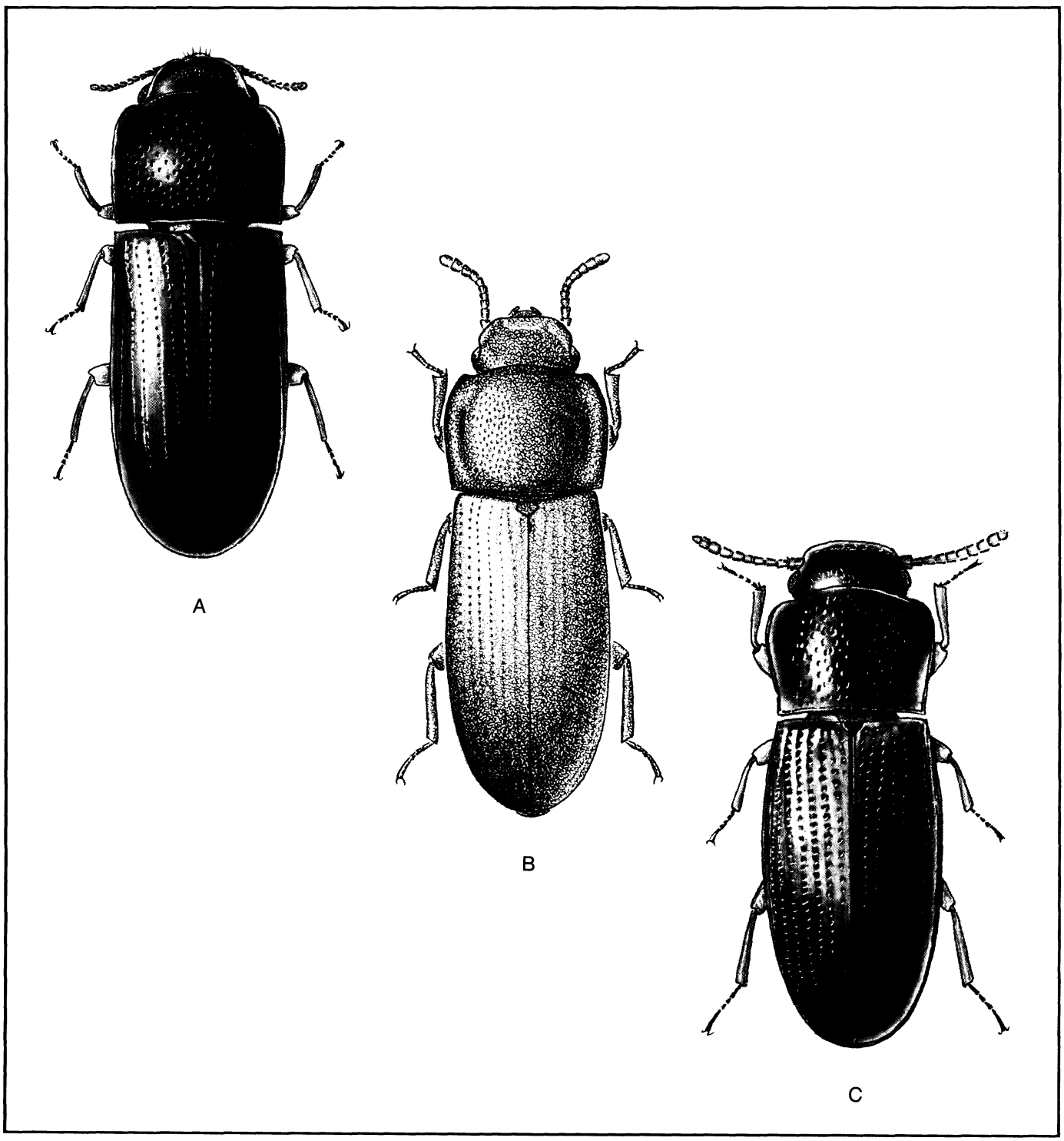


Plate 105. Tenebrionid beetles (Tenebrionidae): A, **depressed flour beetle,** *Palorus subdepressus* (2.7-3); B, *Palorus laesicollis* (2.2-2.9) (drawing by C. Feller); C, **smalleyed flour beetle,** *Palorus ratzeburgii* (2.4-3).

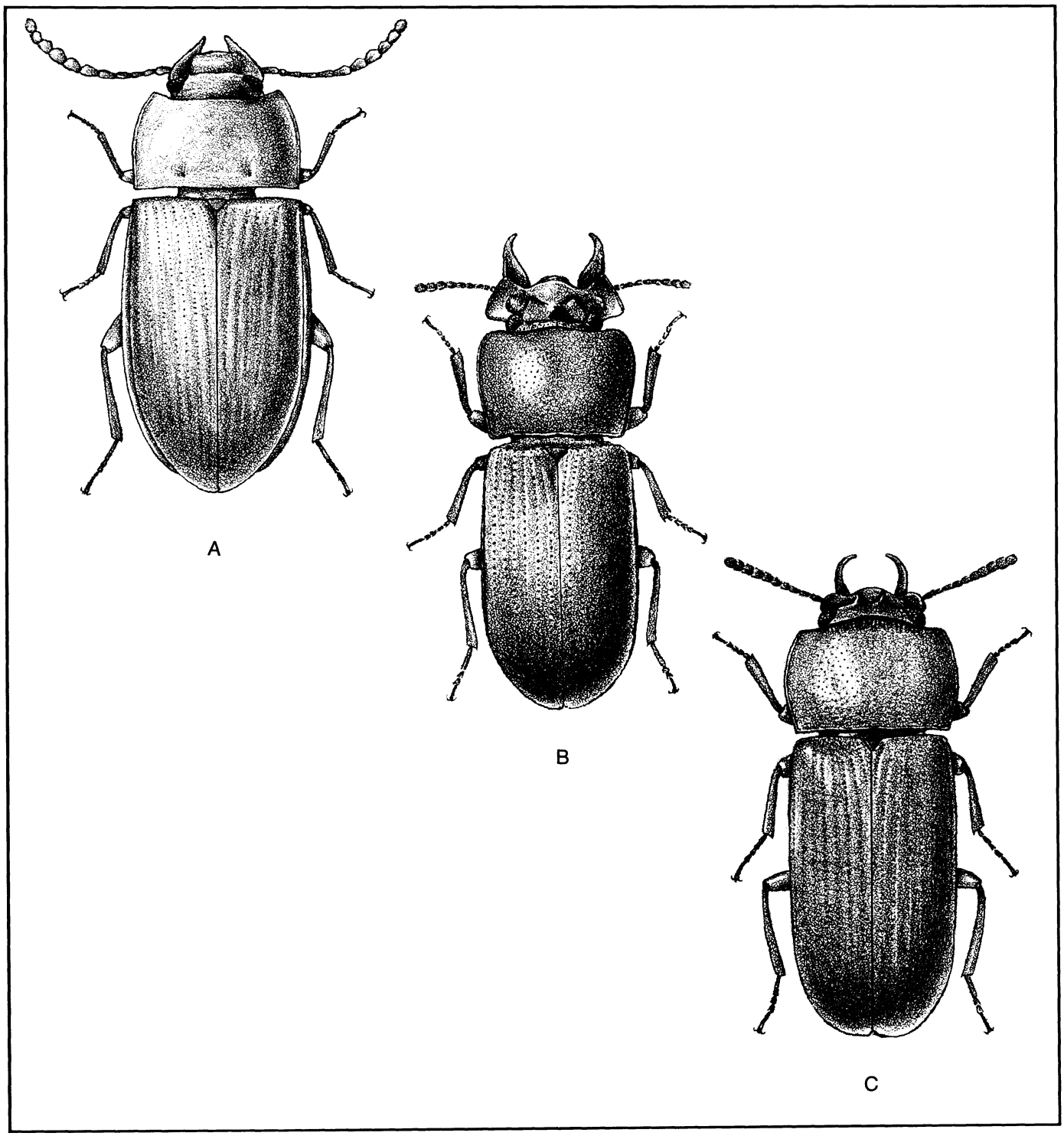


Plate 106. **Darkling beetles** (Tenebrionidae), males: A, *Sitophagus hololeptoides* (5-7.2); B, **broadhorned flour beetle,** *Gnatocerus cornutus* (3.5-4.9); C, **slenderhorned flour beetle,** *Gnatocerus maxillosus* (3-4).

SEED BEETLES (BRUCHIDAE)

These illustrations, drawn by C. Feller unless otherwise noted, are a continuation from part 1, chapter 4 (Larval Beetles), by D.M. Anderson and chapter 12 (Seed Beetles), by J.M. Kingsolver.

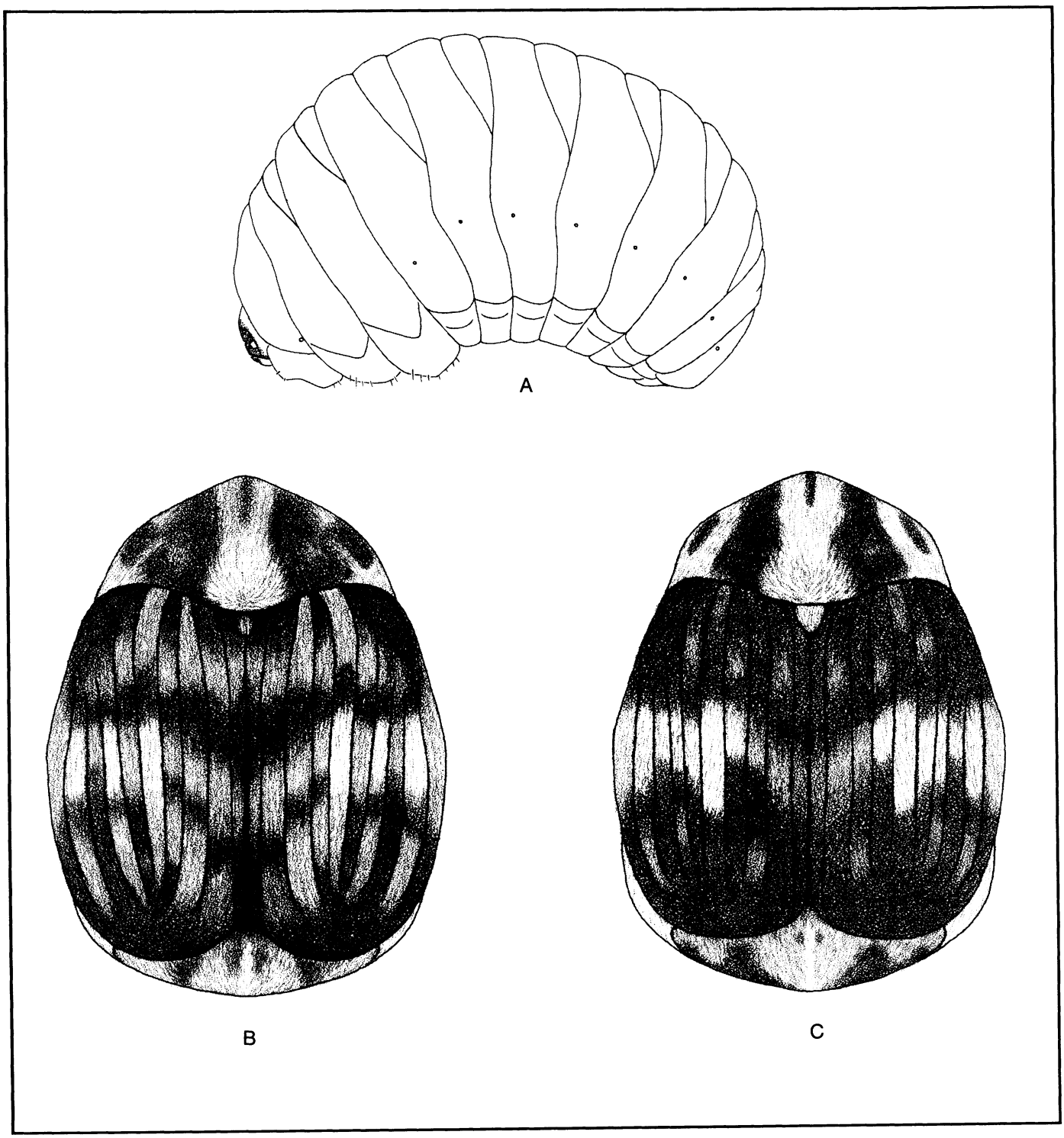


Plate 107. **Mexican bean weevil,** *Zabrotes subfasciatus* (Bruchidae): A, larva (3-3.5); B, male (1.9-2.2); C, female (2.3-2.5).

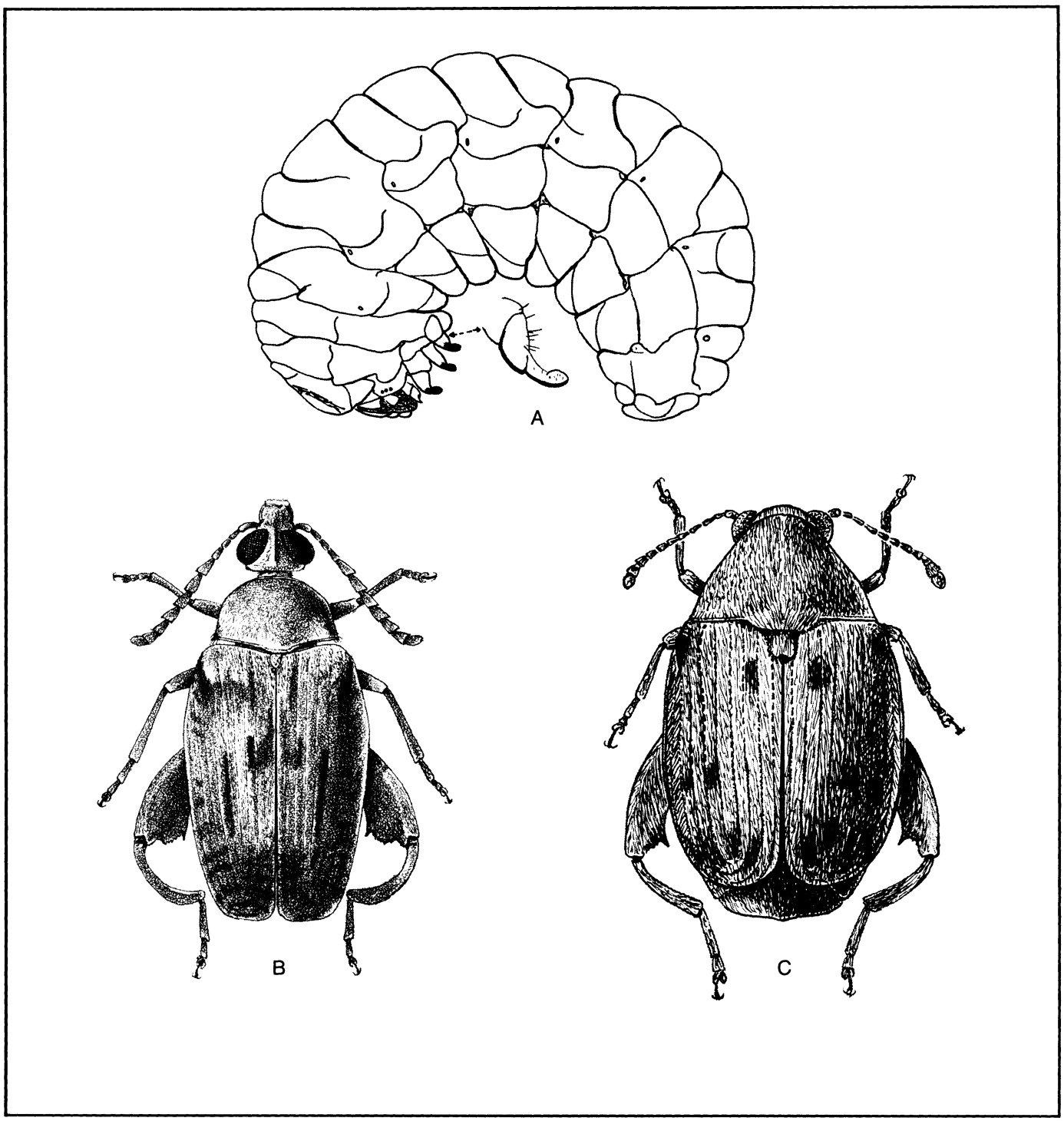
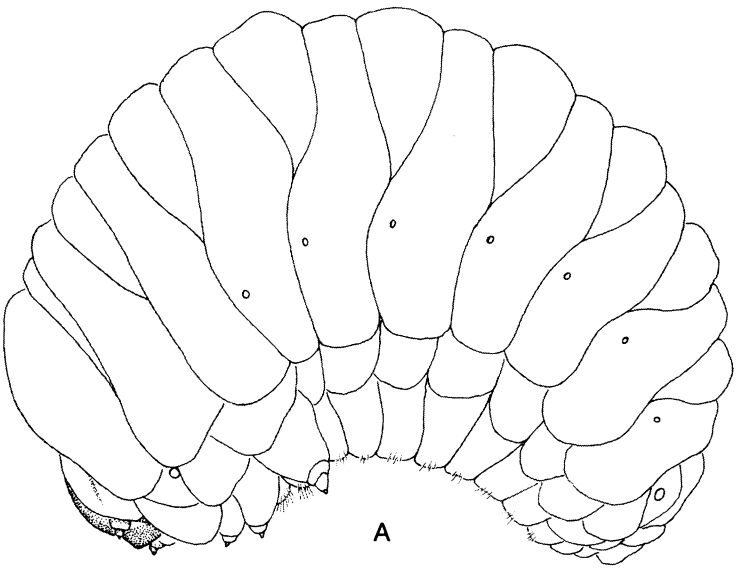


Plate 108. **Seed beetles** (Bruchidae): A, groundnut bruchid, *Caryedon serratus,* larva (6) (drawing by J.M. Kingsolver); B, same, adult (3.5-6.8); C, **bean weevil,** *Acanthoscelides obtectus* (3-4.5) (drawings B&C by A.D. Cushman).



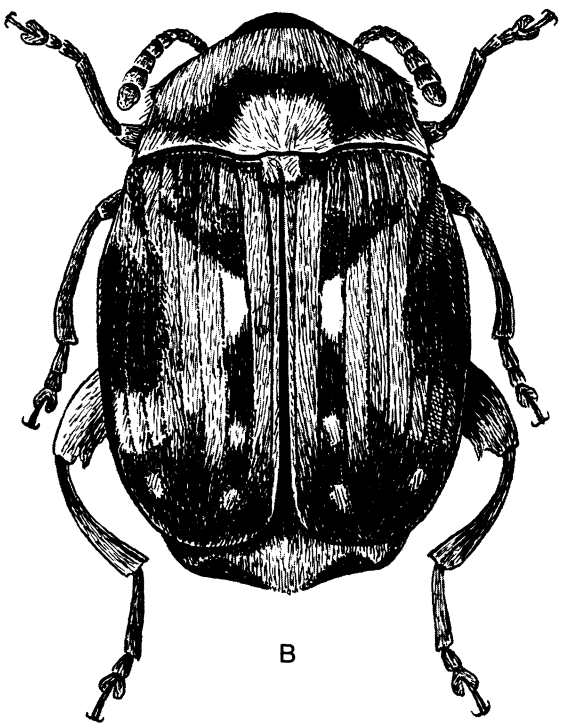


Plate 109. **Pea weevil,** *Bruchus pisorum* (Bruchidae): A, larva (4.5-5); B, adult (4.5-5) (drawing by A.D. Cushman).

WEEVILS (CURCULIONIDAE)

These illustrations, drawn by C. Feller unless otherwise noted, are a continuation from part 1, chapter 4 (Larval Beetles), by D.M. Anderson and chapter 13 (Weevils), by D.R. Whitehead.

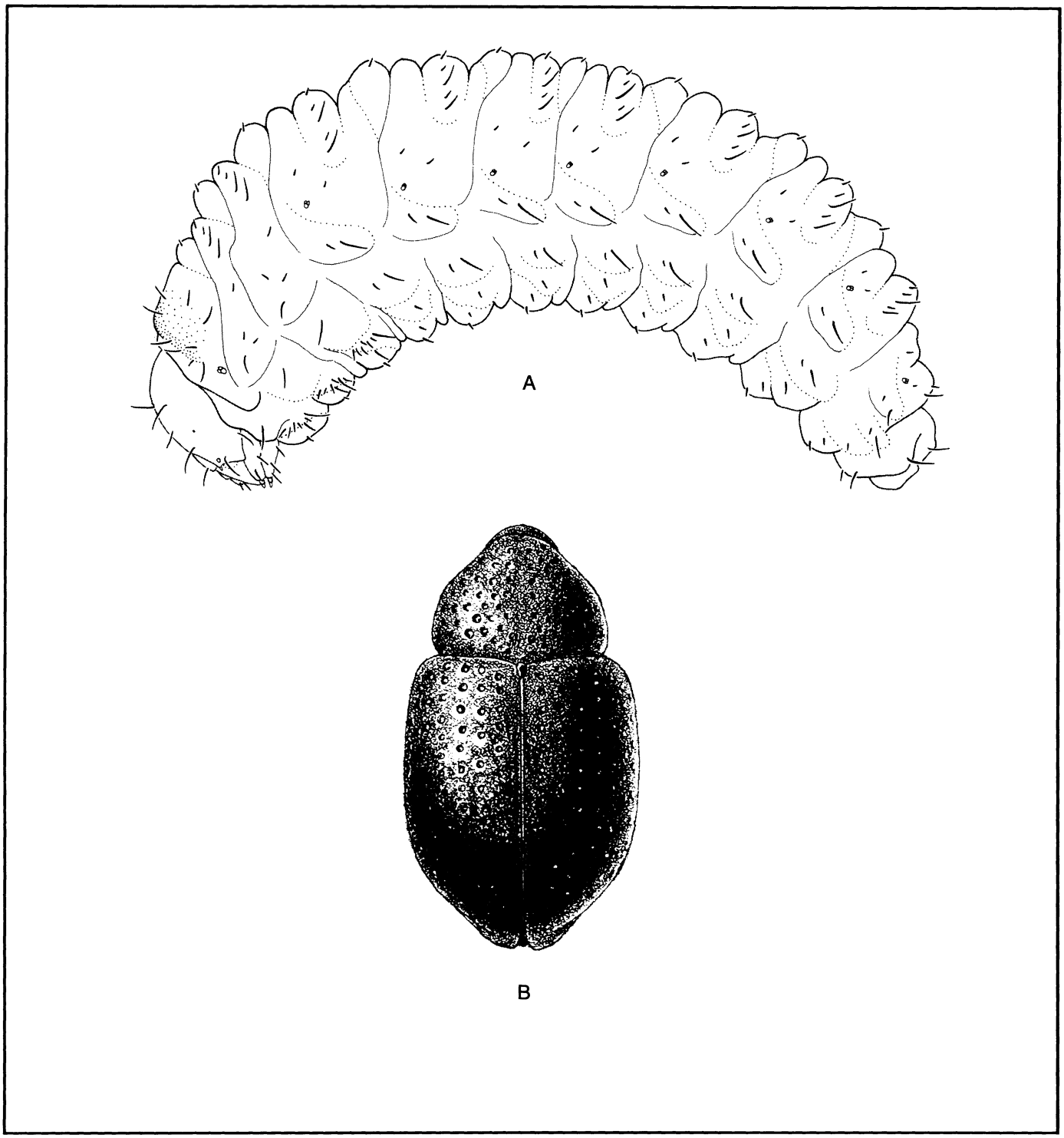


Plate 110. **Cowpea curculio,** *Chalcodermus aeneus* (Curculionidae): A, larva (7) (drawing by M. Ryan); B, adult (4-4.5) (drawing by A.D. Cushman).

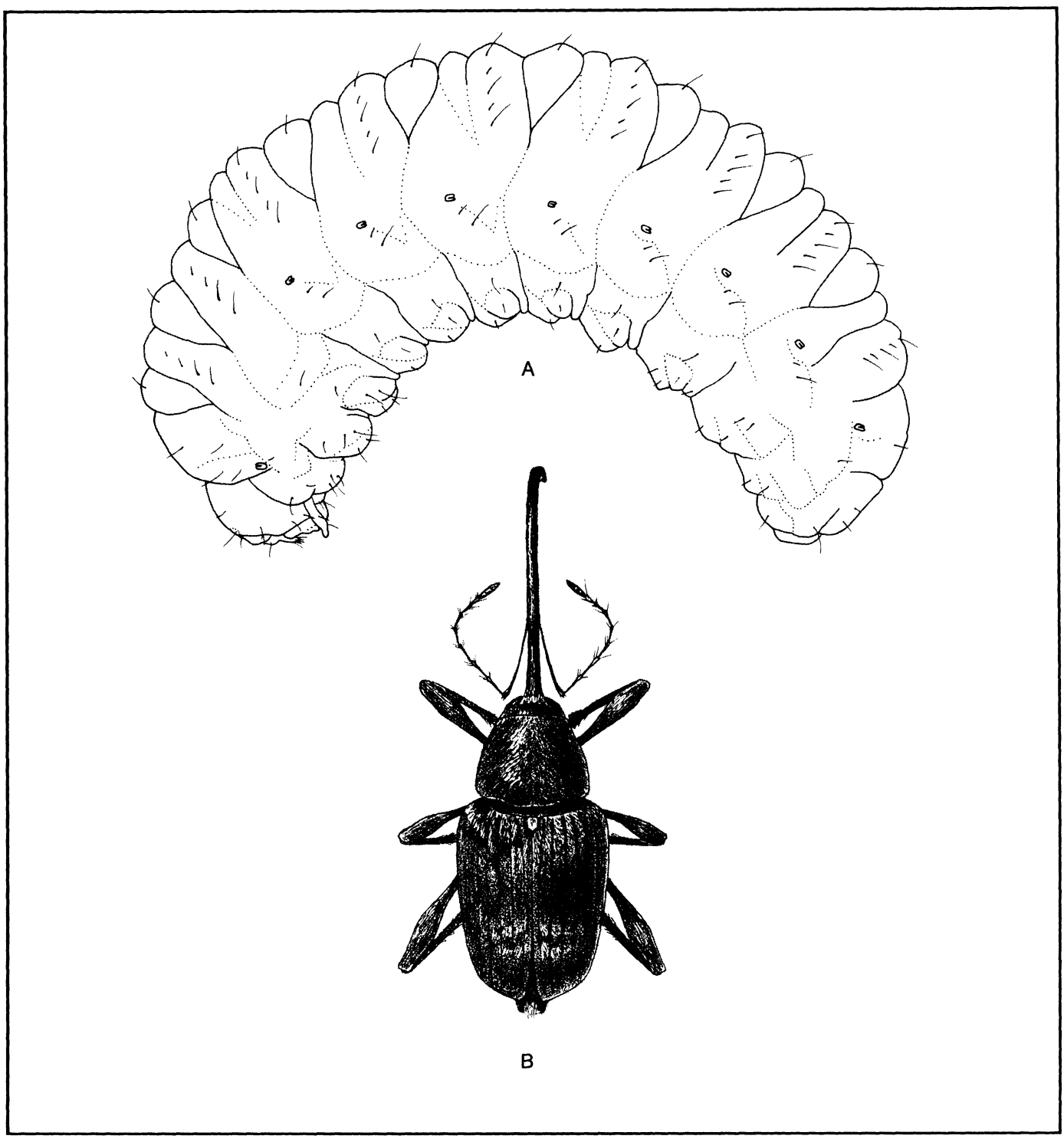


Plate 111. **Pecan weevil,** *Curculio caryae* (Curculionidae): A, larva (15) (drawing by M. Ryan); B, adult (7.5-12) (drawing by A.D. Cushman).

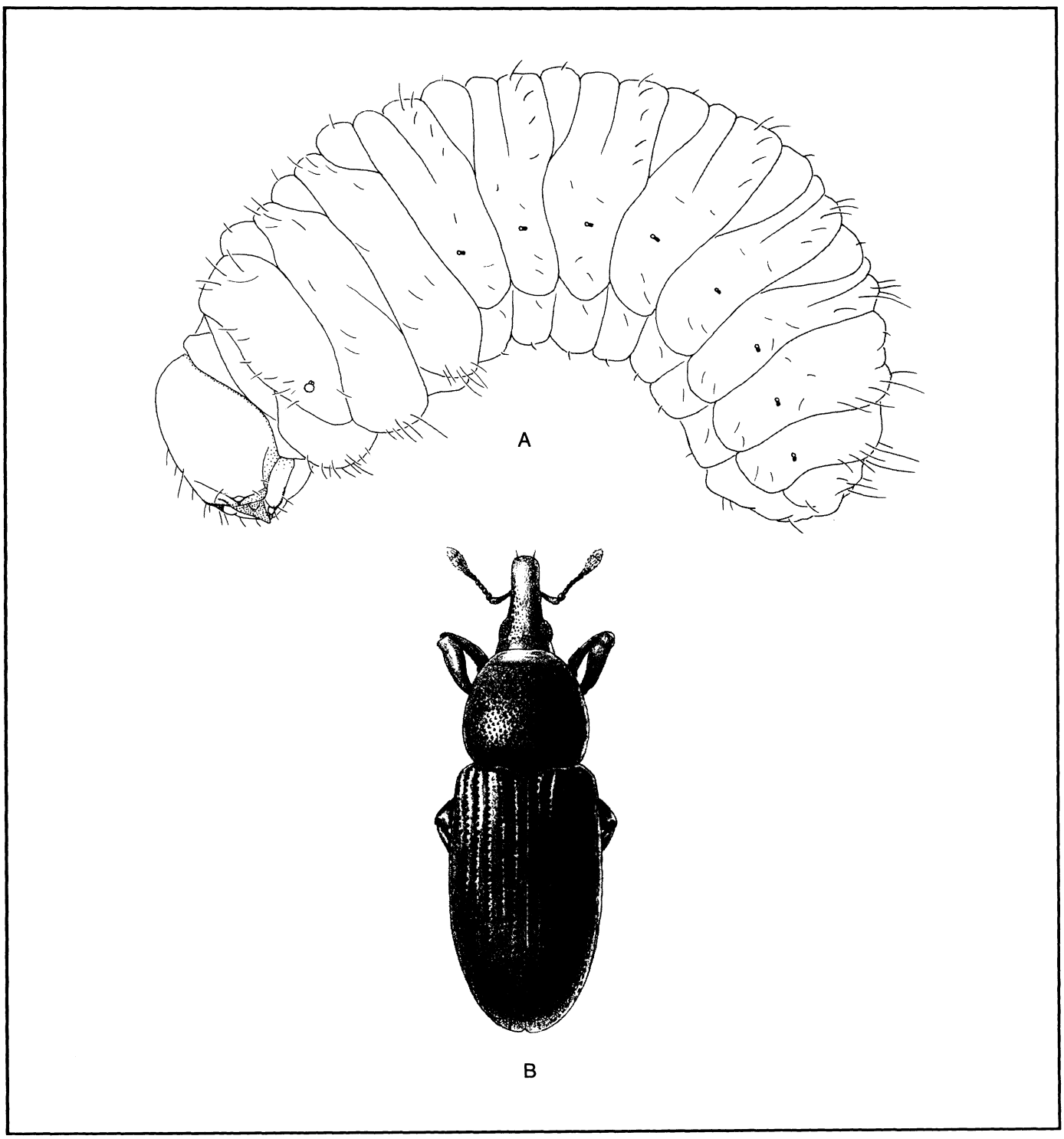


Plate 112. **Broadnosed grain weevil,** *Caulophilus oryzae* (Curculionidae): A, larva (2-2.5); B, adult (2.5-3.5) (drawing by A.D. Cushman).

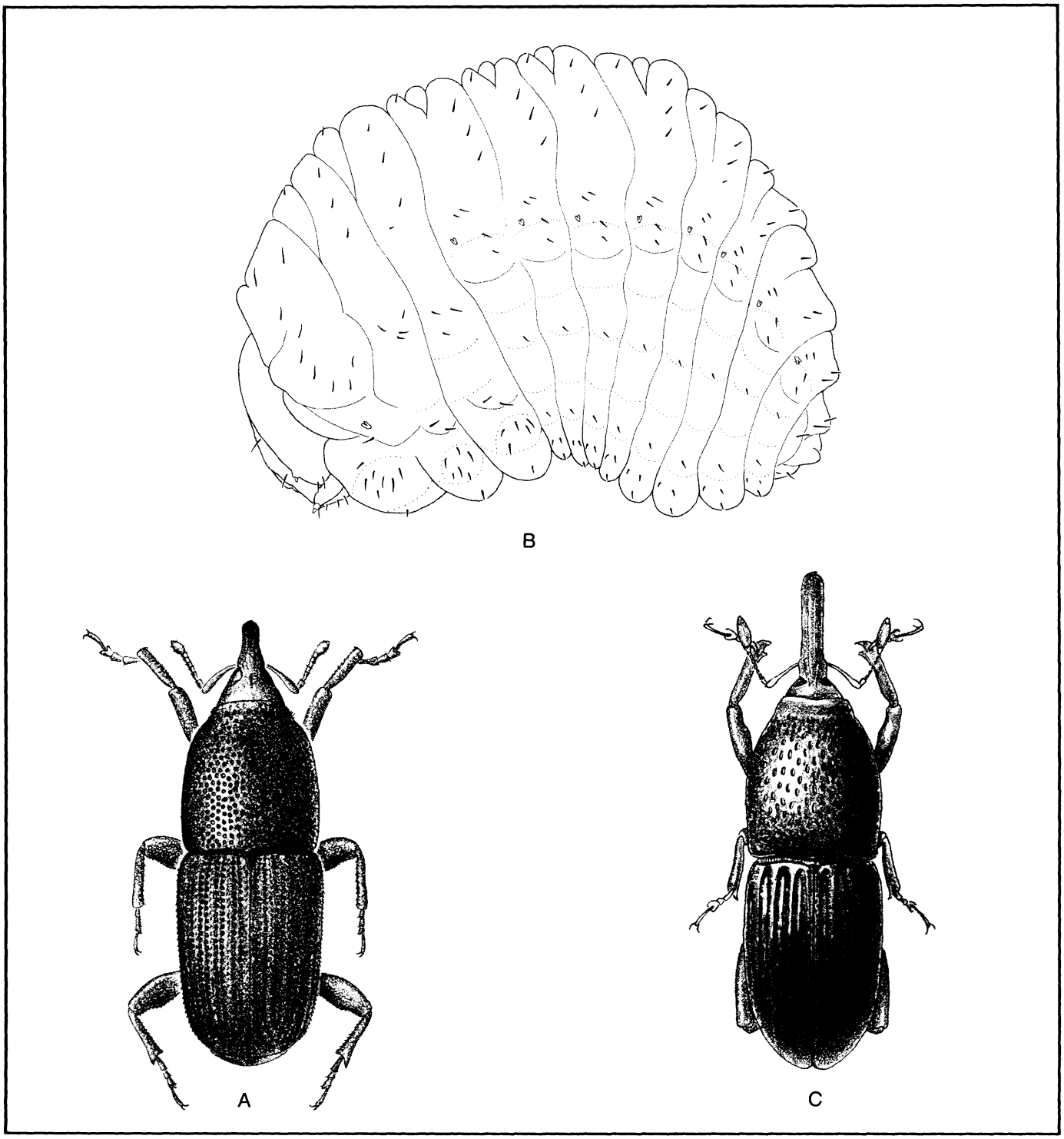


Plate 113. **Weevils** (Curculionidae): A, **tamarind weevil,** *Sitophilus linearis,* adult (3.5-5); B, **granary weevil,** *Sitophilus granarius,* larva (2.5-2.7) (drawing by M. Ryan); C, same, adult (3-4.5) (drawing by A.D. Cushman).

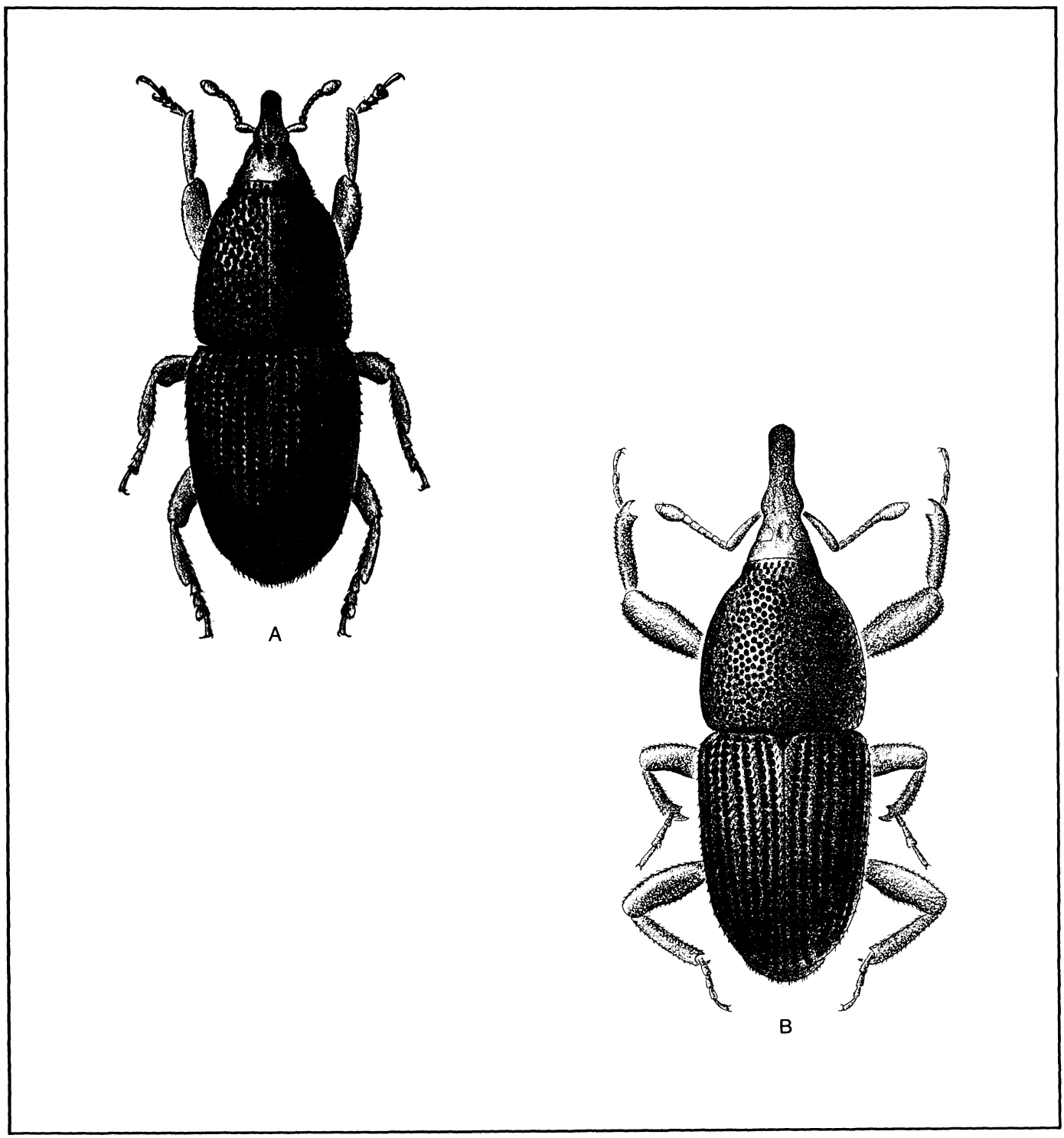


Plate 114. **Weevils** (Curculionidae): A, **rice weevil,** *Sitophilus oryzae* (2.5-4); B, **maize weevil,** *Sitophilus zeamais* (2.5-4.5).

MOTH AND BUTTERFLY LARVAE (LEPIDOPTERA)

This series of illustrations, drawn by C. Feller, is a continuation from part 1, chapter 15 (Larval Moths), by D.M. Weisman.

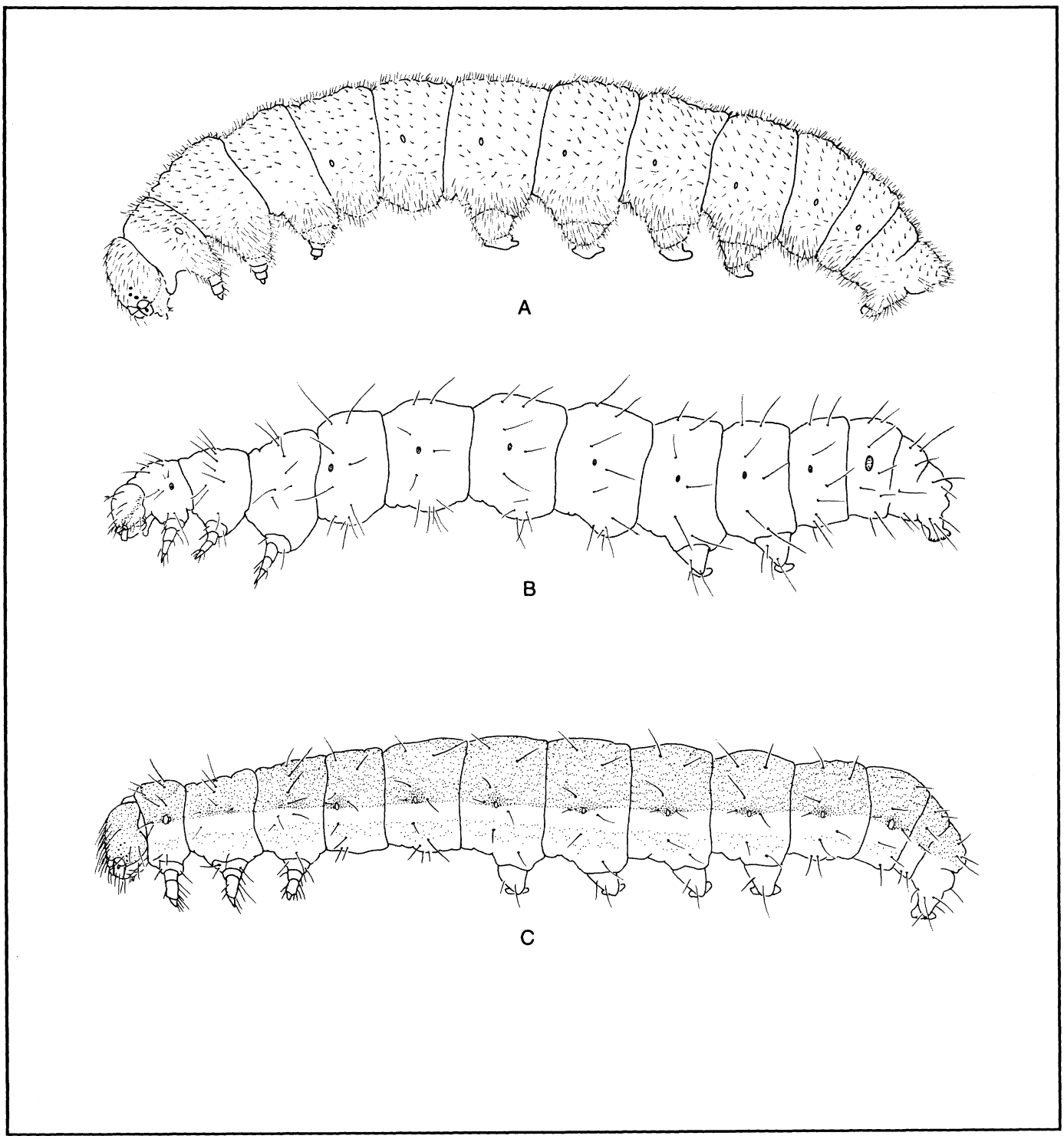


Plate 115. Pierid and noctuid larvae: A, **imported cabbageworm,** *Pieris rapae* (25-30) (Pieridae); B, silver Y moth, *Autographa gamma* (35-45) (Noctuidae); C, cabbage moth, *Mamestra brassicae* (40-45) (Noctuidae).

