THE LABORATORY COCKROACH

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Experiments in cockroach anatomy, physiology and behavior

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PREFACE

Cockroaches are ideal subjects for laboratory investigation at all educational levels. Compared with many other laboratory animals, cockroaches are easily and inexpensively maintained and cultured and require relatively little space. They are hardy and are readily available.

The purpose of this book is to provide background material and experimental leads for utilizing cockroaches in the teaching laboratory and in designing research projects. The level of difficulty of the experiments varies according to the depth of understanding desired by the instructor. In most cases at least a part of each experiment or technique can be incorporated into the laboratory component of elementary, high school or college curriculum. Sections of the lab book are appropriate for courses in Animal Behavior, Entomology, Organismic Biology and Insect Physiology. Aside from this main purpose, the book also provides a wealth of experimental ideas and techniques for a scientist at any level of education.

Lawrence, Kansas
June 15, 1981

W.J.B.

ACKNOWLEDGEMENTS. Virtually all graduate students who have worked on cockroach research in my laboratory have knowingly or unknowingly contributed to this book. The most important contribution was from Sandy Jones McPeak, who encouraged me to finish the project. Segments of various chapters were conceived, developed or reviewed by Michael D. Breed, Sandy Jones McPeak, Michael K. Rust, Coby Schal, Thomas R. Tobin, W. Alexander Hawkins, Gary R. Sams and Chris Parsons Sams. I am most grateful to authors and publishing companies for allowing me to reproduce their published illustrative materials; these sources are listed in an appropriate section of the book. I am indebted to Coletta Spencer, Jan Elder and Tammi Harbert for their patience and artistry in preparing the manuscript, to Sharon Hagan for explaining how to prepare a manuscript for photocopy processing, and to Mary McCoy for original illustrations. High contrast cockroach photographs on the cover and on topic heading pages were skillfully prepared by my colleague, Michael K. Tourtellot. Professors D.M. Guthrie and George W. Byers kindly read and criticized portions of an earlier draft.

-- W. J. B.

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Topic—1—COCKROACH DIVERSITY AND IDENTIFICATION

There are more than 4,000 known species of cockroaches throughout the world, most of which live in the tropics. Aside from living in our houses, cockroaches inhabit leaf litter and tree bark in temperate and tropical forests, grasslands, desert sand dunes, rotting logs, bird and ant nests, and caves. Cockroaches, being primitive insects, are relatives of termites (order Isoptera) and grasshoppers, crickets and katydids (order Orthoptera). The presently accepted scheme of classification places cockroaches in the order Dictyoptera and suborder Blattaria. The other suborder, Mantodea, contains the preying mandids. There are five major families of cockroaches: Cryptocercidae, Blattidae, Blaberidae, Blattellidae and Polyphagidae.

A. IDENTIFICATION. There are various ways to identify cockroaches, using external morphological characteristics, body size and shape of the ootheca (egg case). Information for identification is provided here in three ways: (1) photographs of cockroach species, (2) descriptions in Table I, and (3) a key to common cockroaches. It is probably wise to study and complete Exercise 4.1 on external anatomy before attempting to identify cockroaches with the key.

B. THREE PRINCIPAL SPECIES. The three most common cockroach species in North America and Europe are the American cockroach, Periplaneta americana (family Blattidae), Oriental cockroach, Blatta orientalis (family Blattidae), and German cockroach, Blattella germanica (family Blattellidae). Depending on your geographical location either of the first two might be called 'water bugs.' Since all three species originated in Africa, the references to origin are less than meaningful.

Periplaneta americana is the largest common cockroach species. (Fig. 1.1). It is especially common in urban areas and in southern parts of the U.S. Both sexes have fully developed wings, and males occasionally fly or glide. Identifiers: reddish-brown, large body (29 - 44 mm), yellow blotch on pronotum. Three closely related species, P. brunnea, P. australasiae and P. fuliginosa look similar to P. americana and are found in sub-tropical regions throughout much of the world.