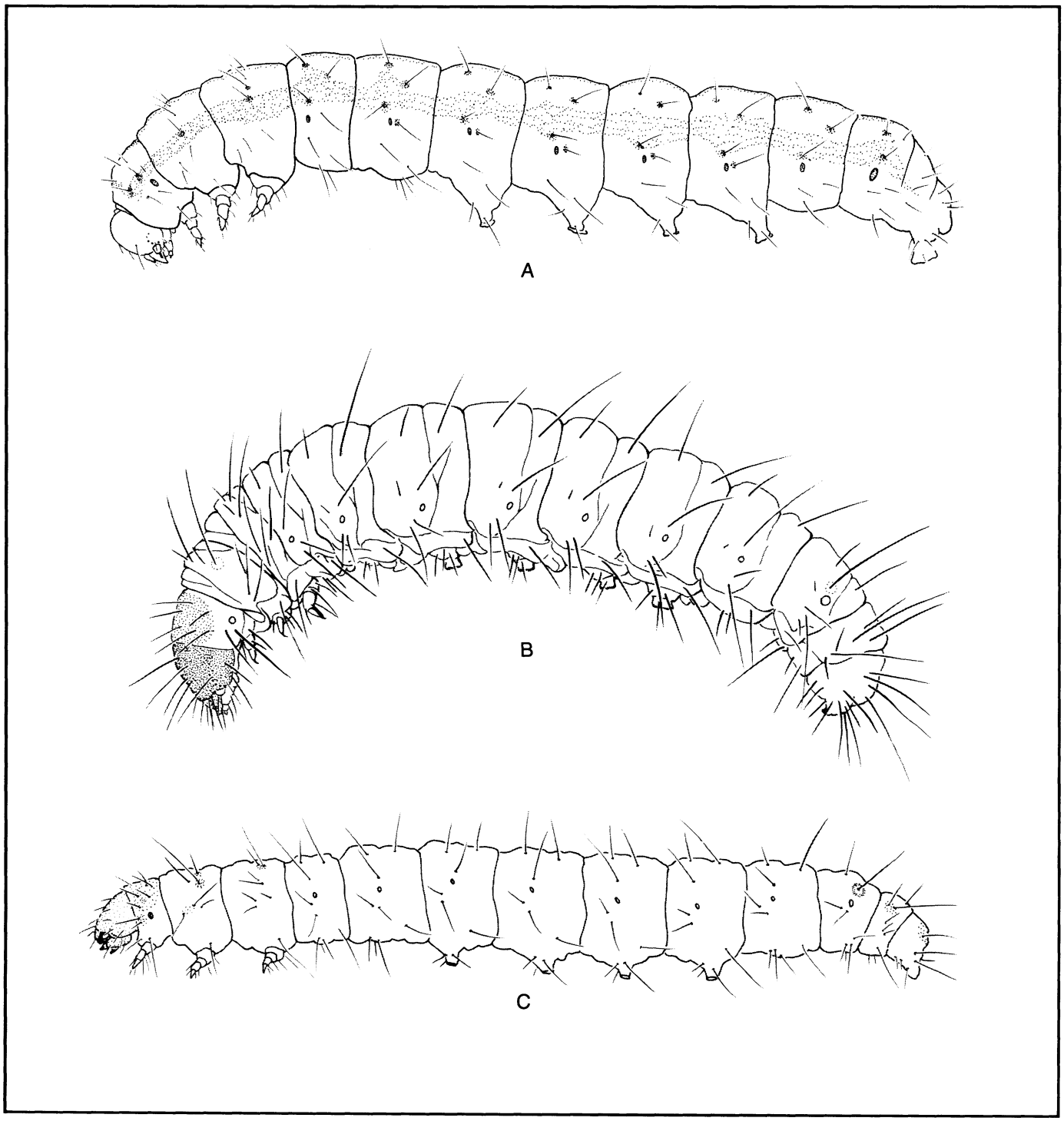


Plate 116. Noctuid and pyralid moth larvae: A, **corn earworm, tomato fruitworm**, *Helicoverpa zea* (25-38) (Noctuidae); B, **Indianmeal moth**, *Plodia interpunctella* (10-15) (Pyralidae); C, **almond moth**, *Cadra cautella* (12-14) (Pyralidae).

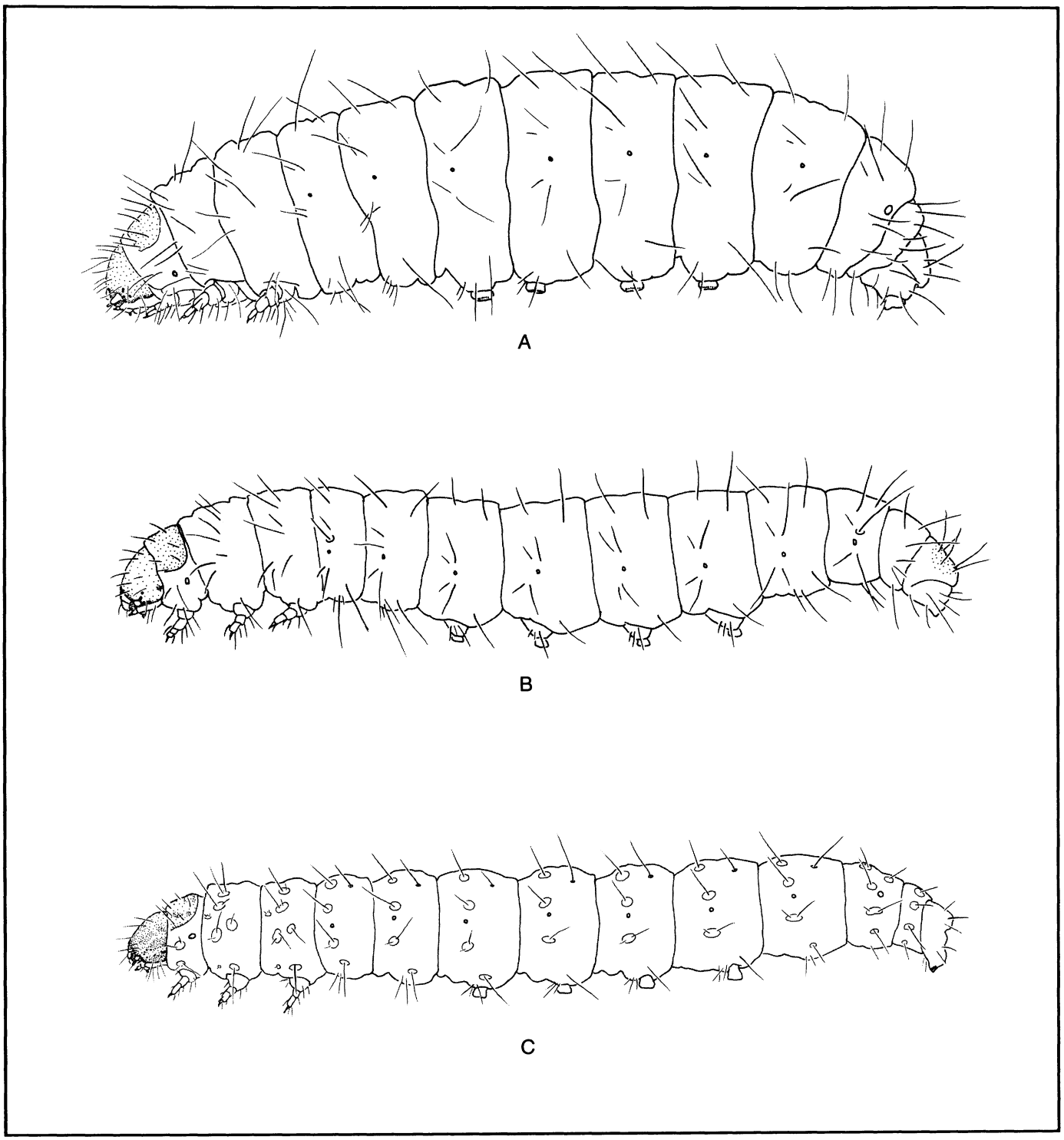


Plate 117. Pyralid moth larvae (Pyralidae): A, **greater wax moth,** *Galleria mellonella* (22-28); B, **rice moth**, *Corcyra cephalonica* (13-15); C, **European corn borer**, *Ostrinia nubilalis* (23-25).

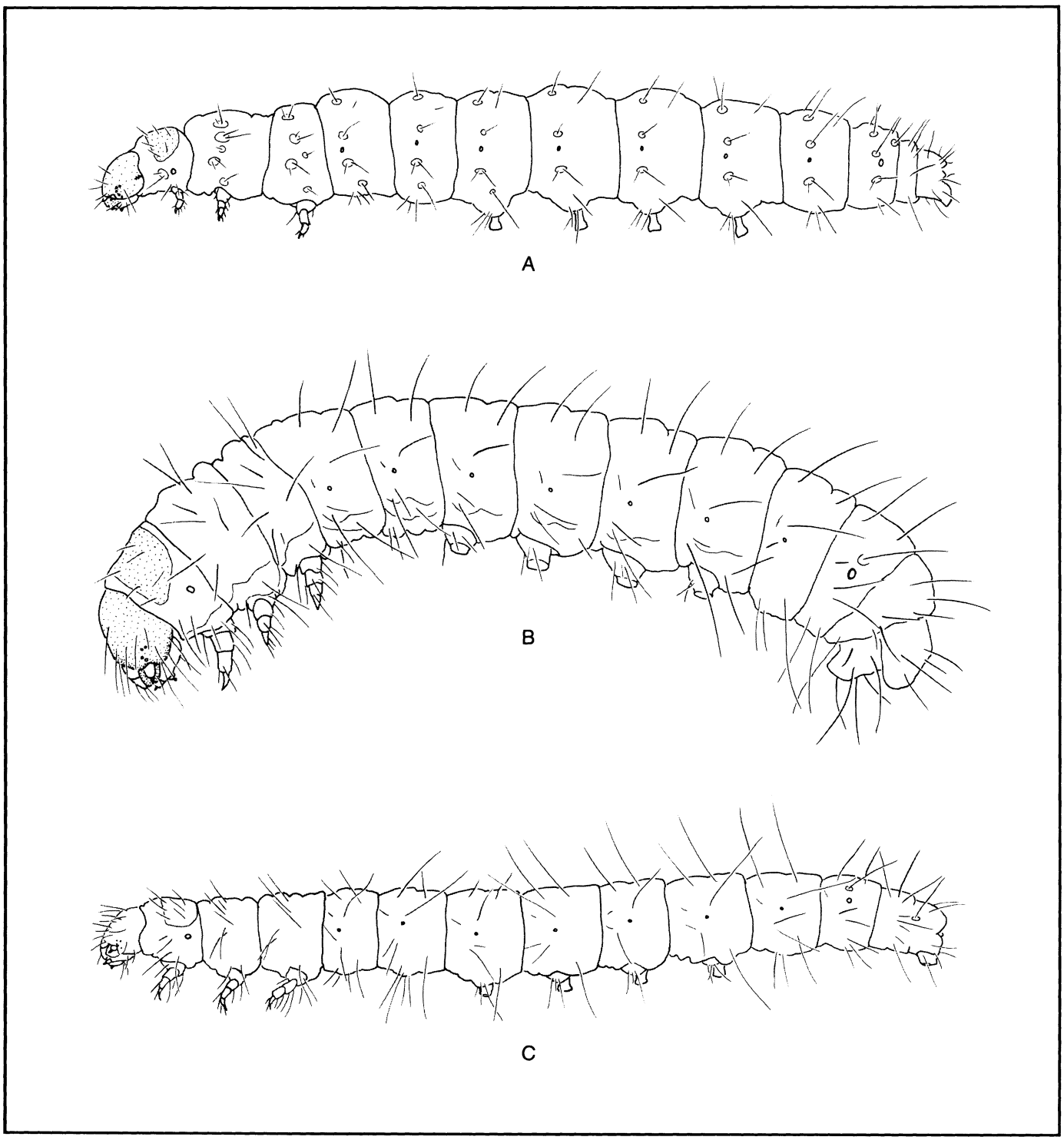


Plate 118. Pyralid moth larvae (Pyralidae): A, **pickleworm,** *Diaphania nitidalis* (25-30); B, **meal moth,** *Pyralis farinalis* (20-25); C, murky meal moth, *Aglossa caprealis* (25-28).

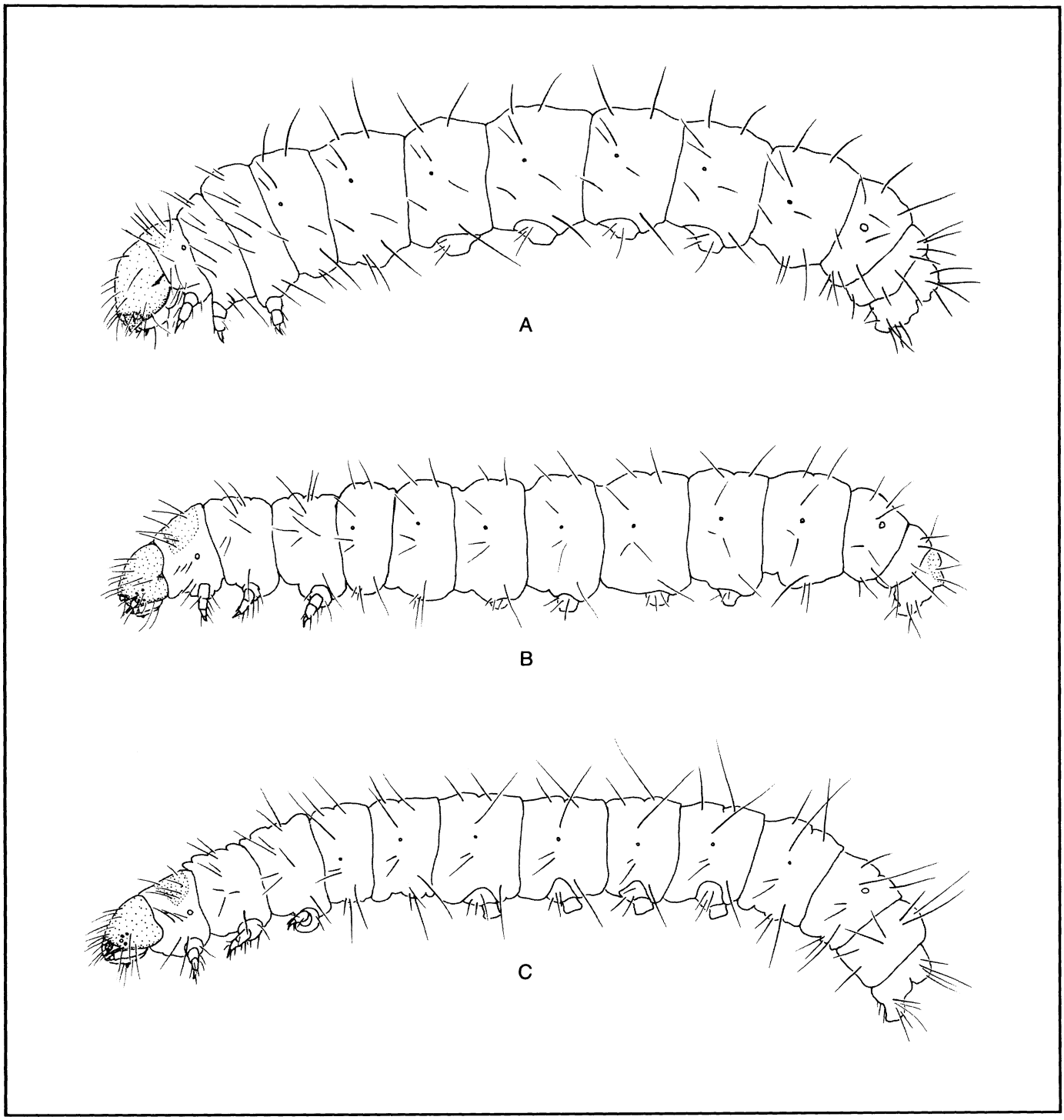


Plate 119. Lepidopterous larvae: A, **webbing clothes moth,** *Tineola bisselliella* (9-10) (Tineidae); B, **codling moth,** *Cydia pomonella* (14-16) (Tortricidae); C, **pink scavenger caterpillar,** *Pyroderces rileyi* (7-8) (Cosmopterigidae).

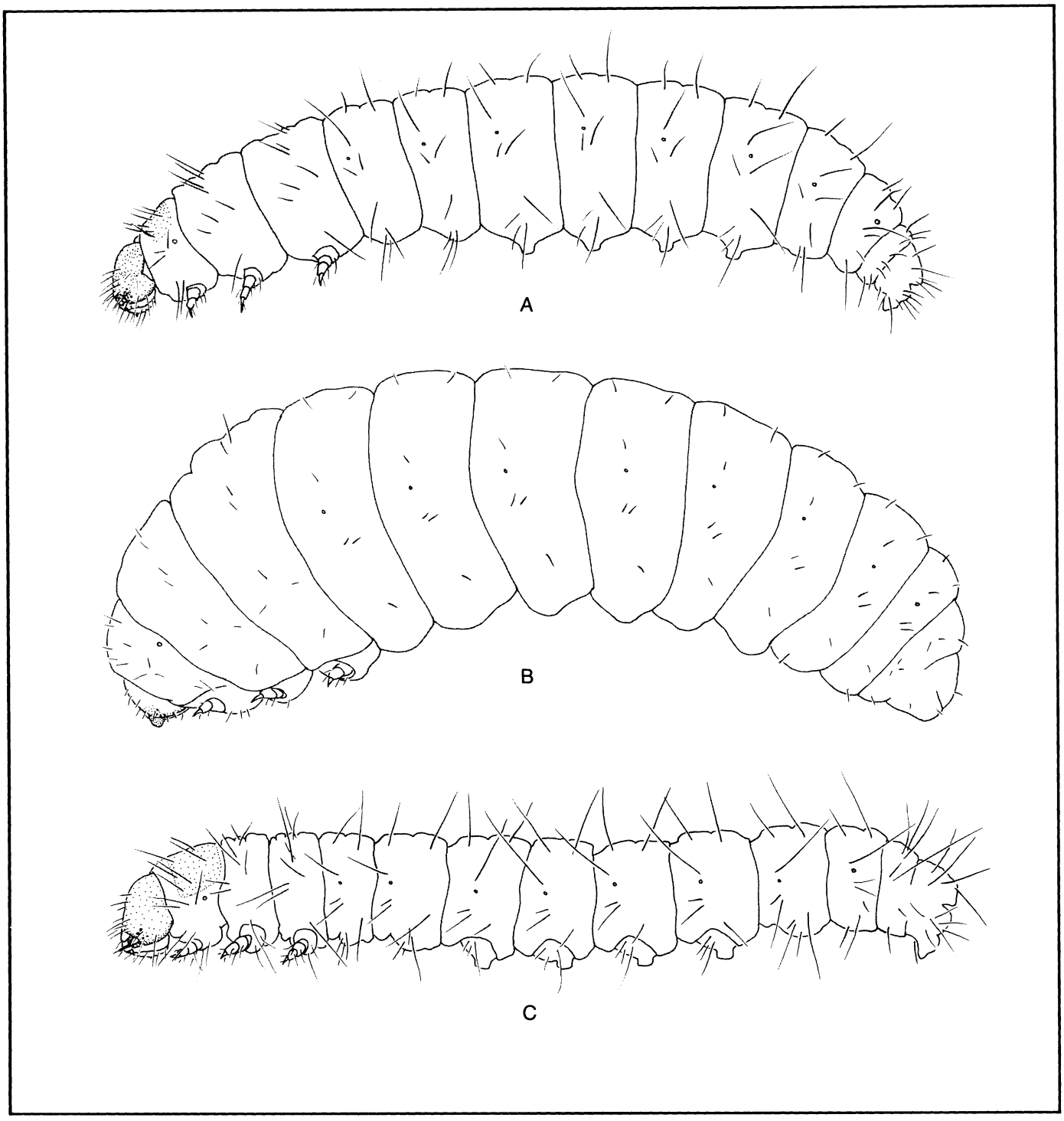


Plate 120. Lepidopterous larvae: A, **apple fruit moth,** *Argyresthia conjugella* (8-10) (Argyresthiidae); B, **Angoumois grain moth,** *Sitotroga cerealella* (4-7) (Gelechiidae); C, **brown house moth,** *Hofmannophila pseudospretella* (14-16) (Oecophoridae).

Notes and Sketches

FLIES (DIPTERA)

This series of illustrations, drawn by C. Feller unless otherwise noted, is a continuation from part 1, chapter 16 (Flies), by R.J. Gagné.

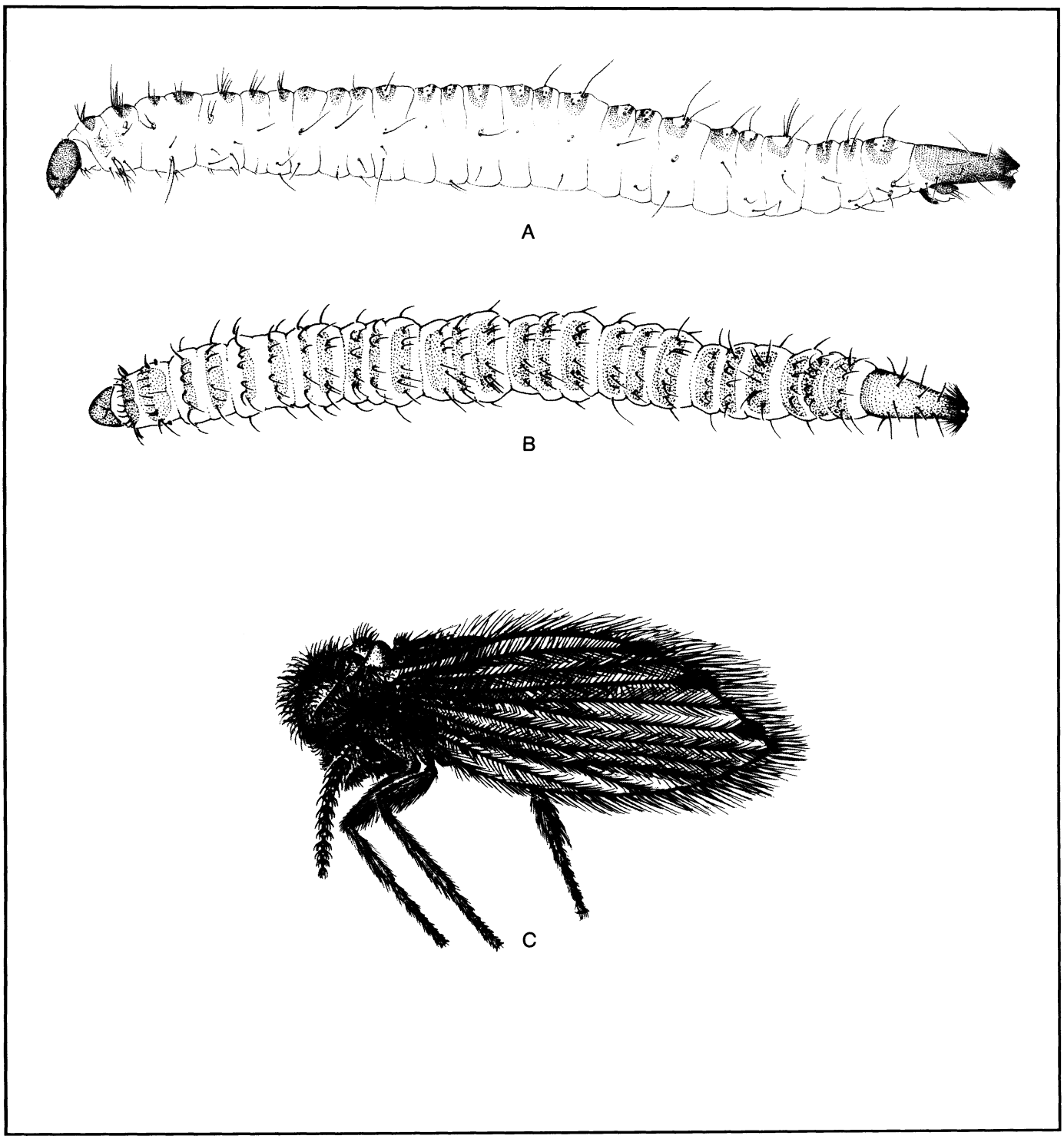


Plate 121. **Moth flies,** *Psychoda* spp. (Psychodinae, Psychodidae): A, larva (4.5-10), lateral view; B, same, dorsal view; C, adult (1.25-1.5).

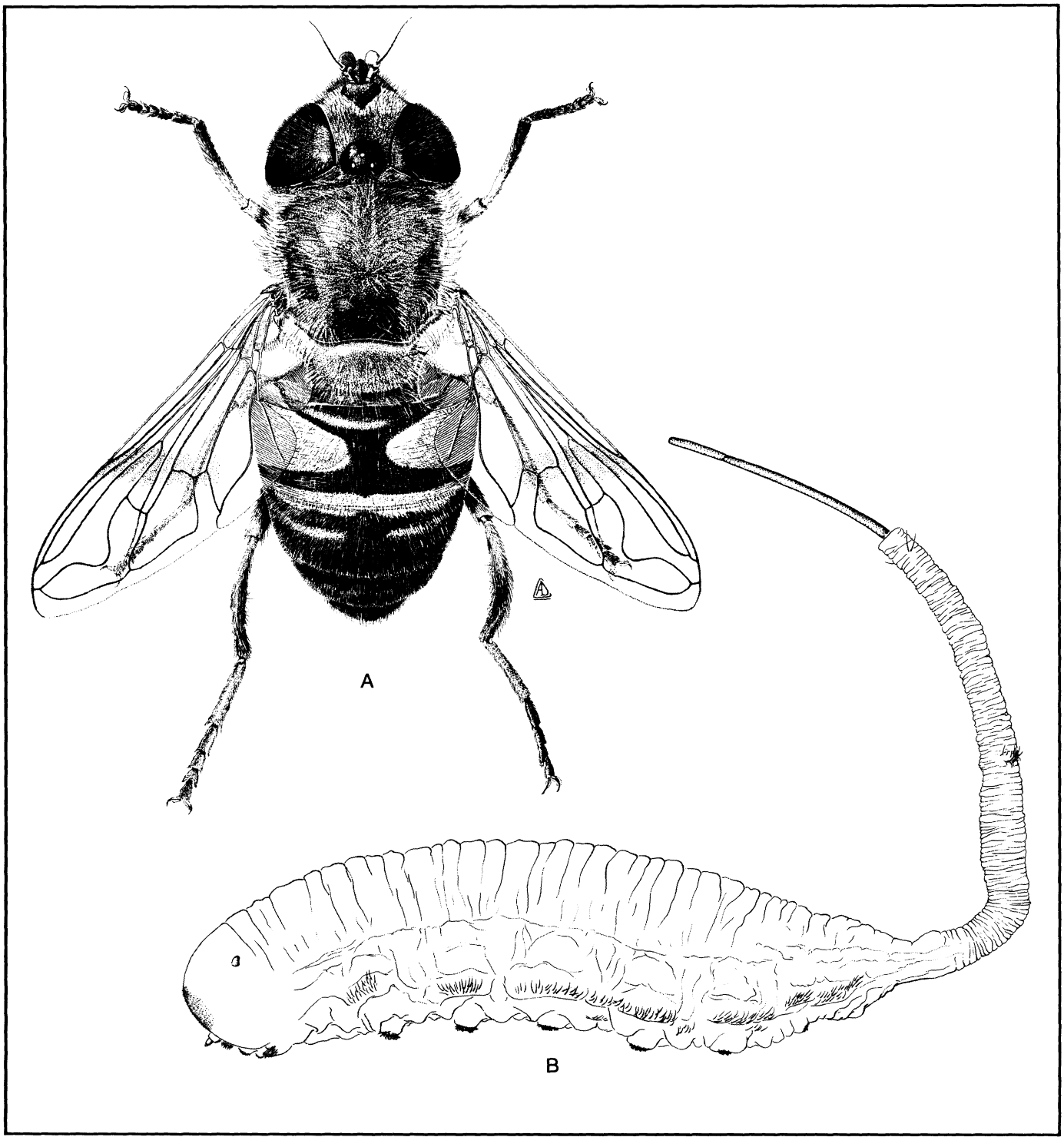


Plate 122. **Drone fly,** *Eristalis tenax* (Syrphidae): A, female (15) (drawing by A.D. Cushman); B, larva (10-15, excluding tail).

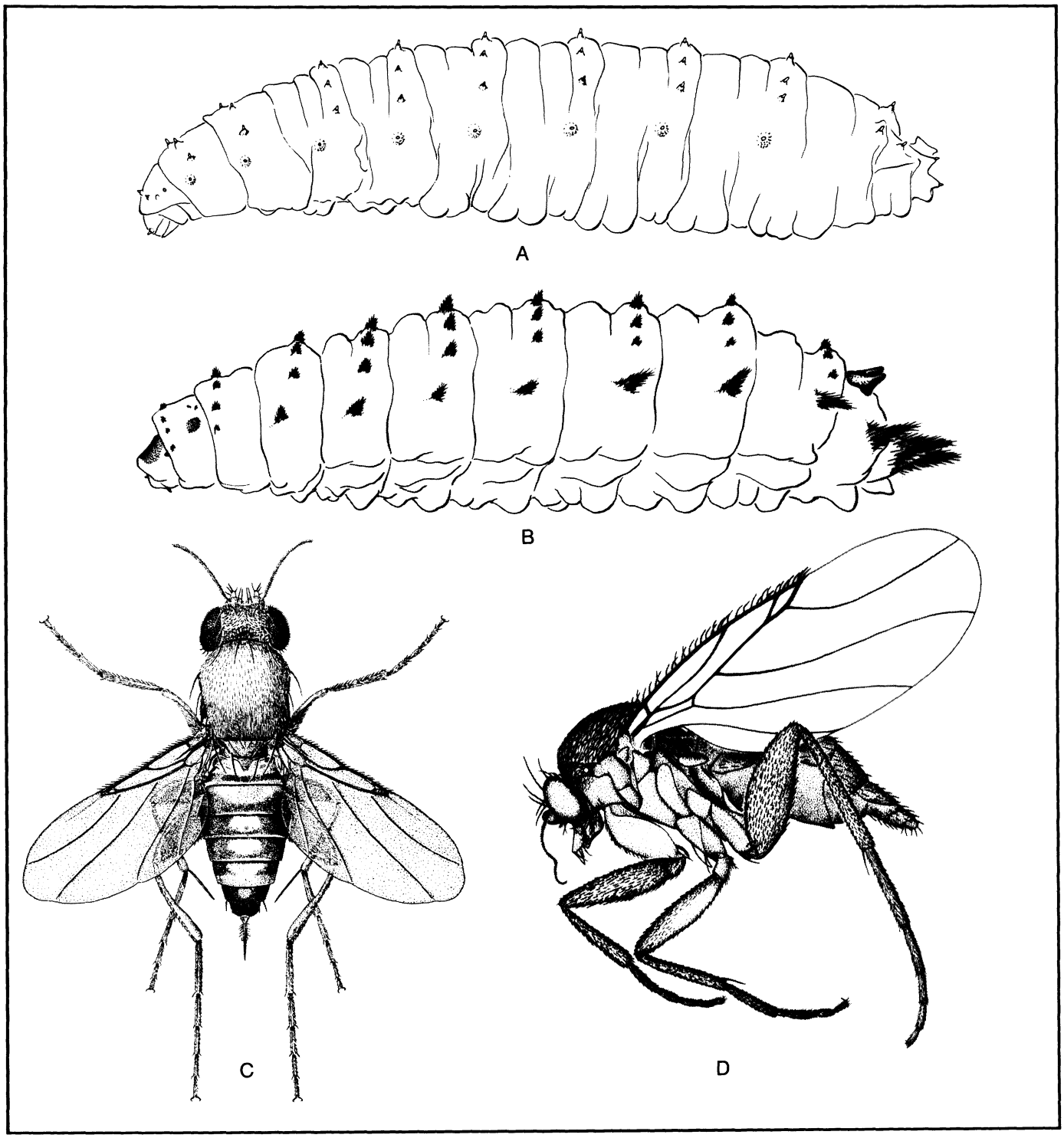


Plate 123. **Humpbacked flies** (Phoridae): A, *Megaselia* sp., larva (3.5-5); B, *Megaselia* sp., larva (3.5-5); C, *Megaselia scalaris,* adult (2-3), dorsal view (drawing by A.D. Cushman); D, *Megaselia* sp., adult, lateral view.

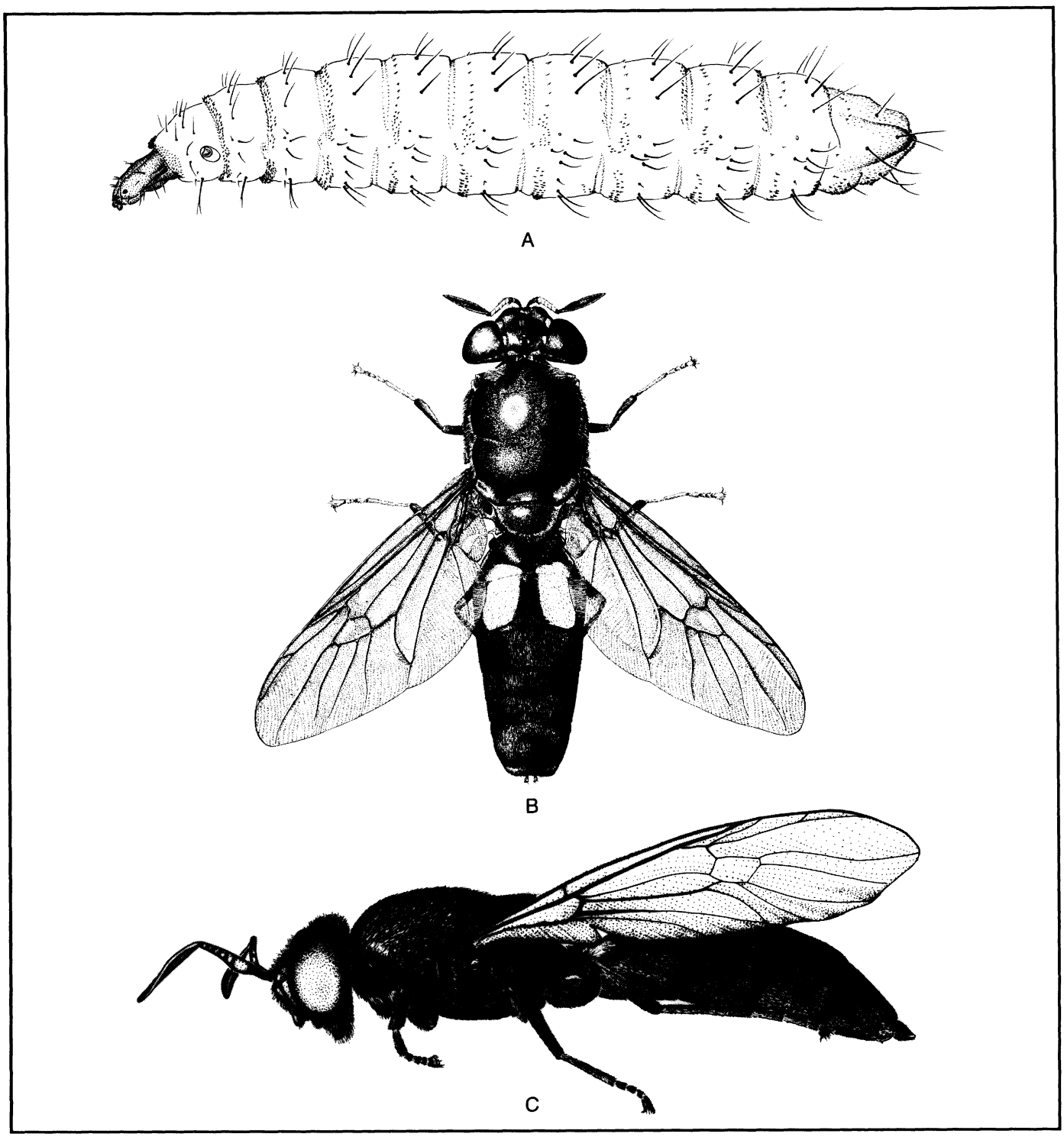


Plate 124. **Black soldier fly,** *Hermetia illucens* (Stratiomyidae): A, larva (15-20); B, female (15-20), dorsal view (drawing by A.D. Cushman); C, same, lateral view.

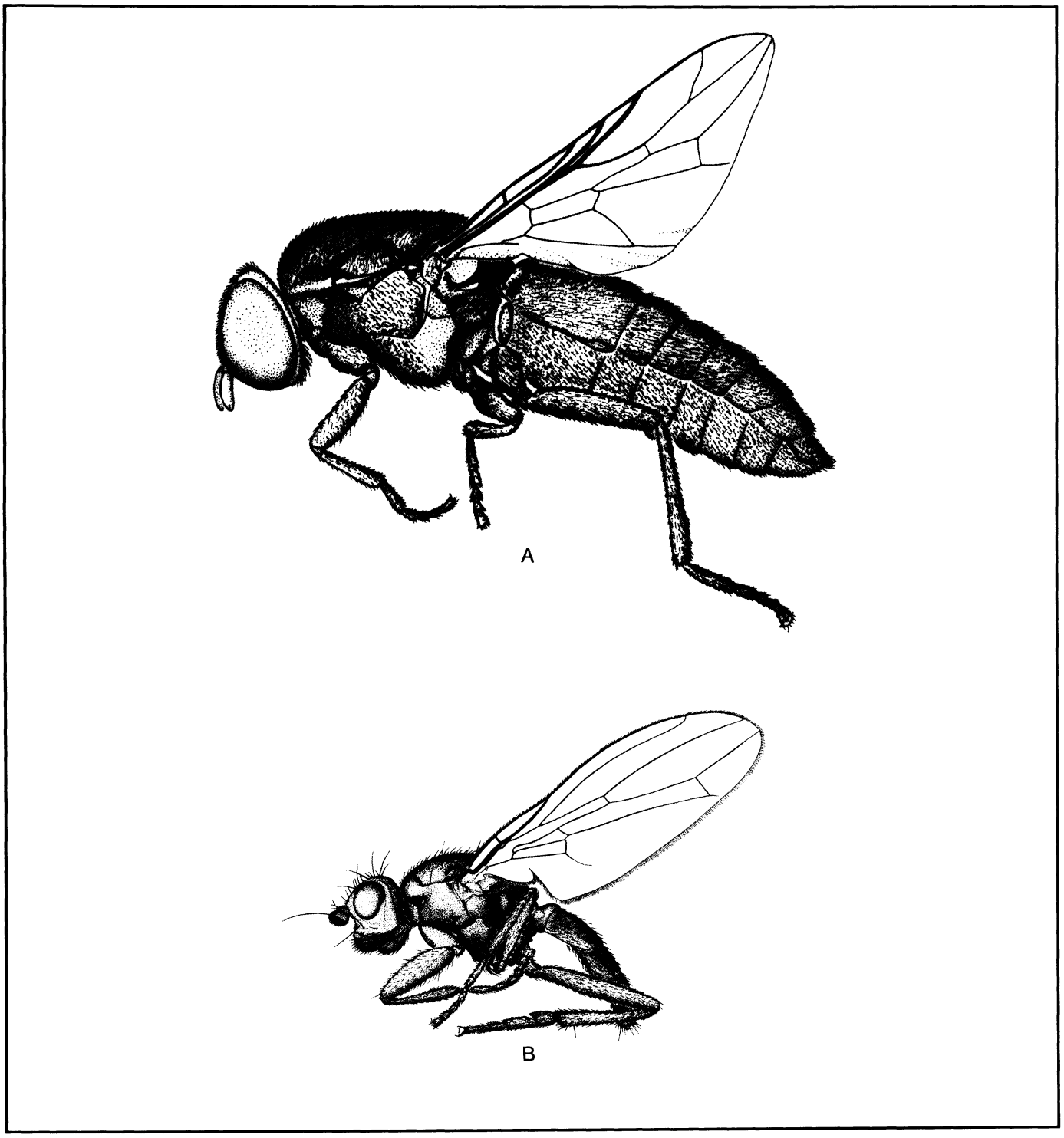


Plate 125. Scenopinid and sphaerocerid flies: A, *Scenopinus* sp. (Scenopinidae), adult (6); B, *Leptocera* sp. (Sphaeroceridae), adult (3).

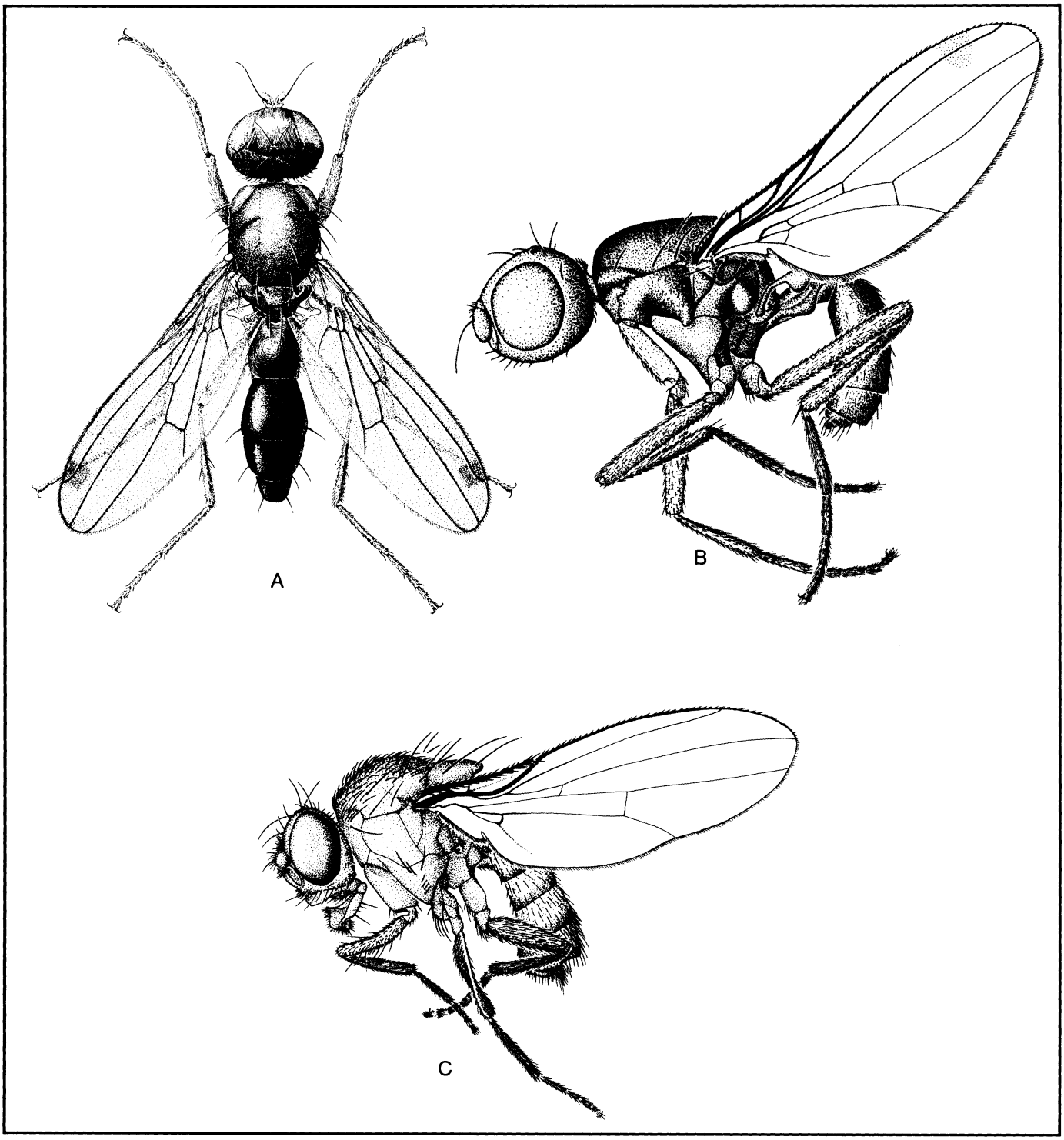


Plate 126. Sepsid and drosophilid flies: A, *Sepsis* sp. (Sepsidae), female (4), dorsal view (drawing by A.D. Cushman); B, same, lateral view; C, *Drosophila* sp. (Drosophilidae), adult (2.5).

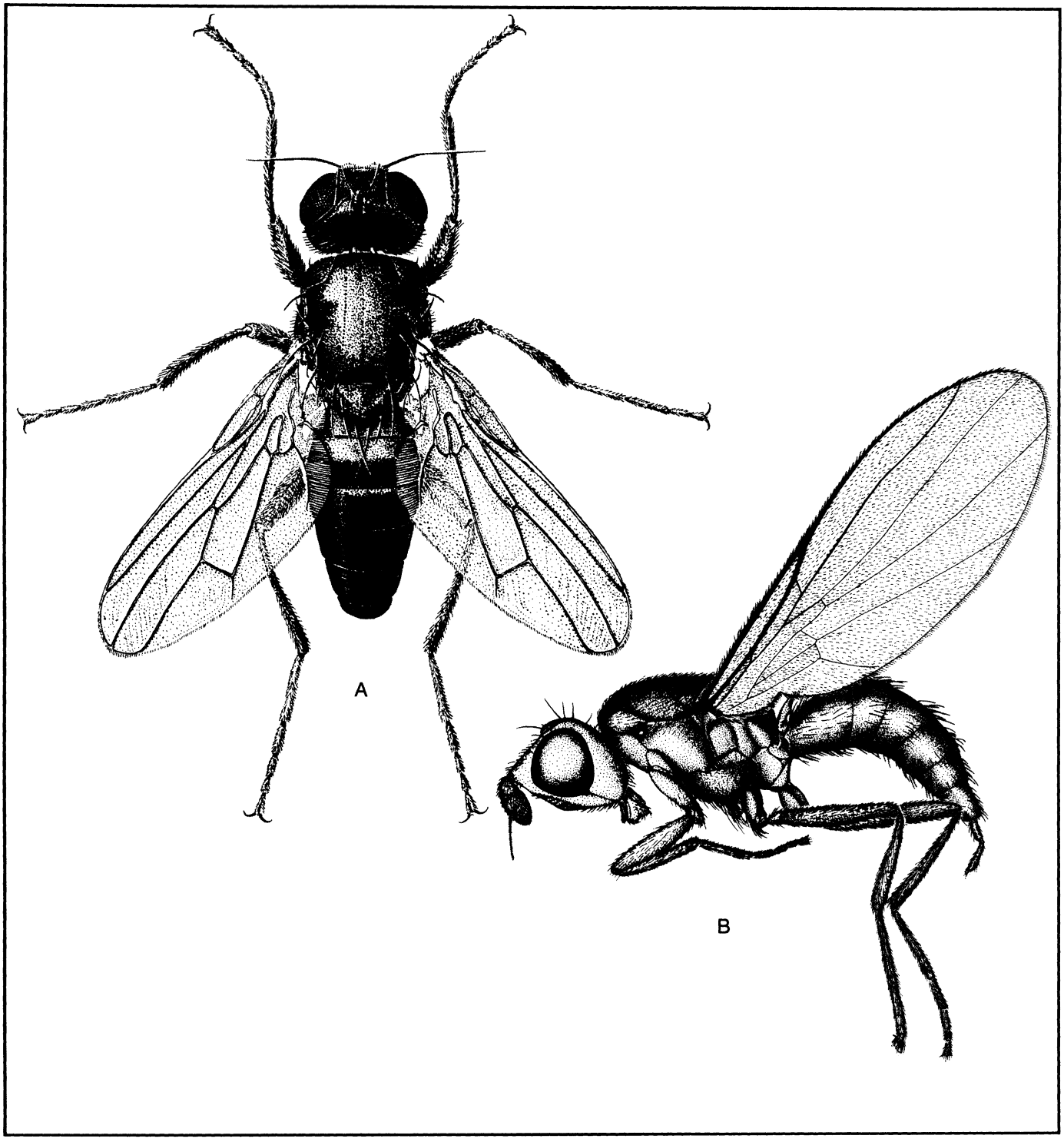


Plate 127. Piophilid and psilid flies: A, **cheese skipper,** *Piophila casei* (Piophilidae), female (2.5-4) (drawing by A.D. Cushman); B, **carrot rust fly,** *Psila rosae* (Psilidae), adult (3).

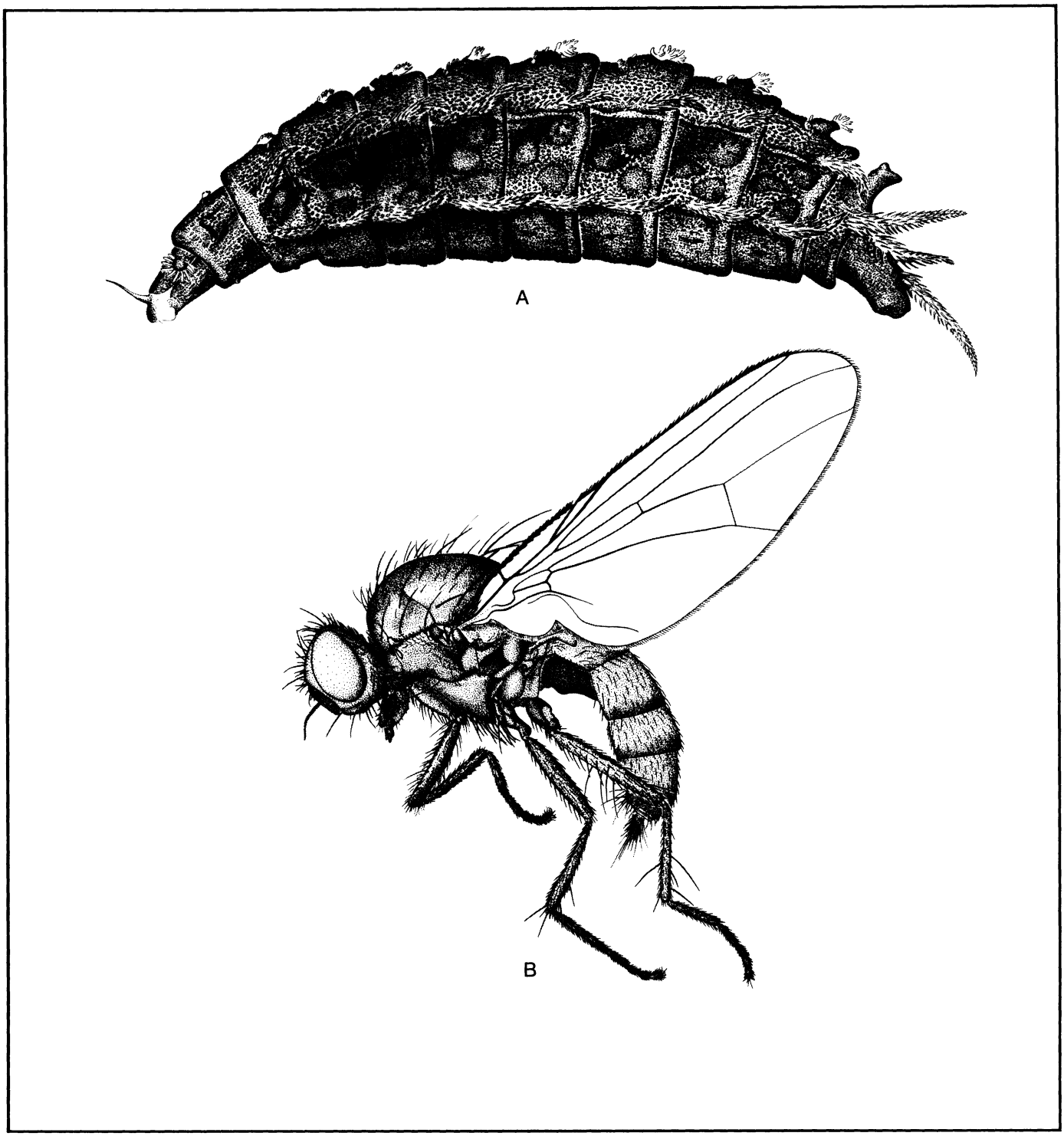


Plate 128. **Little house fly,** *Fannia canicularis* (Muscidae): A, larva (5-8); B, adult (5-7).

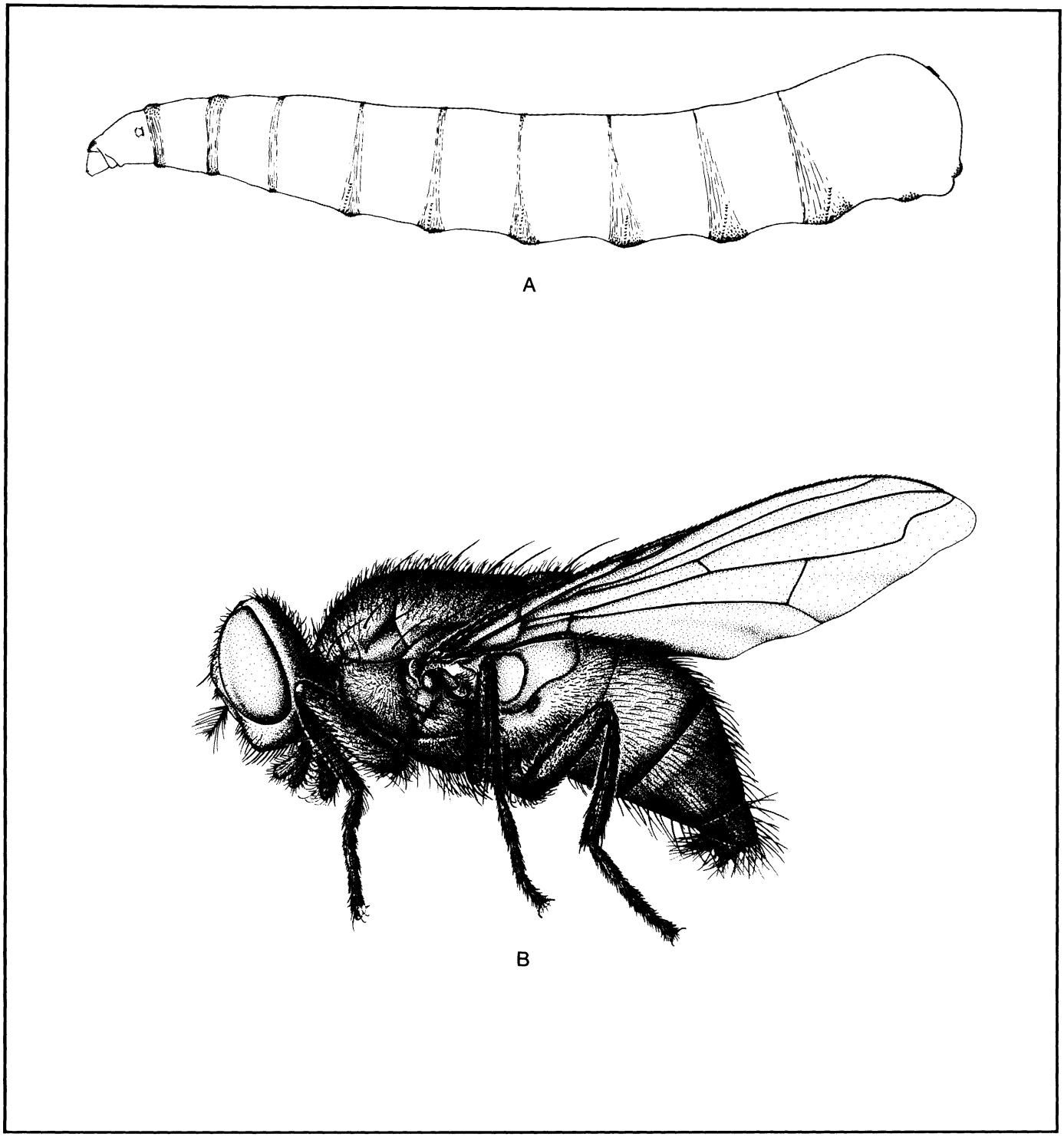


Plate 129. **House fly,** *Musca domestica* (Muscidae): A, larva (10-13); B, adult (6-9).

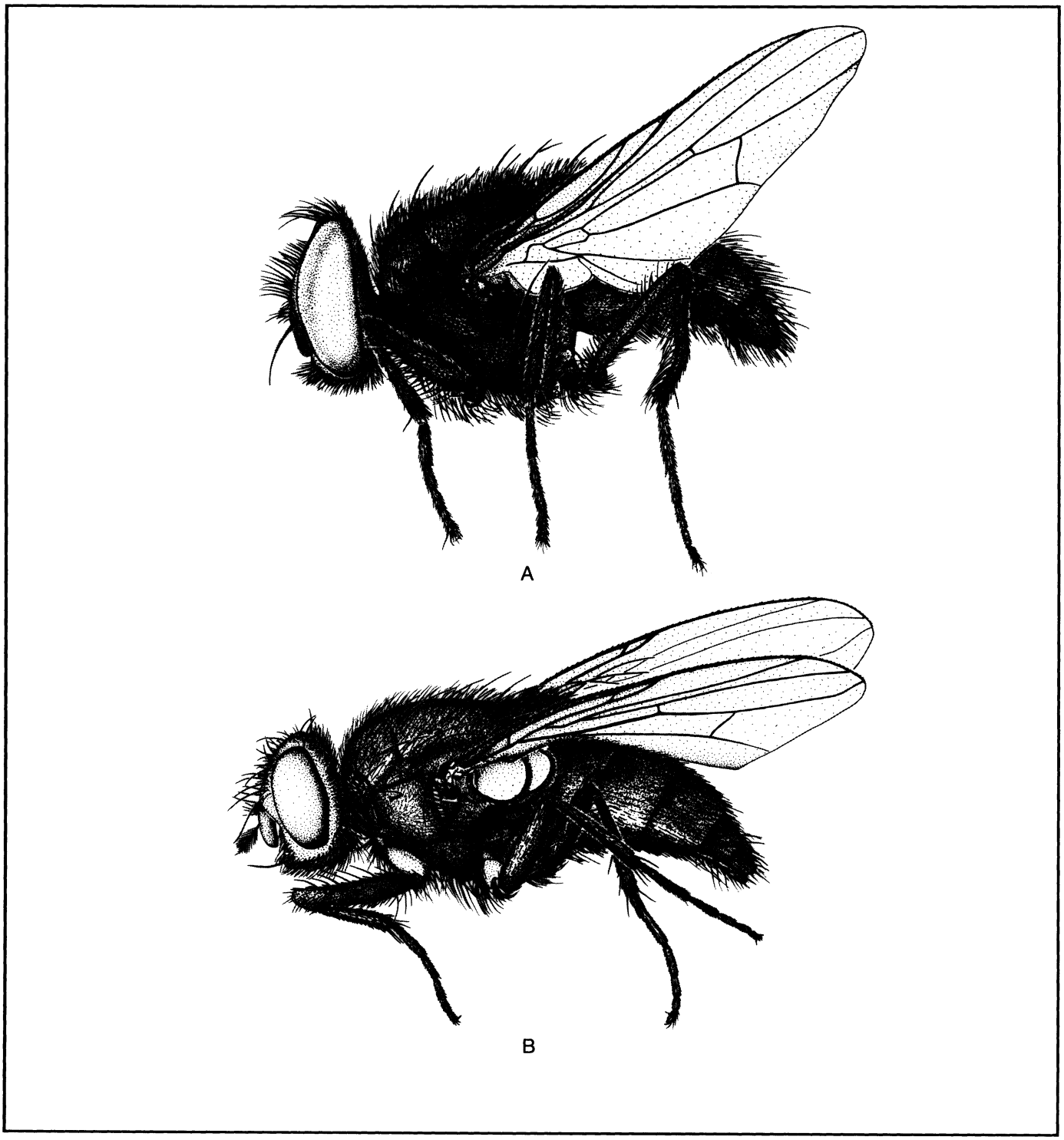
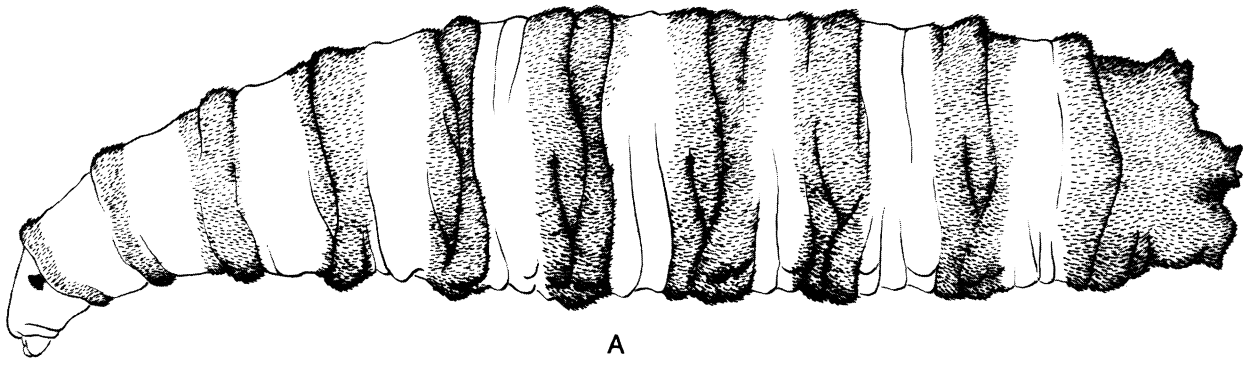
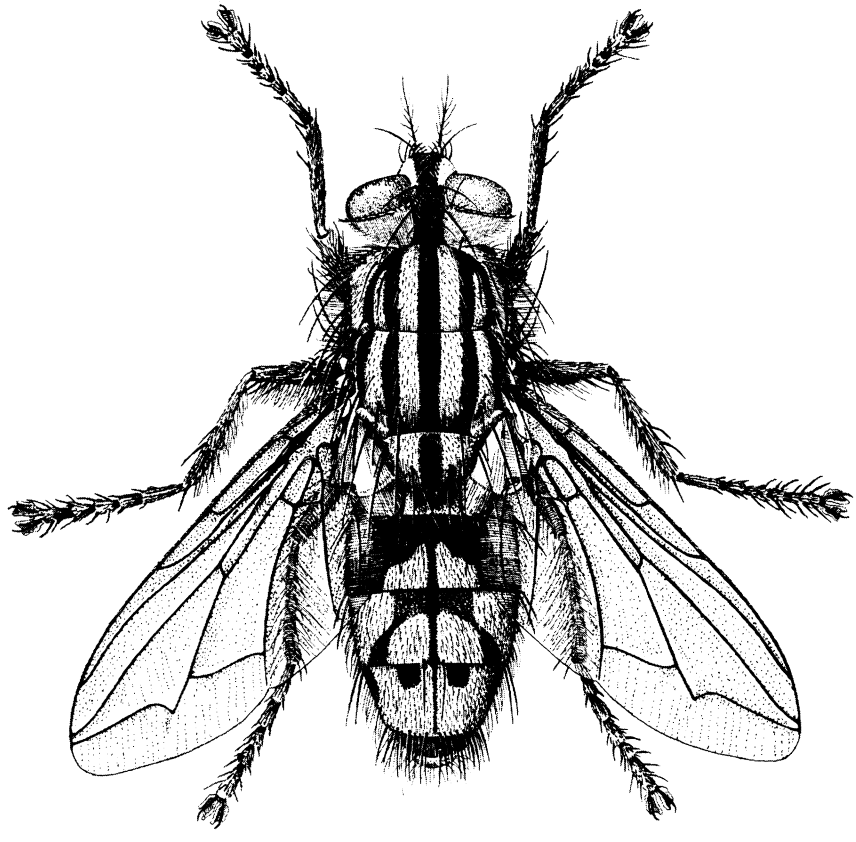


Plate 130. Muscid flies (Muscidae). A, bronze dump fly, *Ophyra aenescens,* adult (7); B, **false stable fly,** *Muscina stabulans,* adult (8).

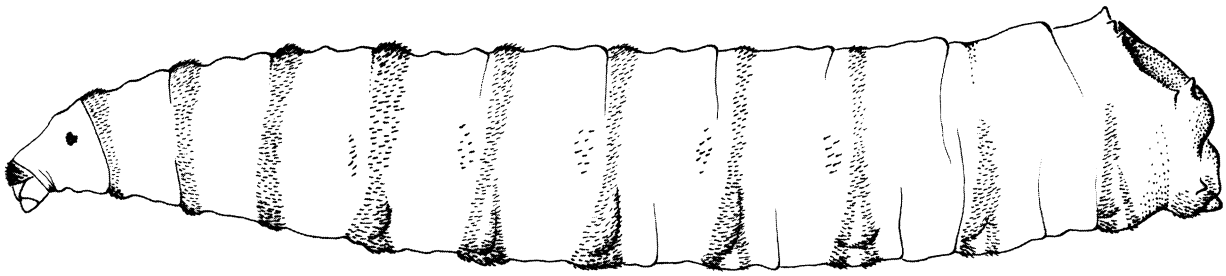


A

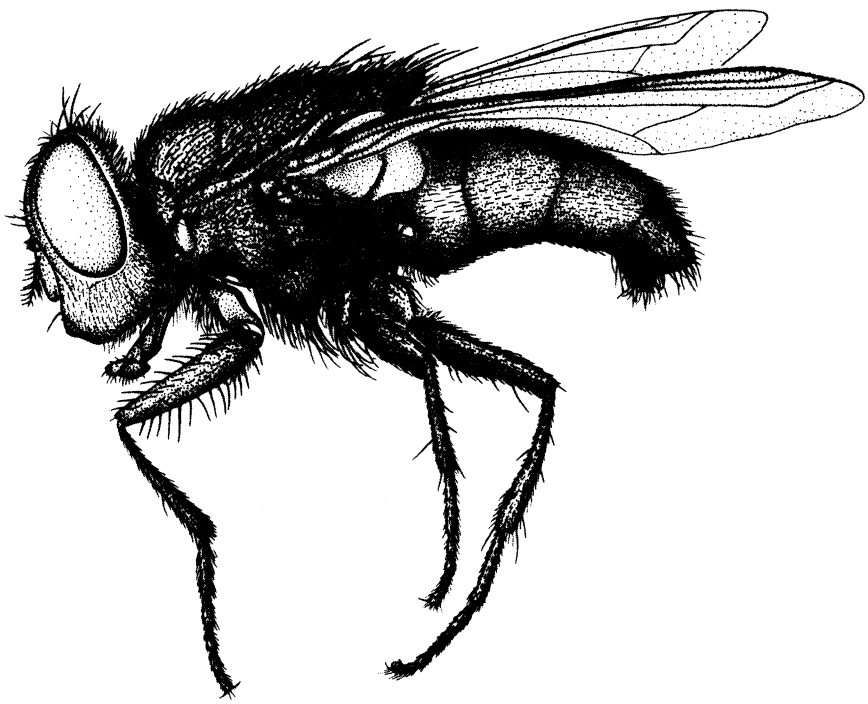


B

Plate 131. **Flesh flies,** *Sarcophaga* spp. (Sarcophagidae): A, *Sarcophaga* sp., larva (15-20); B, redtailed flesh fly, *Sarcophaga haemorrhoidalis,* adult (10-14) (drawing by A.D. Cushman).



A



B

Plate 132. **Secondary screwworm,** *Cochliomyia macellaria* (Calliphoridae): A, larva (12-15); B, adult (8-10).

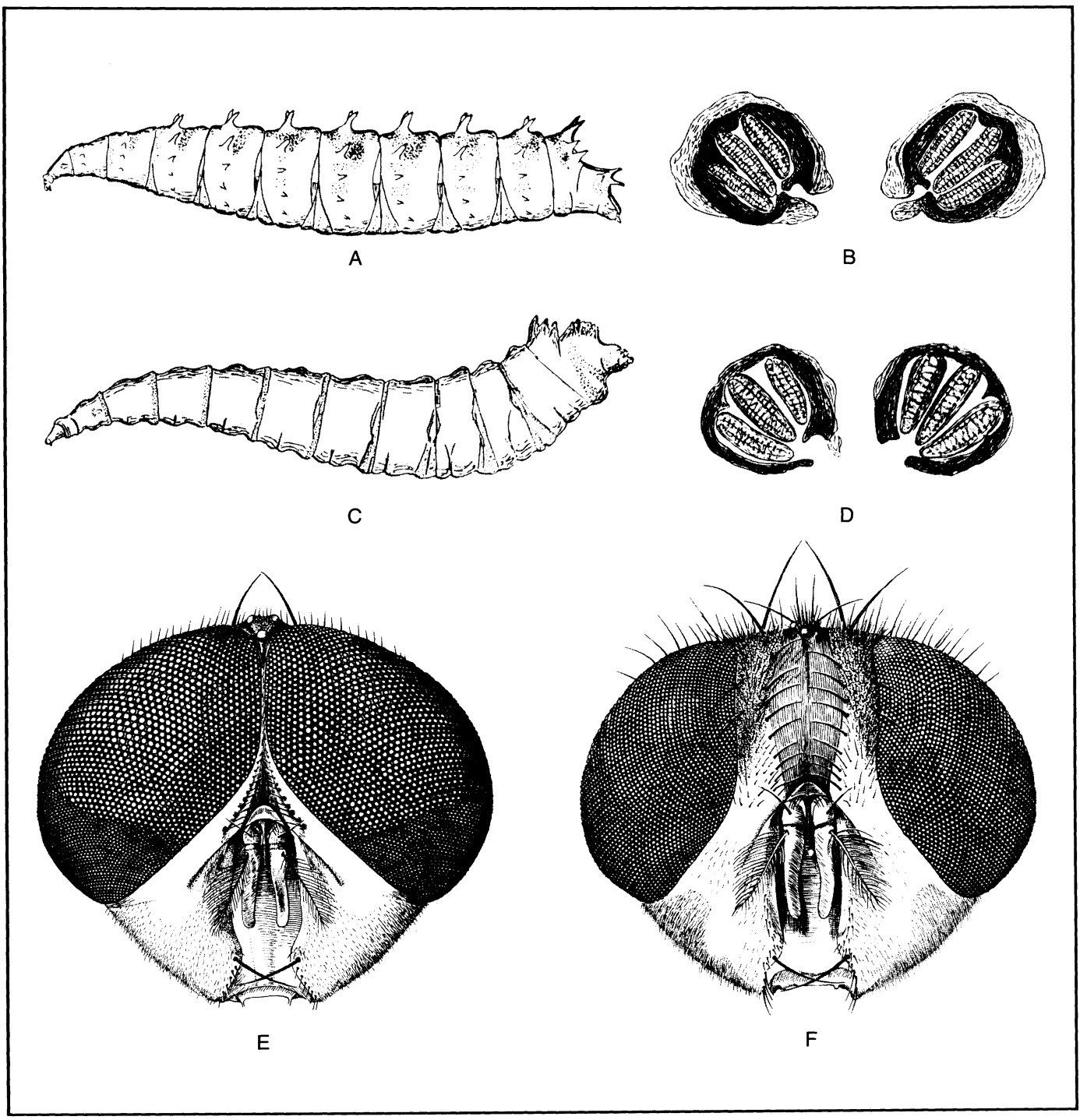


Plate 133. Old World screwworm flies, *Chrysomya* spp. (Calliphoridae) (drawings from 2): A, *Chrysomya albiceps,* larva (14-18); B, same, posterior spiracles; C, *Chrysomya chloropyga,* larva (12); D, same, posterior spiracles; E, *Chrysomya megacephala,* face of male; F, same, face of female.

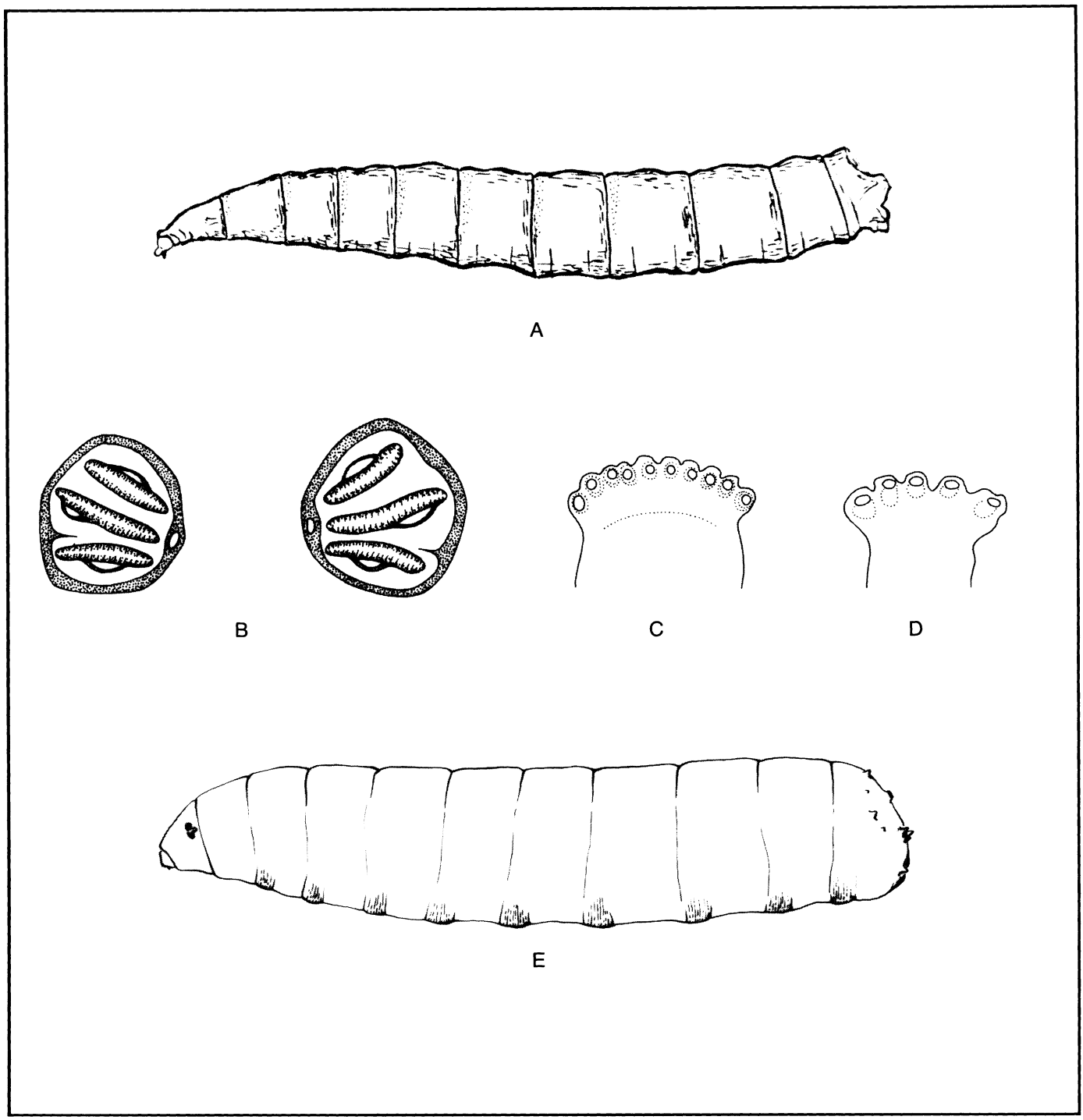
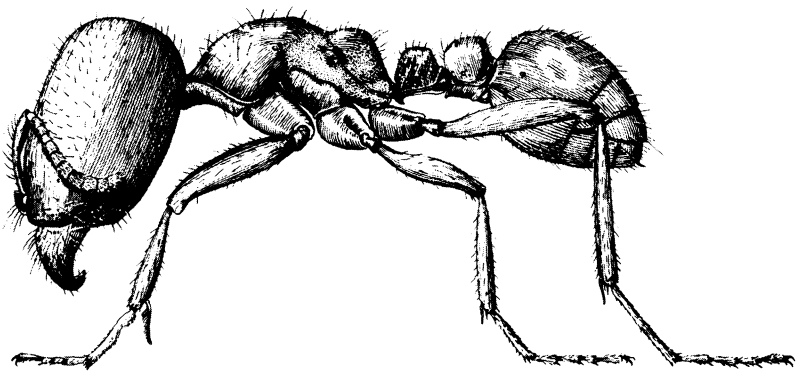


Plate 134. Calliphorid and anthomyiid flies: A, green bottle fly, *Phaenicia sericata* (Calliphoridae), larva (10-15) (drawing from *2*); B, same, posterior spiracles; C, same, anterior spiracle; D, bronze bottle fly, *Phaenicia cuprina,* anterior spiracle of larva; E, *Hylemya* sp. (Anthomyiidae), larva (10).

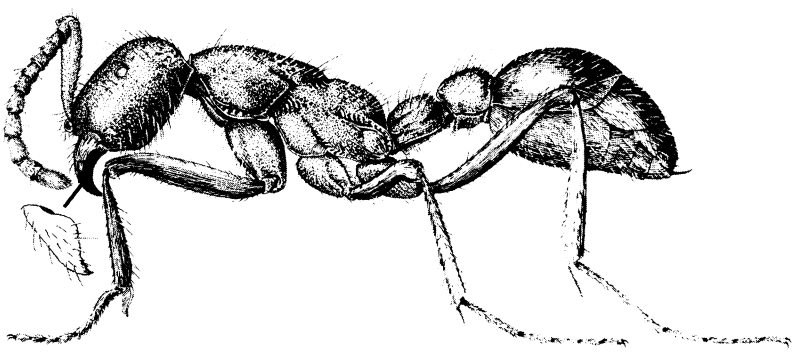
Notes and Sketches

WORKER ANTS (FORMICIDAE)

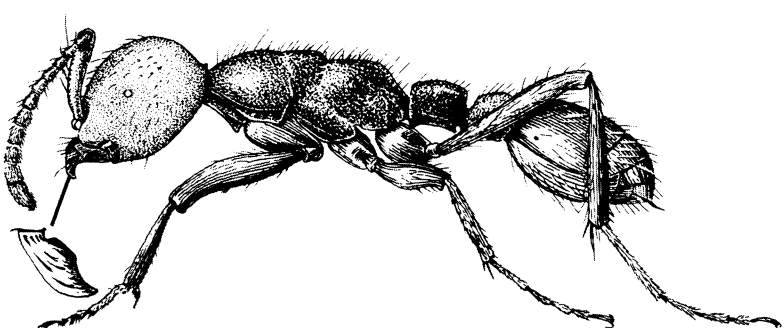
This series of illustrations, drawn by A.D. Cushman unless otherwise noted, is a continuation of chapter 17 (Ants), by D.R. Smith.



A

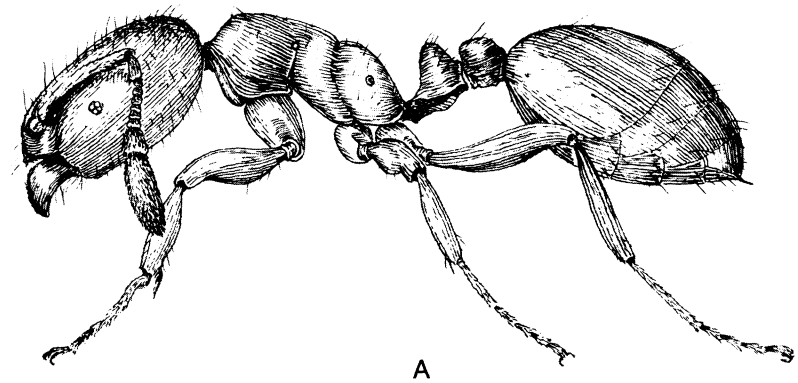


B

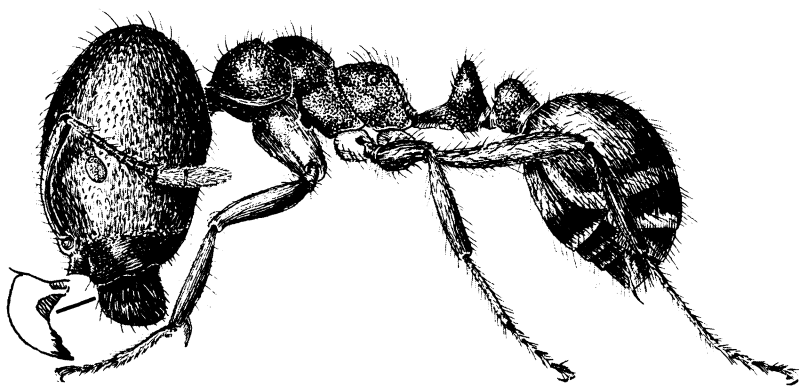


C

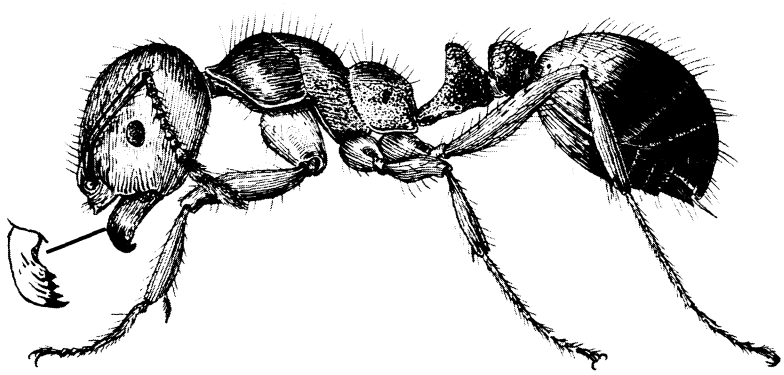
Plate 135. Army ants (Dorylinae, Formicidae): A, *Labidus coecus* (2.9-9.7); B, *Neivamyrmex nigrescens* (2.8-5.8); C, *Neivamyrmex opacithorax* (2.2-4.6).



A



B



C

Plate 136. Myrmicine ants (Myrmicinae, Formicidae): A, **thief ant,** *Solenopsis molesta* (1.3-1.8); B, **fire ant,** *Solenopsis geminata* (2.4-6); C, **red imported fire ant,** *Solenopsis invicta* (2.8-6).

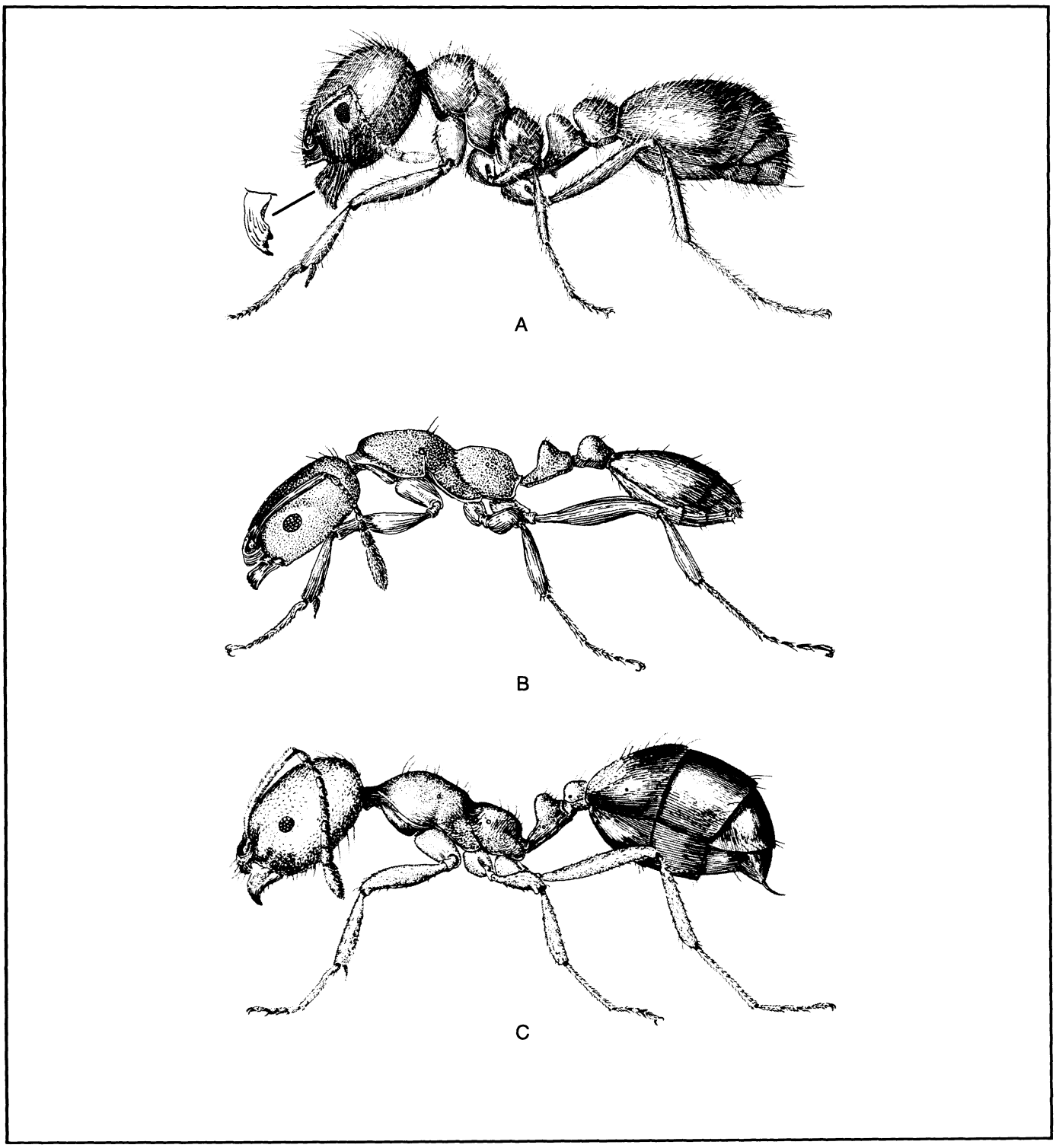


Plate 137. Myrmicine ants (Myrmicinae, Formicidae): A, **southern fire ant,** *Solenopsis xyloni* (1.6-5.8); B, **pharaoh ant,** *Monomorium pharaonis* (2); C, *Monomorium destructor* (1.8-3).

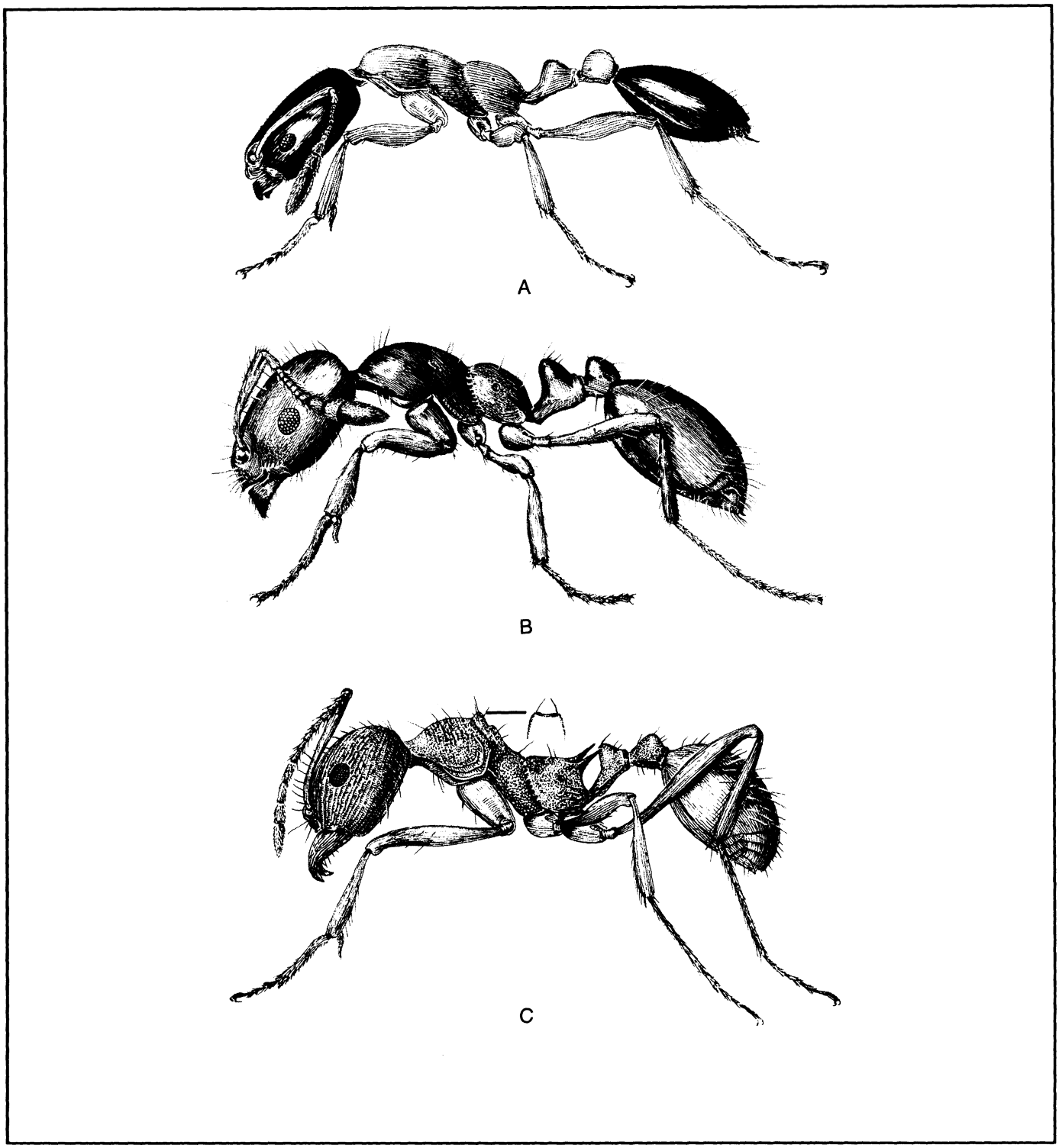


Plate 138. Myrmicine ants (Myrmicinae, Formicidae): A, *Monomorium floricola* (1.4-1.8); B, **little black ant,** *Monomorium minimum* (1.5-2); C, *Aphaenogaster fulva* (3.5-5.8).

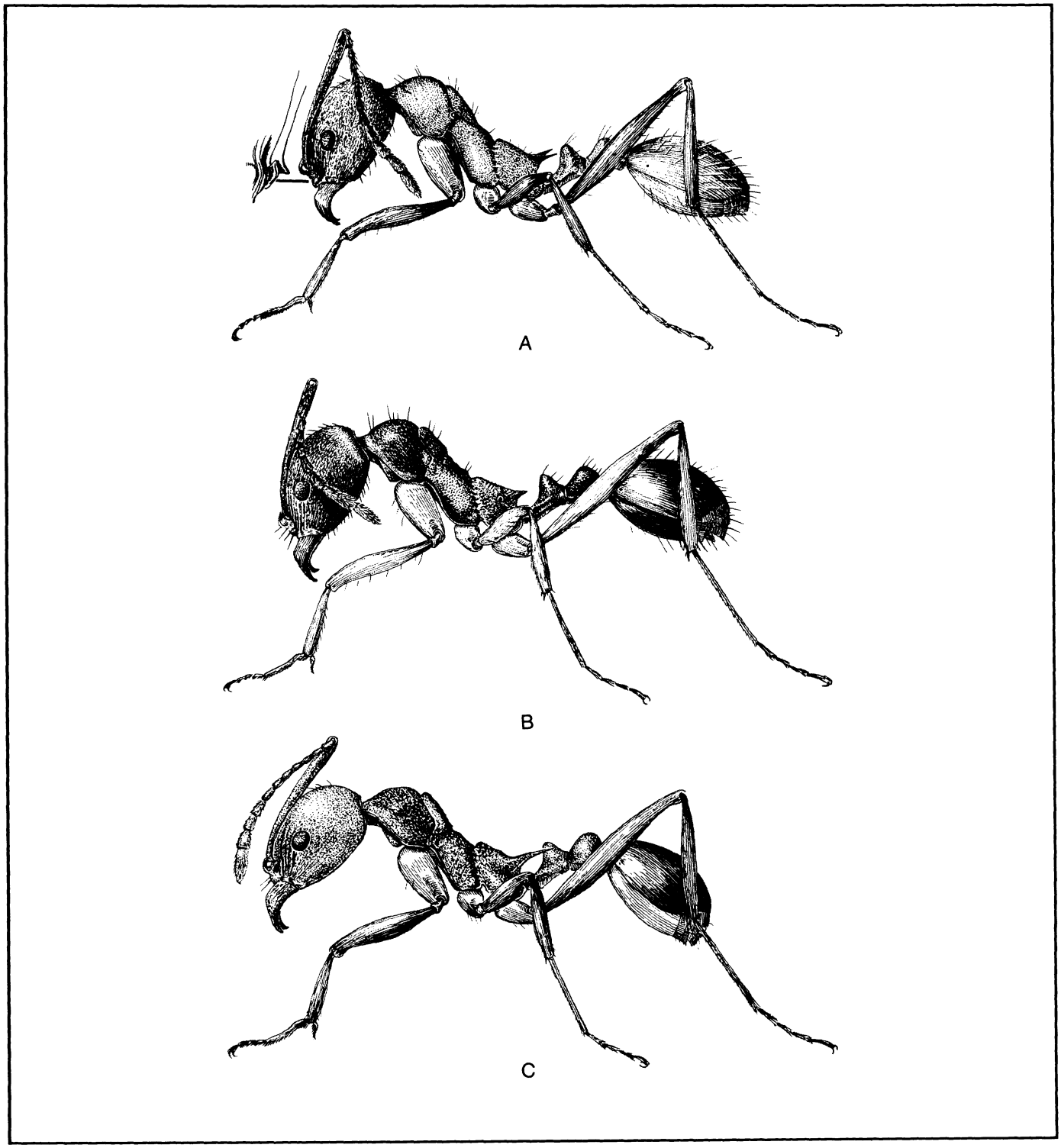


Plate 139. Myrmicine ants (Myrmicinae, Formicidae): A, *Aphaenogaster lamellidens* (4.1-6.5); B, *Aphaenogaster rudis* (4.5-5); C, *Aphaenogaster tennesseensis* (4.1-5.3).