Blattella germanica is the smallest pest species (Fig. 1.2). Both sexes are winged. The German cockroach is now found in all areas of the U.S. and Europe, and is considered to be the most important pest cockroach. Identifiers: small (10 - 15 mm), tan appearance.

Blatta orientalis commonly occurs in sewers, basements and other 'below-ground-level' structures. Females are wingless; males have short wings (Fig. 1.3). Identifiers: shiny black appearance, stout bodies (18 - 27 mm).

C. OTHER COMMON SPECIES. Supella longipalpa (family Blattellidae) (Fig. 1.4), the 'brown-banded cockroach,' is quickly spreading throughout the world as a pest species. It can survive in relatively dry habitats, feeding on book bindings and other types of glue. Identifiers: slender, small (10 - 15 mm), light tan appearance; adults have wings; nymphs have brown bands on thorax and abdomen.

Parcoblatta pennsylvanica (family Blattellidae) is a common cockroach in woodlands throughout the U.S. (Fig. 1.5). Males fly to lights at night,

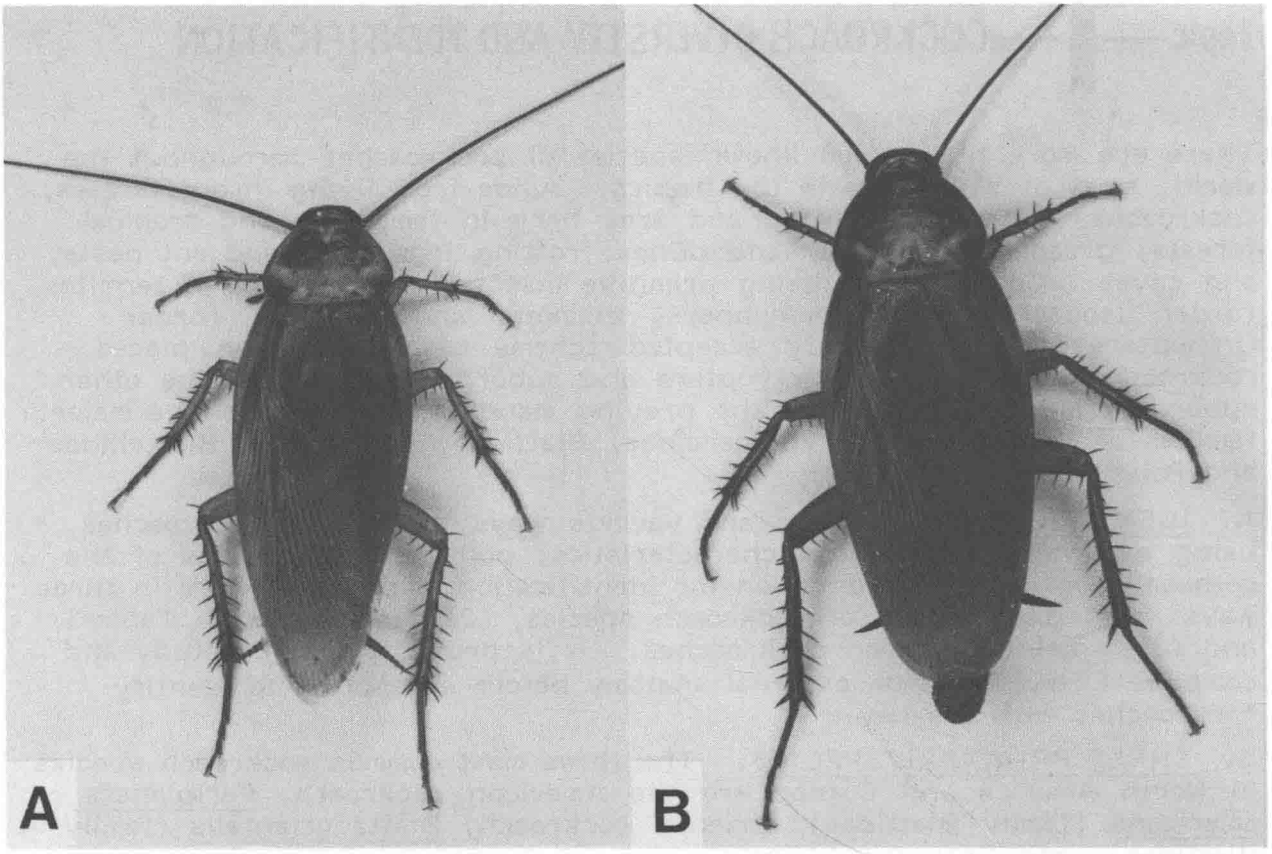

Fig. 1.1. American cockroach, Periplaneta americana; (A) male (B) female.

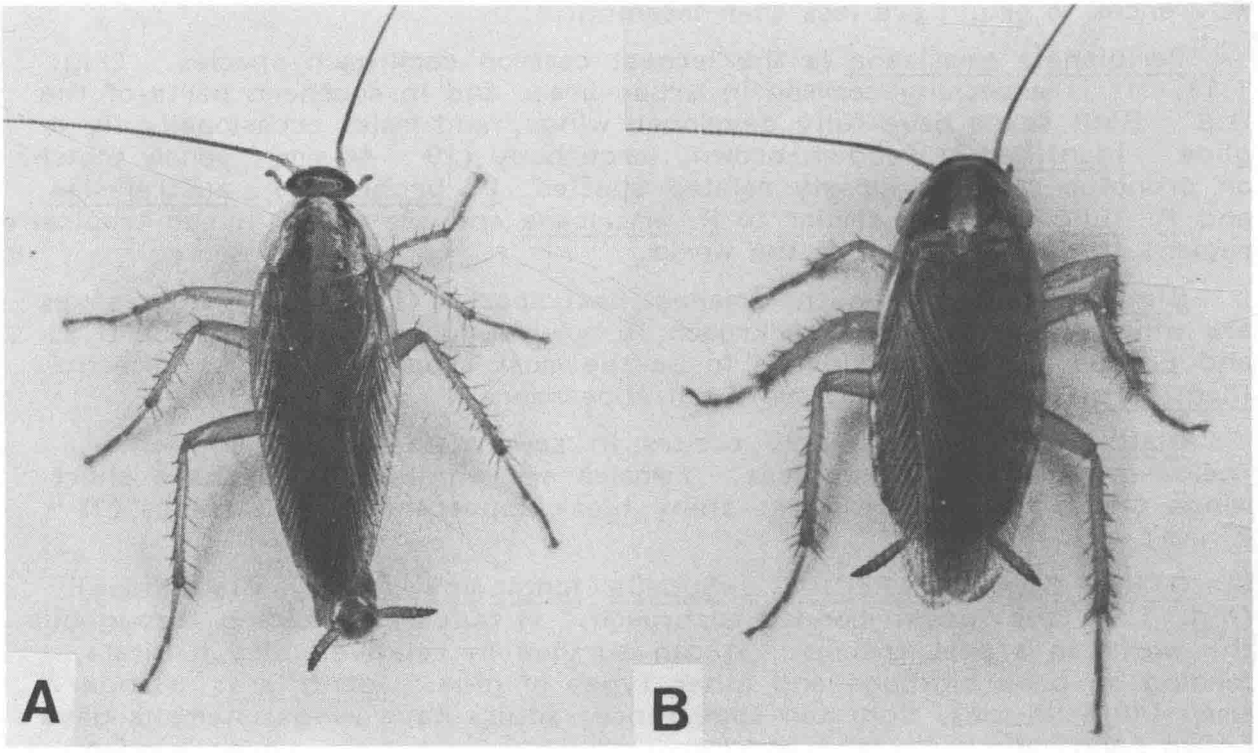

Fig. 1.2. German cockroach, Blattella germanica; (A) male (B) female.

and nymphs are often found under outdoor piles of firewood or rotting logs. Identifiers: males and females dark brown, (13 - 30 mm), thorax and forewings edged with white or yellow. Other species of this genus also are fairly common (Parcoblatta bolliana, P. fulvescens, P. lata, P. uhleriana, and P. virginica). The European counterpart of Parcoblatta is Ectobius, a small wood cockroach. Recently Ectobius has also appeared in New England.