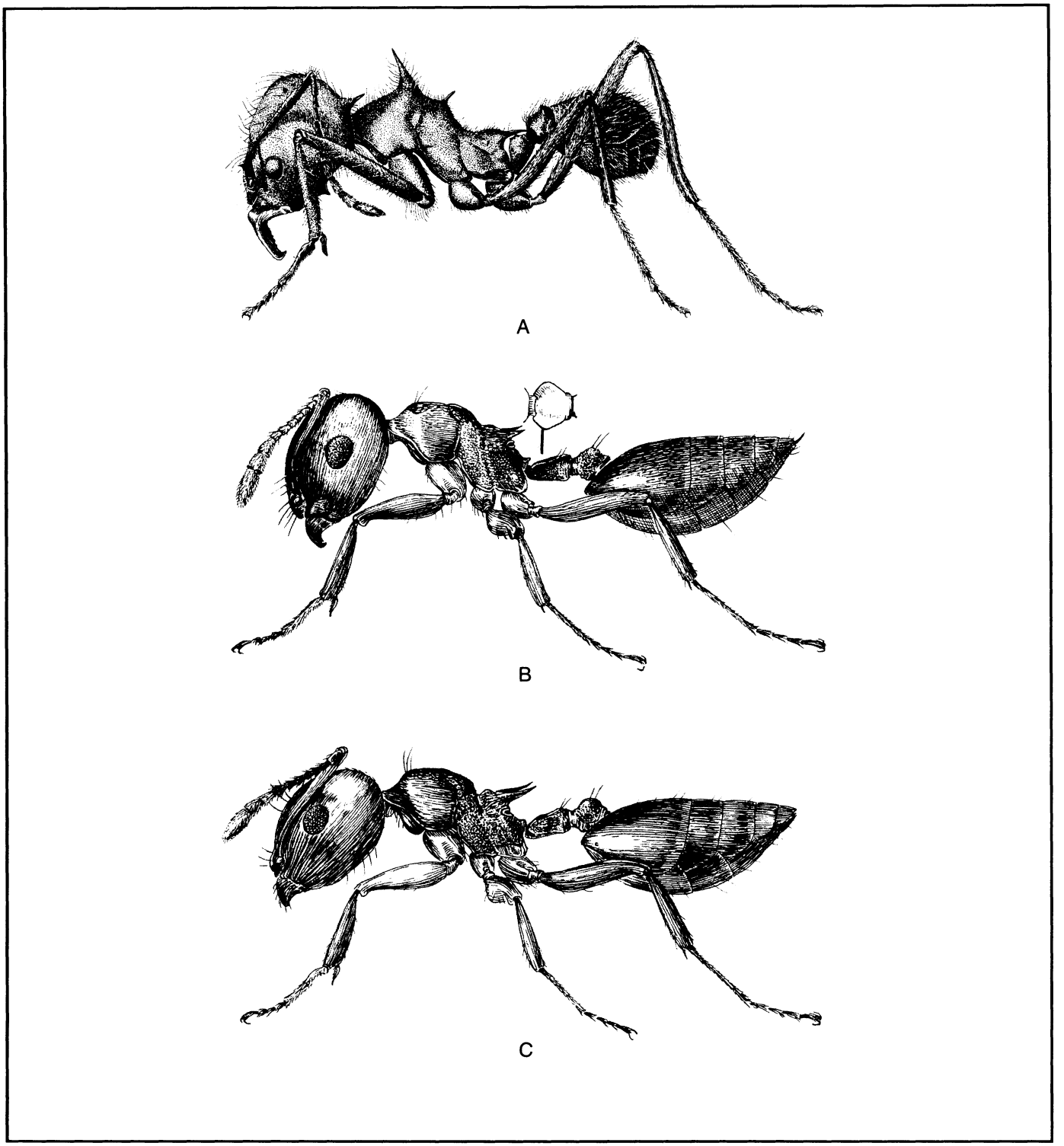


Plate 140. Myrmicine ants (Myrmicinae, Formicidae): A, **Texas leafcutting ant,** *Atta texana* (1.5-12); B, *Crematogaster ashmeadi* (2.6-3.2); C, *Crematogaster cerasi* (2.6-4).

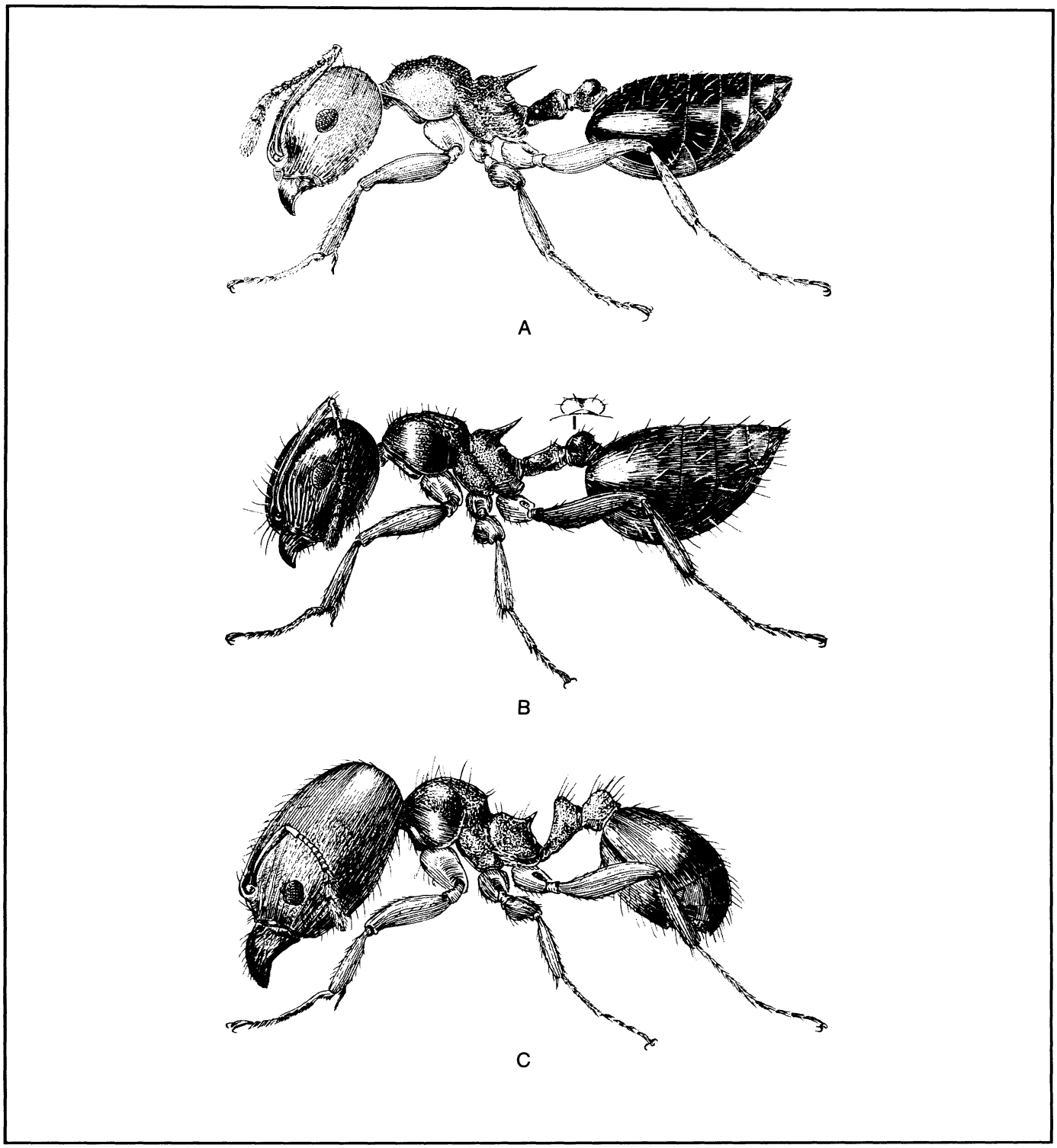
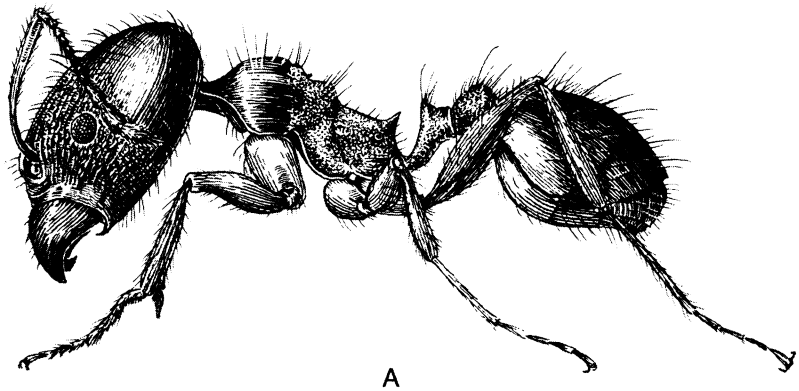
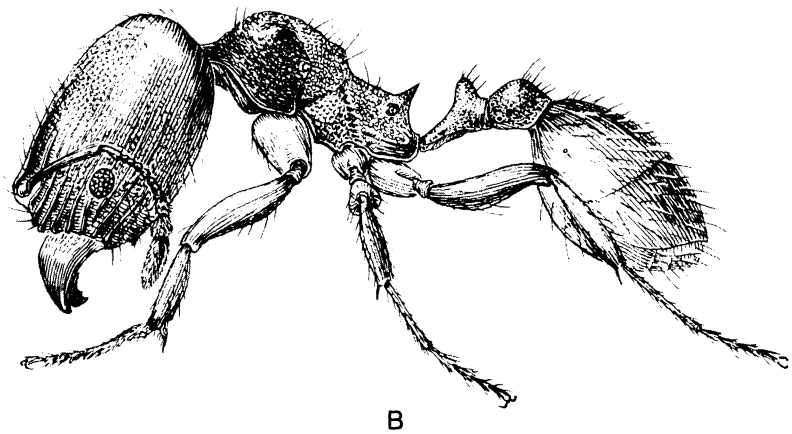


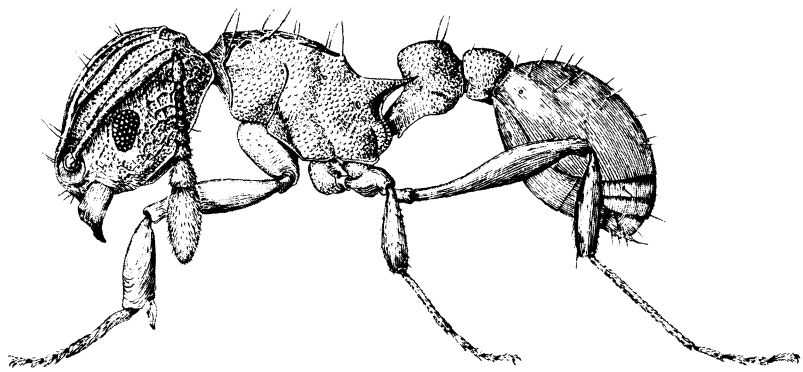
Plate 141. Myrmicine ants (Myrmicinae, Formicidae): A, *Crematogaster clara* (3.3-4); B, *Crematogaster lineolata* (2.5-3.5); C, *Pheidole bicarinata vinelandica* (1.6-3).



A



B



C

Plate 142. Myrmicine ants (Myrmicinae, Formicidae): A, *Pheidole dentata* (2.4-3.8); B, *Pheidole floridana* (1.5-2.6); C, **little fire ant,** *Ochetomyrmex auropunctatus* (1.5).

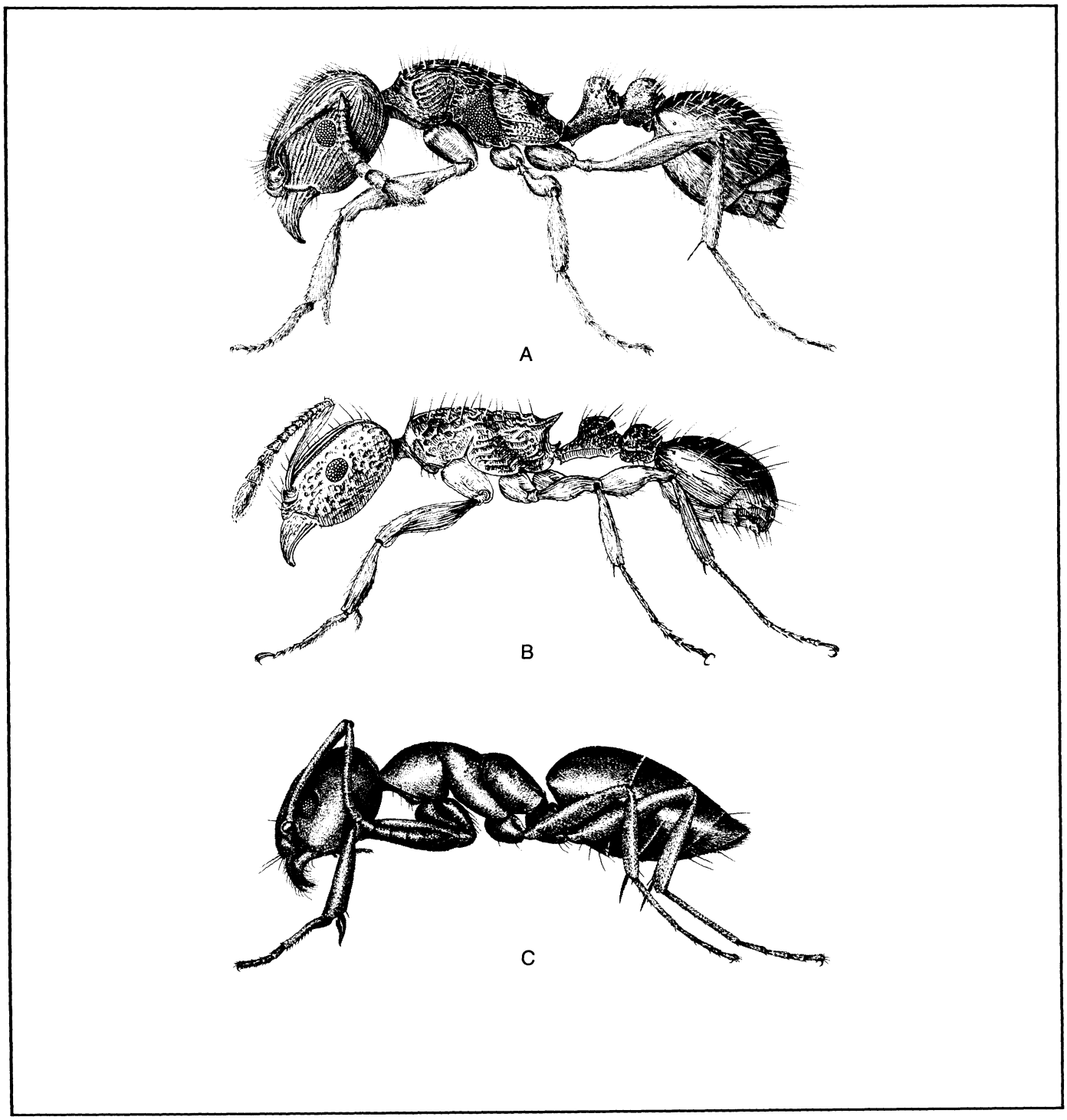


Plate 143. Myrmicine and dolichoderine ants (Formicidae): A, **pavement ant,** *Tetramorium caespitum* (2.5-3) (Myrmicinae); B, **Guinea ant,** *Tetramorium bicarinatum* (3-3.5) (Myrmicinae); C, **odorous house ant,** *Tapinoma sessile* (2.4-3.2) (Dolichoderinae) (drawing by S.H. DeBord).

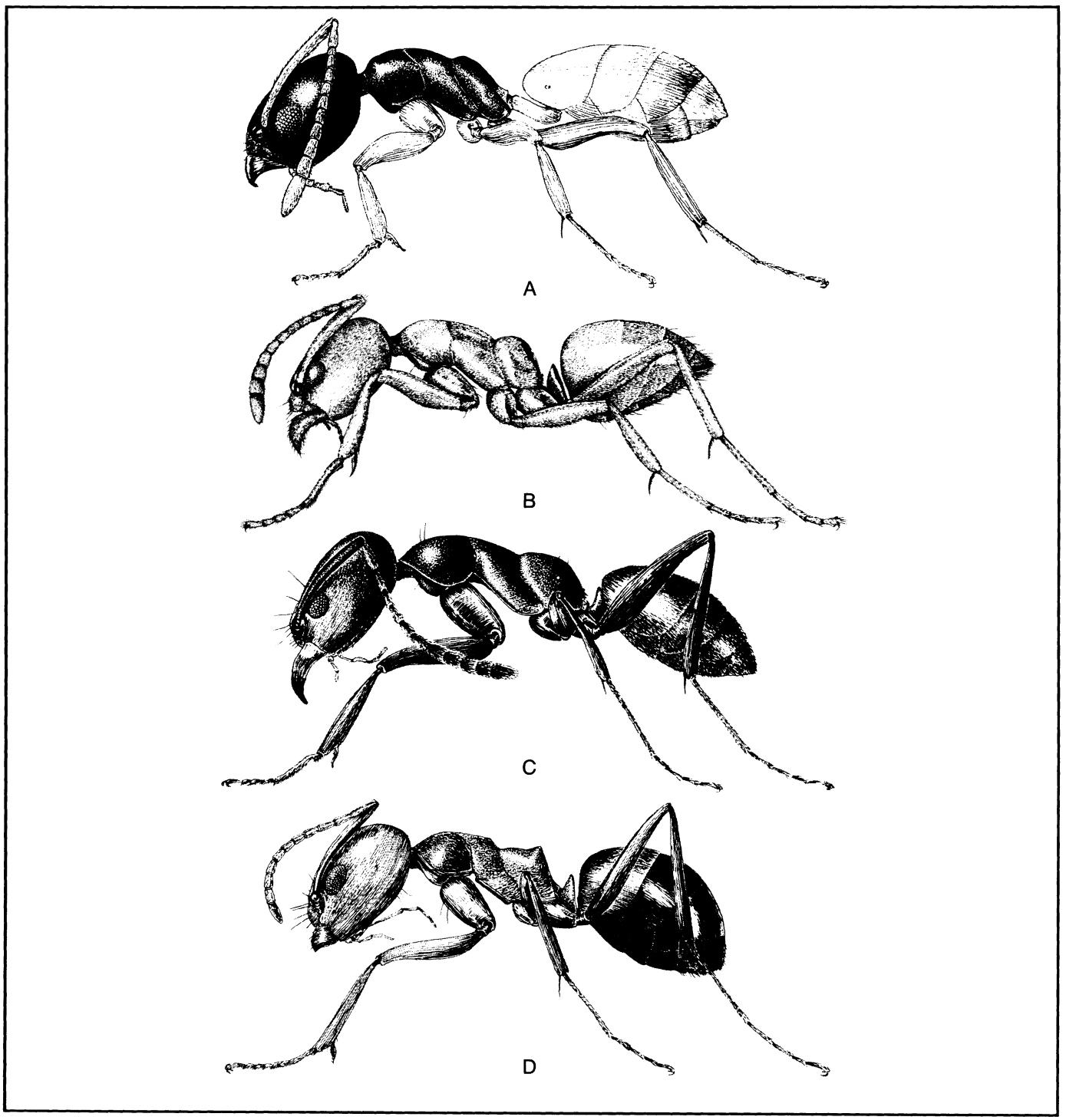


Plate 144. Dolichoderine ants (Dolichoderinae, Formicidae): A, *Tapinoma melanocephalum* (1.3-1.5); B, **Argentine ant,** *Iridomyrmex humilis* (2.2-2.6) (drawing by S.H. DeBord); C, *Iridomyrmex pruinosus* (1.8-2.5); D, **pyramid ant,** *Conomyrma insana* (3).

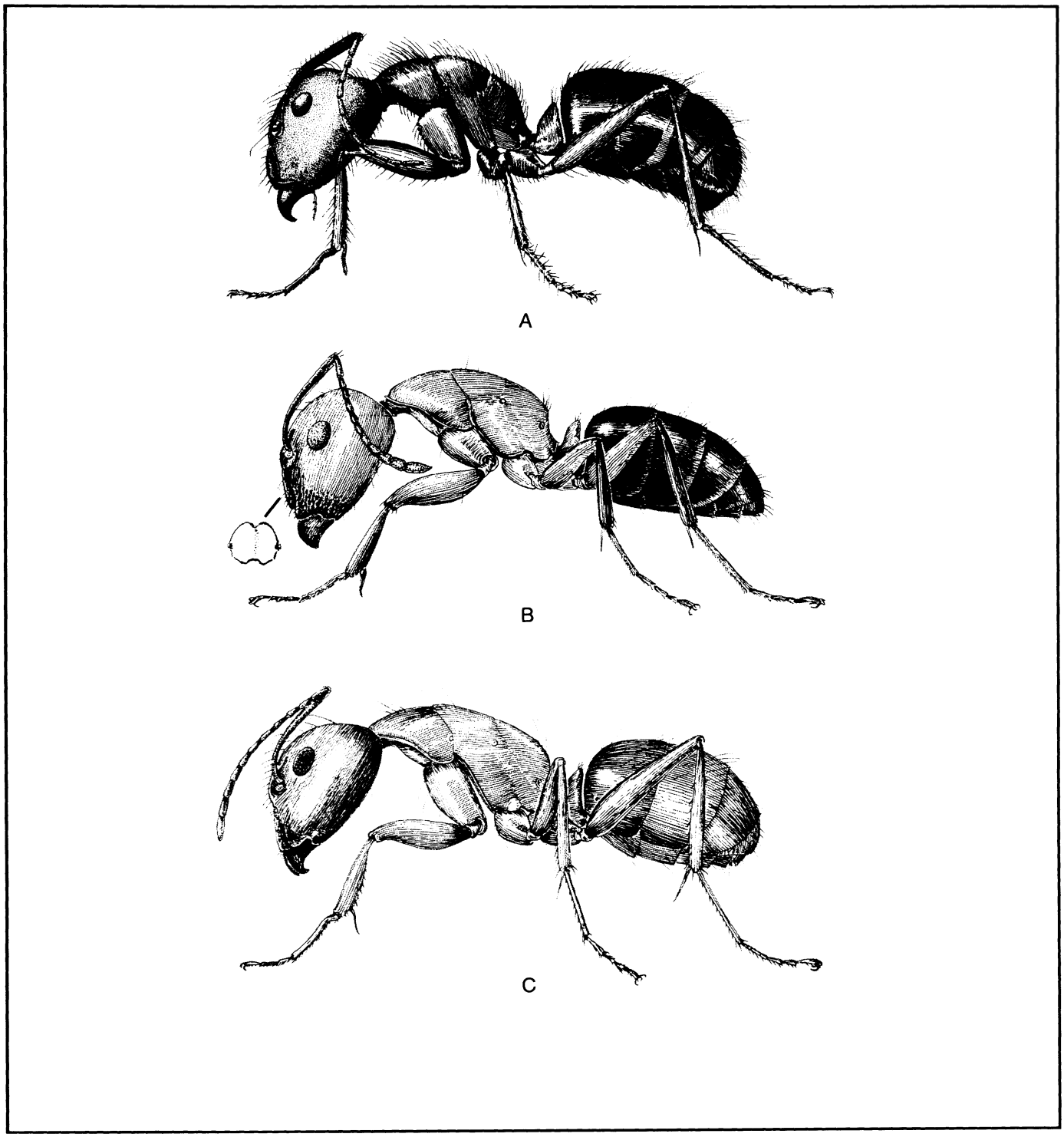


Plate 145. Carpenter ants (Formicinae, Formicidae): A, **Florida carpenter ant,** *Camponotus abdominalis* (5.5-10); B, *Camponotus caryae discolor* (3.5-7.5); C, *Camponotus castaneus* (7-10).

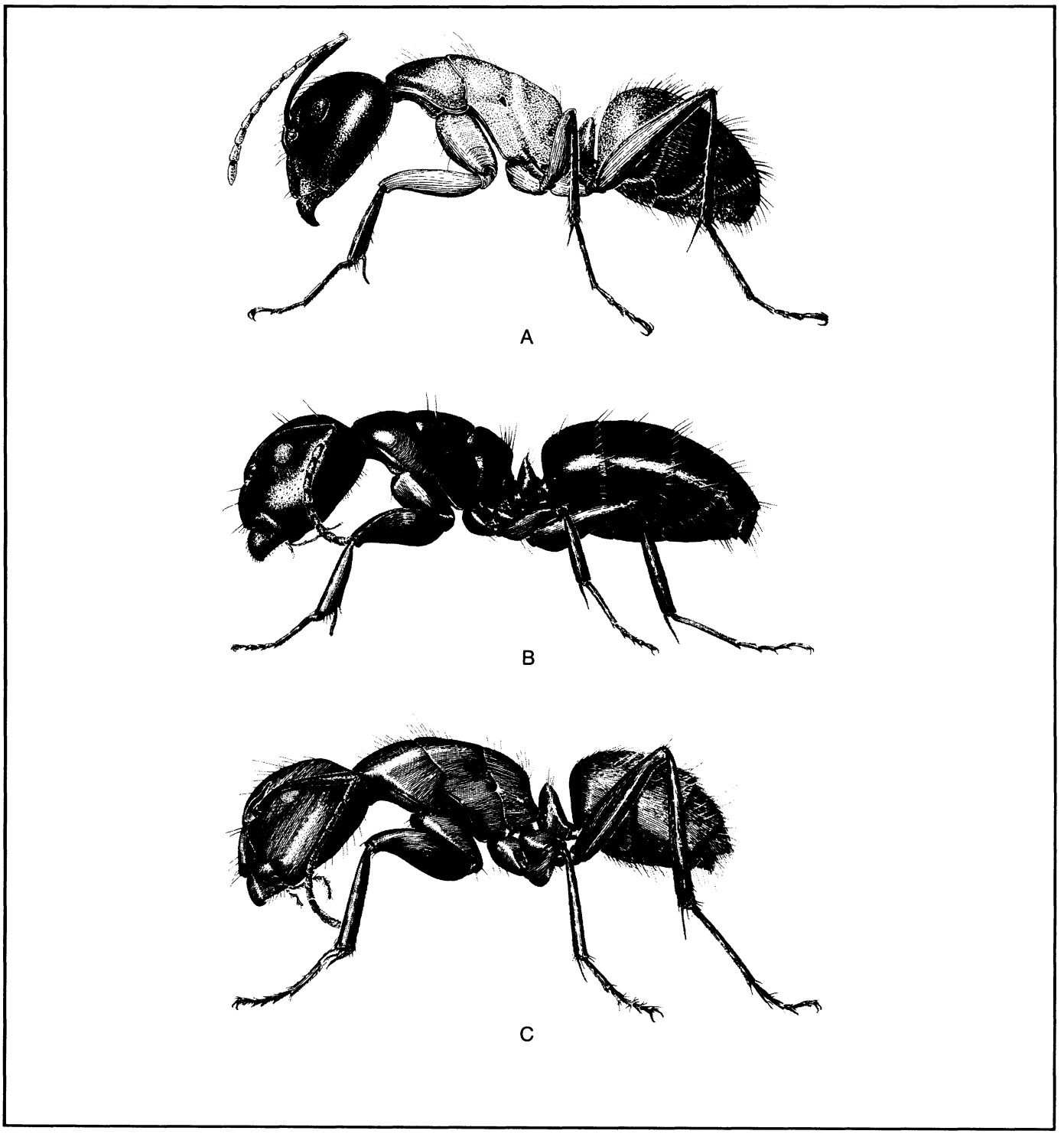


Plate 146. Carpenter ants (Formicinae, Formicidae): A, **red carpenter ant,** *Camponotus ferrugineus* (6-13); B, *Camponotus nearcticus* (4.5-7.5); C, **black carpenter ant,** *Camponotus pennsylvanicus* (6-13).

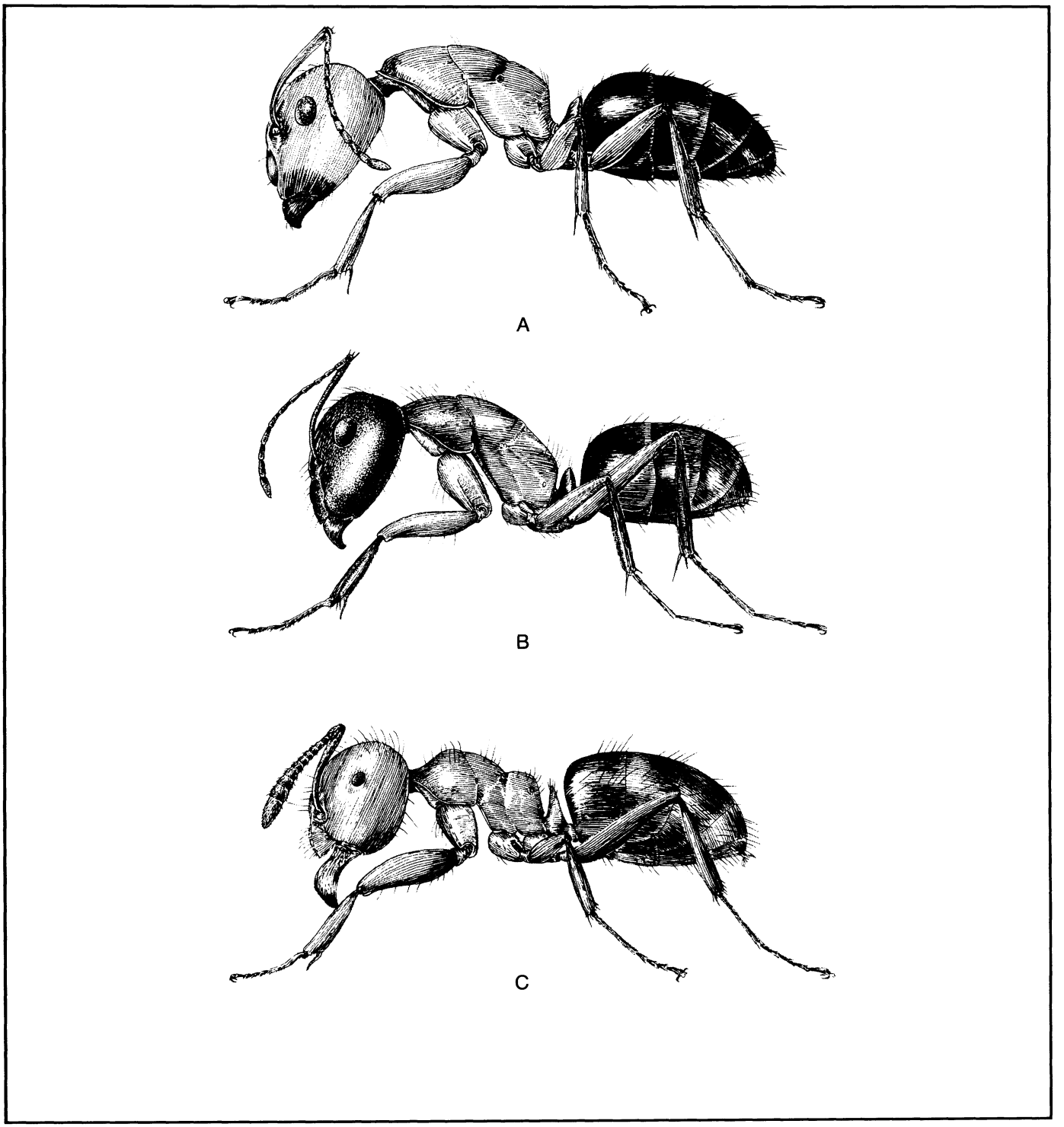


Plate 147. Formicine ants (Formicinae, Formicidae): A, carpenter ant, *Camponotus sayi* (4-9); B, carpenter ant, *Camponotus tortuganus* (6-11); C, **smaller yellow ant,** *Acanthomyops claviger* (3-4).

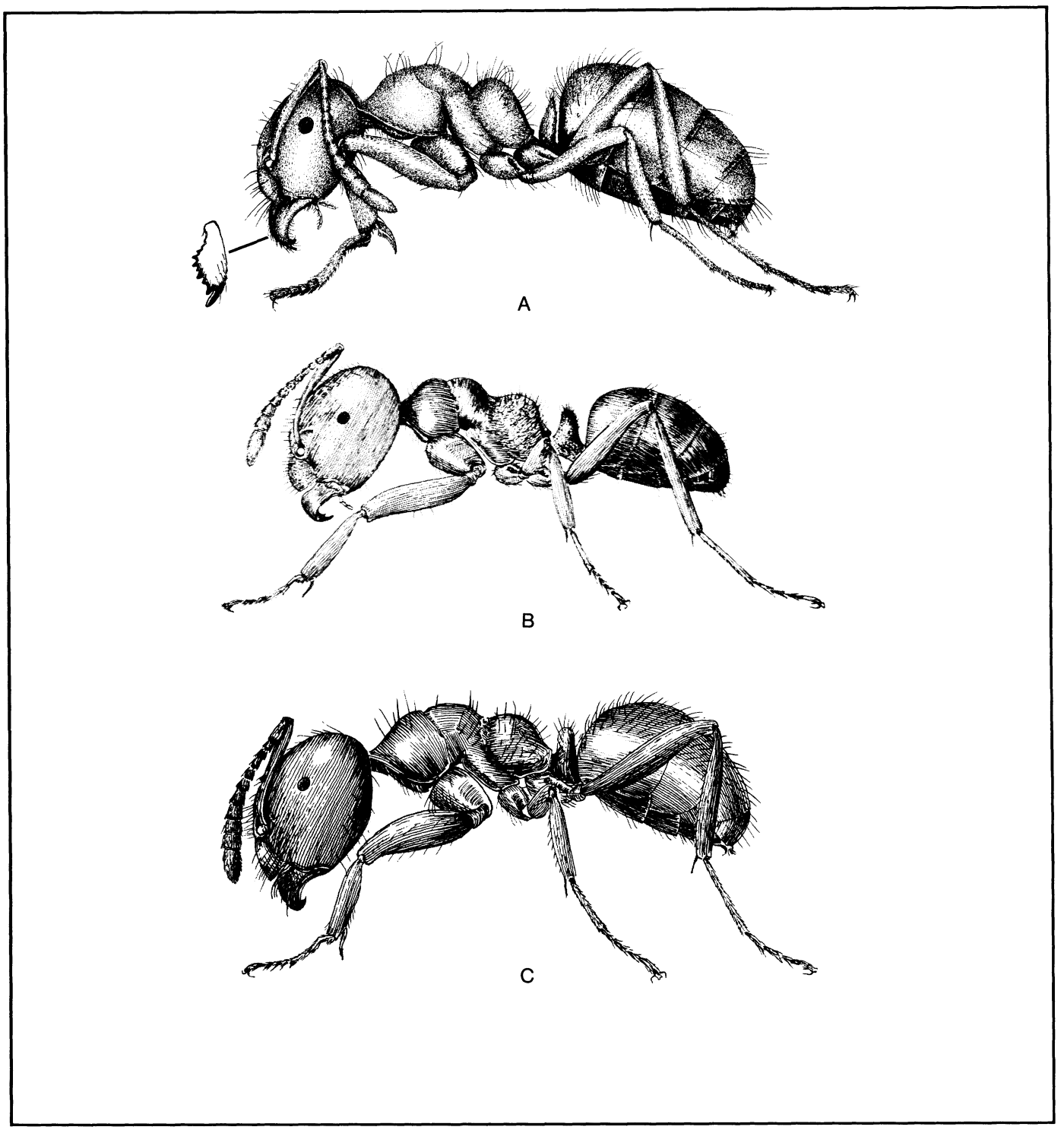


Plate 148. Formicine ants (Formicinae, Formicidae): A, **larger yellow ant,** *Acanthomyops interjectus* (4-4.5) (drawing by S.H. DeBord); B, *Acanthomyops murphyi* (3-3.7); C, *Acanthomyops latipes* (3.5-3.8).

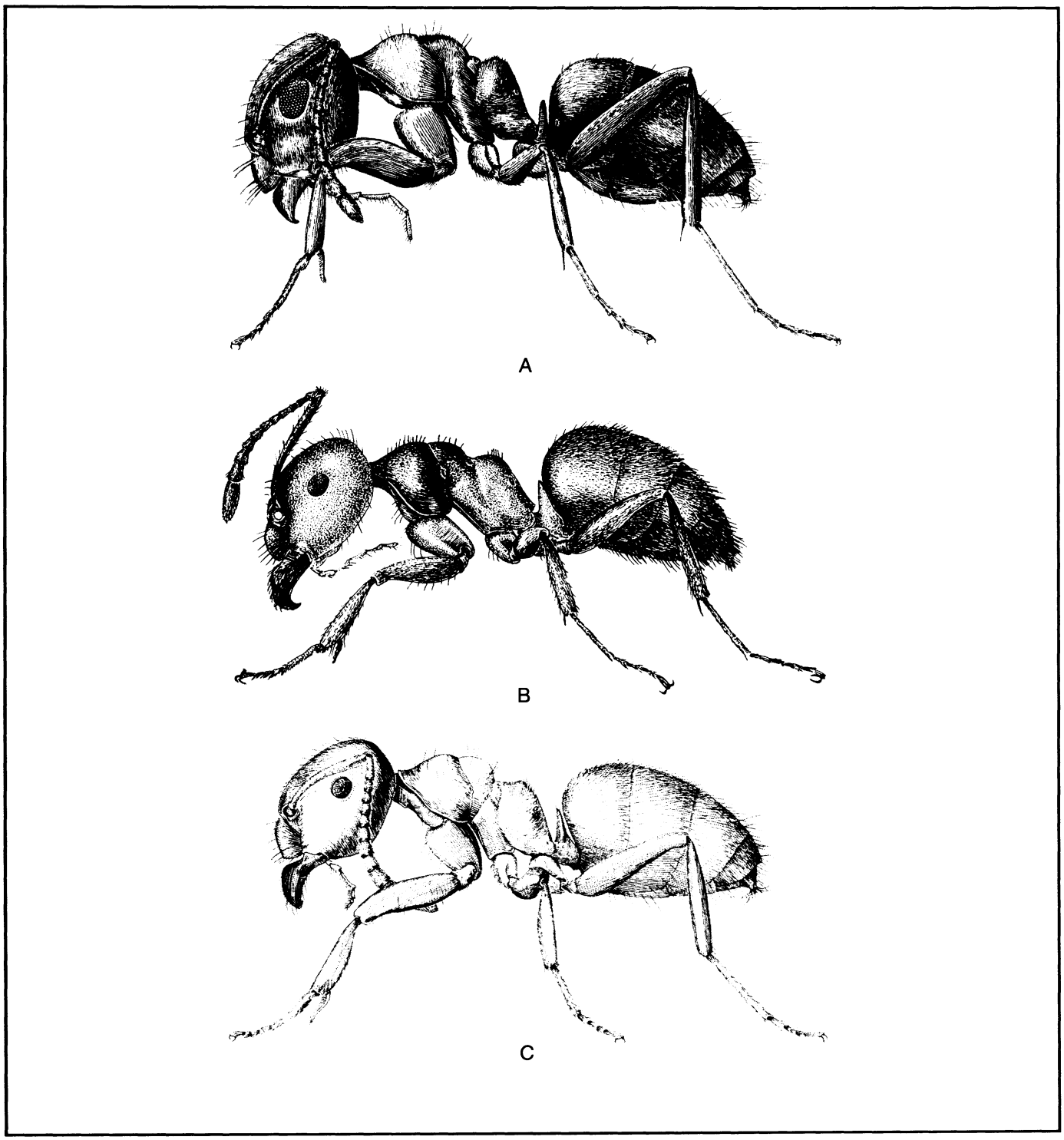


Plate 149. Formicine ants (Formicinae, Formicidae): A, **cornfield ant,** *Lasius alienus* (2-2.5); B, *Lasius neoniger* (2-2.5); C, *Lasius umbratus* (3.3-3.7).

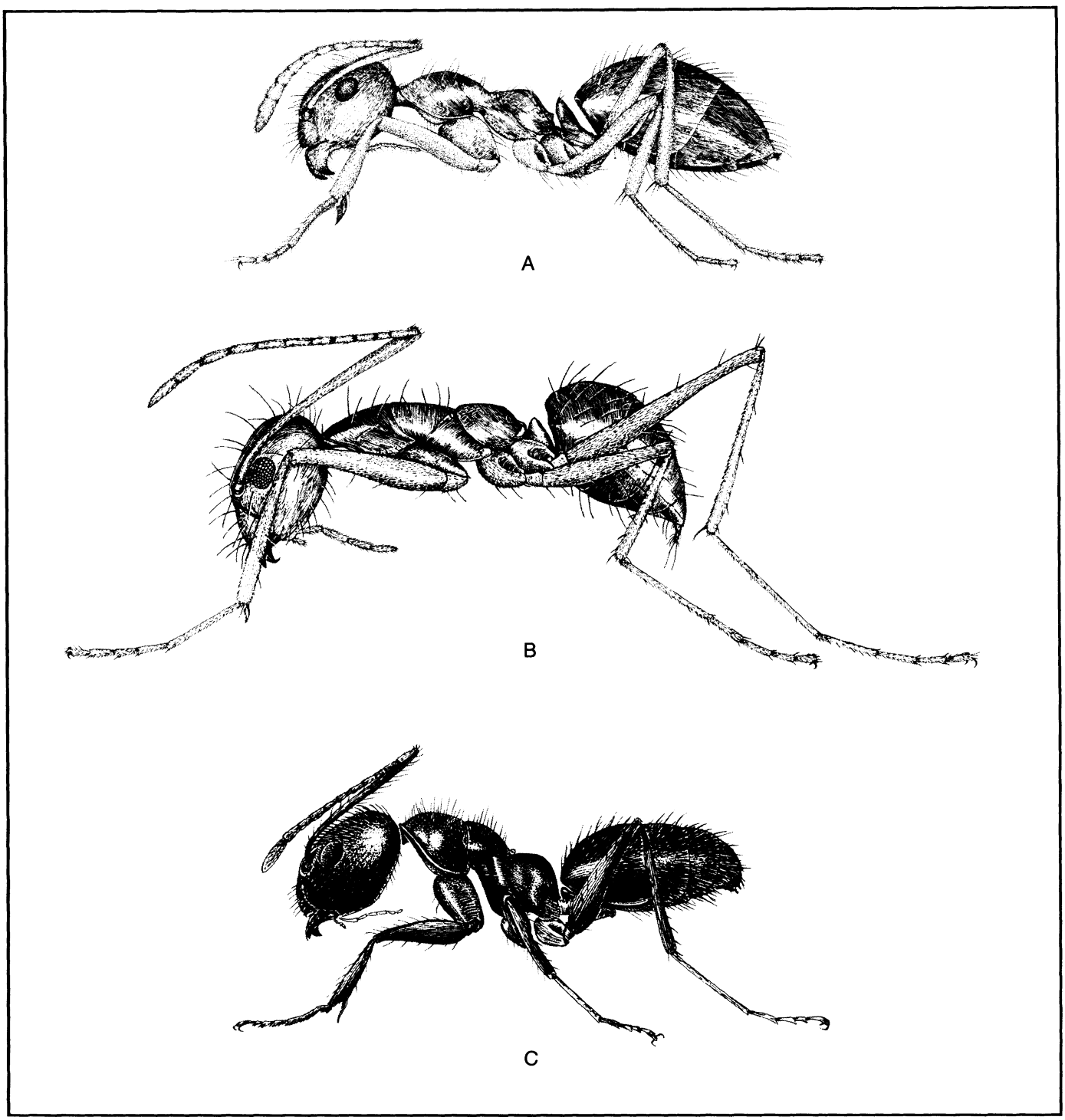


Plate 150. Formicine ants (Formicinae, Formicidae): A, false honey ant, *Prenolepis imparis* (2-4); B, **crazy ant,** *Paratrechina longicornis* (2.2-3) (drawings A&B by S.H. DeBord); C, *Paratrechina* (various species) (2.2-4).

Notes and Sketches

28 ARTHROPOD PESTS OF THE FOOD INDUSTRY: A LIST AND TAXONOMIC BIBLIOGRAPHY

J. Richard Gorham

Food and Drug Administration
Washington DC 20204

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Hundreds of insect and mite species have been associated at one time or another with various aspects of the food industry (***A001-A007, A009-A027***). Since user convenience is an important objective of this list (and of this entire handbook, for that matter), no attempt is made here to record all these species. This list is, however, more inclusive than were the earlier versions (***A012, A013***). Although some rare or unusual species are included, emphasis is given here to the common cosmopolitan pests, to pests likely to be encountered in FDA and USDA operations, and to pests of food stored in the home. Field crop pests have been largely excluded, but many pests associated with other aspects of the food industry, such as storage, transport, processing, vending, and serving, are listed.