Eurycotis floridana (family Blattidae) is a large cockroach often observed outdoors in Florida and in the West Indies (Fig. 1.6). Identifiers: adults wingless, large (30 - 40 mm), red-brown to black; nymphs with yellow stripes. Adults secrete a defensive odor that smells of almonds.

Cryptocercus punctulatus (family Cryptocercidae) is a social cockroach, living in family groups within rotting logs. It is found only in oak-hickory forests in the Appalachians and in the far northwestern U.S. Identifiers: adults large, (23 - 30 mm) and wingless; homogeneous dark-brown; pronotum is thick and grooved; eyes very small; cerci very small (the name Cryptocercus implies 'hidden cerci').

D. TROPICAL SPECIES. The following species are found in tropical, and sometimes, subtropical regions. A few are pests. Colonies of these species are maintained by entomologists who study cockroach biology.

Several species of Gromphadorhina (family Blaberidae) live only in Madagascar, the island off the east coast of Africa. Some species are very large (up to 65 mm). Adults 'hiss' when disturbed and employ the hissing sounds in aggressive and sexual behavior.

Blaberus (family Blaberidae) is a common tropical genus, including Blaberus craniifer (48 - 57 mm) (Fig. 1.7), which is established in Florida and Blaberus giganteus (70 - 80 mm), which is found mainly in tropical rainforests. Males and females are good fliers, often appearing at swimming pools or hotel patios at night.

Two species that are common in tropical regions, Nauphoeta cinerea (25 - 29 mm) and Leucophaea maderae (40 - 50 mm) (family Blaberidae), have now been found in the U.S. L. Maderae (Fig. 1.8) is well established indoors in New York City.

E. CHARACTERISTICS OF COCKROACHES. Table I summarizes a lot of information about cockroaches that might be of value in identifying species and planning experiments. 'Reproduction characteristics' refers to the disposition of the egg cases during egg development; oviparous means that the egg case is held outside the body, ovoviviparous means that it is held inside the body. 'Nymph development' relates the time from when nymphs hatch from an eggcase to when they reach adulthood.

F. KEY TO ADULTS OF COMMON COCKROACHES. To use the key beginning on page 10, follow in sequence beginning with couplet number 1. Refer to the figures as required. The external anatomy exercise (4.1) should be completed before attempting to use the key.

G. SOURCES OF INFORMATION ABOUT COCKROACHES. Four excellent books are available on cockroaches: The Biology of the Cockroach (1968) by D. M. Guthrie and A. R. Tindall, Edward Arnold Ltd., 41 Maddox St., London W1, 408 pp.; The Cockroach, Vol. I (1968) by P. B. Cornwell, Rentokil Library, Hutchinson Press, 178-202 Great Portland St., London

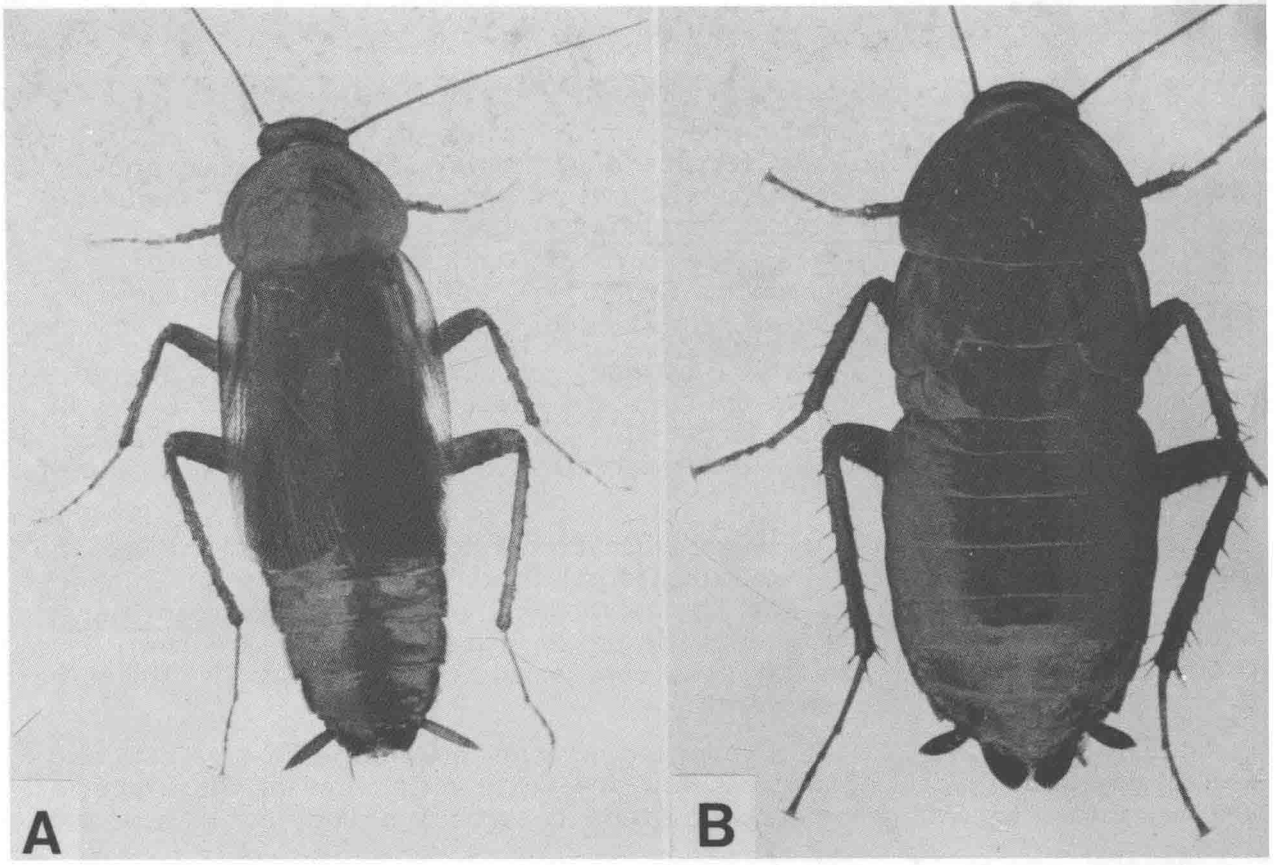

Fig. 1.3. Oriental cockroach, Blatta orientalis; (A) male (B) female.