A basic tenet of research on the prevention, detection, and control of infestations by food pests is that the investigator must be certain that the offending arthropod is correctly identified. Fortunately, many of our food pests (or even fragments thereof in some cases) can be readily identified. This handbook will be especially helpful in dealing with arthropods in that category. In other instances, the services of a taxonomic specialist may be required to produce a trustworthy identification. Therefore, the simple consultation of the keys in this handbook or of the taxomomic literature listed below cannot guarantee correct identification of every specimen. Rather, the keys and references given here and elsewhere in this handbook are intended to assist the operational entomologist in deciding whether to do the identification at the local level or to submit the specimen to a competent taxonomic authority.

In the list below under the heading "Arthropod Pests of the Food Industry," the references are cited by number and are limited to those that provide keys, illustrations, or other useful details about the identification of a given pest. A few long-standing and widely used synonyms are placed in brackets. Common names in **boldface** have been approved by the Committee on Common Names of Insects (***A008***). Names followed by an asterisk (*) represent taxa that have been keyed out or illustrated here. This list also serves as the taxonomic index for the handbook.

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Arthropod Pests of the Food Industry

Taxon	Common Name	Reference	Page
Acari* [Acarina] (subclass)	**mites**	*A017 B001 B002 B004 B006-B009 B012-B015 AQ02 AQ06*	3, 321, 483

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Taxon	Common Name	Reference	Page
Acariformes* (order)	acariform mites	*A017 B002 B007*	4, 7, 14, 492
Astigmata* (suborder)	astigmatid mites	*A017 B002 B006 B007*	4, 14, 16, 494
Acaridae*	**acarid mites**	*A017 B007 C011*	4, 22, 23, 497
*Acarus farris** (Oudemans)		*A017 C005*	25, 500
Acarus gracilis Hughes		*A017 C005*	
*Acarus immobilis** Griffiths		*A017 C004 C005*	25, 501
*Acarus siro L**	**grain mite**	*A017 B004 C005 C011*	24, 499
*Aleuroglyphus ovatus** (Troupeau)	**brownlegged grain mite**	*A017 C001 C011*	27
Caloglyphus [Sancassania]*		*C010 C012*	28
Caloglyphus anomalus Nesbitt		*C010*	
*Caloglyphus berlesei** (Michael)		*A017 C006*	28, 505
Caloglyphus hughesi (Samšiňák)		*A017*	
Caloglyphus mycophagus (Mégnin)		*A017 C006*	
Caloglyphus oudemansi (Zakhvatkin)		*A017*	
Caloglyphus rhizoglyphoides (Zakhvatkin)		*A017*	
*Histiogaster**		*C012 C018*	29
Histiogaster carpio Kramer		*C018*	
Mycetoglyphus fungivorus Oudemans		*A017 C012*	
*Rhizoglyphus**		*A017 C012*	28
Rhizoglyphus callae Oudemans		*A017 C008*	28
Rhizoglyphus echinopus (Fumouze & Robin)	**bulb mite**	*A017 C008 C011*	28
Rhizoglyphus phylloxerae Riley		*C002 C006*	
*Rhizoglyphus robini** Claparède		*C008*	28, 503, 504
*Schwiebia**		*C009*	29
*Suidasia nesbitti** Hughes	**scaly grain mite**	*A017*	22, 497
*Suidasia pontifica** Oudemans [*S. medanensis* Oudemans]		*A017 C003*	22
Thyreophagus entomophagus (Laboulbène)		*A017 C014*	28, 503
Thyreophagus gallegoi Portus & Gomez		*C013*	
Tyroborus lini Oudemans		*A017 C012*	
*Tyrolichus casei** Oudemans	**cheese mite**	*A017 C012 C014*	26, 501
Tyrophagus brevicrinatus Robertson		*A017 B007 C015*	
*Tyrophagus longior** (Gervais)		*A017 B004 C006 C007 C014 C015*	26, 502

Taxon	Common Name	Reference	Page
Tyrophagus palmarum Oudemans		*A017 C007 C015*	
Tyrophagus perniciosus Zakhvatkin		*A017 C007 C015*	
*Tyrophagus putrescentiae** (Schrank)	**mold mite**	*A017 C006 C014 C015 C016 C017*	26, 502
Tyrophagus similis Volgin		*A017 C006 C007 C015 C017*	
Tyrophagus tropicus Robertson		*A017 C007 C015*	26

C001 Baker, E.W., M.D. Delfinado, and M.J. Abbatiello.
1976. Terrestrial mites of New York. II. Mites in birds' nests. Jour. New York Ent. Soc. 84(1)48-66.

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Taxon	Common Name	Reference	Page
Carpoglyphidae*	**driedfruit mites**	*A017*	19, 494
*Carpoglyphus lactis** (L.)	**driedfruit mite**	*A017 B004 D001 D002*	19, 494

D001 Baker, E.W., and M.D. Delfinado.
1978. Notes on the driedfruit mite *Carpoglyphus lactis* (Acarina: Carpoglyphidae) infesting honeybee combs. Jour. Agr. Res. 17(1)52-54.

D002 Chmielewski, W.
1971. Morfologia, biologia i ekologia *Carpoglyphus lactis* (L., 1758) (Glycyphagidae, Acarina). Prace Nauk. Inst. Ochrony Roślin 8(2)63-166.

Taxon	Common Name	Reference	Page
Chortoglyphidae	chortoglyphid mites	*A017 B007*	
Chortoglyphus arcuatus (Troupeau)		*A017*	
Glycyphagidae*	**glycyphagid mites**	*A017*	19, 20, 494-496
*Aeroglyphus robustus** (Banks)	**warty grain mite**	*A017 C001*	20, 495
Austroglycyphagus geniculatus (Vitzthum)		*A017*	
Blomia freemani Hughes		*A017 F001*	

Taxon	Common Name	Reference	Page
Ctenoglyphus plumiger (Koch)		*A017*	
*Glycyphagus domesticus** (De Geer)	**house mite**	*A017 B004 F002*	20, 496
Glycyphagus ornatus Kramer		*A017 F002*	
Glycyphagus privatus Oudemans		*A017*	
*Gohieria fusca** (Oudemans)	**brown flour mite**	*A017*	19, 494
*Lepidoglyphus destructor** (Schrank)		*A017 B004*	20
Lepidoglyphus fustifer (Oudemans)		*A017 B004*	
Lepidoglyphus michaeli (Oudemans)		*A017*	

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1974 [1973]. The genus *Blomia* Oudemans (Acari: Glycyphagidae). II. Comparison of its species. Acarologia 15(3)490-505.

F002 Volgin, V.I.
1965. Two new species of acaroid mites in the Soviet fauna. Ent. Rev. 44(1)112-115 (trans. from Ent. Oboz. 44(1)203-211).

Taxon	Common Name	Reference	Page
Histiostomatidae* [Anoetidae]	histiostomatid mites	*G002*	29, 506-508
Histiostoma feroniarum (Dufour)		*A017 C006 G001 G002*	
*Histiostoma heinemanni** Hill & Deahl		*G001*	29, 506-508

G001 Hill, A., and K.L. Deahl.
1978. Description and life cycle of a new species of *Histiostoma* (Acari: Histiostomidae) associated with commercial mushroom production. Proc. Ent. Soc. Washington 80(3)317-329.

G002 Hughes, R.D., and C.G. Jackson.
1958. A review of the Anoetidae. Virginia Jour. Sci. (n.s.) 9(1)5-198.

Taxon	Common Name	Reference	Page
Lardoglyphidae*	lardoglyphid mites	*A017 B007*	23, 498
Lardoglyphus angelinae Olsen		*H001*	23
*Lardoglyphus konoi** (Sasa & Asanuma)		*A017 H001*	23, 498
*Lardoglyphus zacheri** Oudemans		*A017 H001*	23, 498

H001 Olsen, A.R.
1982. A new pest of dried fish from the Orient, *Lardoglyphus angelinae* n. sp. (Acarina: Acaridae). Jour. Stored Prod. Res. 18(4)181-188.

Taxon	Common Name	Reference	Page
Psoroptidae*	**scab mites**	*B001*	18, 493
*Psoroptes equi** (Raspail)	**scab mite**	*B001*	18, 493

Pyroglyphidae* [Epidermoptidae]	pyroglyphid mites	*A017 J001 J005*	29, 509-513
*Dermatophagoides farinae** Hughes	**American house dust mite**	*J003 J005*	32, 513
*Dermatophagoides microceras** Griffiths & Cunnington		*J004 J005*	32
*Dermatophagoides pteronyssinus** (Trouessart)	**European house dust mite**	*J003 J005*	31
*Euroglyphus longior** (Trouessart)		*J002 J005*	31, 509, 510
*Euroglyphus maynei** (Cooreman)		*J002 J005*	31, 511, 512
Pyroglyphus africanus (Hughes)		*A017 J005*	

J001 Bronswijk, J.E.M.H. van, and R.N. Sinha.
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J002 Fain, A.
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J005 Wharton, G.W.
1976. House dust mites. Jour. Med. Ent. 12(6)577-621.

Taxon	Common Name	Reference	Page
Sarcoptidae*	sarcoptid mites	*K001*	18, 492
*Sarcoptes scabiei** (De Geer)	**itch mite**	*B001 B004 K001 K002*	18, 492

K001 Fain, A.
1968. Etude de la variabilite de *Sarcoptes scabiei* avec une revision des Sarcoptidae. Acta Zool. Path. Antverp. 47:1-196.

K002 Zumpt, F., ed.
1961. The arthropod parasites of vertebrates in Africa south of the Sahara (Ethiopian Region). Vol. 1. Chelicerata. South African Institute for Medical Research, Johannesburg.

Taxon	Common Name	Reference	Page
Cryptostigmata* [Oribatida] (suborder)	beetle mites	*B003 B006 B007*	4, 14, 16
Aphelacaridae	aphelacarid mites		
Aphelacarus acarinus (Berlese)		*B003*	16
Ceratozetidae	ceratozetid mites		
Trichoribates novus (Sellnick)		*A017 M001*	16

M001 Schweizer, J.
1956. Die Landmilben des schweizerischen Nationalparkes. Sarcoptiformes Reuter 1909. Rés. Rech. Scient. Parc Nat. Suisse 5(n.s.)(34)213-377.

Taxon	Common Name	Reference	Page
Oribatulidae	oribatulid mites		
Phauloppia lucorum (Koch)		*A017*	16
*Scheloribates**		*A017*	492
Scheloribates laevigatus (Koch)		*A017 N001*	16

N001 Schweizer, J.
1949. Die Landmilben des schweizerischen Nationalparkes. Parasitiformes Reuter 1909. Rés. Rech. Scient. Parc Nat. Suisse 2(n.s.)(21)1-99, 1 map.

Taxon	Common Name	Reference	Page
Prostigmata (suborder)	prostigmatid mites	*A017 B006 B007 B009 B011*	4, 14, 32, 514
Acarophenacidae	acarophenacid mites	*O001*	
Acarophenax tribolii Newstead & Duvall		*A017 O001*	

O001 Cross, E.A.
1965. The generic relationships of the family Pyemotidae (Acarina: Trombidiformes). Univ. Kansas Sci. Bull. 45(2)29-275.

Taxon	Common Name	Reference	Page
Bdellidae*	bdellid mites	*A017*	36, 516
*Spinibdella bifurcata** Atyeo		*P001*	36, 516

P001 Atyeo, W.T.
1960. A revision of the mite family Bdellidae in North America and Central America (Acarina, Prostigmata). Univ. Kansas Sci. Bull. 40(8)345-499.

Taxon	Common Name	Reference	Page
Cheyletidae*	cheyletid mites	*Q001 Q005*	35, 515
Acaropsella volgini (Gerson)		*Q005*	
Acaropsellina docta (Berlese)		*Q004 Q005*	
Acaropsellina sollers (Rohdendorf)		*Q004*	
*Cheletomorpha lepidopterorum** (Shaw)		*Q001 Q005*	35, 515
Cheyletus aversor Rohdendorf		*Q005*	
*Cheyletus eruditus** (Schrank)		*B004 Q001 Q002 Q005*	36
*Cheyletus malaccensis** Oudemans		*Q001 Q005*	36

Q001 Baker, E.W.
1949. A review of the mites of the family Cheyletidae in the United States National Museum. Proc. U.S. Nat. Mus. 99(3238)267-320.

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Q003 Summers, F.M.
1975. Males of three species of *Cheyletus*. Proc. Ent. Soc. Washington 77(4)446-455.

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Q005 Summers, F.M., and D.W. Price.
1970. Review of the mite family Cheyletidae. Univ. California Pubs. Ent. 61:1-153.

Taxon	Common Name	Reference	Page
Cunaxidae	cunaxid mites	*R001 R002*	
Cunaxa setirostris (Hermann)		*A017 R002*	

R001 Baker, E.W., and A. Hoffmann.
1948. Acaros de la familia Cunaxidae. An. Esc. Nac. Cien. Biol. 5(3-4)229-273.

R002 Smiley, R.L.
1975. A generic revision of the mites of the family Cunaxidae. Ann. Ent. Soc. America 68(2)227-244.

Taxon	Common Name	Reference	Page
Demodicidae*	**follicle mites**		33
*Demodex canis** Leydig	**dog follicle mite**	*B001*	33

Eriophyoidea*	eriophyoid mites	*T002*	32, 35
Eriophyidae	**eriophyid mites**		
*Eriophyes ficus** Cotte	**fig mite**	*T001 T003*	32

T001 Baker, E.W.
1939. The fig mite, *Eriophyes ficus* Cotte, and other mites of the fig tree, *Ficus carica* Linn. California Dept. Agr. Bull. 28(4)266-275.
T002 Jeppson, L.R., H.H. Keifer, and E.W. Baker.
1975. Mites injurious to economic plants. University of California, Berkeley.
T003 Keifer, H.H.
1938. Eriophyid studies. II. California Dept. Agr. Bull. 27(3)301-323.

Taxon	Common Name	Reference	Page
Erythraeoidea*	erythraeoid mites	*U002*	34
Erythraeidae	erythraeid mites		
Balaustium murorum (Hermann)	wall mite	*B011 U001*	34

U001 Rack, G.
1984. Systematik, Morphologie und Biologie von Milben (Acari) in Häusern und Vorräten sowie Milben von medizinischer Bedeutung. 1. Allgemeines. *Balaustium murorum,* (Hermann, 1804). Der praktische Schädlingsbekämpfer 35(9)457-460.
U002 Southcott, R.V.
1961. Studies on the systematics and biology of the Erythraeoidea, with a critical revision of the genera and subfamilies. Australian Jour. Zool. 9(3)367-610.

Taxon	Common Name	Reference	Page
Eupodidae	**eupodid mites**		
Linopodes antennaepes Banks	longlegged mite	*C006 V001*	

V001 Banks, N.
1894. American Acarina. Trans. American Ent. Soc. 21(June)209-222.

Taxon	Common Name	Reference	Page
Halacaridae*	halacarid mites	*W001*	37, 516
Rhombognathides seahami (Hodge)		*W001*	37, 516

W001 Newell, I.M.
1947. A systematic and ecological study of the Halacaridae of Eastern North America. Bul. Bingham Oceanogr. Collect. 10(3)1-232.

Taxon	Common Name	Reference	Page
Myobiidae*	myobiid mites		36
Myobia musculi (Schrank)		*B001 X001*	33, 36
Radfordia affinis (Poppe)		*X001*	36
Radfordia ensifera (Poppe)		*X001*	36

X001 Vitzthum, H.G.
1929. 5. Ordnung: Milben, Acari. Die Tierwelt Mitteleuropas 3(7)1-112.

Taxon	Common Name	Reference	Page
Pterygosomatidae*	pterygosomatid mites		37, 517
Pimeliaphilus cunliffei Jack	cockroach mite	*Y001*	37, 517

Y001 Jack, K.M.
1961. A re-examination of the genera *Pimeliaphilus* Trägårdh 1905 and *Hirstiella* Berlese 1920 (Acari; Prostigmata). Ann. Mag. Nat. Hist. 13(4)305-314.

Taxon	Common Name	Reference	Page
Pyemotidae*	**pyemotid mites**	*O001*	40, 520, 521
*Pyemotes tritici** Lagrèze-Fossat & Montané [*P. ventricosus* (Newport)]	**straw itch mite**	*Z001*	40, 520, 521

Z001 Cross, E.A., and J.C. Moser.
1975. A new, dimorphic species of *Pyemotes* and a key to previously-described forms (Acarina: Tarsonemoidea). Ann. Ent. Soc. America 68(4)723-732.

Taxon	Common Name	Reference	Page
Pygmephoridae*	mushroom mites	*O001 AA01*	40, 522-524
*Pseudopygmephorus smileyi** Hill & Deahl		*AA02*	40, 523, 524
Pygmephorus mesembrinae Canestrini		*AA01*	
*Pygmephorus sellnicki** Krczal		*C006 AA01 AA03*	40, 522

AA01 Gurney, B., and N.W. Hussey.
1967. *Pygmephorus* species (Acarina: Pyemotidae) associated with cultivated mushrooms. Acarologia 9(2)353-358.
AA02 Hill, A., and K.L. Deahl.
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AA03 Smiley, R.L.
1978. Taxonomic studies on *Pygmephorus* species from the Western Hemisphere, with a key to females and an overview of the current problems for classification. Internatl. Jour. Acarol. 4(2)125-160.
AA04 Wicht, M.C., Jr.
1970. Practical key to pyemotid mites found in mushroom houses. Melsheimer Ent. Ser. 7:1-9.

Taxon	Common Name	Reference	Page
Scutacaridae*	scutacarid mites		38, 518, 519
*Scutacarus baculitarsus agaricus** Norton & Ide		*AB01*	38, 518, 519

AB01 Norton, R.A., and G.S. Ide.
1974. *Scutacarus baculitarsus agaricus* n. subsp. (Acarina: Scutacaridae) from commercial mushroom houses, with notes on phoretic behavior. Jour. Kansas Ent. Soc. 47(4)527-534.

Taxon	Common Name	Reference	Page
Tarsonemidae*	**tarsonemid mites**	*AC01 AC02*	39, 525, 526
Tarsonemus floricolus Canestrini & Fanzago		*AC02*	
*Tarsonemus granarius** Lindquist		*AC01 AC04*	40, 41, 526
Tarsonemus lukoschusi Hill & Deahl		*AC03*	39
Tarsonemus mercedesae Hill & Deahl		*AC03*	39
*Tarsonemus scaurus** Ewing		*AC01 AC02*	40, 41, 525

AC01 Beer, R.T.
1954. A revision of the Tarsonemidae of the Western Hemisphere (order Acarina). Univ. Kansas Sci. Bull. 36, pt. 2(16)1091-1387.
AC02 Ewing, H.E.
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AC03 Hill, A., and K.L. Deahl.
1978. Two new species of *Tarsonemus* (Acari: Tarsonemidae) associated with commercial mushroom production. Proc. Ent. Soc. Wash. 80(3)330-334.
AC04 Lindquist, E.E.
1972. A new species of *Tarsonemus* from stored grain (Acari: Tarsonemidae). Canadian Ent. 104(11)1699-1707.

Taxon	Common Name	Reference	Page
Tetranychidae*	**spider mites**	*AD01 AD02*	35, 514
*Bryobia praetiosa** Koch	**clover mite**	*B004 AD02*	35, 514
Oligonychus pratensis (Banks)	**Banks grass mite**	*T002 AD01*	
Petrobia latens (Müller)	**brown wheat mite**	*T002 AD01 AD02*	

AD01 Pritchard, A.E., and E.W. Baker.
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AD02 Tuttle, D.M., and E.W. Baker.
1968. Spider mites of southwestern United States and a revision of the family Tetranychidae. University of Arizona, Tucson.

Taxon	Common Name	Reference	Page
Trombidioidea*	trombidioid mites		34
Trombiculidae	**chigger mites**		34, 514
*Leptotrombidium**	chigger mites	*B001 K002 AE01*	33, 34

AE01 Wharton, G.W., and H.S. Fuller.
1952. A manual of the chiggers. Entomological Society of Washington, Washington, DC.

Taxon	Common Name	Reference	Page
Tydeidae*	**tydeid mites**	*T002 AF01*	38, 517
*Tydeus**		*AF02*	38, 517
Tydeus interruptus Thor		*A017*	

AF01 Baker, E.W.
1965. A revision of the genera of the family Tydeidae. Adv. Acarol. 2:95-133.
AF02 Baker, E.W.
1970. The genus *Tydeus*: Subgenera and species groups with descriptions of new species (Acarina: Tydeidae). Ann. Ent. Soc. America 63(1)165-177.

Taxon	Common Name	Reference	Page
Parasitiformes* (order)	parasitiform mites	*B006 B010 M001*	4, 7, 40
Mesostigmata* (suborder)	mesostigmatid mites	*B006 B010*	4, 7, 8
Ameroseiidae*	ameroseiid mites	*B006 AG01*	9, 485
*Kleemannia plumigera** Oudemans		*A017*	9, 485
*Kleemannia plumosa** (Oudemans)		*A017*	9, 485

AG01 Lindquist, E.E.
1977. Provisional key to genera of Ameroseiidae. [Unpublished]. 1 pl.

Taxon	Common Name	Reference	Page
Ascidae*	ascid mites	*B006 AH02 AH05*	12, 490, 491
Arctoseius butleri (Hughes)		*A017 AH02*	
Arctoseius cetratus (Sellnick)		*B010 C001 M001 AH01*	
Arctoseius idiodactylus Lindquist		*AH01 AH04*	
*Blattisocius dentriticus** (Berlese)		*B006 AH01-AH03 AH06*	13, 490
*Blattisocius keegani** Fox		*B001 AH01 AH03 AH06 AH08*	14, 491
Blattisocius mali (Oudemans)		*A017 AH03*	
Blattisocius quadridentatus Haines		*AH03*	
*Blattisocius tarsalis** (Berlese)		*A017 B001 AH01-AH03 AH06 AH08*	14, 490
*Lasioseius**		*A017*	13
Lasioseius penicilliger Berlese		*A017 AH02*	
Melichares agilis Hering		*A017 B006*	
Proctolaelaps pomorum (Oudemans)		*A017 B006*	
Proctolaelaps pygmaeus (Müller)		*A017 AH01 AH06 AH07*	

AH01 Chant, D.A.
1963. The subfamily Blattisocinae Garman (=Aceosejinae Evans) (Acarina: Blattisocidae Garman) (=Aceosejidae Baker & Wharton) in North America, with descriptions of new species. Canadian Jour. Zool. 41(2)243-319.

AH02 Evans, G.O.
1958. A revision of the British Aceosejinae (Acarina: Mesostigmata). Proc. Zool. Soc. London 131(2)177-229.

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1978. A revision of the genus *Blattisocius* Keegan (Mesostigmata: Ascidae) with especial reference to *B. tarsalis* (Berlese) and the description of a new species. Acarologia 20(1)19-38.

AH04 Lindquist, E.E.
1961. Taxonomic and biological studies of mites of the genus *Arctoseius* Thor from Barrow, Alaska (Acarina: Aceosejidae). Hilgardia 30(11)301-350.

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1965. Taxonomic concepts in the Ascidae, with a modified setal nomenclature for the idiosoma of the Gamasina (Acarina: Mesostigmata). Mem. Ent. Soc. Canada 47:1-64.

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AH07 Ryke, P.A.J.
1964. Acarina associated with *Protea* flowers in the Cape Province. Jour. Ent. Soc. South Africa 26(2)337-354.

AH08 Westerboer, I. von, and F. Bernhard.
1963. Die Familie Phytoseiidae Berlese 1916. *In* H. Stammer, ed., vol. 2, Mesostigmata. Beiträge zur Systematik und Ökologie mitteleuropäischer Acarina. Geest & Portig, Leipzig.

Taxon	Common Name	Reference	Page
Dermanyssidae*	**dermanyssid mites**	***B006 AI02***	11, 487
*Dermanyssus gallinae** (De Geer)	**chicken mite**	***B004 B006 B010 AI01 AI03 AI04***	11, 487

AI01 Evans, G.O., and W.M. Till.
1962. The genus *Dermanyssus* De Geer (Acari: Mesostigmata). Ann. Mag. Nat. Hist., Ser. 13(5)273-293.

AI02 Evans, G.O., and W.M. Till.
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AI04 Moss, W.W.
1968. An illustrated key to the species of the acarine genus *Dermanyssus* (Mesostigmata: Laelapoidea: Dermanyssidae). Jour. Med. Ent. 5(1)67-84.

Taxon	Common Name	Reference	Page
Digamasellidae*	digamasellid mites	*B006 B010*	10
*Digamasellus**		*A017 AJ01*	10

AJ01 Hurlbutt, H.W.
1967. Digamasellid mites associated with bark beetles and litter in North America. Acarologia 9(3)497-534.

Taxon	Common Name	Reference	Page
Laelapidae*	laelapid mites	*B006 B010 X001*	12
*Androlaelaps casalis** (Berlese)		*B010 AI02 AK01*	6, 12
Eulaelaps stabularis (Koch)		*A017 B001 X001*	
Haemogamasus pontiger Berlese		*A017 B001 AI02 AI03*	
Hypoaspis aculeifer (Canestrini)		*A017 B006 AI02*	
Hypoaspis lubrica Voigts & Oudemans		*A017 AI02*	

AK01 Till, W.M.
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Taxon	Common Name	Reference	Page
Macrochelidae*	macrochelid mites	*B006 B010 AL01*	10, 486
Macrocheles matrius (Hull)		*A017*	
*Macrocheles muscaedomesticae** (Scopoli)	house fly mite	*B001 B010*	10, 486

AL01 Krantz, G.W.
1962. A review of the genera of the family Marcrochelidae Vitzthum 1930 (Acari: Mesostigmata). Acarologia 4(2)143-173.

Taxon	Common Name	Reference	Page
Macronyssidae*	**macronyssid mites**	*B006*	11, 488, 489
*Liponyssoides sanguineus** (Hirst)	**house mouse mite**	*B001*	12, 488
*Ornithonyssus bacoti** (Hirst)	***tropical rat mite***	*B001 B004 B006 AI02*	12, 489
*Ornithonyssus sylviarum** Canestrini & Fanzago	***northern fowl mite***	*B001 B004 AI02 AI03*	12, 489
Parasitidae	parasitid mites	*B006 B010*	
Eugamasus butleri Hughes		*A017*	
Phytoseiidae	phytoseiid mites	*B006 AO02*	
Amblyseius		*A017 AO01*	
Neoseiulus barkeri Hughes		*A017*	

AO01 Chant, D.A., and R.I.C. Hansell.
1971. The genus *Amblyseius* (Acarina: Phytoseiidae) in Canada and Alaska. Canadian Jour. Zool. 49(5)703-758.
AO02 Muma, M.H., and H.A. Denmark.
1970. Phytoseiidae of Florida. Florida Department of Agriculture and Consumer Services, Gainesville.

Taxon	Common Name	Reference	Page
Uropodidae*	uropodid mites	*B006*	8, 484
*Fuscuropoda marginata** (Koch)		*B006 B010 X001*	8, 484
Leiodinychus krameri (G. & R. Canestrini)		*B010 X001*	8, 484
Trematura jacksonia Hughes		*A017 B006*	
Uroseius acuminatus (Koch)		*A017 B010 X001*	

Insecta* [Hexapoda] (class)	**insects**	*AQ01-AQ26*	319-322, 334

AQ01 Bland, R.G., and H.E. Jaques.
1978. How to know the insects. Brown, Dubuque.
AQ02 Borror, D.J., D.M. DeLong, and C.A. Triplehorn.
1981. An introduction to the study of insects. Saunders College, Philadelphia.
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Taxon	Common Name	Reference	Page
Dictyoptera* [Orthoptera, in part] (order)	dictyopterans		45, 46
Blattaria [Blattodea] (suborder)	**cockroaches**	*AQ02 AQ04 AS01-AS08*	46, 47, 527

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AS08 Zimmerman, E.C.
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Taxon	Common Name	Reference	Page
Blaberidae*	blaberid cockroaches	*AQ02 AQ04*	45, 46, 62, 65, 539-543
Archimandrita tessellata Rehn			
*Blaberus**	giant cockroaches	*AQ18 AS01 AT02*	46, 47, 64, 65, 542
*Blaberus craniifer** Burmeister		*AQ22 AS03 AS07 AT02*	46, 64, 542
*Blaberus discoidalis** Serville		*AS07 AT02*	46, 64, 542
*Blaberus giganteus** L.	giant cockroach	*AS04 AS07*	46, 64, 542
Epilampra abdomennigrum (De Geer)		*AT04*	
Epilampra maya Rehn		*AT01 AT04*	46
*Leucophaea maderae** (Fabricius)	**Madeira cockroach**	*AQ18 AQ20 AQ22 AS01 AS04 AS07 AS08*	46, 64, 542
Nauclidas nigra (Brunner von Wattenwyl)			
*Nauphoeta cinerea** (Olivier)	**cinereous cockroach**	*AQ18 AQ22 AS01 AS04 AS07*	46, 63, 541
*Panchlora nivea** (L.)	**Cuban cockroach**	*AQ18 AQ22 AS01 AS04*	46, 62, 539
*Pycnoscelus indicus** (Fabricius)	Indian cockroach	*AT03*	46, 63, 540
*Pycnoscelus surinamensis** (L.)	**Surinam cockroach**	*AQ18 AS01 AS03 AS04 AS06 AS08 AT03*	46, 62, 63, 539

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Taxon	Common Name	Reference	Page
Blattellidae* [includes Ectobiidae]	blattellid cockroaches	*AQ02 AQ04 AS02*	45, 46, 48, 65, 534-538
*Aglaopteryx** [*Euthlastoblatta*] *gemma* Hebard	little gem cockroach	*AS03 AS04*	46, 48, 536
Blattella asahinai Mizukubo [*B. beybienkoi* Roth]	**Asian cockroach**		46, 58
*Blattella germanica** (L.)	**German cockroach**	*AQ18 AQ22 AS01-AS04 AS06-AS08 AU05 AU09 AU11*	46, 57, 58, 68, 534
*Blattella lituricollis** (Walker)	**false German cockroach**	*AS08 AU01 AU10 AU11*	46, 57, 534
*Blattella vaga** Hebard	field cockroach	*AQ18 AQ22 AS01 AS07 AU05 AU11*	46, 57, 58, 68, 534
Ectobius		*AS01*	
*Ectobius lapponicus** (L.)	dusky cockroach	*AS02 AS05-AS07 AU04*	46, 60, 537
*Ectobius pallidus** (Olivier)	**spotted Mediterranean cockroach**	*AQ18 AQ22 AS02 AS04 AS05-AS07 AU04 AU06*	46, 60, 66, 67, 537
Ectobius panzeri Stephens	lesser cockroach	*AS02 AS05 AS06 AU04*	
*Ectobius sylvestris** (Poda)	forest cockroach	*AS02 AS05 AS07 AU07*	46, 60, 66, 537
Eudromiella			
Ischnoptera deropeltiformis (Brunner)	dark wood cockroach	*AS04*	
Ischnoptera vulpina Hebard			
Lupparia [*Onychostylus*] *vilis* (Brunner)	arboreal cockroach	*AS01 AU02*	46, 48
*Nyctibora noctivaga** Rehn	banana cockroach	*AQ22 AS07 AT02*	46, 48, 535
*Parcoblatta**	wood cockroaches	*AQ18 AQ22 AS01 AS03 AS04*	46, 47, 49, 60, 67
Parcoblatta kyotensis Asahina	Kyoto woodroach	*AU03*	60

Taxon	Common Name	Reference	Page
*Parcoblatta pennsylvanica** (De Geer)	Pennsylvania woodroach	*AS01 AS03 AS07*	61, 538
*Parcoblatta virginica** (Brunner)	Virginia woodroach	*AS03 AS04 AS07*	538
*Shawella couloniana** (Saussure)		*AQ04 AS01 AS07 AU08*	46, 48, 535
*Supella longipalpa** (Fabricius) [*S. supellectilium* (Serville)]	**brownbanded cockroach**	*AQ18 AQ20 AQ22 AS02 AS03 AS04 AS07 AU09 AU10*	46, 59, 66 67, 536

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Taxon	Common Name	Reference	Page
Blattidae*	blattid cockroaches	*AQ02 AQ04 AS02*	45, 46, 48, 65, 528-533
*Blatta lateralis** (Walker)	**Turkestan cockroach**	*AS01 AS05 AV01*	46, 51, 56, 69, 532
*Blatta orientalis** L.	**oriental cockroach**	*AQ18 AQ20 AQ22 AS01 AS03-AS07*	46, 49, 51, 56, 69, 322, 533
*Deropeltis erythrocephala** Fabricius		*AS07 AV04*	46, 49, 532
Eurycotis biolleyi Rehn			
*Eurycotis floridana** (Walker)	Florida stinkroach	*AQ18 AQ22 AS01 AS03 AS04 AS07*	46, 55, 70, 533
*Lamproblatta**		*AS04 AS07*	46, 47, 49, 531
*Methana marginalis** (Saussure)		*AQ04 AV02*	46, 41, 531
*Neostylopyga rhombifolia** (Stoll)	**harlequin cockroach**	*AS01 AS03 AS04 AS07 AS08 AU09*	46, 54, 70, 529
*Pelmatosilpha**		*AT01 AV05*	46, 49
*Periplaneta americana** (L.)	**American cockroach**	*AQ18 AQ20 AQ22 AS01 AS02 AS03 AS06-AS08 AU08 AU09 AV03*	46, 50, 53, 69, 70, 529
*Periplaneta australasiae** (Fabricius)	**Australian cockroach**	*AQ18 AQ20 AQ22 AS01 AS03 AS04 AS06-AS08 AU08 AU09 AV03*	46, 52, 70, 529
*Periplaneta brunnea** Burmeister	**brown cockroach**	*AQ04 AQ18 AQ22 AS01 AS03 AS04 AS07 AS08 AU09 AV03*	46, 53, 70, 529
*Periplaneta fuliginosa** (Serville)	**smokybrown cockroach**	*AQ18 AQ22 AS01 AS03 AS04 AS07 AV03*	46, 50, 70, 528
*Periplaneta japonica** Karny	Japanese cockroach	*AS01 AS07 AV03*	46, 49, 528

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Taxon	Common Name	Reference	Page
Cryptocercidae*	cryptocercid cockroaches	*AQ02*	45, 46, 62, 65, 539
*Cryptocercus punctulatus** Scudder	brownhooded cockroach	*AS03 AS04 AS07*	46, 47, 62, 539
Polyphagidae*	polyphagid cockroaches	*AQ02 AQ04 AS02*	45-47, 61, 65, 538
*Arenivaga**	sand cockroaches	*AS02-AS05 AU08*	46, 47, 61, 538
Polyphaga aegyptiaca (L.)		*AS01 AS02 AS05 AS07 AX01*	47, 61
Polyphaga saussurei (Dohrn)		*AS01 AV01*	61

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Taxon	Common Name	Reference	Page
Coleoptera* (order)	**beetles**	*A016 AQ02 AQ04 AQ10 AQ14 AQ17 AY01-AY11*	75-77, 95, 96, 331-334, 347, 349, 545

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Taxon	Common Name	Reference	Page
Anobiidae*	**deathwatch** and **drugstore beetles**	*AQ01 AQ03 AQ13 AZ01 AZ05*	82, 84, 98, 551
Anobium punctatum (De Geer)	**furniture beetle**	*AQ07 AZ01*	
*Lasioderma serricorne** (Fabricius)	**cigarette beetle**	*AQ07 AQ22 AY09 AZ01 AZ02 AZ03*	84, 97, 335, 551
*Stegobium paniceum** (L.)	**drugstore beetle**	*AQ07 AQ22 AY09 AZ01 AZ02 AZ03*	84, 98, 551
Tricorynus [*Catorama*] *confusus* (Fall)		*AZ01 AZ04 AZ06 AZ07*	84
Tricorynus herbarius (Gorham)	Mexican book beetle	*AZ02 AZ04 AZ06 AZ07*	84
Tricorynus tabaci (Guérin-Méneville)		*AZ02 AZ06 AZ07*	84

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Taxon	Common Name	Reference	Page
Anthicidae*	**antlike flower beetles**	*A016 AQ02 BA01*	80, 105, 548
Anthicus [*Omonadus*] *australis* (King)			
*Anthicus floralis** (L.)	**narrownecked grain beetle**	*A016 AQ07 BA04 BA05 BA06*	80, 105, 548

Taxon	Common Name	Reference	Page
Anthicus troilus Hinton		*A016*	
Notoxus calcaratus Horn		*BA02 BA03*	
Notoxus desertus Casey [*N. constrictus* Casey]		*BA02 BA03*	
Notoxus monodon (Fabricius)		*A016 BA03*	

BA01 Buck, F.D.
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Taxon	Common Name	Reference	Page
Anthribidae*	**fungus weevils**	*A016 AQ02 BB03 BB04*	78, 100, 546
*Araecerus fasciculatus** (De Geer)	**coffee bean weevil**	*AQ07 BB01-BB03 BB05 BB06*	78, 100, 546
Araecerus viellardi (Montrouzier)		*BB06*	

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Taxon	Common Name	Reference	Page
Bostrichidae*	**false powderpost beetles**	*A016 AQ02 BC02*	89, 99, 554, 555
Bostrychoplites cornutus (Olivier)		*BC02*	
Dinoderus bifoveolatus (Wollaston)		*BC02*	
*Dinoderus minutus** (Fabricius)	**bamboo powderpost beetle**	*BC02 BC05*	90, 100, 554
*Prostephanus truncatus** (Horn)	**larger grain borer**	*AQ22 BC02 BC03*	89, 100, 554
*Rhyzopertha dominica** (Horn)	**lesser grain borer**	*AQ07 AQ22 BC02-BC04 BC06*	90, 99, 555
Scobicia declivis (LeConte)	**leadcable borer**	*BC01 BC02*	

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Taxon	Common Name	Reference	Page
Bruchidae*	**seed beetles**	*A016 AO02 BD11*	75-77, 82, 87, 101, 109, 215, 216, 599-602
Acanthoscelides argillaceus (Sharp) [*A. obreptus* Bridwell]		*BD02 BD04*	
*Acanthoscelides obtectus** (Say)	**bean weevil**	*AQ22 AY08 BD01 BD02 BD04 BD09*	218, 601
Acanthoscelides obvelatus Bridwell		*BD02 BD04*	
Acanthoscelides zeteki Kingsolver		*BD02 BD06*	

Taxon	Common Name	Reference	Page
Bruchidius antrolineatus (Pic)		***BD11***	
Bruchidius incarnatus Boheman		***BD01***	
Bruchus affinis Froelich		***BD03***	
Bruchus brachialis Fåhraeus		***BD01 BD03***	
Bruchus dentipes (Baudi)		***BD01 BD03***	
Bruchus emarginatus Allard		***BD01 BD03***	
Bruchus ervi Froelich		***BD01 BD03***	
Bruchus lentis Froelich		***BD01 BD03***	
*Bruchus pisorum** (L.)	**pea weevil**	***AQ07 AQ22 AY09 BD01 BD03***	101, 219, 602
Bruchus rufimanus Boheman	**broadbean weevil**	***AY09 BD01***	
Bruchus rufipes Herbst		***BD03***	
Bruchus signaticornis Gyllenhal		***BD01 BD03***	
Bruchus tristiculus Fåhraeus		***BD01 BD03***	
Bruchus tristis Boheman		***BD03***	
Bruchus viciae Olivier		***BD03***	
Callosobruchus ademptus (Sharp)		***BD05***	
Callosobruchus analis (Fabricius)		***BD03 BD05***	
*Callosobruchus chinensis** (L.)	southern cowpea weevil	***BD01 BD05 BD12***	ii, iii, 220
*Callosobruchus maculatus** (Fabricius)	**cowpea weevil**	***AQ22 AY09 BD01 BD05 BD11 BD13***	ii, iii, 40, 220
Callosobruchus phaseoli (Gyllenhal)		***BD01 BD05***	
Callosobruchus rhodesianus (Pic)		***BD05 BD11 BD12***	
Callosobruchus subinnotatus (Pic)		***BD05 BD11***	
*Caryedon serratus** (Olivier) [*C. gonagra* (Fabricius)]	groundnut bruchid, tamarind seed beetle	***BD01 BD07 BD10 BD11***	87, 101, 218, 601
*Zabrotes subfasciatus** (Boheman)	**Mexican bean weevil**	***BD01 BD08 BD09***	217, 600

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Taxon	Common Name	Reference	Page
Byturidae*	**fruitworm beetles**	*AQ02*	87, 104
Byturus fumatus Fabricius		*BE02*	
Byturus tomentosus (De Geer)		*BE02*	
*Byturus unicolor** Say [*B. bakeri* Barber, *B. rubi* Barber]	**raspberry fruitworm**	*BE01*	87, 553

BE01 Springer, C.A., and M.A. Goodrich.
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Taxon	Common Name	Reference	Page
Carabidae	**ground beetles**	*A016 AQ02*	
Harpalus rufipes (De Geer)		*A016*	
Laemostenus [*Pristonychus*] *complanatus* (Dejean)		*A016*	
Laemostenus terricola (Herbst)		*A016*	
Plochionus pallens (Fabricius)		*A016*	
Somotrichus unifasciatus (Dejean)		*A016*	
Sphodrus leucophthalmus (L.)		*A016*	
Cerylonidae* [Murmidiidae]	cerylonid beetles	*A016 AQ02 BG01*	80, 96, 548
*Murmidius ovalis** (Beck)	oval grain beetle	*A016 BG02*	80, 96, 548
Murmidius segregatus Waterhouse		*A016*	

BG01 Gupta, T.S., and R.A. Crowson.
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Taxon	Common Name	Reference	Page
Chrysomelidae*	**leaf beetles**	*A016 AQ02*	81, 82, 107, 549
*Crioceris asparagi** (L.)	**asparagus beetle**		ii, iii, 82, 107, 549
*Crioceris duodecimpunctata** (L.)	**spotted asparagus beetle**		81, 107, 549
*Leptinotarsa decemlineata** (Say)	**Colorado potato beetle**		
Cleridae*	**checkered beetles**	*A016 AQ02 BI01 AQ07*	87, 103, 149, 150, 573, 574
Exkorynetes analis (Klug)		*AQ07*	
*Necrobia ruficollis** (Fabricius)	**redshouldered ham beetle**	*AQ07 AQ22 BI02 BI03*	ii, iii, 150
*Necrobia rufipes** (De Geer)	**redlegged ham beetle**	*AQ07 AQ12 AQ22 BI02 BI03*	ii, iii, 150, 577
*Necrobia violacea** (L.)	blacklegged ham beetle	*AQ07 AQ22 BI02 BI03*	ii, iii, 150
Tarsostenus univitattus (Rossi)		*AQ07*	
Thaneroclerus buqueti (Lefebvre)		*AQ07*	

BI01 Barr, W.F.
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BI02 Knull, J.N.
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BI03 Van Emden, F.I.
1943. Larvae of British beetles, IV. Various small families. Ent. Monthly Mag. 79(952)209-223; (954)259-264; (955)265-270.

Taxon	Common Name	Reference	Page
Colydiidae	colydiid beetles	*A016 AQ02*	
Aglenus brunneus (Gyllenhal)		*A016*	
Anchomma costatum LeConte			
Colobicus parilis Pascoe		*A016*	
Myrmechixenus			
Sassaka			
Cryptophagidae*	**silken fungus beetles**	*A016 AQ02*	78, 107, 175-177, 581, 582
*Cryptophagus**			78, 107, 176
*Cryptophagus acutangulus** (Gyllenhal)	**acute-angled fungus beetle**	*A016 BK01 BK02*	177
*Cryptophagus cellaris** (Scopoli)	cellar beetle	*A016 BK01 BK02*	178, 582
Cryptophagus croceus Zimmermann		*A016 BK02*	
Cryptophagus dentatus (Herbst) [*C. fumatus* (Marsham)]		*A016 BK01 BK02*	
Cryptophagus distinguendus Sturm		*A016 BK01 BK02*	
Cryptophagus hexagonalis Tournier		*BK01 BK02*	
Cryptophagus laticollis Lucas [*C. affinis* Sturm; *C. inscitus* Casey]		*A016 BK01 BK02*	582
Cryptophagus lecontei Harold		*BK02*	
Cryptophagus obsoletus Reitter		*BK01 BK02*	
Cryptophagus pilosus Gyllenhal		*A016 BK01 BK02*	
Cryptophagus saginatus Sturm		*A016 BK01 BK02*	
Cryptophagus scanicus (L.)		*A016 BK01 BK02*	
Cryptophagus schmidti Sturm		*A016 BK01*	
Cryptophagus scutellatus Newman		*A016 BK01 BK02*	
Cryptophagus setulosus Sturm		*BK01 BK02*	
Cryptophagus subfumatus Kraatz		*A016 BK01 BK02*	
Cryptophagus tuberculosus Mäklin		*BK02*	
*Cryptophagus valens** Casey		*BK02*	178
*Cryptophagus varus** (Woodroffe & Coombs)	**sigmoid fungus beetle**	*BK02*	177

Taxon	Common Name	Reference	Page
Ephistemus			
Henoticus californicus (Mannerheim)		*A016 AQ07*	

BK01 Coombs, C.W., and G.E. Woodroffe.
1955. A revision of the British species of *Cryptophagus* Herbst (Coleoptera: Cryptophagidae). Trans. Roy. Ent. Soc. London 106(6)237-282.