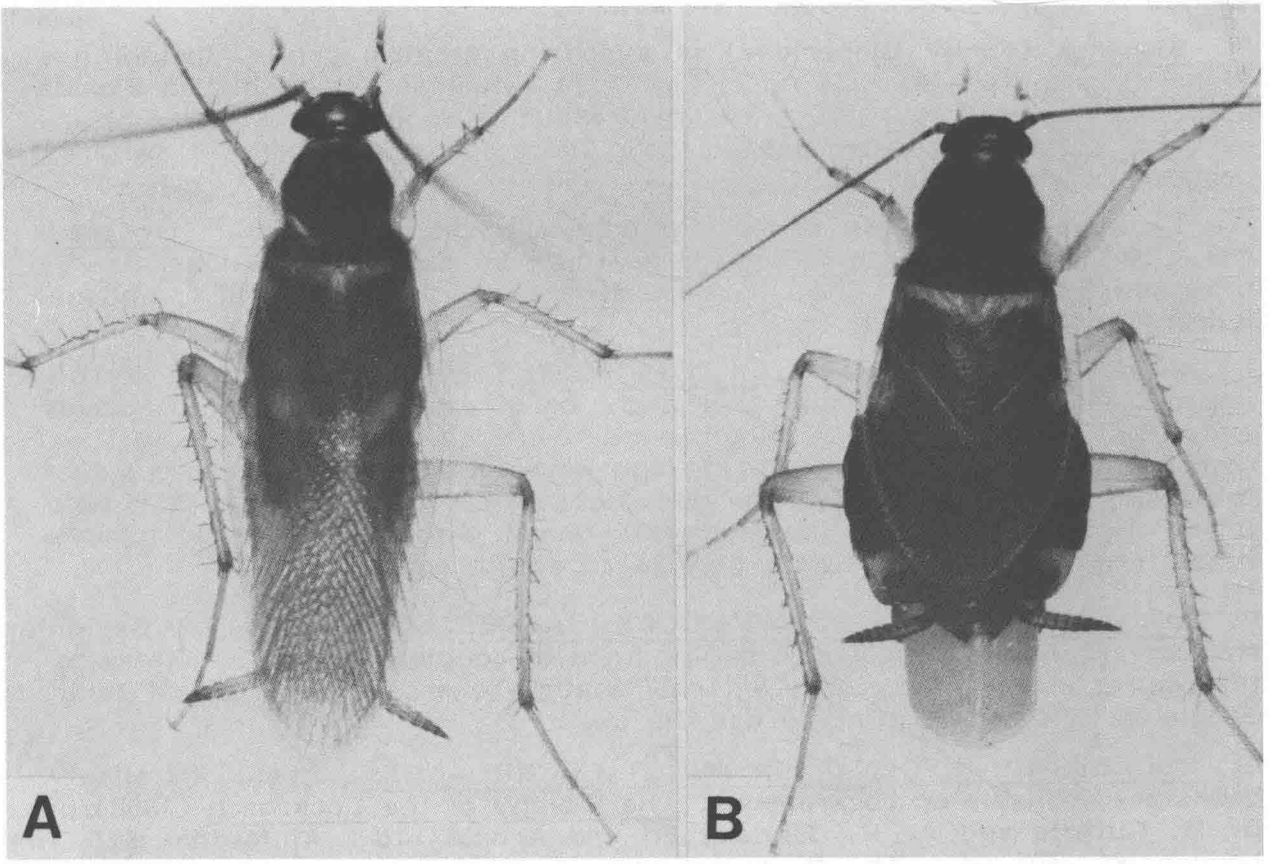

Fig. 1.4. Brown-banded cockroach, Supella longipalpa; (A) male (B) female.

W1, 391 pp.; The Cockroach, Vol II (1976), by P. B. Cornwell (same publisher as above); The American Cockroach (1981), edited by W. J. Bell and K. G. Adiyodi, Chapman & Hall, London, 550 pp.

Except for Cornwell's Vol. II, which mainly concerns cockroach control, the books cover the following topics: exoskeleton, reproduction, metamorphosis, hormones, nervous system, behavior, muscles and locomotion, feeding and digestion, metabolism, excretion, circulation, respiration and natural history. At least one of these books should be available as a resource for students experimenting with cockroaches.

References are provided at the end of each chapter for readings in the general subject area (GENERAL READINGS) and for more details and technical information (RESEARCH REPORTS). In some chapters, as noted, the readings are essential either for carrying out the experiments (where the techniques are very complicated) or for a complete understanding of the concepts involved.

GENERAL READINGS

Cameron, E. 1961. The cockroach, Periplaneta americana L. London: Heinemann.

Cornwell, P. B. 1968. Chapters 2 and 3. In: The Cockroach. London: Hutchinson Press.

McKittrick, F. A. 1964. Evolutionary Studies of Cockroaches. Memoir 389, Cornell Univ. Agric. Expt. Sta.

Roth, L. M. 1981. Introduction to Periplaneta. In: The American Cockroach. Ed. by W. J. Bell and K. G. Adiyodi. London: Chapman & Hall.

Roth L. M. and E. R. Willis. 1960. The biotic associations of cockroaches. Smithsonian Misc. Collect. 141: 1-470.

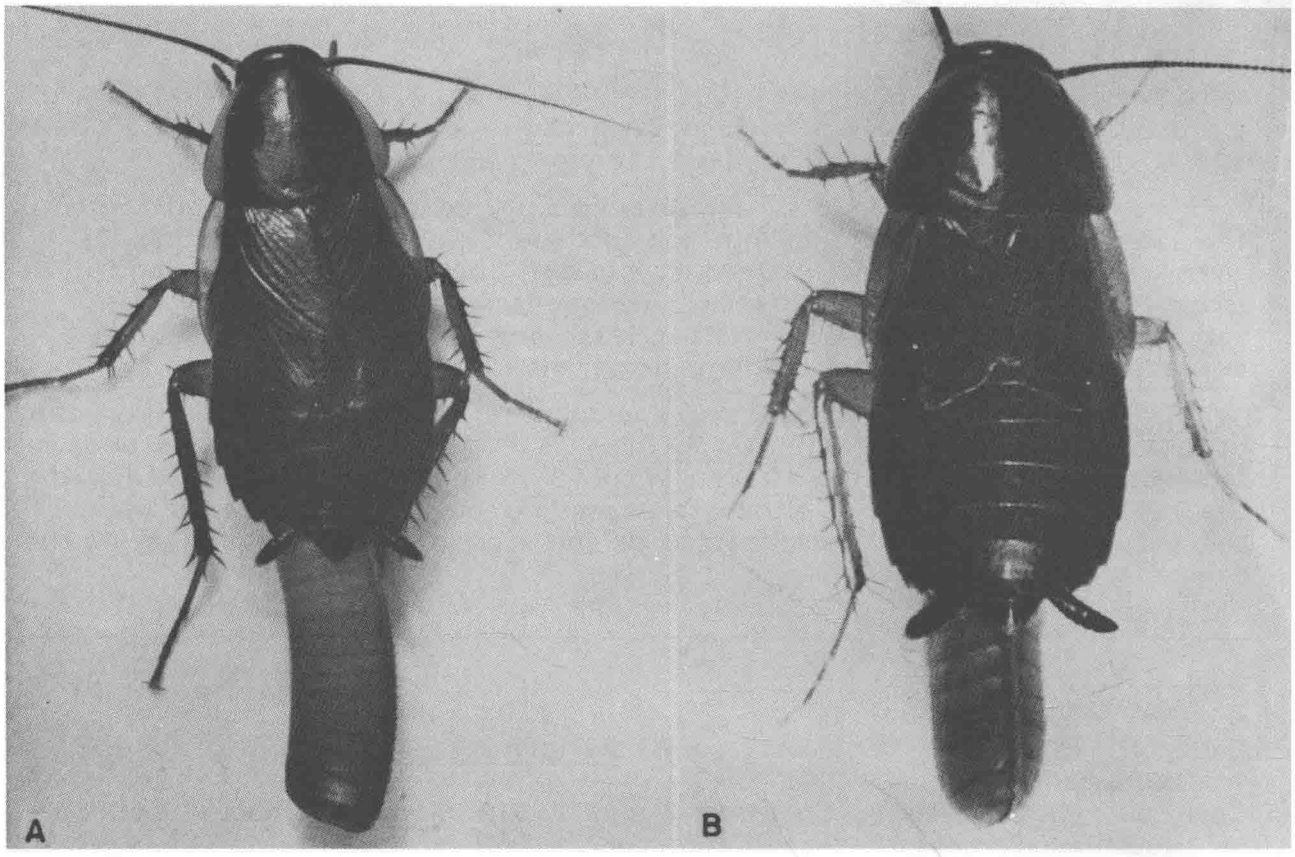

Fig. 1.5. Wood cockroaches; (A) female Parcoblatta pennsylvanica (B) female Parcoblatta virginica.