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Taxon	Common Name	Reference	Page
Cucujidae* [Silvanidae]	cucujid beetles	*A016 AQ02*	79, 83, 85, 105, 108, 547, 550, 552
*Ahasverus advena** (Waltl)	**foreign grain beetle**	*AQ07 AQ22 AY09 BL04*	86, 552
*Cathartus quadricollis** (Guérin-Méneville)	**squarenecked grain beetle**	*AQ22 AY09*	86, 552
*Cryptolestes**		*AQ22 AY09*	83, 105, 550
Cryptolestes capensis (Waltl)	Cape grain beetle	*BL01 BL08*	83
Cryptolestes duplicatus (Waltl)		*BL04 BL08*	
Cryptolestes ferrugineus (Stephens)	**rusty grain beetle**	*AQ22 BL01-BL03 BL05 BL08 BL10*	83
Cryptolestes klapperichi Lefkovitch		*BL05*	83
Cryptolestes pusilloides (Steel & Howe)		*BL01 BL08*	83
Cryptolestes pusillus (Schönherr)[*C. minutus* (Olivier)]	**flat grain beetle**	*AQ22 BL01-BL03 BL05 BL08 BL10*	83, 550
Cryptolestes turcicus (Grouvelle)	Turkish grain beetle	*AQ22 BL01 BL02 BL08 BL10*	83
Cryptolestes ugandae (Steel & Howe)		*BL01*	83
Leptophloeus janeti (Grouvelle)		*BL08*	
Monanus concinnulus (Walker)		*BL09*	
Oryzaephilus acuminatus Halstead		*BL07 BL12*	
Oryzaephilus gibbosus Aitken		*BL07*	
*Oryzaephilus mercator** (Fauvel)	**merchant grain beetle**	*AQ07 BL04 BL07 BL08 BL11 BL12*	79, 547
*Oryzaephilus surinamensis** (L.)	**sawtoothed grain beetle**	*AQ07 AQ22 BL04 BL07 BL11 BL12*	40, 79
*Silvanus planatus** Germar		*BL06*	

BL01 Banks, H.J.
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Taxon	Common Name	Reference	Page
Curculionidae*	**snout beetles, weevils**	*A016 AQ02 BM07*	78, 109, 11, 223, 224, 603-608

Taxon	Common Name	Reference	Page
Balanogastris kolae (Desbrochers)	kola nut weevil		224
*Caulophilus oryzae** (Gyllenhal)[*C. latinasus* (Say)]	avocado seed weevil	*AQ07 AQ22 AY09 BB02 BM06*	112, 226, 606
Caulophilus rufotestaceus (Champion)		*BM06*	
*Chalcodermus aeneus** Boheman	**cowpea curculio**		111, 225, 604
Conotrachelus		*BM10*	
Craponius inaequalis (Say)	**grape curculio**		224
*Curculio**		*BM10*	224
Curculio caryae (Horn)	**pecan weevil**	*BM02 BM10*	225, 605
Curculio caryatrypes (Boheman)		*BM02 BM10*	
Curculio obtusus (Blanchard)	**hazelnut weevil**	*BM02*	
Curculio occidentis (Casey)	**filbert weevil**	*BM02*	
Curculio sayi (Gyllenhal)	**small chestnut weevil**	*BM02 BM10*	
Dinocleus [*Cleonus*] *pilosus* (LeConte)			
Heilipus	avocado weevils		224
*Sitophilus granarius** (L.)	**granary weevil**	*AQ07 AQ22 AY09 BB02 BM04 BM05*	110, 228, 607
Sitophilus linearis (Herbst)	**tamarind weevil**		227, 607
*Sitophilus oryzae** (L.)	**rice weevil**	*AQ07 AQ22 AY09 BB02 BM01 BM04 BM05 BM08 BM09*	40, 110, 229, 608
*Sitophilus zeamais** Motschulsky	**maize weevil**	*AQ07 AQ22 AY09 BM01 BM04 BM08 BM09*	110, 229, 608

BM01 Boudreau, H.B.
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Taxon	Common Name	Reference	Page
Dermestidae* [including Thorictidae]	**dermestid beetles**	*A016 AQ02 AY08 BN14 BN19*	82, 83, 91, 101, 115, 559-566
Anthrenocerus australis (Hope)		*A016*	
Anthrenus caucasicus Reitter		*A016*	
Anthrenus coloratus Reitter		*A016 BN11 BN22 BN25*	
Anthrenus fuscus Olivier		*A016 BN22 BN25*	
Anthrenus museorum (L.)		*A016 AY07 BN14 BN25*	
Anthrenus pimpinellae Fabricius		*A016 BN22 BN25*	
Anthrenus sarnicus Mroczkowski		*BN22*	
*Anthrenus scrophulariae** (L.)	**carpet beetle**	*A016 AQ22 AY08 BN02 BN14 BN22 BN23 BN25*	ii, iii, 4, 82, 120, 131
*Anthrenus verbasci** (L.)	**varied carpet beetle**	*A016 AQ22 AY08 BN02 BN11 BN14 BN22 BN25*	ii, iii, 4, 120, 131, 563
Anthrenus vorax Waterhouse		*A016 AY08 BN14*	
*Attagenus brunneus** Faldermann [*A. elongatulus* Casey]		*BN06 BN09*	121, 131
Attagenus cyphonoides Reitter		*BN09 BN18*	
Attagenus fasciatus (Thunberg) [*A. gloriosae* (Fabricius)]		*A016 BN06 BN18*	
Attagenus insidiosus Halstead		*BN09*	
Attagenus lobatus Rosenhauer		*A016 BN06*	
*Attagenus pellio** (L.)	felt beetle, fur beetle	*A016 AQ07 AQ22 AY08 AY09 BN02 BN06 BN14 BN18*	121, 130

Taxon	Common Name	Reference	Page
Attagenus schaefferi (Herbst)		*BN06 BN09 BN14 BN24*	
Attagenus smirnovi Zhantiev		*BN09 BN18*	
*Attagenus unicolor unicolor** (Brahm) [*A. megatoma* (Fabricius); *A. piceus* (Olivier) of authors]	**black carpet beetle**	*A016 AQ07 AQ22 AY08 BN02 BN06 BN09 BN14 BN18 BN24*	121, 131, 564
Attagenus unicolor japonicus Reitter		*BN09*	
Attagenus unicolor simulans Solskij		*BN09*	
*Dermestes ater** De Geer	**black larder beetle**	*A016 AQ07 AQ22 AY08 BN01 BN10 BN13 BN14 BN20*	119, 130, 554
Dermestes bicolor Fabricius		*A016*	
Dermestes caninus Germar		*BN09BN14*	
Dermestes carnivorus Fabricius		*AQ07 AY08 BN10 BN13 BN14*	
Dermestes dimidiatus Steven		*A016*	
Dermestes frischii Kügelann		*AQ07 BN10 BN13 BN14*	119, 128
*Dermestes haemorrhoidalis** Küster	sheepskin dermestid	*AQ07 BN01 BN17*	119, 129, 561
*Dermestes lardarius** L.	**larder beetle**	*A016 AQ07 AQ22 AY08 AY09 BN02 BN10 BN13 BN14 BN17 BN20*	118, 130, 561
Dermestes leechi Kalik		*BN01*	
*Dermestes maculatus** De Geer	**hide beetle**	*A016 AQ07 AQ22 AY08 BN02 BN10 BN13 BN19*	117, 128, 561
Dermestes marmoratus Say		*A016 BN10*	
Dermestes murinus L.		*A016 AY08*	
Dermestes mustelinus Erichson		*A016*	
Dermestes nidum Arrow		*A016 BN14*	
*Dermestes peruvianus** (Castelnau)	Peruvian larder beetle	*AQ07 AQ22 BY07 BN01 BN02 BN17 BN20*	119, 129, 561
Dermestes undulatus Brahm		*A016 AY08*	
Megatoma variegata (Horn)		*A016*	
Novelsis aequalis (Sharp)		*BN06 BN12*	
Phradonoma tricolor (Arrow)		*A016*	
Phradonoma villosulum (Duftschmid)		*A016*	
Reesa vespulae (Milliron)			
Thorictodes heydeni Reitter		*BN08*	
*Thylodrias contractus** Motschulsky	**odd beetle**	*A016 AQ22 BN02 BN14*	91, 116, 127, 560
Trogoderma cavum Beal		*BN07*	
*Trogoderma glabrum** (Herbst)	glabrous cabinet beetle	*BN02-BN05 BN15*	124, 134, 565

Taxon	Common Name	Reference	Page
*Trogoderma granarium** Everts	**khapra beetle**	*A016 AQ07 AQ22 AY08 AY09 BN04 BN05 BN14 BN15 BN21*	123, 124, 133, 565
*Trogoderma inclusum** LeConte	larger cabinet beetle	*AQ07 AQ22 AY09 BN02 BN04 BN15 BN16*	ii, iii, 4, 124, 134
*Trogoderma ornatum** (Say)	ornate cabinet beetle	*AQ22 BN02-BN05 BN14 BN16*	ii, iii, 4, 126, 134
*Trogoderma simplex** Jayne	plain cabinet beetle	*AQ22 BN03-BN05 BN15 BN16*	122, 132, 565
Trogoderma sternale Jayne		*A016 BN03 BN15 BN16*	
*Trogoderma variabile** Ballion [*T. parabile* Beal]	**warehouse beetle**	*A016 AQ22 BN02-BN05 BN15 BN16*	ii, iii, 4, 125 134, 566
*Trogoderma versicolor** (Creutzer)	European larger cabinet beetle	*AY08 BN14*	126, 134, 565

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Taxon	Common Name	Reference	Page
Discolomidae [Notiophygidae]			
Parafallia simoni John			
Endomychidae* [Mycetaeidae]	handsome fungus beetles	*A016 AQ02*	85, 99, 552
*Mycetaea subterranea** (Fabricius) [*M. hirta* (Marsham)]	hairy cellar beetle	*A016 AQ07 AQ22*	85, 99, 552
Histeridae	**hister beetles**	*A016 AQ02*	
Acritus analis LeConte			
Carcinops mayeti Marseul		*BQ02 BQ03*	
Carcinops pumilio (Erichson) [*C. quattuordecimstriatus* (Stephens)]		*AQ07 BQ01 BQ02*	
Carcinops troglodytes (Paykull)		*BQ02*	
Dendrophilus punctatus (Herbst)		*BQ01 BQ02*	
Dendrophilus xavieri Marseul		*BQ01 BQ03*	
Gnathoncus nannetensis (Marseul)		*BQ01 BQ03*	
Gnathoncus nanus (Scriba)		*BQ01 BQ03*	
Hypocacculus metallescens (Erichson)		*A023 BQ03*	
Peranus bimaculatus (L.)		*BQ01*	
Saprinus semipunctatus (Fabricius)		*BQ03*	
Saprinus semistriatus (Scriba)		*A023 BQ01 BQ03*	

BQ01 Halstead, D.G.H.
1963. Coleoptera: Histeroidea. Handb. Ident. British Insects 4(10)1-18.

BQ02 Halstead, D.G.H.
1969. A key to the species of *Carcinops* Marseul (Coleoptera, Histeridae) associated with stored products, including *C. troglodytes* (Paykull) new to this habitat. Jour. Stored Prod. Res. 5(1)83-85.

BQ03 Hinton, H.E.
1945. The Histeridae associated with stored products. Bul. Ent. Res. 35(4)309-340 [key applicable mainly to temperate climates].

Taxon	Common Name	Reference	Page
Languriidae* [Erotylidae]	**lizard beetles**	*A016 AQ02 BR01*	93, 107, 558
Cryptophilus integer (Heer)		*A016*	
*Pharaxonotha kirschi** Reitter	Mexican grain beetle	*A016 AQ22 AY09*	93, 107, 558

BR01 Roberts, A.W.R.
1958. On the taxonomy of Erotylidae (Coleoptera), with special reference to the morphological characters of the larvae. II. Trans. Roy. Ent. Soc. London 110(8)245-285.

Taxon	Common Name	Reference	Page
Lathridiidae* [including Merophysiidae]	**minute brown scavenger beetles**	*A016 AQ02 BS04*	84, 108, 179-181, 583-587
Adistemia rileyi Hinton		*A016*	
*Adistemia watsoni** (Wollaston)		*A016 BS01*	181, 584
Aridius [*Coninomus*] *nodifer* (Westwood)		*A016 BS01 BS03 BS04*	584
Aridius subfasciatus Reitter		*A016*	
Cartodere [*Coninomus*] *constricta** (Gyllenhall)	**plaster beetle**	*A016 AQ07 BS03*	184, 587
Corticaria elongata (Gyllenhal)		*A016 BS01 BS04*	
Corticaria fenestralis (L.)		*A016 BS04*	
Corticaria fulva (Comolli)		*A016 BS01*	
Corticaria punctulata Marsham [*C. pubescens* (Gyllenhal)]		*A016 AQ07 BS01 BS04*	
Corticaria subtilissima Reitter		*A016*	
Cortinicara [*Corticarina*] *gibbosa* (Herbst)		*BS01 BS02*	
Dienerella [*Cartodere; Microgramme*] *arga** (Reitter)		*A016 BS01*	183, 585
*Dienerella costulata** (Reitter)		*A016 BS01*	183, 586
*Dienerella filiformis** (Gyllenhal)		*A016 BS01 BS03*	183, 586
*Dienerella filum** (Aubé)		*A016 BS01*	182, 585
Dienerrella ruficollis (Marsham)		*A016 BS01*	182, 585
Enicmus histrio Joy & Tomlin		*A016*	
Eufalloides holmesi Hinton		*A016*	
Holoparamecus caularum (Aubé)		*A016 BS01*	
Holoparamecus depressus Curtis		*A016*	
Holoparamecus ragusae Reitter		*A016 BS01*	
Holoparamecus singularis (Beck)		*A016 BS01*	
Lathridius [*Enicmus*] *anthracinus* Mannerheim			
*Lathridius minutus** (L.)	**squarenosed fungus beetle**	*A016 BS01 BS03*	184, 587

Taxon	Common Name	Reference	Page
Lathridius protensicollis Mannerheim		*A016 BS01*	184, 587
Lathridius pseudominutus (Strand)			
Lathridius suspectus (Fall)		*A016 BS01*	
Melanophthalma americana (Mannerheim)		*A016 BS01*	
Melanophthalma distinguenda (Comolli)		*A016 BS01*	
Melanophthalma longipennis (LeConte)		*A016 BS01*	
Melanophthalma picta (LeConte)		*A016 BS01*	
Metophthalmus serripennis (Broun)		*A016*	
Migneauxia orientalis Reitter		*A016*	
Thes [*Lathridius*] *bergrothi* (Reitter)	**ridgewinged fungus beetle**	*A016 AQ07 BS03*	

BS01 Fall, H.C.
1899. Revision of the Lathridiidae of Boreal America. Trans. American Ent. Soc. 26(Nov.-Dec.)101-190, 3 pl.

BS02 Johnson, C.
1975. *Cortinicara,* a new genus of Corticariinae (Coleoptera: Lathridiidae). Ent. Scandinavica 6(3-4)283-285.

BS03 Walkley, L.M.
1952. Revision of the Lathridiini of the state of Washington. Proc. Ent. Soc. Washington 54(5)217-235.

BS04 Watt, J.C.
1969. Keys to genera and some species of New Zealand Lathridiidae. New Zealand Ent. 4(2)49-67.

Taxon	Common Name	Reference	Page
Lyctidae*	**powderpost beetles**	*A016 AQ02*	90, 98
*Lyctus brunneus** (Stephens)	brown powderpost beetle	*AQ07 AQ22 BT01*	90, 555

BT01 Gerberg, E.J.
1957. A revision of the New World species of powder-post beetles belonging to the family Lyctidae. U.S. Dept. Agr. Tech. Bull. 1157:1-55, 14 pl.

Taxon	Common Name	Reference	Page
Mycetophagidae*	**hairy fungus beetles**	*A016 AQ02*	92, 106, 557
*Litargus balteatus** *LeConte*		*A016 BU03*	93, 106, 557
Mycetophagus quadriguttatus Müller		*A016 AQ07 BU03*	
*Typhaea stercorea** (L.)	**hairy fungus beetle**	*A016 AQ07 AY09 BU01* BU02 *BU03*	92, 106, 557

BU01 Hayashi, N.
1971. On the larvae of Mycetophagidae occurring in Japan (Coleoptera: Cucujoidea). Kontyû 39(4)361-367.
BU02 Klausnitzer, B.
1974. Zur Unterscheidung der Larven von *Typhaea* Curtis und *Mycetophagus* Hellwig (Col., Mycetophagidae). Ent. Nachr. 18(11-12)188.
BU03 Parsons, C.T.
1975. Revision of the Nearctic Mycetophagidae (Coleoptera). Coleop. Bull. 29(2)93-108.

Taxon	Common Name	Reference	Page
Nitidulidae*	**sap beetles**	*A016 AQ02*	87, 102, 575-580
Brachypeplus pilosellus Murray			
*Carpophilus dimidiatus** (Fabricius)	**corn sap beetle**	*A016 AQ07 BV03 BV04*	160, 173, 579
Carpophilus flavipes Murray		*A016*	152
*Carpophilus freemani** Dobson		*BV02*	162, 173, 579
*Carpophilus fumatus** Boheman		*BV03*	152, 163, 172, 579
*Carpophilus hemipterus** (L.)	**driedfruit beetle**	*A016 AQ07 BV02-BV04*	159, 171, 322, 578
*Carpophilus humeralis** (Fabricius) [*Urophorus humeralis* (Fabricius)]	pineapple sap beetle	*A016 BV02-BV04*	157, 167, 577
Carpophilus immaculatus Lucas		*A016*	152
*Carpophilus ligneus** Murray		*A016 AQ07 BV03*	164, 168, 580
*Carpophilus lugubris** Murray	**dusky sap beetle**	*BV02 BV04*	164, 171, 580
*Carpophilus maculatus** Murray		*A016 BV03*	110, 161, 579
*Carpophilus marginellus** Motschulsky		*A016 BV02 BV03*	161, 165, 170, 580
*Carpophilus mutilatus** Erichson		*BV02 BV03*	163, 172
*Carpophilus obsoletus** Erichson		*A016 AQ07 BV03 BV04*	159, 169, 578
*Carpophilus pilosellus** Motschulsky		*BV04*	152, 160, 173, 579
Carpophilus sexpustulatus (Fabricius)		*A016*	152
*Conotelus stenoides** Murray		*BV01 BV04*	156, 167, 577
*Glischrochilus fasciatus** (Olivier)		*A016 BV01 BV02 BV04*	152, 154, 576
*Glischrochilus quadrisignatus** (Say)		*A016 BV01 BV02 BV04*	154, 576
Haptoncus flavidus (Fairmaire)		*A016*	152
*Haptoncus luteolus** (Erichson)	yellowbrown sap beetle	*A016 BV01 BV04*	152, 155, 576

Taxon	Common Name	Reference	Page
*Lobiopa insularis** (Castelnau)		*BV01 BV04*	155, 166, 576
*Nitidula bipunctata** (L.)		*A016 BV04*	152, 157, 577
*Nitidula ziczac** Say		*BV04*	152, 157, 577

BV01 Böving, A.G., and J.G. Rozen.
1962. Anatomical and systematic study of mature larvae of Nitidulidae (Coleoptera). Ent. Meddel. 31:265-299.

BV02 Connell, W.A.
1956. Nitidulidae of Delaware. Univ. Delaware Expt. Sta. Bull. (Tech.) 318:1-67.

BV03 Dobson, R.M.
1954. The species of *Carpophilus* Stephens (Col., Nitidulidae) associated with stored products. Bull. Ent. Res. 45(2)389-402.

BV04 Parsons, C.T.
1943. A revision of the Nearctic Nitidulidae (Coleoptera). Bul. Mus. Comp. Zool. 92(3)119-278, 13 pl.

Taxon	Common Name	Reference	Page
Ptinidae*	**spider beetles**	*A016 AQ02 BW05*	89, 97, 137
Gibbium aequinoctiale Boieldieu		*BW08*	140
*Gibbium psylloides** (Czenpinski)	hump beetle	*AY07 AT09 BW03-BW06 BW08*	140, 568
*Mezium affine** Boieldieu	northern spider beetle	*AQ07 AY09 BW03-BW06*	140
*Mezium americanum** (Laporte)	**American spider beetle**	*AY09 BW01 BW04-BW06*	ii, iii, 140, 331, 568
*Niptus hololeucus** (Faldermann)	**golden spider beetle**	*AQ07 AY09 BW01-BW04 BW07*	ii, iii, 142, 569
Pseudeurostus alienus Brown		*AY09 BW01*	
*Pseudeurostus hilleri** (Reitter)		*AQ07 BW03-BW05*	143, 570
Ptinus bicinctus Sturm		*BW01 BW04 BW05*	
*Ptinus clavipes** Panzer [*P. latro* of authors; *P. mobilis* Moore; *P. brunneus* Duftschmid; *P. hirtellus* Sturm]	**brown spider beetle**	*AQ07 AY09 BW03-BW06*	145, 146
*Ptinus fur** (L.) [*P. latro* Fabricius]	**whitemarked spider beetle**	*AQ07 AY09 BW03-BW05*	143-146, 572
*Ptinus gandolphei** Pic		*BW05 BW06*	144
Ptinus japonicus Reitter		*BW04*	
*Ptinus ocellus** Brown [*P. tectus* Boieldieu]	**Australian spider beetle**	*AQ07 AY09 BW01 BW03 BW04 BW05*	143, 571
Ptinus pusillus Sturm		*AQ07 BW03 BW04*	
*Ptinus raptor** Sturm	Canadian spider beetle	*AY08 BW01 BW03-BW05*	144
Ptinus sexpunctatus Panzer		*BW03 BW04*	
*Ptinus villiger** (Reitter)	**hairy spider beetle**	*AY09 BW01 BW02 BW04 BW06*	

Taxon	Common Name	Reference	Page
*Sphaericus gibboides** (Boieldieu)	humpbacked spider beetle	*BW04-BW06*	141, 569
Stethomezium squamosum Hinton		*BW03*	
Tipnus unicolor (Piller & Mitterpacher)		*AQ07 AY09 BW01 BW03 BW04-BW06*	
*Trigonogenius globulum** (Solier)	**globular spider beetle**	*AQ07 AY09 BW01 BW03-BW06*	143, 569

BW01 Brown, W.J.
1940. A key to the species of Ptinidae occurring in dwellings and warehouses in Canada (Coleoptera). Canadian Ent. 72(6)115-122.

BW02 Brown, W.J.
1959. *Niptus* Boield. and allied genera in North America (Coleoptera: Ptinidae). Canadian Ent. 91(10)627-633.

BW03 Hall, D.W., and R.W. Howe.
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BW04 Hinton, H.E.
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BW05 Papp, C.S.
1962. An illustrated and descriptive catalog of the Ptinidae of North America. Deut. Ent. Ztschr. (n.f.) 9(5)367-423.

BW06 Papp, C.S., and G.T. Okumura.
1959. A preliminary study of the Ptinidae of California. California Dept. Agr. Bull. 48(4)228-248.

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1968. Two new species of *Niptus* from North American caves (Coleoptera: Ptinidae). Southwest. Nat. 13(2)193-200.

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BW08 Bellés, X., and D.G.H. Halstead.
1985. Identification and geographical distribution of *Gibbium aequinoctiale* Boieldieu and *Gibbium psylloides* (Czenpinski) (Coleoptera: Ptinidae). Jour. Stored Products Res. 21(3)151-155.

Taxon	Common Name	Reference	Page
Scarabaeidae	**scarabs**	*A016 AQ02*	334
Cotinus mutabilis (Gory & Percheron) [*C. texana* Casey]	fig beetle	*BX01*	

BX01 Goodrich, M.A.
1966. A revision of the genus *Cotinus* (Coleoptera: Scarabaeidae). Ann. Ent. Soc. America 59(3)550-568.

Taxon	Common Name	Reference	Page
Scolytidae*	**bark beetles**	*A016 AQ02*	90, 112, 556

Taxon	Common Name	Reference	Page
*Hypothenemus hampei** (Ferrari) [*Stephanoderes coffeae* Hagedorn]	**coffee berry borer**	*AQ12 BY01 BY03*	90, 112, 555
Pagiocerus		*BY02*	
Pagiocerus frontalis (Fabricius) [*P. fiorii* (Egger)]		*BY03*	

BY01 Duffy, E.A.J.
1958. Coleoptera: Scolytidae and Platipodidae. Handb. Ident. British Insects 5(15)1-20.

BY02 Schedl, K.E.
1955. The genus *Pagiocerus* Eichh., important pests of maize. Riv. Agr. Subtropic. Tropic. 59:300-307.

BY03 Wood, S.L.
1982. The bark and ambrosia beetles of North and Central America (Coleoptera: Scolytidae), a taxonomic monograph. Great Basin Nat. Mem. 6:1-1359.

Taxon	Common Name	Reference	Page
Staphylinidae	**rove beetles**	*A016 AQ02*	331
Aleochara sparsa Heer		*A016 BZ05*	
Anotylus [*Oxytelus*] *tetracarinatus* (Block)		*A016 AQ07 BZ04 BZ08*	
Atheta celata (Erichson) [*A. arenicola* Thomson]		*A016 BZ05*	
Atheta coriaria (Kraatz)		*A016 BZ05*	
Atheta nigricornis (Thomson)		*A016 BZ05*	
Atheta trinotata (Kraatz)		*A016 BZ05*	
Carpelimus pusillus (Gravenhorst)		*A016 BZ04 BZ08*	
Cilea [*Leucoparyphus*] *silphoides* (L.)		*A016 BZ01 BZ04*	
Crataraea suturalis (Mannerheim)		*A016 BZ05*	
Creophilus maxillosus (L.)	**hairy rove beetle**	*A016 BZ04*	
Falagria concinna Erichson		*BZ05*	
Gabrius nigritulus (Gravenhorst)		*BZ04*	
Leptacinus pusillus (Stephens) [*L. linearis* (Gravenhorst)]		*A016*	
Lithocharis ochracea (Gravenhorst)		*BZ04*	
Oligota apicata Erichson		*A016 BZ05 BZ09 BZ11*	
Oligota chrysopyga Kraatz		*BZ09 BZ11*	
Oligota granaria Erichson		*A016 BZ05 BZ09*	
Oligota parva Kraatz		*A016 BZ05 BZ09 BZ10*	
Oligota pseudoparva Williams		*BZ10*	
Oligota puctulata Heer [*O. ruficornis* Sharp]		*A016 BZ05 BZ09*	
Oligota pusillima Gravenhorst [*O. atomaria* Erichson]		*A016 BZ05 BZ09*	

Taxon	Common Name	Reference	Page
Omalium rivulare (Paykull)		*A016 BZ04 BZ08*	
Oxytelus sculptus Gravenhorst		*A016 BZ04 BZ08*	
Paederus duplex Eppelsheim		*BZ03*	
Philonthus discoideus (Gravenhorst)		*BZ04*	
Philonthus nigriventris Thomson		*BZ04*	
Philonthus sordidus (Gravenhorst)		*A016 BZ04*	
Philonthus varians (Paykull)		*BZ04*	
Phloeostiba plana (Paykull) [*Phloeonomus planus* (Paykull)]		*A016 BZ04 BZ08*	
Proteinus ovalis Stephens		*A016 BZ04 BZ08*	
Quedius fulgidus (Fabricius) [*Q. assimilis* (Nordmann)]		*A016 BZ04 BZ06*	
Quedius fuliginosus (Gravenhorst)		*A016 BZ04*	
Quedius mesomelinus (Marsham)		*A016 BZ04 BZ06*	
Tachyporus		*BZ02 BZ04*	
Xylodromus concinnus (Marsham)		*A016 BZ04 BZ08*	
Xylodromus depressus (Gravenhorst)		*A016 BZ04 BZ08*	

BZ01 Campbell, J.M.
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1979. A revision of the genus *Tachyporus* Gravenhorst (Coleoptera: Staphylinidae) of America north of Mexico. Mem. Ent. Soc. Canada 109:i-v, 1-95.

BZ03 Fagel, G.
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BZ04 Freude, H., K.W. Harde, and G.A. Lohse (eds.).
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1982. Revision of the subfamily Xantholininae of America north of Mexico (Coleoptera: Staphylinidae). Mem. Ent. Soc. Canada 120:i-viii, 1-389.

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1970. Notes on the genus *Oligota* Mannerheim (Col., Staphylinidae) and key to the British species. Ent. Monthly Mag. 106(1268-1270)54-62.

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1972. A Brazilian species of *Oligota* (Col., Staphylinidae) new to science and imported into Britain. Ent. Monthly Mag. 108(1292-1294)38-39.

BZ11 Williams, S.A.
1974. *Oligota* (*Holobus*) *chrysopyga* Kraatz (Col., Staphylinidae) imported into Britain from Brazil. Ent. Monthly Mag. 109(1310-1312)164-165.

Taxon	Common Name	Reference	Page
Tenebrionidae*	**darkling beetles**	*A016 AQ02 CA14*	82, 83, 102, 185, 589-598
*Alphitobius diaperinus** (Panzer)	**lesser mealworm**	*AQ07 AQ22 CA05 CA08 CA16*	194, 208, 595
*Alphitobius laevigatus** (Fabricius) [*A. piceus* (Olivier)]	**black fungus beetle**	*AQ07 AQ22 CA02 CA05 CA08 CA16*	195, 208
*Alphitobius viator** Mulsant & Godart		*CA05*	186, 195, 595
*Alphitophagus bifasciatus** (Say)	**twobanded fungus beetle**	*AQ07 AQ22 CA02 CA08 CA16*	ii, iii, 187, 211
*Apsena rufipes** Eschscholtz	fig engraver beetle		186, 188, 590
Blaps mucronata Latreille	churchyard beetle	*AQ07 CA16*	
*Blapstinus discolor** Horn [*B. fuliginosus* Casey; *B. rufipes* Casey]	fig darkling beetle	*CA03*	193, 207, 594
*Coelopalorus** [*Palorus*] *carinatus* (Blair)		*CA06*	596
*Coelopalorus foveicollis** (Blair)		*CA06 CA13*	186, 196, 596
*Cynaeus angustus** (LeConte)	**larger black flour beetle**	*AY09 BC06*	199, 595
*Gnatocerus cornutus** (Fabricius)	**broadhorned flour beetle**	*AQ07 AQ22 CA02 CA08*	200, 212, 598
*Gnatocerus maxillosus** (Fabricius)	**slenderhorned flour beetle**	*AQ07 AQ22 CA02*	200, 210, 598
*Latheticus oryzae** Waterhouse	**longheaded flour beetle**	*AQ07 AQ22 CA02 CA08 CA16*	199, 204, 596
Lepidocnemeplatia [*Cnemaplatia*] *sericea** (Horn)			186, 187, 590
*Neatus tenebrioides** Palisot			191, 208, 592
*Palembus dermestoides** (Fairmaire)			194, 212, 594
*Palembus ocularis** Casey		*CA15*	194, 211, 594
Palorinus [*Palorus*] *humeralis** (Gebien)		*CA06*	186, 196
*Palorus cerylonoides** (Pascoe)		*CA06*	186, 198
*Palorus ficicola** (Wollaston)		*CA06*	186, 198
*Palorus genalis** Blair		*CA06*	186, 197

Taxon	Common Name	Reference	Page
*Palorus laesicollis** (Fairmaire)		*CA06*	186, 196, 597
*Palorus ratzeburgii** (Wissmann)	**smalleyed flour beetle**	*AQ07 AQ22 CA02 CA06 CA08 CA13*	198, 203, 597
*Palorus subdepressus** (Wollaston)	**depressed flour beetle**	*AQ07 AQ22 CA02 CA06 CA08 CA13*	197, 203, 597
*Platydema ruficorne** (Sturm)	redhorned grain beetle	*AQ22 CA15*	193, 210, 592
*Sitophagus hololeptoides** (Laporte)		*CA04*	199, 210, 598
*Tenebrio molitor** L.	**yellow mealworm**	*CA07 AQ22 CA02 CA08 CA15*	186, 192, 203, 335, 593
*Tenebrio obscurus** Fabricius	**dark mealworm**	*AQ07 AQ22 CA02 CA08 CA15*	192, 203, 593
*Tribolium audax** Halstead	**American black flour beetle**	*CA01 CA07 CA12*	190, 206, 592
*Tribolium brevicorne** (LeConte)	giant flour beetle	*CA09*	188, 206, 590
*Tribolium castaneum** (Herbst)	**red flour beetle**	*AQ07 AQ22 CA02 CA09 CA10 CA12 CA16*	186, 190, 205, 591
*Tribolium confusum** Jacquelin du Val	**confused flour beetle**	*AQ07 AQ22 CA02 CA08 CA09 CA10 CA12 CA16*	186, 189, 206, 591
*Tribolium destructor** Uyttenboogaart	dark flour beetle	*AQ07 AQ22 CA02 CA08 CA10 CA12 CA16*	189, 206, 590
Tribolium freemani Hinton		*CA11*	
*Tribolium madens** (Charpentier)	black flour beetle	*AQ22 CA01 CA07 CA09 CA10 CA12 CA16*	190, 205, 592

CA01 Becker, E.C.
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CA02 Brendell, M.J.D.
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CA03 Davis, J.C.
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CA04 Doyen, J.T.
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CA06 Halstead, D.G.H.
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CA16 Van Emden, F.I.
1947. Larvae of British beetles. VI. Tenebrionidae. Ent. Monthly Mag. 83(997)154-160, (998)161-171.

Taxon	Common Name	Reference	Page
Trogositidae* [Ostomidae, Ostomatidae, Lophocateridae]	**trogositid beetles**	*A016 AQ02*	91, 103, 556, 558
*Lophocateres pusillus** (Klug)	Siamese grain beetle	*AQ19 AQ23 AY09 CB01 CB02*	93, 104, 558
Tenebroides mauritanicus (L.)*	**cadelle**	*AQ07 AQ19 AQ23 AY09 CB01 CB02*	91, 104, 556

CB01 Barron, J.R.
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Taxon	Common Name	Reference	Page
Lepidoptera* (order)	**moths, butterflies**	*AQ02 AQ05 AQ10 AQ13 AQ17 AQ20 AQ25 CC01 CC02-CC10*	231, 245, 248, 314, 343, 609-615

CC01 Capps, H.W
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CC04 Hinton, H.E.
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CC09 Weisman, D.M.
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CC10 Zimmerman, E.C.
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Taxon	Common Name	Reference	Page
Argyresthiidae* [Yponomeutidae]	**argyresthiid moths**	*AQ02 CC09*	264, 615
*Argyresthia conjugella** (Zeller)	**apple fruit moth**	*CC01 CC09 CD01*	264, 615

CD01 Werner, K.
1958. Die Larvalsystematik einiger Kleinschmetterlingsfamilien (Hyponomeutidae, Orthoteliidae, Acrolepiidae, Tineidae, Incurvariidae und Adelidae). Akademie-Verlag, Berlin.

Taxon	Common Name	Reference	Page
Cosmopterigidae*	cosmopterigid moths	*CC01 CC09*	264, 614
*Pyroderces** *[Sathrobrota] rileyi* Walsingham	**pink scavenger caterpillar**	*AQ07 AQ22 AQ23 CC02 CC04 CC06 CC07*	264, 335, 614
Gelechiidae*	**gelechiid moths**	*CC01 CC04 CC09*	242, 265, 615
Keiferia lycopersicella (Walsingham)	**tomato pinworm**	*CC01 CC09 CE01*	
Phthorimaea [*Gnorimoschema*] *operculella* (Zeller)	**potato tuberworm**	*CC01 CE02*	
*Sitotroga cerealella** (Olivier)	**Angoumois grain moth**	*AQ07 AQ19 AQ23 AQ25 CC01 CC02 CC04 CC09 CC10*	40, 242, 265, 314, 615

CE01 Capps, H.W.
1946. Description of the larva of *Keiferia peniculo* Heinrich, with a key to the larvae of related species attacking eggplant, pepper, potato and tomato in the United States (Lepidoptera: Gelechiidae). Ann. Ent. Soc. America 39(4)561-563.

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1982. The potato moth—*Phthorimaea operculella* Zeller (Lepidoptera, Gelechiidae). Ent. Rev. 61(4)112-116.

Taxon	Common Name	Reference	Page
Libytheidae	snout butterflies	*AQ02*	
Libytheana bachmanii (Kirtland)		*AQ02*	
Noctuidae* [Phalaenidae]	**owlet moths, underwings**	*AQ02 CC01 CC09 CC10 CG03*	247, 610, 611
*Autographa gamma** (L.)	silver Y moth	*CC05 CC09 CG01*	248
Helicoverpa [*Heliothis*] *zea** (Boddie)	**corn earworm, tomato fruitworm, bollworm**	*AQ13 CC01 CC07-CC09 CG02 CG04*	249, 611
*Mamestra brassicae** (L.)	cabbage moth	*CC05 CC09 CG01*	249, 610
*Trichoplusia ni** (Hübner)	**caggage looper**	*CC08 CC09 CG03-CG05*	248

CG01 Beck, H.
1960. Die Larvalsystematik der Eulen (Noctuidae). Akademie-Verlag, Berlin.

CG02 Crumb, S.E.
1926. The Nearctic budworms of the lepidopterous genus *Heliothis*. Proc. U.S. Nat. Mus. 68(2617)1-8, 1 pl.

CG03 Crumb, S.E.
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CG04 Dekle, G.W.
1976. Illustrated key to caterpillars on corn (with photographs of adults). Fla. Dept. Agr. and Consum. Serv. Bull. 4 (revised), Gainesville.

CG05 Eichlin, T.D.
1975. A guide to the adult and larval Plusiinae of California (Lepidoptera: Noctuidae). California Dept. Food Agr. Occ. Papers Ent. 21:1-73.

Taxon	Common Name	Reference	Page
Oecophoridae*	oecophorid moths	*AQ02 CC01 CC04 CC09*	242, 265, 615
*Endrosis sarcitrella** (L.) [*E. lactella* (Schiffermüller)]	**whiteshouldered house moth**	*AQ07 AQ23 CC01 CC02 CC04 CC09 CC10 CH01 CH02 CH03*	243, 265, 314
Hofmannophila [*Borkhausenia*] *pseudospretella** (Stainton)	**brown house moth**	*AQ25 CC01 CC02 CC04 CH02 CH03*	243, 314, 615

CH01 Arbogast, R.T., G. Chauvin, R.G. Strong, and R.V. Byrd.
1983. The egg of *Endrosis sarcitrella* (Lepidoptera: Oecophoridae): Fine structure of the chorion. Jour. Stored Prod. Res. 19(2)63-68.
CH02 Clarke, J.F.G.
1941. Revision of the North American moths of the family Oecophoridae, with descriptions of new genera and species. Proc. U.S. Natl. Mus. 90(3107)33-286, 48 pl., i-viii.
CH03 Hodges, R.W.
1974. Gelechioidea: Oecophoridae (in part) (fasc. 6.2). *In* The moths of North America north of Mexico. Classey, London.

Taxon	Common Name	Reference	Page
Pieridae*	**whites, sulphur butterflies**	*CC01 CC09 CC10*	246, 610
Pieris brassicae (L.)	cabbageworm	*CC01 CC09*	
Pieris [*Artogeia*] *rapae** (L.)	**imported cabbageworm**	*CC01 CC09*	246, 610
Pyralidae*	**pyralid moths**	*AQ02 CC04 CC09 CC10 CJ04*	232, 247, 611-613
*Achroia grisella** (Fabricius)	**lesser wax moth**	*AQ23 CC02 CC04 CC10 CJ04 CJ07*	236, 256, 314
*Acrobasis nuxvorella** Neunzig	**pecan nut casebearer**	*CC02 CC04 CC06*	250
*Acrobasis vaccinii** Riley	**cranberry fruitworm**	*CJ06*	250
*Aglossa caprealis** Hübner	murky meal moth	*AQ25 CC02 CC04 CC06 CC09 CJ04*	235, 259, 613
Amyelois transitella (Walker)	**navel orangeworm**	*AQ20 CC01 CC02 CC07 CC09 CJ01 CJ10*	237, 251
*Anagasta kuehniella** (Zeller)	**Mediterranean flour moth**	*AQ03 AQ07 AQ19 AQ22 AQ23 AQ25 CC02 CC04 CC06 CC07 CC09 CC10 CJ01 CJ04 CJ05 CJ07 CJ09*	238, 254, 314
*Cadra calidella** (Guenée)	carob moth	*CC02 CC09 CJ01 CJ04 CJ09*	241, 255

Taxon	Common Name	Reference	Page
*Cadra cautella** (Walker)	**almond moth**	*AQ07 CC02 CC04 CC06 CC09 CC10 CJ01 CJ04 CJ07 CJ09*	241, 254
*Cadra figulilella** (Gregson)	**raisin moth**	*AQ20 CC02 CC07 CC09 CC10 CJ03 CJ04 CJ09*	240, 255
*Corcyra cephalonica** (Stainton)	**rice moth**	*AQ07 AQ23 AQ25 CC02 CC04 CC09 CC10 CJ04*	232, 235, 236, 257, 314, 612
*Diaphania hyalinata** (L.)	**mellonworm**	*AQ13 CC09*	258
*Diaphania nitidalis** (Stoll)	**pickleworm**	*AQ13 CC09*	258, 613
*Ephestia elutella** (Hübner)	**tobacco moth**	*AQ23 AQ25 CC02 CC04 CC07 CC09 CC10 CJ04 CJ05*	239, 254, 314
*Ephestiodes gilvescentella** Ragonot [*E. nigrella* Hulst]	**dusky raisin moth**	*AQ20 CC07*	237, 252
*Galleria mellonella** (L.)	**greater wax moth**	*AQ23 CC02 CC04 CC10 CJ04 CJ07*	234, 235, 256, 314, 612
*Ostrinia nubilalis** Hübner	**European corn borer**	*AQ13 CC01 CC09 CG04 CJ05*	258, 327, 612
Paralipsa [*Aphomia*] *gularis** (Zeller)	**stored nut moth**	*AQ07 AQ23 AQ25 CC02 CC04 CC06 CC09 CC10 CJ04*	234, 236, 257, 314
*Plodia interpunctella** (Hübner)	**Indianmeal moth**	*AQ07 AQ19 AQ20 AQ23 AQ25 CC01 CC02 CC04 CC06 CC07 CC09 CC10 CJ01 CJ04 CJ07 CJ08*	237, 253, 314, 592
*Pyralis farinalis** L.	**meal moth**	*AQ03 AQ07 AQ19 AQ23 AQ25 CC02 CC04 CC06 CC09*	233, 259, 314, 322, 613
Vitula edmandsii serratilineella Ragonot	**driedfruit moth**	*CC02 CC06 CJ06 CJ08*	239, 252

CJ01 Aitken, A.D.
1963. A key to the larvae of some species of Phycitinae (Lepidoptera, Pyralidae) associated with stored products, and some related species. Bull. Ent. Res. 54(2)175-188.

CJ02 Allyson, S.
1981. Last instar larvae of Pyraustini of America north of Mexico (Lepidoptera: Pyralidae). Canadian Ent. 113(6)416-518.

CJ03 Donohoe, H.C., *et al.*
1949. Biology of the raisin moth. U.S. Dept. Agr. Tech. Bull. 994:1-23.

CJ04 Hasenfuss, I.
1960. Die Larvalsystematik der Zünsler (Pyralidae). Akademie-Verlag, Berlin.

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1919. Note on the European corn borer (*Pyrausta nubilalis* Hübner) and its nearest American allies, with description of larvae, pupae, and one new species. Jour. Agr. Res. 18(3)171-178, 5 pl.

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1972. Taxonomy of *Acrobasis* larvae and pupae in eastern North America (Lepidoptera: Pyralidae). U.S. Dept. Agr. Tech. Bull. 1457:1-158.

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1955. Illustrated key to lepidopterous larvae associated with honeybee combs in California (T-4). California Department of Agriculture, Sacramento.

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1932. A contribution to the study of the genera *Ephestia,* Gn. (including *Strymax* Dyar), and *Plodia,* Gn. (Lepidoptera, Phycitidae), with notes on parasites of the larvae. Trans. Ent. Soc. London 80(2)169-250, 8 pl.

CJ10 Wade, W.H.
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Taxon	Common Name	Reference	Page
Tineidae*	tineid moths	***AQ02 CC04 CC09 CK01***	242, 259, 614
Dasyses rugosella (Stainton)			
Decadarchis miniscula (Walsingham)			
Haplotinea insectella (Fabricius)		***CK01 CK02***	
*Monopsis crocicapitella** (Clemens)		***AQ25 CC02***	243, 260
*Nemapogon granella** (L.)	**European grain moth**	***AQ03 AQ07 AQ22 CC02 CC04 CC07 CD01 CK01***	244, 260, 314
*Tineola bisselliella** (Hummel)	**webbing clothes moth**	***AQ07 AQ23 AQ25 CC02 CC04 CC09 CC10 CD01 CK01***	244, 260, 314, 614

CK01 Hinton, H.E.
1956. The larvae of the species of Tineidae of economic importance. Bull. Ent. Res. 47(2)251-346.

CK02 Madrid, F.J., and R.N. Sinha.
1984. *Haplotinea insectella* (Fabricius) (Lepidoptera: Tineidae)—a potential pest of stored cereals in North America. Jour. Stored Prod. Res. 20(2)107-110.

Taxon	Common Name	Reference	Page
Tortricidae* [Olethreutidae]	**leafroller moths**	***AQ02 CC01 CL04***	261, 614
Argyrotaenia velutinana (Walker)	**redbanded leafroller**		
Cydia [*Carpocapsa, Enarmonia, Laspeyresia*] *caryana** (Fitch)	**hickory shuckworm**	***CL03 CL04***	263
*Cydia nigricana** (Fabricius)	**pea moth**	***CC04 CL02 CL03***	263
*Cydia pomonella** (L.)	**codling moth**	***CC01 CC02 CC04 CC06 CC09 CL01 CL03 CL04***	263

Taxon	Common Name	Reference	Page
Cydia [Melissopus] latiferreana (Walsingham)	**filbertworm**	*CC06 CL03*	262
Endopiza [Paralobesia] viteana Clemens	**grape berry moth**		
*Grapholita [Grapholitha, Laspeyresia] molesta** (Busck)	**oriental fruit moth**	*CL01 CL03*	261
*Grapholita packardi** (Zeller)	**cherry fruitworm**	*CL03*	262
*Grapholita prunivora** (Walsh)	**lesser appleworm**	*CL03*	262

CL01 Baker, C.R.B.
1963. Notes on the larvae and pupae of two fruit moths, *Grapholita funebrana* Treitschke and *G. molesta* Busck (Lepidoptera: Olethreutidae). Proc. Roy. Ent. Soc. London A38(10-12)212-222.

CL02 Hanson, A.J., and R.L. Webster.
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CL03 MacKay, M.R.
1959. Larvae of the North American Olethreutidae (Lepidoptera). Canadian Ent. 91(suppl. 10)1-338.

CL04 Swatschek, B.
1958. Die Larvalsystematik der Wickler (Tortricidae und Carposinidae). Akademie-Verlag, Berlin.

Taxon	Common Name	Reference	Page
Diptera*	**flies**	*AQ02 AQ10 AQ18 AQ19 AQ21 CM01-CM07*	269, 327, 334, 341, 345, 346, 617

CM01 Cole, F.R.
1969. The flies of western North America. University of California, Berkeley.

CM02 Greenberg, B.
1971. Flies and disease, vol. 1. Ecology, classification, and biotic associations. Princeton University, Princeton.

CM03 Hennig, W.
1948 -52. Die Larvenformen der Dipteren. 3 vol. (vol. 1, 1948; vol. 2, 1950; vol. 3, 1952). Akademie-Verlag, Berlin.

CM04 James, M.T.
1947 [1948]. The flies that cause myiasis in man. U.S. Dept. Agr. Misc. Publ. 631:1-175.

CM05 McAlpine, J.F., et al.
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1987. Manual of Nearctic Diptera, vol. 2. Agriculture Canada, Ottawa.

CM07 Oldroyd, H.
1949. Diptera: Introduction and key to families. Handb. Ident. British Insects 9(1)1-49, 1 pl.

Taxon	Common Name	Reference	Page
Agromyzidae*	**leafminer flies**	*AQ02 AQ18 CM01 CM05 CM07 CN01*	289, 631
Liriomyza brassicae (Riley)	**serpentine leafminer**	*CN01*	
Liriomyza sativae Blanchard	**vegetable leafminer**	*CN01*	
Ophiomyia simplex (Loew)	**asparagus miner**	*CN01*	

CN01 Spencer, K.A.
1973. Agromyzidae (Diptera) of economic importance. Series Entomologica, vol. 9. Junk, The Hague.

Taxon	Common Name	Reference	Page
Anthomyiidae*	**anthomyiid flies**	*AQ02 CM01 CM02 CM07 CO03 CO04 CO07*	292, 631
*Hylemya** [*Delia*]			292, 631
Hylemya antiqua (Meigen)	onion maggot	*CM03 CO04*	
Hylemya brassicae (Bouché)	cabbage maggot	*CM03 CO01 CO04*	
Hylemya cinerella (Fallén)		*CM02*	
Hylemya radicum (L.)		*CM02*	
Pegomya hyoscyami (Panzer)	**spinach leafminer**	*CO01 CO04-CO07*	

CO01 Brooks, A.R.
1951. Identification of the root maggots (Diptera: Anthomyiidae) attacking cruciferous garden crops in Canada, with notes on biology and control. Canadian Ent. 83(5)109-120.

CO02 Chillcott, J.G.
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CO03 Hennig, W.
1966 -76. Anthomyiidae (63a). *In* Die Fliegen der palaearktischen Region, E. Lindner, ed. Schweizerbart'sche, Stuttgart.

CO04 Huckett, H.C.
1924. A systematic study of the Anthomyiinae of New York, with especial reference to the male and female genitalia. Agricultural Experiment Station Memoir 77. Cornell University, Ithaca.

CO05 Huckett, H.C.
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CO06 Huckett, H.C.
1965. The Muscidae of northern Canada, Alaska, and Greenland (Diptera). Mem. Ent. Soc. Canada 42:1-369.

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Taxon	Common Name	Reference	Page
Calliphoridae*	**blow flies**	*AQ02 AQ18 AQ19 AQ21 CM01-CM07 CP01*	270, 279, 293, 629-631
Anastellorhina [*Calliphora*] *augur* (Fabricius)	lesser brown blow fly	*CM02 CP06*	
*Calliphora terraenovae** Macquart	Nearctic blow fly	*CP01 CP03*	284
Calliphora uralensis Villeneuve	Ural blow fly	*CM02*	
*Calliphora vicina** Robineau-Desvoidy [*C. erythrocephala* Meigen]	cosmopolitan blue bottle fly	*CM02 CM04 CP01 CP02*	284
*Calliphora vomitoria** (L.)	Holarctic blue bottle fly	*AQ23 CM02 CM04 CP01 CP02*	284
*Chrysomya**			281, 294
*Chrysomya albiceps** (Wiedemann)	banded blow fly	*CM02 CM04*	
Chrysomya chloropyga (Wiedemann)	greentail blue bottle fly	*CM04*	
Chrysomya marginalis (Wiedemann)		*CM04*	
*Chrysomya megacephala** (Fabricius)		*CM02 CM04*	630
Chrysomya putoria (Wiedemann)		*CM04*	
Chrysomya rufifacies (Macquart)	**hairy maggot blow fly**	*CM04*	
*Cochliomyia macellaria** (Fabricius)	**secondary screwworm**	*AQ23 CM02 CM04 CP01 CP02*	281, 294, 629
Cynomya mortuorum (L.)		*CM02 CP01 CP02 CP06*	
*Cynomyopsis cadaverina** Robineau-Desvoidy	blue bottle fly	*AQ23 CM04 CP01 CP02*	283, 293
*Phaenicia** [*Lucilia*]		*CP06*	282, 293
*Phaenicia cuprina** Wiedemann [*P. pallescens* (Shannon)]	bronze bottle fly	*AQ23 CM02 CM04 CP01 CP02*	283, 631
*Phaenicia sericata** (Meigen)	green bottle fly	*CM02 CM04 CP01 CP02 CP06*	283, 631
*Phormia regina** (Meigen)	**black blow fly**	*AQ19 AQ23 CM02 CM04 CP01 CP02 CP05 CP06*	281, 294, 631
*Pollenia rudis** (Fabricius)	**cluster fly**	*AQ23 CM02 CM04 CP01 CP02 CP03 CP06*	282
*Protophormia terraenovae** (Robineau-Desvoidy)	Holarctic blow fly	*AQ23 CM02 CP01 CP02 CP06*	281
Lucilia caesar (L.)		*CM02 CM04 CP01 CP04 CP06*	
Lucilia illustris (Meigen)		*CM02 CM04 CP01 CP02 CP04 CP06*	

CP01 Hall, D.G.
1948. The blowflies of North America. Thomas Say Foundation, [Entomological Society of America, Lanham MD].

CP02 Hall, R.D., and L.H. Townsend, Jr.
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CP05 Perlstein, J.M.
1965. Pictorial keys to common domestic flies in California. California Vector Views 12(5)1-4.

CP06 Van Emden, F.I.
1954. Diptera: Cyclorrhapha, Calyptrata (I), section (a), Tachinidae and Calliphoridae. Handb. Ident. British Insects 10(4a)1-133.

Taxon	Common Name	Reference	Page
Cecidomyiidae	**gall midges**	*AQ02 AQ18 CM01 CM05 CM07 CQ02-CQ04*	272, 285
Henria psalliotae Wyatt		*CQ05*	
Heteropeza pygmaea Winnertz		*CQ05*	
Lestremia cinerea Macquart		*CQ05*	
Mycophila barnesi Edwards		*CQ05*	
Mycophila fungicola Felt		*CQ01 CQ05*	
Mycophila speyeri (Barnes)		*CQ03 CQ05*	

CQ01 Foote, R.H., and C.A. Thomas.
1959. *Mycophila fungicola* Felt: A redescription and review of its biology (Diptera, Itonididae). Ann. Ent. Soc. America 52(3)331-334.

CQ02 Gagné, R.J.
1981. Cecidomyiidae. *In* Manual of Nearctic Diptera, vol. 1, ed. by J.F. McAlpine *et al.* Agriculture Canada, Ottawa.

CQ03 Hardy, D.E.
1960. Diptera: Nematocera-Brachycera (except Dolichopodidae). *In* Insects of Hawaii, vol. 10, E.C. Zimmerman, ed. University of Hawaii, Honolulu.

CQ04 Harris, K.M.
1966. Gall midge genera of economic importance (Diptera: Cecidomyiidae). Part 1. Introduction and subfamily Cecidomyiinae; supertribe Cecidomyiidi. Trans. Roy. Ent. Soc. London 118(10)313-358.

CQ05 Wyatt, I.J.
1964. Immature stages of Lestremiinae (Diptera: Cecidomyiidae) infesting cultivated mushrooms. Trans. Roy. Ent. Soc. London 116(2)15-27.

Taxon	Common Name	Reference	Page
Chironomidae	**midges**	*CM05*	286

Drosophilidae*	**small fruit flies**	*AQ02 AQ18 AQ19 AQ21 AQ23 CM02 CM05 CM07*	276, 289, 290, 346
*Drosophila**		*CM02*	276
Drosophila funebris (Fabricius)	rotten potato drosophila	*CM02 CM04 CR01*	
Drosophila melanogaster Meigen	drosophilid fruit fly	*CM02 CM04 CR01*	
Drosophila repleta Wollaston	latrine drosophila	*CM02 CR01*	

CR01 Sturtevant, A.H.
1942. The classification of the genus *Drosophila*, with descriptions of nine new species. Univ. Texas Publ. 4213:5-51.

Taxon	Common Name	Reference	Page
Lonchaeidae	lonchaeid flies	*AQ02 CM07 CS01*	
Lonchaea aristella Becker		*CS01*	

CS01 Czerny, L.
1934 [1949]. 43. Lonchaeidae. *In* Die Fliegen der palaearktischen Region, vol. 5, E. Lindner, ed. Schweizerbart'sche, Stuttgart.

Taxon	Common Name	Reference	Page
Muscidae*	muscid flies	*AQ02 AQ18 AQ19 AQ21 CM01-CM07 CO06 CQ01 CT04 CT07 CT10*	277, 288, 291, 292, 625-627
Atherigona orientalis Schiner		*CT05*	
Dasyphora		*CM02 CT03*	
*Fannia**		*CT03*	287, 288, 336, 345
*Fannia canicularis** (L.)	**little house fly**	*AQ21 AQ23 CM02 CM04 CT02 CT03 CT09*	278, 625
Fannia leucosticta (Meigen)		*CM02 CT02 CT09*	
*Fannia scalaris** (Fabricius)	**latrine fly**	*CM02 CM04 CT02 CT03 CT09*	625
Musca autumnalis De Geer	**face fly**	*AQ23 CM02 CT03*	
*Musca domestica** L.	**house fly**	*AQ19 AQ21 AQ23 CM02 CM04 CO06 CT03*	10, 278, 291, 335, 626
Musca sorbens Wiedemann	market fly	*CM02 CM04*	279, 291
*Muscina**		*CT03*	
Muscina assimilis (Fallén)		*CM02 CM04 CT03*	279
Muscina stabulans (Fallén)	**false stable fly**	*AQ21 AQ23 CM02 CM04 CO06 CT03 CT08*	279, 627
*Ophyra**	dump flies	*CT03*	279, 292
*Ophyra aenescens** (Wiedemann)	bronze dump fly	*CT01 CT06*	279, 626

Taxon	Common Name	Reference	Page
Ophyra chalcogaster (Wiedemann)		*CT06*	
*Ophyra leucostoma** (Wiedemann)	dump fly	*CM02 CT01 CT03*	279
Ophyra nigra (Wiedemann)		*CT06*	

CT01 Adams, R.G.
1984. *Ophyra* species as predators in animal houses, with a key to species occurring in Europe (Diptera: Muscidae). Ent. Gaz. 35(4)243-246.

CT02 Chillcott, J.G.
1960. A revision of the Nearctic species of Fanniinae (Diptera: Muscidae). Canadian Ent. 92(suppl. 14)1-295.

CT03 D'Assis Fonseca, E.C.M.
1968. Diptera: Cyclorrhapha, Calyptrata, section (b), Muscidae. Handb. Ident. British Insects 10(4b)1-119.

CT04 Hennig, W.
1955 -64. Muscidae (63b). *In* Die Fliegen der palaearktischen Region, E. Lindner, ed. Schweizerbart'sche, Stuttgart.

CT05 Pont, A.C.
1972. 2. A review of the Oriental species of *Atherigona* Rondani (Diptera, Muscidae) of economic importance. *In* Control of sorghum shoot fly, ed. by M.G. Jotwani and W.R. Young. Oxford & IBH, New Delhi.

CT06 Sabrosky, C.W.
1949. The muscid genus *Ophyra* in the Pacific Region (Diptera). Proc. Hawaiian Ent. Soc. 13(3)423-432.

CT07 Shinonaga, S., and R. Kano.
1971. Fauna Japonica. Muscidae (Insecta: Diptera), vol. 1. Academic Press of Japan, Tokyo.

CT08 Snyder, F.M.
1955. Notes and descriptions of *Muscina* and *Dendrophaonia* (Diptera: Muscidae). Ann. Ent. Soc. America 48(6)445-452.

CT09 Van Emden, F.I.
1941. Keys to the Muscidae of the Ethiopian Region: Scatophaginae, Anthomyiinae, Lispinae, Fanniinae. Bull. Ent. Res. 32(3)251-275.

CT10 Van Emden, F.I.
1965. Diptera. Muscidae, part 1. *In* The fauna of India and the adjacent countries, vol. 7, R.B.S. Sewell and M.L. Roonwal, eds. Zoological Survey of India, Calcutta.

Taxon	Common Name	Reference	Page
Phoridae*	**humpbacked flies,** scuttle flies	*AQ02 AQ18 AQ19 AQ21 AQ23 CM01-CM05 CM07*	273, 288, 290, 345, 620
*Megaselia** [*Aphiochaeta*]			620
Megaselia agarici (Lintner)		*CU04*	
Megaselia bovista (Gimmerthal)		*CU02 CU04*	
*Megaselia halterata** (Wood)	mushroom phorid	*CU04*	327, 620
Megaselia nigra (Meigen)		*CU02 CU04*	

Taxon	Common Name	Reference	Page
*Megaselia rufipes** (Meigen)		*CM02 CU02*	620
Megaselia sandhui Disney		*CU03*	
*Megaselia scalaris** (Loew)		*CU02*	620
Spiniphora bergenstammi (Mik)	snail phorid	*CU01*	

CU01 Borgmeier, T.
1963. Revision of the North American phorid flies. Part I. The Phorinae, Aenigmatiinae and Metopininae, except *Megaselia* (Diptera, Phoridae). Studia Ent. 6(n.s.)(1-4)1-256.

CU02 Borgmeier, T.
1965. Revision of the North American phorid flies. Part III. The species of the genus *Megaselia,* subgenus *Megaselia* (Diptera, Phoridae). Studia Ent. 8(n.s.)(1-4)1-160.

CU03 Disney, R.H.L.
1981. *Megaselia sandhui* sp. n. (Diptera: Phoridae), a pest of cultivated mushrooms in India. Bull. Ent. Res. 71(3)509-512.

CU04 Robinson, W.H.
1977. Phoridae (Diptera) associated with cultivated mushrooms in eastern North America. Proc. Ent. Soc. Washington 79(3)452-462.

Taxon	Common Name	Reference	Page
Piophilidae*	**skipper flies**	*AQ02 AQ18 AQ21 AQ23 CM01-CM05 CM07*	276, 290, 624
*Piophila casei** (L.)	**cheese skipper**	*CM02 CM04 CV01 CV02*	276, 290, 624

CV01 Hennig, W.
1943 [1949]. 40. Piophilidae. *In* Die Fliegen der palaearktischen Region, vol. 5, ed. by E. Lindner. Schweizerbart'sche, Stuttgart.

CV02 Melander, A.L.
1924. Review of the dipterous family Piophilidae. Psyche 31(2)78-86.

Taxon	Common Name	Reference	Page
Psilidae*	rust flies	*AQ02 AQ18 CM01 CM05 CM07*	276, 290
*Psila rosae** (Fabricius)	**carrot rust fly**	*CW01*	276, 290

CW01 Hennig, W.
1941 [1949]. 41. Psilidae. *In* Die Fliegen der palaearktischen Region, vol. 5, E. Lindner, ed. Schweizerbart'sche, Stuttgart.

Taxon	Common Name	Reference	Page
Psychodidae*	**moth flies**	*AQ02 AQ18 AQ21 CM01 CM02-CM05 CM07 CQ01*	271, 286, 344, 346, 618
*Psychoda**	drain flies	*CX01-CX04*	618

CX01 Duckhouse, D.A.
1966. Psychodidae (Diptera, Nematocera) of southern Australia: Subfamily Psychodinae. Trans. Roy. Ent. Soc. London 118(6)153-220.
CX02 Freeman, P.
1950. Family Psychodidae. Handb. Ident. British Insects 9(2)77-96.
CX03 Satchell, G.H.
1954. Keys to the described species of New Zealand Psychodidae with descriptions of eight new species. Trans. Roy. Ent. Soc. London 105(20)475-491.
CX04 Usinger, R.L. (ed.).
1956. Aquatic insects of California with keys to North American genera and California species. University of California, Berkeley.

Taxon	Common Name	Reference	Page
Sarcophagidae*	**flesh flies**	*AQ02 AQ18 AQ21 CM01-CM06 CY02*	279, 293, 628
*Sarcophaga**		*AQ21 CM01 CM02 CP06 CY01*	279, 628
*Sarcophaga haemorrhoidalis** (Fallén)	redtailed flesh fly	*CM02 CP06 CY01*	628
Sarcophaga hirtipes (Wiedemann)		*CY02*	
Sarcophaga melanura Meigen		*CM02 CP06*	

CY01 Aldrich, J.M.
1916. *Sacrophaga* and allies in North America. Thomas Say Foundation, [Entomological Society of America, College Park].
CY02 Rohdendorf, B.B.
1937. Fam. Sarcophagidae. Fauna USSR, vol. 19, No. 1. Academy of Sciences USSR, Moscow.

Taxon	Common Name	Reference	Page
Scatopsidae*	minute black scavenger flies	*AQ02 AQ18 CM01 CM03 CM05 CM07 CQ01 CZ01*	272, 286, 344

CZ01 Duda, O.
1929 [1930]. 5. Scatopsidae. *In* Die Fliegen der palaearktischen Region, vol. 2(1), E. Lindner, ed. Schweizerbart'sche, Stuttgart.

Taxon	Common Name	Reference	Page
Scenopinidae* [Omphralidae]	window flies	*AQ02 AQ18 CM01 CM02 CM03 CM05 CM07 CQ01*	274, 287, 344, 622
*Scenopinus**		*CM01 CM05 DA01 DA02*	274, 287
Scenopinus fenestralis (L.)	cosmopolitan window fly	*A023 DA01 DA02*	
Scenopinus glabrifrons Meigen	European window fly	*A023 DA01 DA02*	

DA01 Hardy, D.E.
1944. A revision of North American Omphralidae (Scenopinidae). Jour. Kansas Ent. Soc. 17(1)31-51.

DA02 Kelsey, L.P.
1969. A revision of the Scenopinidae (Diptera) of the world. U.S. National Museum Bulletin 277. Smithsonian Institution, Washington, DC.

Taxon	Common Name	Reference	Page
Sciaridae* [Lycoriidae]	**darkwinged fungus gnats**	***AQ02 AQ18 CM01 CM03 CM05 CQ01 DB02***	272, 344
Bradysia coprophila (Lintner)			
Lycoriella [*Sciara*] *agraria* (Felt)		***DB01***	
Lycoriella auripila (Winnertz)		***DB01***	
Lycoriella mali (Fitch) [*Neosciara pauciseta* Felt]			
Lycoriella multiseta (Felt)			

DB01 Lengersdorf, F.
1930. 7. Lycoriidae. *In* Die Fliegen der palaearktischen Region, vol. 2(1), E. Lindner, ed. Schweizerbart'sche, Stuttgart.

DB02 Steffan, W.A.
1966. A generic revision of the family Sciaridae (Diptera) of America north of Mexico. Univ. California Pubs. Ent. 44:1-77.

Taxon	Common Name	Reference	Page
Sepsidae*	black scavenger flies	***AQ02 AQ18 CM01-CM05 CM07 CQ01 DC02***	276, 289, 290, 346
*Sepsis**		***CM01 DC01***	

DC01 Hennig, W.
1943 [1949]. 39a. Sepsidae. *In* Die Fliegen der palaearktischen Region, vol. 5, E. Lindner, ed. Schweizerbart'sche, Stuttgart.

DC02 Zuska, J., and D.H. Colless.
1984. Australian Sepsidae (Diptera). J. Australian Ent. Soc. 23(1)59-67.

Taxon	Common Name	Reference	Page
Sphaeroceridae* [Borboridae]	small dung flies	***AQ02 CM01 CM02 CM05 CQ01 DD01 DD03***	275, 622
*Leptocera**		***CM01***	275, 622
Leptocera caenosa (Rondani)		***DD02***	

DD01 Duda, O.
1938. 57. Sphaeroceridae (Cypselidae). *In* Die Fliegen der palaearktischen Region, vol. 6(1), ed. by E. Lindner. Schweizerbart'sche, Stuttgart.

DD02 Roháček, J.
1982. Revision of the subgenus *Leptocera* (s. str.) of Europe (Diptera, Sphaeroceridae). Ent. Abhandl. 47(1)1-44.

DD03 Spuler, A.
1923. North American genera and subgenera of dipterous family Borboridae. Proc. Acad. Nat. Sci. Philadelphia 75:369-378.

Taxon	Common Name	Reference	Page
Stratiomyidae*	**solider flies**	*AQ02 AQ18 AQ21 CM01 CM03-CM05 CM07 CQ01 DE02*	274, 285
*Hermetia illucens** (L.)	**black soldier fly**	*CM04 CQ01 DE01 DE02*	274, 285, 336 621

DE01 James, M.T.
1935. The genus *Hermetia* in the United States (Diptera, Stratiomyidae). Bull. Brooklyn Ent. Soc. 30(4)165-170.
DE02 McFadden, M.W.
1967. Soldier fly larvae in America north of Mexico. Proc. U.S. Natl. Mus. 121(3569)1-72.

Taxon	Common Name	Reference	Page
Syrphidae*	**flower flies**	*AQ02 AQ18 CM01-CM05 CM07 CQ01*	273, 289, 346, 619
*Eristalis [Tubifera] tenax** (L.)	**drone fly**	*CM04 CM05 CX01 DF02 DF03*	273, 289, 619
Ornidia [Volucella] obesa (Fabricius)		*DF01*	

DF01 Curran, C.H.
1926. Partial synopsis of American species of *Volucella* with notes on Wiedemann's types. Ann. Ent. Soc. America 19(1)50-66.
DF02 Dixon, T.J.
1960. Key to and descriptions of the third instar larvae of some species of Syrphidae (Diptera) occurring in Britain. Trans. Roy. Ent. Soc. London 112(13)345-379.
DF03 Telford, H.S.
1939. The Syrphidae of Minnesota. Minnesota Agricultural Experiment Station Tech. Bull 140. St. Paul.

Taxon	Common Name	Reference	Page
Tephritidae* [Trypetidae, Trupaneidae]	**fruit flies**	*AQ02 AQ18 CM01 CM04 CM07*	274, 291, 622
Anastrepha fraterculus (Wiedemann)	South American fruit fly	*AQ18 DG02 DG09 DG10*	
Anastrepha ludens (Loew)	**Mexican fruit fly**	*AQ18 DG02 DG09 DG10*	
Anastrepha obliqua (Macquart) *[A. mombinpraeoptans* Seín]	**West Indian fruit fly**	*DG09 DG10*	
Ceratitis capitata (Wiedemann)	**Mediterranean fruit fly**	*AQ18 DG04 DG07 DG08 DG14*	
Dacus dorsalis Hendel	**oriental fruit fly**	*AQ18 DG03*	
Dacus oleae (Gmelin)	**olive fruit fly**	*AQ18 DG12*	
Rhagoletis cingulata (Loew)	**cherry maggot**	*AQ18 DG05*	

Taxon	Common Name	Reference	Page
Rhagoletis indifferens Curran	**western cherry fruit fly**	*DG05*	
Rhagoletis mendax Curran	**blueberry maggot**	*AQ18 DG06*	
Rhagoletis pomonella (Walsh)	**apple maggot**	*AQ18 DG07 DG13 DG15*	

DG01 Biological Assessment Support Staff.
1982. Pests not known to occur in the United States or of limited distribution, No. 18: South American fruit fly. U.S. Dept. of Agr. APHIS 81-40. Washington, DC.

DG02 Biological Assessment Support Staff.
1982. Pests not known to occur in the United States or of limited distribution, No. 19: Mexican fruit fly. U.S. Dept. of Agr. APHIS 81-40. Washington, DC.

DG03 Biological Assessment Support Staff.
1982. Pests not known to occur in the United States or of limited distribution, No. 20: Oriental fruit fly. U.S. Dept. of Agr. APHIS 81-40. Washington, DC.

DG04 Biological Assessment Support Staff.
1982. Pests not known to occur in the United States or of limited distribution, No. 26: Mediterranean fruit fly. U.S. Dept. of Agr. APHIS 81-41. Washington, DC.

DG05 Bush, G.L.
1966. The taxonomy, cytology, and evolution of the genus *Rhagoletis* in North America (Diptera, Tephritidae). Bull. Mus. Comp. Zool. (Harvard) 134(11)431-562.

DG06 Lathrop, F.H., and C.B. Nickels.
1932. The biology and control of the blueberry maggot in Washington County, Me. USDA Tech. Bul. 275:1-76 [*Rhagoletis mendax* is referred to as the blueberry form of *R. pomonella* in this paper].

DG07 Phillips, V.T.
1946. The biology and identification of trypetid larvae (Diptera: Trypetidae). Mem. American Ent. Soc. 12:1-161.

DG08 Quayle, H.J.
1929. The Mediterranean and other fruit flies. California Agricultural Experiment Station Circular 315. University of California, Berkeley.

DG09 Steyskal, G.C.
1977. Pictorial keys to species of the genus *Anastrepha* (Diptera: Tephritidae). Entomological Society of Washington, Washington, DC.

DG10 Stone, A.
1942. The fruitflies of the genus *Anastrepha.* U.S. Dept. Agr. Misc. Pub. 439. Washington, DC.

DG11 Weems, H.V., Jr.
1963. Mexican fruit fly (*Anastrepha ludens* (Loew)) (Diptera: Tephritidae). Fla. Dept. Agr. and Cons. Serv., Div. Plant Indus. Ent. Cir. 16. Gainesville.

DG12 Weems, H.V., Jr.
1966. Olive fruit fly (*Dacus oleae* (Gmelin)) (Diptera: Tephritidae). Fla. Dept. Agr. and Cons. Serv., Div. Plant Indus., Ent. Cir. 44. Gainesville.

DG13 Weems, H.V., Jr.
1972. Apple maggot, *Rhagoletis pomonella* (Walsh) (Diptera: Tephritidae). Fla. Dept. Agr. and Cons. Serv., Div. Plant Indus., Ent. Cir. 126. Gainesville.

DG14 Weems, H.V., Jr.
1981. Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae). Fla. Dept. Agr. and Cons. Serv., Div. Plant Indus., Ent. Cir. 230. Gainesville.

DG15 Westcott, R.L.
1982. Differentiating adults of apple maggot, *Rhagoletis pomonella* (Walsh) from snowberry maggot, *R. zephyria* Snow (Diptera: Tephritidae) in Oregon. Pan-Pacific Ent. 58(1)25-30.

Taxon	Common Name	Reference	Page
Hymenoptera*	**ants, bees, wasps**	*AQ01 AQ02 AQ04-AQ06 AQ15 AQ17 AQ19 DH01 DH02 DH03*	297, 298, 323, 330, 334, 349

DH01 Ferrière, C., and G.J. Kerrich.
1958. Hymenoptera: Chalcidoidea. Agaontidae, Leucospidae, Calcididae, Eucharitidae, Perilampidae, Cleonymidae and Thysanidae. Handb. Indent. British Insects 8(2a)1-40.

DH02 Richards, O.W.
1977. Hymenoptera: Introduction and key to families. Handb. Ident. British Insects 6(1)1-94.

DH03 Short, J.R.T.
1952. The morphology of the head of larval Hymenoptera with special reference to the head of the Ichneumonoidea, including a classification of the final instar larvae of the Braconidae. Trans. Roy. Ent. Soc. London 103(2)27-84.

Taxon	Common Name	Reference	Page
Agaonidae	**fig wasps**	*AQ02*	349
Blastophaga psenes (L.)	**fig wasp**	*AQ20*	
Apidae	honeybees	*AQ02*	
*Apis mellifera** L.	honeybee	*AQ23 DJ01 DJ02*	330, 334, 349

DJ01 Batra, S.W.T.
1976. Honey bees (*Apis* spp.) likely to be intercepted at quarantine stations. Coop. Plant Pest Rpt. 1(48-52)900-902.

DJ02 Economic Insect Survey and Detection.
1972. An African honey bee (*Apis mellifera adansonii*). Coop. Econ. Insect Rpt. 22(12)158-160.

Taxon	Common Name	Reference	Page
Bethylidae*	**bethylid wasps**	*A023 AQ02 DK01-DK04*	450, 465
*Cephalonomia**		*DK01-DK04*	469
*Cephalonomia gallicola** (Ashmead)		*DK02 DK03*	469
*Cephalonomia tarsalis** (Ashmead)		*DK02-DK04*	468

Taxon	Common Name	Reference	Page
*Cephalonomia waterstoni** Gahan	**parasitic grain wasp**	*DK02-DK04*	469
Epyris		*A023*	
*Goniozus emigratus** (Rohwer)		*DK02*	466
*Holepyris hawaiiensis** (Ashmead)		*A023 DK02-DK04*	467
*Holepyris sylvanidis** (Brèthes)		*DK02 DK03*	467
*Laelius anthrenivorus** Trani			467
*Laelius centratus** (Say)		*DK01 DK02*	467
*Plastanoxus chittendenii** (Ashmead)		*DK01-DK03*	470
*Plastanoxus westwoodi** (Kieffer)		*DK01-DK04*	470
Rhabdepyris zeae Turner & Waterson		*A023*	
*Sclerodermus immigrans** Bridwell			466

DK01 Evans, H.E.
1964. A synopsis of the American Bethylidae (Hymenoptera, Aculeata). Bul. Mus. Comp. Zool. (Harvard) 132(1)1-222.

DK02 Evans, H.E.
1978. The Bethylidae of America north of Mexico. Mem. American Ent. Inst. 27:1-332.

DK03 Perkins, J.F.
1976. Hymenoptera: Bethyloidea (except Chrysididae). Handb. Ident. British Insects 6(3a)1-38.

DK04 Richards, O.W.
1939. The British Bethylidae (*s.l.*) (Hymenoptera). Trans. Roy. Ent. Soc. London 89(8)185-344.

Taxon	Common Name	Reference	Page
Braconidae*	**braconid wasps**	*A023 AQ02 DH02 DL01 DL02*	450, 470
*Apanteles araeceri** Wilkins			475
*Apanteles carpatus** (Say)			475
*Apanteles nephoptericis** (Packard)			475
Bassus [*Agathis*] *hawaiicola** (Ashmead)			476
Chelonus sulcatus Jurine		*A023*	
*Chremylus rubiginosus** (Nees)			474
Habrobracon [*Bracon*] *brevicornis** (Wesmael)			473
*Habrobracon crassicornis** (Thomson)			473
*Habrobracon hebetor** (Say)		*A023*	473
*Habrobracon kitcheneri** (Dudgeon & Gough)			473
*Hecabolus sulcatus** Curtis			474
*Meteorus ictericus** (Nees)			476
*Spathius exarator** (L.)			474

DL01 Marsh, P.M.
1963. A key to the subfamilies of the family Braconidae (Hymenoptera). Ann. Ent. Soc. America 56(4)522-527.

DL02 Marsh, P.M.
1971. A key to the Nearctic genera of the families Braconidae, Aphidiidae, and Hybrizontidae (Hymenoptera). Ann. Ent. Soc. America 64(4)841-850.

Taxon	Common Name	Reference	Page
Chalcididae*	chalcidids	***AQ02 DH01***	450, 455
*Antrocephalus aethiopicus** Masi			456
*Antrocephalus mahensis** Masi			456
Encyrtidae	encyrtids	***AQ02***	450
Comperia merceti (Compere)			
Copidosoma koehleri Blanchard		***DN01***	
Copidosoma phthorimaea Logvinovskaya		***DN01***	

DN01 Logvinovskaya, T.V.
1982. A new parasitic wasp, *Copidosoma phthorimaeae* sp. n. (Hymenoptera, Encyrtidae), of the potato moth, *Phthorimaea operculella* Zeller (Lepidoptera, Gelechiidae). Ent. Rev. 61(4)117-119.

Taxon	Common Name	Reference	Page
Eulophidae*	eulophids	***AQ02 DH01***	450, 457
Aprostocetus [Tetrastichodes, Tetrastichus] *hagenowii** (Ratzeburg)			457, 459
*Entedon longiventris** Ratzeburg			457
*Melittobia chalybii** Ashmead			458
*Paraolinx typica** (Howard) [*P. nigriventris* (Girault)]			458
Tetrastichus asthenogmus (Waterston)			
*Tetrastichus coerulescens** Ashmead			457, 459
*Tetrastichus hagenowii** (Ratzeburg)			457, 459
*Tetrastichus periplanetae** Crawford			451, 457, 459
Eupelmidae*	eupelmids	***AQ02 DH01***	450, 456
Anastatus tennipes Bolivar			
*Eupelmus cushmani** (Crawford)			457
*Eupelmus javae** Girault			457
Eurytomidae*	**seed chalcids, eurytomids**	***A023 DQ01 DQ02***	450, 458, 460
*Aximopsis javensis** Girault			460
*Aximopsis tephrosiae** Girault			460
*Eurytoma tylodermatis** Ashmead		***DP01***	460
Systole geniculata Foerster	fennel seed wasp		

DP01 Bugbee, R.E.
1967. Revision of chalcid wasps of genus *Eurytoma* in America north of Mexico. Proc. U.S. Natl. Mus. 118(3533)433-552.

DP02 Burks, B.D.
1971. A synopsis of the genera of the family Eurytomidae (Hymenoptera: Chalcidoidea). Trans. American Ent. Soc. 97(1)1-89.

Taxon	Common Name	Reference	Page
Evaniidae*	**ensign wasps**	*A023 AQ02 DQ02*	324, 450, 453
*Evania appendigaster** (L.)		*AQ02 DH01 DP02*	453
Evania dimidiata Spinola		*A023*	
*Prosevania fuscipes** (Illiger) [*P. punctata* (Brullé)]			453
*Szepligetella sericea** (Cameron)	**lesser ensign wasp**		453

DQ01 Crosskey, R.W.
1951. The morphology, taxonomy, and biology of the British Evanioidea (Hymenoptera). Trans. Roy. Ent. Soc. London 102(5)247-301.

DQ02 Townes, H.
1949. The Nearctic species of Evaniidae (Hymenoptera). Proc. U.S. Natl. Mus. 99(3253)525-539.

Taxon	Common Name	Reference	Page
Formicidae*	**ants**	*AQ02 DR01-DR18*	297, 298, 633-649

DR01 Allred, D.M.
1982. Ants of Utah. Great Basin Nat. 42(4)415-511.

DR02 Bolton, B.
1973. The ant genera of West Africa: A synonymic synopsis with keys (Hymenoptera: Formicidae). Bul. British Mus. (Nat. Hist) Ent. 27(6)319-368.

DR03 Bolton, B., and C.A. Collingwood.
1975. Hymenoptera. Formicidae. Handb. Ident. British Insects 6(3)(c)1-34.

DR04 Creighton, W.S.
1950. The ants of North America. Bul. Mus. Comp. Zool. (Harvard) 104:1-585.

DR05 Gorham, J.R.
1956. A preliminary study of the ants of Oxford, Ohio, and vicinity (Hymenoptera, Formicidae). Thesis, Miami University, Oxford.

DR06 Gregg, R.E.
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Taxon	Common Name	Reference	Page
Dolichoderinae*	dolichoderine ants	***AQ02 DR01-DR11 DR14***	307, 642, 643
*Conomyrma insana** (Buckley) [*Dorymyrmex pyramicus* (Roger)]	**pyramid ant**	***DR04 DR05 DR07 DR09 DR11-DR13 DR15***	643
*Iridomyrmex humilis** (Mayr)	**Argentine ant**	***DR03 DR04 DR06 DR08 DR11 DR12 DR17***	307, 324, 643
*Iridomyrmex pruinosus** (Roger)		***DR04-DR08 DR11 DR12 DR15 DR18***	643
*Tapinoma melanocephalum** (Fabricius)		***DR03 DR09 DR11 DR17***	307, 324, 643
*Tapinoma sessile** (Say)	**odorous house ant**	***DR04 DR05 DR07 DR08 DR11 DR12 DR15 DR17 DR18***	307, 324, 643
Technomyrmex albipes (Smith)	whitefooted ant		
Dorylinae*	doryline ants	***DR04 DR08 DR14 DR18***	303, 634
*Labidus coecus** (Latreille)		***DR04 DR11 DR12 DR18 DT01***	634
*Neivamrymex nigrescens** (Cresson)		***DR04 DR11 DR12 DR15 DR18 DT01***	634
*Neivamyrmex opacithorax** (Emery)		***DR04 DR11 DR12 DR18 DT01***	634

DT01 Watkins, J.R., II.
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Taxon	Common Name	Reference	Page
Formicinae*	formicine ants	*DR01-DR11 DR14*	
*Acanthomyops claviger** (Roger)	**smaller yellow ant**	*DR04 DR05 DR11-DR13 DR18 DU03*	646
*Acanthomyops interjectus** (Mayr)	**larger yellow ant**	*DR04 DR05 DR11 DR12 DR16 DR18 DU03*	302, 646
*Acanthomyops latipes** (Walsh)		*DR04 DR05 DR11 DR16 DR18 DU03*	646
*Acanthomyops murphyi** (Forel)		*DR04 DR05 DR11 DR16 DU03*	646
Anoplolepis longipes (Jerdon)	**longlegged ant**	*DR17*	
*Camponotus abdominalis** (Fabricius)	**Florida carpenter ant**	*DR04 DR11*	644
*Camponotus caryae discolor** (Buckley)		*DR04-DR06 DR11-DR13 DR18*	644
*Camponotus castaneus** (Latreille)		*DR04-DR06 DR11 DR12 DR18*	644
*Camponotus ferrugineus** (Fabricius)	**red carpenter ant**	*DR04-DR06 DR11 DR12*	645
Camponotus herculeanus (L.)		*DR07*	
Camponotus modoc Wheeler		*DR07 DU04*	
*Camponotus nearcticus** Emery		*DR04 DR05 DR07 DR11 DR12 DR13 DR18*	645
*Camponotus pennsylvanicus** (De Geer)	**black carpenter ant**	*DR04-DR07 DR11-DR13 DR18*	645
*Camponotus sayi** Emery [*C. rasilis* Wheeler]		*DR04 DR07 DR11 DR12 DR18*	646
*Camponotus tortuganus** Emery		*DR04 DR11*	646
Camponotus vicinus (Mayr)		*DR07*	
*Lasius alienus** (Foerster)	**cornfield ant**	*DR03 DR04 DR06 DR07 DR11-DR13 DR15 DR18 DU02*	648
Lasius brunneus (Latreille)		*DU02*	
*Lasius neoniger** Emery		*DR04 DR06 DR07 DR11 DR12 DR13 DR18 DU02*	648
Lasius pallitarsis (Provancher) [*L. sitkaensis* Pergande]		*DU02*	
*Lasius umbratus** (Nylander)		*DR04-DR06 DR11 DU02*	648
*Paratrechina**		*DR02 DR04-DR06 DR08 DR11 DR18 DU01*	308, 309, 649
*Paratrechina longicornis** (Latreille)	**crazy ant**	*DR03-DR05 DR09 DR11 DR17 DR18 DU01*	309, 649

Taxon	Common Name	Reference	Page
Paratrechina vividula (Nylander)		*DU01*	
*Prenolepis imparis** (Say)		*DR04-DR06 DR08 DR11 DR12 DR18*	649

DU01 Trager, J.C.
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Taxon	Common Name	Reference	Page
Myrmicinae*	myrmicine ants	*AQ02 DR01-DR11 DR14*	303, 305, 635-642
*Aphaenogaster fulva** Roger		*DR04-DR06 DR11 DR12 DR18*	637
*Aphaenogaster lamellidens** Mayr		*DR04 DR05 DR11 DR12*	638
*Aphaenogaster rudis** (Emery)		*DR04 DR05 DR11 DR12*	638
*Aphaenogster tennessensis** (Mayr)		*DR04-DR06 DR11 DR12 DR18*	638
*Atta texana** (Buckley)	**Texas leafcutting ant**	*DR11*	
*Crematogaster ashmeadi** Mayr		*DR04 DR11 DV01*	
*Crematogaster cerasi** (Fitch)		*DR04 DR06 DR11 DV01*	
*Crematogaster clara** Mayr		*DR04 DR11 DV01*	640
*Crematogaster lineolata** (Say)		*DR04-DR06 DR11 DV01*	640
*Monomorium destructor** (Jerdon)		*DR04 DR08 DR09 DR11 DR17*	636
*Monomorium floricola** (Jerdon)		*DR04 DR09 DR11*	637
*Monomorium minimum** (Buckley)	**little black ant**	*DR04-DR08 DR11-DR13 DR15 DR18*	323, 637
*Monomorium pharaonis** (L.)	**pharaoh ant**	*DR03-DR06 DR08 DR09 DR11-DR13 DR17 DR18*	305, 636

Taxon	Common Name	Reference	Page
Ochetomyrmex [*Wasmania*] *auropunctatus** (Roger)	**little fire ant**	***DR08 DR09 DR11***	641
*Pheidole bicarinata vinelandica** Forel		***DR04-DR07 DR11 DR12 DR18 DV04***	640
*Pheidole dentata** Mayr		***DR04 DR11 DR12 DR18 DV04***	641
*Pheidole floridana** Emery		***DR04 DR11 DV04***	641
*Pheidole megacephala** (Fabricius)		***DV04***	
Pogonomyrmex occidentalis (Cresson)		***DR07 DV03***	
*Solenopsis geminata** (Fabricius)	**fire ant**	***DR04 DR09 DR11 DR12 DR17 DV02 DV05 DV06***	635
*Solenopsis invicta** Buren	**red imported fire ant**	***DV02 DV05 DV06***	635
*Solenopsis molesta** (Say)	**thief ant**	***DR04 DR05 DR07 DR08 DR11-DR13 DR15 DR18***	304, 635
Solenopsis richteri Forel	**black imported fire ant**	***DV02***	
*Solenopsis xyloni** McCook	**southern fire ant**	***DR04 DR07 DR11-DR13 DR18 DV02 DV05 DV06***	636
Tetramorium bicarinatum (Nylander) [*T. guineense* (Fabricius)]	**Guinea ant**	***DR03 DR04 DR09 DR11 DR12 DR17***	642
*Tetramorium caespitum** (L.)	**pavement ant**	***DR03-DR05 DR08 DR11***	300, 301, 306, 330, 642

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Taxon	Common Name	Reference	Page
Ponerinae*	ponerine ants	*DR01-DR11 DR14*	306
Hypoponera punctatissima (Roger)			
Ichneumonidae*	**ichneumons**	*A023 AQ02 DX01 DX02*	450, 470
*Diadegma**		*A023*	472
Diadegma armillata (Gravenhorst)		*A023*	
Diadegma chrysostictus (Gmelin)		*A023*	
*Hypiscera curvata** (Fabricius)			472
*Limnerium ephestiae** (Ashmead)			472
*Mesostenus gracilis** Cresson			472
*Trathala flavoorbitalis** Cameron			471
Venturia canescens (Gravenhorst)		*A023*	471

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Taxon	Common Name	Reference	Page
Pteromalidae*	pteromalids	*A023 AQ02 DH01 DY01*	450, 460
*Anisopteromalus**			463
Anisopteromalus calandrae (Howard)		*A023*	
*Caenacis**		*DY01*	464
*Cerocephala aquila** (Girault)			463
*Cerocephala cornigera** Westwood		*DY01*	463
*Cerocephala rufa** (Walker)		*DY01*	463
*Choetospila elegans** Westwood		*A023 DY01*	330, 462
*Dibrachys**		*DY01*	463
Dibrachys cavus (Walker)		*A023*	464
*Dimachus**		*DY01*	
Dinarmus laticeps (Ashmead)		*A023*	
*Lariophagus**		*DY01*	465
*Meraporus requisitus** Tucker			463
*Norbanus**		*DY01*	464
*Pteromalus** [*Habrocytus*]		*DY01*	465
Pteromalus cerealellae (Ashmead)		*A023*	
*Ptinobius**			462
*Spalangia**		*DY01*	461

Taxon	Common Name	Reference	Page
*Theocolax formiciformis** Westwood		*DY01*	462
Tritneptis [*Systellogaster*] *ovivora** (Gahan)			463, 464
*Zatropis**			463

DY01 Graham, M.W.R. de V.
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Taxon	Common Name	Reference	Page
Trichogrammatidae*	**trichogrammatid wasps**	*A023 AQ02 DH01*	415, 457
*Trichogramma**		*DZ01*	457
Trichogramma evanescens Westwood			

DZ01 Doutt, R.L., and G. Viggiani.
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Taxon	Common Name	Reference	Page
Vespidae	vespid wasps	*AQ02 AQ19*	
Dolichovespula [*Vespula*] *arenaria* (Fabricius)	**aerial yellowjacket**	*AQ05 AQ19 EA01 EA02*	
Polistes annularis (L.)	large paper wasp	*AQ19 EA02*	
Polistes apachus Saussure		*EA02*	
Polistes exclamans Viereck	zebra paper wasp	*AQ19 EA02*	
Vespula [*Paravespula*] *germanica* (Fabricius)	**German yellowjacket**	*AQ05 EA01 EA02*	
Vespula maculifrons (Buysson)	**eastern yellowjacket**	*AQ05 AQ19 EA01 EA02*	
Vespula pensylvanica (Saussure)	**western yellowjacket**	*AQ05 AQ19 EA01 EA02*	
Vespula vulgaris (L.)	common yellowjacket	*AQ05 AQ19 EA01 EA02*	

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Taxon	Common Name	Reference	Page
Collembola*	**springtails**	*AQ02 AQ19 EB01-EB12*	323, 351

EB01 Christiansen, K., and P. Bellinger.
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EB12 Snider, R.J.
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Taxon	Common Name	Reference	Page
Entomobryidae*	entomobryid springtails	*EB01 EB02 EB04 EC01*	
*Entomobrya atrocincta** Schött		*EB01 EB05 EB11*	358
*Entomobrya griseoolivata** (Packard)		*EB01 EB06 EB11 EB12*	358
*Entomobrya nivalis** (L.)		*EB01 EB02 EB05 EB07 EB11 EB12 EC01*	358
*Entomobrya [Entomobryoides] purpurascens** (Packard)		*EB01 EB05 EB06*	358
*Heteromurus [Alloscopus, Ptenura, Verhoeffiela]**		*EB01 EB02 EB05 EB10*	357
*Lepidocyrtinus domesticus** (Nicolet)			359
*Lepidocyrtus curvicollis** Bourlet		*EB01-EB03 EB05 EB11*	360
Lepidocyrtus cyaneus Tullberg	silvery springtail	*EB01 EB07 EB12*	359
*Orchesella albosa** Guthrie		*EB01 EB06 EB11 EB12*	357

Taxon	Common Name	Reference	Page
*Pseudosinella**		*EB01 EB02 EB04 EB05 EB12*	360
Seira [*Sira, Willowsia*] *buski** (Lubbock)	damp grain springtail	*EB01-EB03 EB05 EB11 EB12*	359
*Seira platani** (Nicolet) [*Willowsia nigromaculata* (Lubbock)]		*EB02 EB05 EB06 EB11 EB12*	359

EC01 South, A.
1961. The taxonomy of the British species of *Entomobrya* (Collembola). Trans. Roy. Ent. Soc. London 113(13)387-416.

Taxon	Common Name	Reference	Page
Isotomidae*	isotomid springtails	*EB01 EB02 EB04 EB08 EB10*	356
Cryptopygus [*Isotoma*] *thermophilus* (Axelson)		*EB01 ED02*	
*Folsomia quadrioculata** (Tullberg)		*EB01 EB02 EB05-EB07 EB12 ED01*	361
Isotomodes [*Dagamaea*] *tenuis** (Folsom)		*EB01 EB06*	361
*Proisotoma frisoni** (Folsom)		*EB01 EB11 ED02*	360
Proisotoma tenella (Reuter) [*Isotoma simplex* Folsom]		*EB01 ED02*	

ED01 Scott, H.G.
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Taxon	Common Name	Reference	Page
Hypogastruridae*	hypogastrurid springtails	*EB01 EB08*	354
Hypogastrura [*Achorutes*] *armata** (Nicolet)	gray springtail	*EB02 EB05-EB07 EB11 EB12*	355
*Hypogastrura manubrialis** (Tullberg)		*EB01 EB02 EB05 EB07 EB11*	355
Hypogastrura pseudarmata (Folsom)		*EB05 EB11*	355

Onychiuridae*	onychiurid springtails	*EB01 EB02 EB04 EB08 EB10 EF01*	354
*Onychiurus armatus** (Tullberg)		*EB01 EB02 EB05-EB07 EB11*	355
*Onychiurus fimetarius** (L.)		*EB05 EB07 EB11*	355

EF01 Salmon, J.T.
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Taxon	Common Name	Reference	Page
Poduridae*	podurid springtails	*EB01 EB02 EB06 EB07*	353
*Podura aquatica** L.		*EB01 EB02 EB05 EB06 EB08 EB10 EB12*	353
Tomoceridae*	tomocerid springtails	*EB08 EB10*	356
*Tomocerus**		*EB01 EB02 EB05 EB06 EB10 EB12 EH01*	356

EH01 Scott, H.G.
1962. The Collembola of New Mexico. VIII. Tomocerinae (Entomobryidae). Ent. News 73(6)141-145.

Taxon	Common Name	Reference	Page
Thysanura*	silverfish	*AQ02 AQ05 AQ07 AQ14 AQ19 EI01*	322, 334, 363, 364

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Taxon	Common Name	Reference	Page
Lepismatidae*	silverfish	*EI01 EJ03*	364-366,
*Acrotelsa collaris** (Fabricius)		*EJ03*	364, 365
*Ctenolepisma lineata pilifera** (Lucas) [*C. quadriseriata* (Packard)]	fourlined silverfish	*AQ14 EJ01 EJ03*	365-368
Ctenolepisma longicaudata Escherich [*C. urbana* Slabaugh]	gray silverfish	*AQ14 EJ01 EJ03*	364-368
*Ctenolepisma villosa** (Fabricius)			368
*Lepisma saccharina** L.	common silverfish	*AQ14 EI01 EJ01 EJ03*	364, 365, 367
*Namunukulina funambuli** Wygodzinsky		*EJ02*	367
*Peliolepisma calva** Ritter		*EJ03*	367
*Thermobia aegyptiaca** (Lucas)		*EJ03*	369
*Thermobia campbelli** (Barnhart)		*EJ03*	369
*Thermobia domestica** (Packard)	**firebrat**	*AQ14 EI01 EJ01 EJ03*	364, 366, 368, 369

EJ01 Slabaugh, R.E.
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EJ03 Wygodzinsky, P.
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Taxon	Common Name	Reference	Page
Nicoletiidae*	nicoletiid silverfish	*EK01*	364, 365
*Nicoletia phytophila** Gervais [*N. meinerti* Silvestri]		*EK01*	364, 365

EK01 Wygodzinsky, P.
1980. A survey of the Nicoletiinae of Europe (Nicoletiidae, Thysanura, Insecta). American Mus. Novitates 2695:1-24.

Taxon	Common Name	Reference	Page
Psocoptera*	**psocids**	*AQ02 EL01-EL05*	324, 371, 372

EL01 New, T.R.
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EL02 New, T.R.
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EL03 Smithers, C.N.
1969. The Psocoptera of New Zealand. Rec. Canterbury Mus. 8(4)259-344.
EL04 Thornton, I.W.B., S.S. Lee, and W.D. Chui.
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EL05 Turner, B.D.
1975. The Psocoptera of Jamaica. Trans. Roy. Ent. Soc. London 126(4)533-609.

Taxon	Common Name	Reference	Page
Psocomorpha* (suborder)	psocomorph psocids	*EL01-EL03*	374
Ectopsocidae*	ectopsocids	*EL01 EL02 EL04*	395, 396
*Ectopsocopsis cryptomeriae** (Enderlein)			372, 398
*Ectopsocus briggsi** McLachlan		*EL01 EL03 EL04 EM01*	399
*Ectopsocus maindroni** Badonnel		*EL01 EL04*	401
*Ectopsocus pumilis** Banks		*EM01*	372, 401
*Ectopsocus richardsi** (Pearman)		*EL01 EM01*	399
*Ectopsocus vachoni** Badonnel		*EL01*	400

EM01 Broadhead, E., and A.M. Richards.
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Taxon	Common Name	Reference	Page
Hemipsocidae*	hemipsocids	*EL02 EL04*	396
*Hemipsocus africanus** Enderlein			396

Lachesillidae*	lachesillids	*EL01 EL02 EL04 EL05*	395, 396

Taxon	Common Name	Reference	Page
*Lachesilla nubilis** (Aaron)		*EN01*	397
*Lachesilla pedicularia** (L.)	**cosmopolitan grain psocid**	*EL01 EL04 EN01*	395, 397
*Lachesilla rena** Sommerman		*EN01*	397

EN01 Sommerman, K.M.
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Taxon	Common Name	Reference	Page
Troctomorpha* (suborder)	troctomorph psocids	*EL01-EL03*	374, 383
Liposcelidae*	liposcelids	*EL01-EL03*	374
*Belaphotroctes ghesquierei** Badonnel			386
*Belaphotroctes simulans** Badonnel			386
*Embidopsocus minor** Pearman			386
*Embidopsocus oleaginus** (Hagen)			386
*Liposcelis albothoracicus** Broadhead		*EL01*	388
*Liposcelis bostrychophilus** Badonnel		*EL01 EP01*	372, 394
*Liposcelis bouilloni** Badonnel			389
*Liposcelis corrodens** Heymons	**booklouse**		372, 393
*Liposcelis entomophilus** (Enderlein)		*EL01 EP01*	388
*Liposcelis exiguus varians** Badonnel		*EP01*	391
*Liposcelis kidderi** (Hagen)			372, 390
*Liposcelis liparus** Broadhead		*EL01 EP01*	387
*Liposcelis mendax** Pearman		*EL01 EP01*	391, 392
*Liposcelis minutus** Badonnel			394
*Liposcelis obscurus** Broadhead		*EL01*	392
*Liposcelis paetulus** Broadhead		*EL01 EP01*	392
*Liposcelis paetus** Pearman		*EL01 EP01*	392
*Liposcelis pubescens** Broadhead		*EL01 EP01*	391
*Liposcelis rufus** Broadhead		*EL01 EP01*	390
*Liposcelis simulans** Broadhead		*EL01 EP01*	372, 390
*Liposcelis decolor** Pearman		*EL01 EP01*	390
*Liposcelis transvaalensis** (Enderlein)		*EP01*	388

EP01 Broadhead, E.
1950. A revision of the genus *Liposcelis* Motschulsky with notes on the position of this genus in the order Corrodentia and on the variability of ten *Liposcelis* species. Trans. Roy. Ent. Soc. London 101(10)335-388, 3 pl.

Taxon	Common Name	Reference	Page
Pachytroctidae*	pachytroctids	*EL01 EL02 EL04*	384
*Nanopsocus oceanicus** Pearman			372, 384
Sphaeropsocidae*	sphaeropsocids	*EL01*	384
*Badonnelia titei** Pearman		*EL01*	384
Trogiomorpha* (suborder)	trogiomorph psocids	*EL01-EL03*	373, 374
Lepidopsocidae*	lepidopsocids	*EL01-EL04*	377
*Lepolepis bicolor** Broadhead		*EL01*	378
*Soa flaviterminata** Enderlein		*EL01*	378
Psoquillidae*	psoquillids	*EL01-EL04*	378
*Psoquilla marginepunctata** (Hagen)		*EL01*	379
*Rhyopsocus bentonae** Sommerman			380
*Rhyopsocus disparilis** Pearman		*EL01*	380
*Rhyopsocus peregrinus** (Pearman)		*EL01*	379
Psyllipsocidae*	psyllipsocids	*EL01-EL04*	374
*Dorypteryx domestica** (Smithers)			376
*Dorypteryx pallida** Aaron			375
*Psocatropos microps** (Enderlein)		*EL05*	372, 376
*Psocatropos pilipennis** Enderlein			376
*Psyllipsocus ramburi** Sélys-Longchamps		*EL01 EL03 EL04*	375
Trogiidae*	**trogiids**	*EL01-EL03*	378
Cerobasis [*Myopsocnema*] *annulata** (Enderlein)			383
*Lepinotus inquilinus** Heyden		*EL01 EL03*	382
*Lepinotus patruelis** Pearman		*EL01 EL03*	382
*Lepinotus reticulatus** Enderlein	**reticulatewinged trogiid**	*EL01 EL03*	381
*Trogium pulsatorium** (L.)	**larger pale trogiid**	*EL01 EL03*	383
Thysanoptera*	**thrips**	*AQ02 EQ01-EQ03*	325, 329, 403

EQ01 Bailey, S.F.
1957. The thrips of California. Part 1. Suborder Terebrantia. Bull. California Insect Survey 4(5)143-220.
EQ02 Mound, L.A., G.D. Morison, B.R. Pitkin, and J.M. Palmer.
1976. Thysanoptera. Handb. Indent. British Insects 1(11)1-79.
EQ03 Stannard, L.J.
1968. The thrips, or Thysanoptera, of Illinois. Illinois Nat. Hist. Survey Bull. 29(4)215-552.

Taxon	Common Name	Reference	Page
Terebrantia* (suborder)		*AQ02 EQ01-EQ03*	404
Aeolothripidae*		*AQ02 EQ01-EQ03*	405
Aeolothrips		*EQ01 EQ03*	
*Rhipidothrips brunneus** Williams		*EQ01 EQ02*	405
*Rhipidothrips gratiosus** Uzel		*EQ01 EQ02*	657
Thripidae*		*EQ01-EQ03 ER02 ER03*	405
Panchaetothripinae [Heliothripinae]			408
Caliothrips [*Heliothrips*] *fasciatus** (Pergande)	**bean thrips**	*EQ01 EQ03 ER01 ER02 ER05*	408
*Heliothrips haemorrhoidalis** (Bouché)	**greenhouse thrips**	*EQ01-EQ03 ER01 ER02 ER03 ER05*	408
Hercinothrips [*Heliothrips*] *femoralis** (O.M. Reuter)	**banded greenhouse thrips**	*EQ01-EQ03 ER01-ER03 ER05*	409
*Selenothrips rubrocinctus** (Giard)	**redbanded thrips**	*ER01 ER02 ER05*	409
Thripinae*			408
*Anaphothrips obscurus** (Müller)	**grass thrips**	*EQ01-EQ03 ER01 ER03*	406
*Chirothrips aculeatus** Bagnall		*EQ01 EQ02 ER06*	411
Chirothrips manicatus Haliday	timothy thrips	*EQ01-EQ03 ER03 ER06*	
*Chirothrips mexicanus** Crawford		*EQ01 EQ03 ER01 ER02 ER06*	411
*Frankliniella**		*EQ01 EQ03 ER01 ER02 ER04*	409
Frankliniella fusca (Hinds)	**tobacco thrips**	*EQ03 ER02*	
*Frankliniella minuta** (Moulton)		*EQ01 ER01 ER04*	409
Frankliniella occidentalis (Pergande)	**western flower thrips**	*EQ01 ER01 ER03*	
Frankliniella tritici (Fitch)	**flower thrips**	*EQ03 ER02*	
Frankliniella williamsi Hood		*ER01 ER02*	
*Limothrips angulicornis** Jablonowski		*EQ01 EQ03 ER01*	412
*Limothrips cerealium** (Haliday)	**grain thrips**	*EQ01-EQ03 ER01-ER03*	412
Scirtothrips [*Euthrips*] *citri** (Moulton)	citrus thrips	*EQ01 ER01*	413

Taxon	Common Name	Reference	Page
*Thrips hawaiiensis** (Morgan)	**Hawaiian flower thrips**	*ER01 ER03*	407, 413
*Thrips tabaci** Lindeman	**onion thrips**	*EQ01-EQ03 ER01-ER03*	407

ER01 Kono, T., and C.S. Papp.
1977. Handbook of agricultural pests. Department of Food and Agriculture, Sacramento.

ER02 Medina Gaud, S.
1961. The Thysanoptera of Puerto Rico. Univ. Puerto Rico Agr. Expt. Sta. Tech. Paper 32:1-160.

ER03 Mound, L.A., and A.K. Walker.
1982. Terebrantia (Insecta: Thysanoptera). Fauna of New Zealand 1:1-113.

ER04 Sakimura, K., and K. O'Neill.
1979. *Frankliniella*, redefinition of genus and revision of *minuta* group species (Thysanoptera: Thripidae). U.S. Dept. Agr. Tech. Bull. 1572:1-49.

ER05 Wilson, T.H.
1975. A monograph of the subfamily Panchaetothripinae (Thysanoptera: Thripidae). Mem. American Ent. Inst. 23:1-354.

ER06 Zur Strassen, R.
1960. Key to and catalogue of the known species of *Chirothrips* Haliday, 1836 (Thysanoptera: Thripidae). J. Ent. Soc. South Africa 23(1)144-176.

Taxon	Common Name	Reference	Page
Tubulifera* (suborder)		*AQ02 EQ02 EQ03 ER02*	404
Phlaeothripidae*		*EQ02 EQ03 ER02*	404
*Gynaikothrips ficorum** (Marchal)	**Cuban laurel thrips**	*EQ02 ER01 ER02*	413
*Haplothrips gowdeyi** (Franklin)	**black flower thrips**	*ER01 ER02*	414
*Haplothrips mali** (Fitch)	**black hunter thrips**	*EQ03 ER01*	414
Homoptera*	aphids, scales, and others	*AQ02*	326, 329, 415, 421, 422
Aphididae*	**aphids**	*AQ02*	326, 329, 415
Acyrthosiphon scariolae (Nevski) [*Macrosiphum barri* Essig]		*ET02*	
*Aphis fabae** Scopoli	**bean aphid**	*ET02*	417
*Brevicoryne brassicae** (L.)	**cabbage aphid**	*ET02 ET03*	417
Lipaphis [Hyadaphis] *erysimi* (Kaltenbach) [*Rhopalosiphum pseudobrassicae* (Davis)]	**turnip aphid**	*ET02 ET03*	
Macrosiphum dactynotus (Thomas) [*M. ambrosiae* (Thomas)]	ambrosia aphid	*ET02 ET03*	
Macrosiphum euphorbiae (Thomas) [*M. solanifolii* (Ashmead)]	**potato aphid**	*ET02*	

Taxon	Common Name	Reference	Page
*Myzus persicae** (Sulzer)	**green peach aphid**	*ET01-ET03*	329, 418
*Phorodon humuli** (Schrank)	**hop aphid**	*ET02*	418

ET01 Mason, P.W.
1940. A revision of the North American aphids of the genus *Myzus*. U.S. Dept. Agr. Misc. Publ. 371:1-30.

ET02 Palmer, M.A.
1952. Aphids of the Rocky Mountain Region. Thomas Say Foundation, [Entomological Society of America, College Park].

ET03 Smith, C.F., L.F. Martorell, M.E. Perez E.
1963. Aphididae of Puerto Rico. Univ. Puerto Rico Agr. Expt. Sta. Tech. Paper 37:1-121.

Taxon	Common Name	Reference	Page
Coccoidea*	scale insects	*AQ02 EU01*	326, 327, 421, 422

EU01 Howell, J.O., and M.L. Williams.
1976. An annotated key to the families of scale insects (Homoptera: Coccoidea) of America, north of Mexico, based on characteristics of the adult female. Ann. Ent. Soc. America 69(2)181-189.

Taxon	Common Name	Reference	Page
Asterolecaniidae*	**pit scales**	*AQ02 EU01 EV01*	424, 439

EV01 Russell, L.M.
1941. A classification of the scale insect genus *Asterolecanium*. U.S. Dept. Agr. Misc. Publ. 424:1-322.

Taxon	Common Name	Reference	Page
Coccidae*	**soft scales**	*AQ02 EU01*	422, 425, 429, 440, 441
Coccus hesperidum L.	**brown soft scale**	*EW01*	425, 429, 441
*Saissetia coffeae** (Walker)	**hemispherical scale**	*EW01*	425, 440

EW01 Williams, M.L., and M. Kosztarab.
1972. Morphology and systematics of the Coccidae of Virginia with notes on their biology (Homoptera: Coccoidea). Virginia Polytechnic Institute and State University, Blacksburg.

Taxon	Common Name	Reference	Page
Dactylopiidae	**dactylopiid scales**	*AQ02 EU01*	422
Dactylopius coccus Costa	**cochineal insect**		
Diaspididae*	**armored scales**	*AQ02 EU01*	422
*Aonidiella aurantii** (Maskell)	**California red scale**		424, 435
*Aonidiella citrina** (Coquillett)	**yellow scale**		424, 435

Taxon	Common Name	Reference	Page
*Aspidiotus nerii** Bouché	**oleander scale**		424, 437
*Chrysomphalus aonidum** (L.)	**Florida red scale**		424, 437
*Hemiberlesia lataniae** (Signoret)	**latania scale**		424, 437
*Lepidosaphes beckii** (Newman)	**purple scale**		423, 434
*Lepidosaphes gloveri** (Packard)	**Glover scale**		423, 433
*Parlatoria pergandii** Comstock	**chaff scale**		424, 436
*Pinnaspis aspidistrae** (Signoret)	**fern scale**		423, 432
*Pinnaspis strachani** (Cooley)	lesser snow scale		423, 432
*Pseudaulacaspis pentagona** (Targioni-Tozzetti)	**white peach scale**		424, 436
*Quadraspidiotus perniciosus** (Comstock)	**San Jose scale**		423, 434
*Unaspis citri** (Comstock)	**citrus snow scale**		423, 433
Eriococcidae*	**eriococcid scales**	*AQ02 EU01*	425, 442
Margarodidae*	**margarodid scales**	*AQ02 EU01*	423, 431
Ortheziidae*	**ensign scales**	*AQ02 EU01 EY01*	422, 430

EY01 Morrison, H.
1952. Classification of the Ortheziidae. U.S. Dept. Agr. Tech. Bull. 1052:1-80

Taxon	Common Name	Reference	Page
*Pseudococcidae	**mealybugs**	*AQ02 EU01*	422, 425-427, 443-448
*Dysmicoccus brevipes** (Cockerell)	**pineapple mealybug**		426, 447
*Dysmicoccus neobrevipes** Beardsley	**gray pineapple mealybug**		426, 448
*Nipaecoccus nipae** (Maskell)	**coconut mealybug**		425, 446
*Planococcus citri** (Risso)	**citrus mealybug**		425, 443
*Pseudococcus longispinus** (Targioni-Tozzetti)	**longtailed mealybug**		425, 427, 444
*Pseudococcus maritimus** (Ehrhorn)	**grape mealybug**		425, 445
Hemiptera*	**true bugs**	*AQ02 FC01-FC03*	326, 329

FC01 China, W.E., and N.C.E. Miller.
1959. Check-list and keys to the families and subfamilies of the Hemiptera-Heteroptera. Bull. British Mus. (Nat. Hist.) Ent. 8(1)1-45.

FC02 Slater, J.A., and R.M. Baranowski.
1978. How to know the true bugs (Hemiptera-Heteroptera). Brown, Dubuque.

FC03 Southwood, T.R.E., and D. Leston.
1959. Land and water bugs of the British Isles. Warne, London.

Taxon	Common Name	Reference	Page
Anthocoridae [Cimicidae]	**flower bugs, minute pirate bugs**	*AQ02 FC01-FC03*	
Lyctocoris campestris (Fabricius)		*FC02 FC03 FD02*	
Xylocoris flavipes (Reuter)	**warehouse pirate bug**	*FC03 FD01*	
Xylocoris galactinus (Fieber)		*FC03 FD02*	

FD01 Arbogast, R.T., M. Carthon, and J.R. Roberts, Jr.
1971. Developmental stages of *Xylocoris flavipes* (Hemiptera: Anthocoridae), a predator of stored-product insects. Ann. Ent. Soc. America 64(5)1131-1134.

FD02 Blatchley, W.S.
1926. Heteroptera or true bugs of eastern North America, with special reference to the faunas of Indiana and Florida. Nature, Indianapolis.

Taxon	Common Name	Reference	Page
Joppeicidae	joppeicids	*A023 FC01*	
Joppeicus paradoxus Puton		*A023 FE01*	

FE01 Davis, N.T., and R.L. Usinger.
1970. The biology and relationships of the Joppeicidae. Ann. Ent. Soc. America 63(2)577-587.

Taxon	Common Name	Reference	Page
Lygaeidae	**seed bugs, lygaeid bugs**	*AQ02 FC01 FC03*	
Elasmolomus [*Aphanus*] *sordidus* (Fabricius)			
Miridae	**plant bugs**	*AQ02 FC01-FC03*	
*Lygus lineolaris** (Palisot de Beauvois)	**tarnished plant bug**	*FC02 FG01*	328

FG01 Kelton, L.A.
1980. The plant bugs of the Prairie Provinces of Canada. Heteroptera: Miridae. Insects Arachnids Canada 8:1-408.

Taxon	Common Name	Reference	Page
Reduviidae	**assassin bugs**	*A023 AQ02 FC01-FC03*	
Amphibolus venator (Klug)		*A023 FH01*	
Coranus aegyptius (Fabricius)		*A023 FH02*	
Peregrinator [*Allaeocranum*] *biannulipes* (Montrouzier)		*FH03*	
Reduvius personatus (L.)	**masked hunter**	*FC02 FC03 FH04*	

FH01 Dispons, P.
1951. Révision du genre *Amphibolus* Klug (Hem. Reduviidae) en Afrique du Nord. Bull. Soc. Ent. France 56(5)71-73.

FH02 Dispons, P., and W. Stichel.
1959. Familia Reduviidae Latreille (Hemiptera-Heteroptera). Illustrierte Bestimmungstabellen der Wanzen II. Europa 3:81-96.

FH03 Distant, W.L.
1904. Rhynchota. II (Heteroptera). *In* The Fauna of British India, including Ceylon and Burma. Taylor and Francis, London.

FH04 Wygodzinsky, P., and R.L. Usinger.
1964. The genus *Reduvius* Fabricius in western North America (Reduviidae, Hemiptera, Insecta). American Mus. Novitates 2175:1-15.

Taxon	Common Name	Reference	Page
Orthoptera*	orthopterans	*AQ02 AS04*	325, 331, 671
Gryllacrididae	**cave crickets, camel crickets**	*AS04*	
Pristoceuthophilus [*Ceuthophilus*] *pacificus* (Thomas)	mushroom camel cricket	*AS04*	
Dermaptera*	**earwigs**	*AQ02 AS04 FK01 FK02*	323, 331

FK01 Hincks, W.D.
1956. Dermaptera and Orthoptera. Handb. Ident. British Insects 1(5)1-21.

FK02 Langston, R.L., and J.A. Powell.
1975. The earwigs of California (order Dermaptera). Bull. California Insect Surv. 20:1-25.

Taxon	Common Name	Reference	Page
Carcinophoridae (including Labiduridae in part)	ringlegged earwigs	*AQ02*	
Euborellia [*Anisolabis*] *annulipes* (Lucas)	**ringlegged earwig**	*AS04 FK01 FK02*	
Chelisochidae	**black earwigs**	*AQ02 FK01*	
Chelisoches flavipennis (Fabricius)			
Forficulidae	European earwigs	*AQ02 FK01*	
Forficula auricularia L.	**European earwig**	*FK01 FK02*	
Labiduridae	**striped earwigs**	*AQ02 FK01*	
Labidura riparia (Pallas)	**shore earwig**	*FK01*	
Labiidae	**little earwigs**	*AQ02 FK01*	
Marava [*Prolabia*] *arachidis* (Yersin)	chief earwig	*AS04 FK01 FK02*	
Isoptera*	**termites**	*AQ02 AS04*	325, 330
Araneae* [Araneida]	**spiders**	*AQ02*	4, 321
Opiliones* [Phalangida]	**daddylonglegs, harvestmen**	*AQ02 FQ01 FQ02*	320

FQ01 Sankey, J.H.P., and T.H. Savory.
1974. British harvestmen. Arachnida: Opiliones. Keys and notes for the identification of the species. Synopses British Fauna (n.s.) 4:1-76.

FQ02 Todd, V.
1948. Key to the determination of the British harvestmen (Arachnida, Opiliones). Ent. Monthly Mag. 84(1008)109-113.

Taxon	Common Name	Reference	Page
Leiobunidae	leiobunids		
Leiobunum blackwallii (Meade)		*FQ01 FQ02*	
Leiobunum rotundum (Latreille)		*FQ01 FQ02*	
Phalangiidae	phalangiids		
Platybunus triangularis (Herbst)		*FQ01 FQ02*	
Pseudoscorpiones* [Chelonithida]	**pseudoscorpions**	*AQ02 FT01-FT04*	321

FT01 Beier, M.
1932. Cheliferinea. Pseudoscorpionidea II. Das Tierreich 58:i-xxi, 1-294.

FT02 Hoff, C.C.
1949. The pseudoscorpions of Illinois. Bull. Illinois Nat. Hist. Surv. 24(4)407-498.

FT03 Manley, G.V.
1969. A pictorial key and annotated list of Michigan pseudoscorpions (Arachnida: Pseudoscorpionida). Michigan Ent. 2(1-2)2-13.

FT04 Nelson, S., Jr.
1975. A systematic study of Michigan Pseudoscorpionida (Arachnida). American Midl. Nat. 93(2)257-301.

Taxon	Common Name	Reference	Page
Cheiridiidae	cheiridiids	*FT01*	
Cheiridium museorum (Leach)			
Cheliferidae	cheliferids	FT03	
*Chelifer cancroides** (L.)	house pseudoscorpion, book pseudoscorpion	*FT01-FT04*	321
Paisochelifer callus Beier		*FT02-FT04*	
Chernetidae	chernetids	*FT03*	
Lamprochernes minor Hoff		*FT02-FT04*	
Withiidae [Withiinae of Cheliferidae]	withiids		
Allowithius congicus Beier		*FT01*	
Allowithius kaestneri Vachon			
Withius piger (Simon) [*W. subruber* (Simon)]		*FT01*	
Isopoda	**pillbugs, sowbugs**	*AQ02 FW01 FW02*	

FW01 Edney, E.B.
1953. The woodlice of Great Britain and Ireland. A concise systematic monograph. Proc. Linn. Soc. London 164(1)49-98.

FW02 Sutton, S.
1972. Woodlice. Ginn, London.

Taxon	Common Name	Reference	Page
Armadillidiidae	armadillidiids		
Armadillidium vulgare (Latreille)	greenhouse pillbug	*FW01 FW02*	
Porcellionidae	porcellionids		
Porcellio laevis Latreille	dooryard sowbug	*FW01 FW02*	

Notes and Sketches

APPENDIX

U.S. DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE — PLANT SCIENCES INSTITUTE
SYSTEMATIC ENTOMOLOGY LABORATORY-TAXONOMIC SERVICES UNIT

IDENTIFICATION REQUEST

NOTE:
- Please *type or print* all information.
- Do not write in shaded areas.
- Give explanations where requested in "Remarks" section at bottom of form.
- Attach additional pages if (and only if) more space is needed.

TSU LOT NO.	TSU PRIORITY
DATE	Sender's Reference No.

DATE IDENTIFICATION REQUIRED *(month, day, year)*
If less than two months, explain below.

TOTAL NUMBER SENT
Pinned: Vials: Slides:
Other:

NAME & COMPLETE MAILING ADDRESS OF SENDER *(Include Zip Code)*

RETURN TO *(If other than sender) (Include Zip Code)*

SOURCE

AR ☐	ARS	**SU** ☐	State University
AP		**OS** ☐	Other State
AQ ☐	APHIS-PPQ	**PU** ☐	Private University
FS ☐	FS	**IN** ☐	Individual
DD ☐	U.S. Military	**CO** ☐	Commercial Organization
OF ☐	Other Federal	**FN** ☐	Non-U.S.
SA ☐	State Agricultural Agency	**CI** ☐	CICP

LEVEL/TYPE OF IDENTIFICATION NEEDED
☐ Family ☐ Genus ☐ Species

☐ Positive or negative verification of ecological group:

☐ phytophagous ☐ parasitic ☐ predaceous

☐ saprophagous ☐ aphidophagous ☐ other:

OTHER INFORMATION REQUESTED—Will be supplied as conditions allow, as determined by taxonomist. Note reasons information is needed.

SOURCE OF PROJECT SUPPORT
☐ ARS ☐ APHIS ☐ FS ☐ CSRS Regional project no:
☐ Hatch ☐ EPA ☐ DOI ☐ NIH ☐ NSF ☐ FAO
☐ USAID ☐ Other *(Specify)*

REASON FOR IDENTIFICATION *(Check and complete as appropriate)*

a Biological control
- **1** ☐ Scientific name of target pest:
- **2** ☐ General quarantine or biocontrol research
- **3** ☐ Identity of host of natural enemy
- **4** ☐ Recovery of released natural enemy
- **5** ☐ Suspected contaminant in culture
- **6** ☐ Quarantine reference collection
- **7** ☐ Voucher specimen of field release
- **8** ☐ Holding living material pending identification

b ☐ Damaging crop, plants—*identify host plants:*

c ☐ Suspected pest of regulatory concern—*give details below*

d ☐ Stored product pest—*commodity affected:*

e ☐ Livestock, wildlife, or domestic animal pest—*host:*

f ☐ Danger to human health

g ☐ Household pest—*damage:*

h ☐ Possible immigrant—*new to:*

i ☐ Reference collection—*for:*

j ☐ Survey—*explain in detail below*

k ☐ Thesis problem—*describe project below* ☐ M.S. ☐ Ph.D.

l ☐ Other—*explain below*

SPECIMENT DISPOSITION—See Instruction Sheet. If you wish specimens returned, please provide justification below. Duplicate specimens encouraged — see instruction sheet.
☐ Return ☐ Keep or discard

TELEMAIL/ASRR or BITNET USER ID:

TELEPHONE REPORT REQUESTED
If yes, give number-include area code and extension.
Requests are handled at the discretion of SEL, TSU

DESCRIPTION OF PROJECT—Include Project Title and name of Project Leader. **(Reference previous communications pertaining to this submittal)**

REMARKS *(Explanations, tentative identification, etc.)*

FOR TSU USE
DATE RECEIVED

NO.
LABEL
SORTED
PREPARED

DATE ACCEPTED

CC's OR TEXT

ARS-748 (9/88)

PART 1—SEL COPY

United States Department of Agriculture | Agricultural Research Service | Beltsville Area Plant Sciences Institute | Systematic Entomology Laboratory Beltsville, Maryland 20705

IDENTIFICATION REQUEST — INFORMATION/INSTRUCTIONS

The *Systematic Entomology Laboratory* (SEL) of the *Plant Sciences Institute* (PSI), is the primary U.S. Federal agency responsible for providing identifications and other taxonomic services for insects and related organisms. The *Taxonomic Services Unit* (TSU) is the unit within SEL that receives, sorts, and distributes the specimens and reports the identifications. We are pleased to be of assistance; however, it is appropriate that you determine if sources of identifications are available in your area or country *before submitting material.*

1. Use this form for submission of each *lot—not* for individual specimens. Retain Part III for your records. Send Part I *in advance* and Part II enclosed with your submittal (or send Parts I and II with your submittal) to:
   Taxonomic Services Unit, Systematic Entomology Laboratory
   Plant Sciences Institute
   Building 046, Room 101A, Beltsville Agricultural Research Center-West
   Agricultural Research Service, USDA
   Beltsville, Maryland 20705
   U.S.A.
2. Each specimen or collection of specimens, whether on a pin, in a vial, or on a slide, *must* be labeled with complete collection data — specific locality (country, state, or other political subdivision, and city or pertinent local landmark), date of collection, name of collector, family, genus, and species names of host *(if known)*, and voucher number (*if appropriate*). Include duplicate data labels when submitting specimens in alcohol, in the event the taxonomist wishes to keep part of the material. Each specimen should have a brief, unique number to facilitate reporting of identifications. Specimen label data should be recorded in the event the specimens are kept for the U.S. National Museum. See reverse side for preparation of specimens. Please see our statement on parasitic Hymenoptera for information on our requirements on host data for parasitic wasps.
3. A brief description of your project will enable us to place the proper priority on your request. Early submittals, and submittals of small lots as studies progress, will ensure faster service. *Please*, do not wait until your project is complete to submit specimens for identification.
4. Lots relating to agricultural interests are given highest priority. Requests for information on hosts, distribution, identification characteristics, literature references, etc., are generally answered at the option of the taxonomists based on their evaluation of the request and time available. To provide the requested information the taxonomist often must spend considerable time and effort. Please request only the information that is critically needed.
5. Inquiries on the status of an identification request may be made by —
   Correspondence to Taxonomic Services Unit at the above address
   Telephone — Mary Lacey (301) 344-3041
   Telemail — MLACEY or PPQ.ARS.MLACEY; ASRR - MLACEY; BITNET - MLACEY@UMDARS

   Please refer to the TSU "lot" number when known.
6. In recent years the cost of returning specimens has become a major bugetary concern. With the current budget restraints, we ask that you help us keep costs to a minimum. Therefore, we would be grateful if you would retain duplicate specimens in your collection so that material we identify can be retained in the U.S. National Collection or discarded. If it is important that material be returned, please indicate your need and we will attempt to accommodate your request. Specimens that represent new species, new host records, or new distribution records may be retained at the discretion of the taxonomist for placement in the U.S. National Collection of Insects in the Smithsonian Institution. Approximately 25,000 specimens are added to the National Collection every year as a result of the SEL identification service. The opportunity to retain specimens of interest is one way in which our collaborators can be recompensed for their assistance.
7. Users of this service should appropriately cite the taxonomist who provided the identifications in their publications and reports. If the identifier cannot be given after the name of the taxon (*e.g.*, in tables or lists), a footnote or other means of acknowledgment should be used. Proper formatting, as appropriate, is as follows:
   Name of taxonomist, Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture
   Name of taxonomist, Department of Entomology, Smithsonian Institution
   Cooperating entomologists at other institutions should be listed in similar format.
8. We would greatly appreciate your sending reprints of publications and other documents in which our identifications are used to the *TSU, SEL* at the above address and to the taxonomist(s) who provided the determination(s).

Form ARS-748A (9/88)

The insect and mite taxonomic service program of the Systematic Entomology Laboratory, with the aid of entomologists in the Smithsonian Institution and other cooperators, provides identifications of about one-third million specimens per year (about 30,000 scientific names, or 17,000 consignments or lots) for an extremely wide variety of users. Unfortunately, some specimens must be returned unidentified because the poor condition of a specimen may prevent its identification, the classification of a group may need or be undergoing revision, the quantity of material may be too large for us to accept, or the request may not be in line with our priorities. We also lack specialists or cooperators for some groups (*see list below*).

Immature stages are accepted for identification, but the classification of immature forms is so poorly known in many groups that even identification to family is not possible. For this reason we urge all collectors to *rear some of the specimens* and *submit adults with the associated immature stages.*

Preparation of Specimens Submitted for Identification. . . Because of a lack of sufficient technical assistance to prepare specimens for identification, we are including the following instructions to help you prepare specimens in a condition suitable for study.

PINNED—Most specimens should be pinned; those too small or fragile for direct pinning should be double mounted on minuten nadeln or carefully glued to paper points. Glue the point to the ***right side*** of the specimen, using care that the glue does not conceal critical characters. Do not glue tiny *moths* or *flies* to points; use minuten nadeln. Specimens should be pinned while fresh. *Moths* should be submitted with wings spread. Examination of properly prepared genitalia is necessary to identify many insects to genus or species level. Specific instructions for preparing genitalia will be supplied upon request. Puparia, pupal skins, cocoons, etc., should be placed in a gelatin capsule or glued to a card either separately or pinned below the adult.

SLIDE MOUNTS—Submit *mites, fleas, thrips, aphids, whiteflies, psychodid flies,* most *scales,* and *mosquito larvae* on microscope slides, if you can prepare good slides. This will enable us to identify the material more quickly. Some *trichogrammatid* and *mymarid wasps* and other minute insects must also be mounted on slides. Larval *ticks* are acceptable as slide mounts if they are not engorged. Specific instructions for slide-mounting the above groups will be supplied upon request.

ALCOHOL—Submit the following specimens in alcohol: *ichneumonid wasps, mayflies, bat flies,* all *soft-bodied insects* (including all *larvae* and *pupae*), and most *insects under 2 mm* in length, except as indicated below. Also, specimens in the groups listed under *Slide Mounts* should be preserved in 70% alcohol if not slide-mounted. Adult *whiteflies* may be submitted in alcohol, but identification of this stage usually is not possible. **Never** submit adults of the following in alcohol: *moths, bees, true bugs, psychodids and all other flies except minute Nematocera flies.* **Place Only One Kind of Insect in Each Vial.** Use neoprene-, rubber-, or silicone-stoppered vials rather than screw-capped or shell vials. Use clear glass vials of sufficient size to allow the use of forceps or an eye dropper to remove the specimens; however, if the vial is too large, very small specimens will be difficult to find. Do not use methanol or formalin solutions: use 70, 80, or 95% ethanol if possible. Isopropanol, the drugstore variety, is adequate only for temporary storage. To prevent dilution of the alcohol and subsequent decomposition of specimens, fresh alcohol must be placed in the vials within 24 hours after *initial immersion* of specimens. All vials containing soft-bodied insects should be shipped exclusive of all air bubbles. Insert a paperclip or pin with the stopper to eliminate all air bubbles; then remove the paperclip or pin.

PREPARATION of SPECIFIC FORMS—Kill *larvae* by placing them in boiling water or in an alcohol-glacial acetic acid mixture, then transfer them to 70% alcohol. *Ichneumonid wasps* and *mayflies* should be killed and preserved in 95% ethanol; *thrips* should be killed and preserved in AGA (9 parts 70% alcohol:1 part glycerine:1 part glacial acetic acid). Nymphal, adult, and engorged larval *ticks* should be preserved in 70-80% ethanol.

DRY, UNMOUNTED—If *whiteflies and diaspidid scales* are not mounted on slides, they should be submitted on host plants placed between pieces of dry paper towel, blotters, or other absorbent paper. Do not place specimens belonging to these families in plastic bags.

PILLBOXES—Pillboxes and matchboxes are **NOT** acceptable containers for submitting insects, but they may be used to submit associated plant samples, galls, or similar material. Soft tissue paper or cellucotton, *not cotton,* should be used in such boxes.

Identification Capability. . . Adults and immatures of all groups of insects and related arthropods are accepted for identification by SEL taxonomists, except those listed below. Groups marked by an asterisk are accepted but referred to cooperators outside the Institute. Identification of these is at the *discretion of the cooperator.* Groups *not marked* by an asterisk are usually returned unidentified. With appropriate justification, we may attempt to identify some of these groups or may provide names and addresses of other experts.

INSECT GROUPS

*Anoplura
Collembola
Diplura
*Ephemeroptera
*Mallophaga
*Mecoptera
*Neuroptera
*Odonata
*Plecoptera
Protura
*Psocoptera
*Siphonaptera
Thysanura
*Trichoptera

COLEOPTERA[1]
Amphizoidae
Anthicidae
*Buprestidae
Carabidae
Cicindelidae
*Cleridae
Dryopidae
Dytiscidae
Elmidae
Georyssidae
Gyrinidae
Haliplidae
Hydraenidae
Hydrophilidae
Hydroscaphidae
Lagriidae
Limnichidae
Melandryidae
Mordellidae
Nitidulidae[2]
Noteridae
*Oedemeridae
Pedilidae
Psephenidae
Rhysodidae
Silphidae
Sphaeriidae
Staphylinidae[3]

DIPTERA
Acroceridae
Apioceridae
Asilidae
*Blephariceridae
Bombyliidae
*Camillidae
*Celyphidae
*Ceratopogonidae
Chironomidae
*Coelopidae
*Culicidae
*Curtonotidae
*Diastatidae
*Drosophilidae
*Dryomyzidae
Empididae
*Ephydridae
*Heleomyzidae
*Lauxaniidae
Mydidae
Nemestrinidae
*Ptychopteridae
Scenopinidae
*Tanyderidae
*Tipulidae
*Trichoceridae
*Trixoscelididae

HEMIPTERA
*Tingidoidea

HOMOPTERA
Coccoidea
Psyllidae

LEPIDOPTERA (adults)
Bombycoidea
Copromorphoidea
*Cossoidea
*Eriocranioidea
*Hepialoidea
Hesperioidea
*Incurvarioidea
*Micropterygoidea
*Nepticuloidea
*Papilionoidea[4]
*Sesiidae
Sphingidae
*Tineioidea
Tortricoidea
Yponomeutoidea
Zygaenoidea

1 There are also several minor families for which no specialist is available.
2 USDA material will be accepted.
3 ARS Biological Control material will be accepted
4 True butterflies (Papilionoidea)—from outside North America only will be identified if (1) voucher specimens may be retained, (2) the specimens have been reared or parasitized, and (3) all specimens are fully labeled, including food plant data.

NON-INSECT GROUPS

*Araneida (spiders)
*Argasidae ("softbacked ticks")
Chelonethida (pseudoscorpions)
Chilopoda (centipedes)
Crustacea (includes sowbugs & pillbugs)
Diplopoda (millipedes)
Gastropoda (snails & slugs)
Hydrachnellae (water mites)
*Ixodidae ("hardbacked ticks")
*Oligochaeta (earthworms)
Pedipalpida ("whip scorpions")
*Phalangida ("daddy longlegs")
Scorpionida (scorpions)
Solpugida (solpugids)
Symphyla ("symphylans")

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