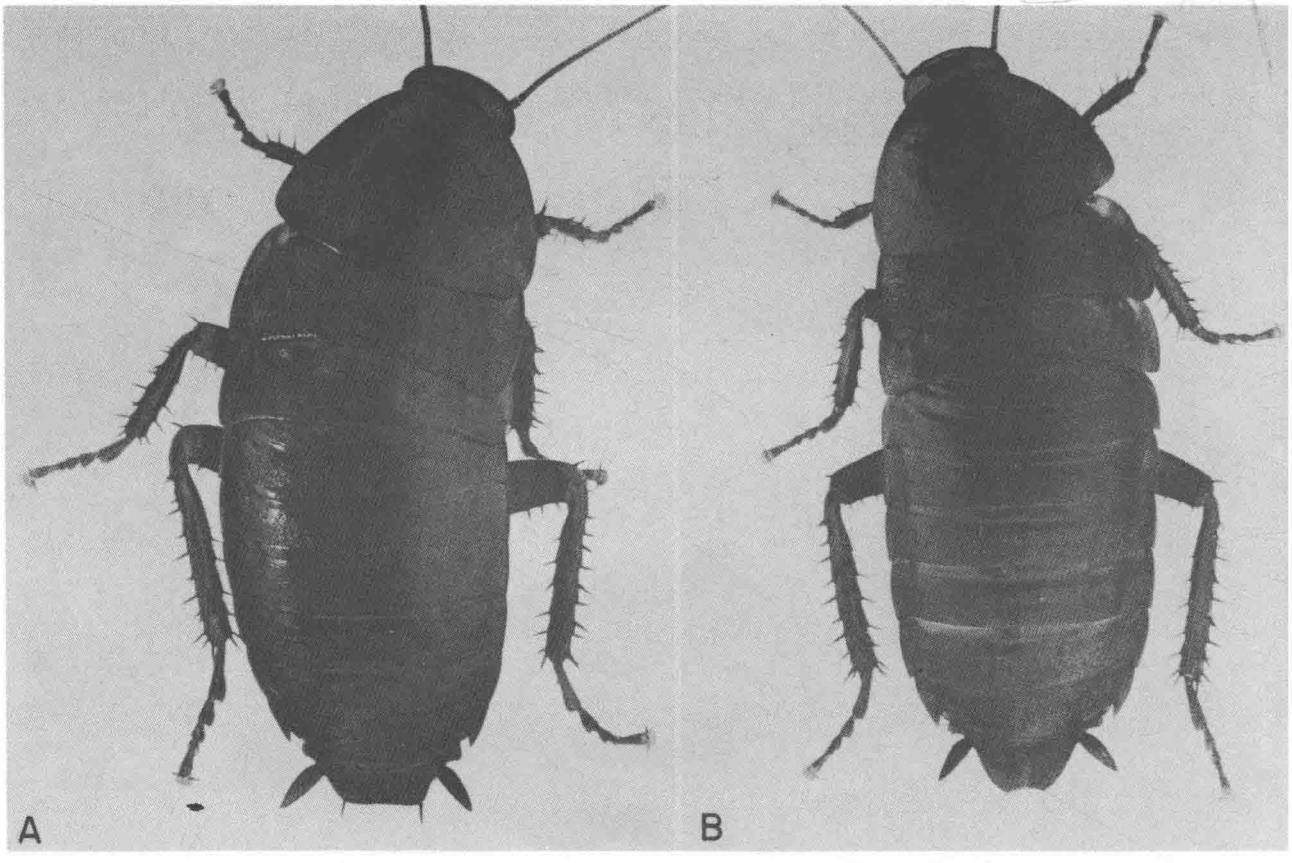

Fig. 1.6. Eurycotis floridana; (A) male (B) female.

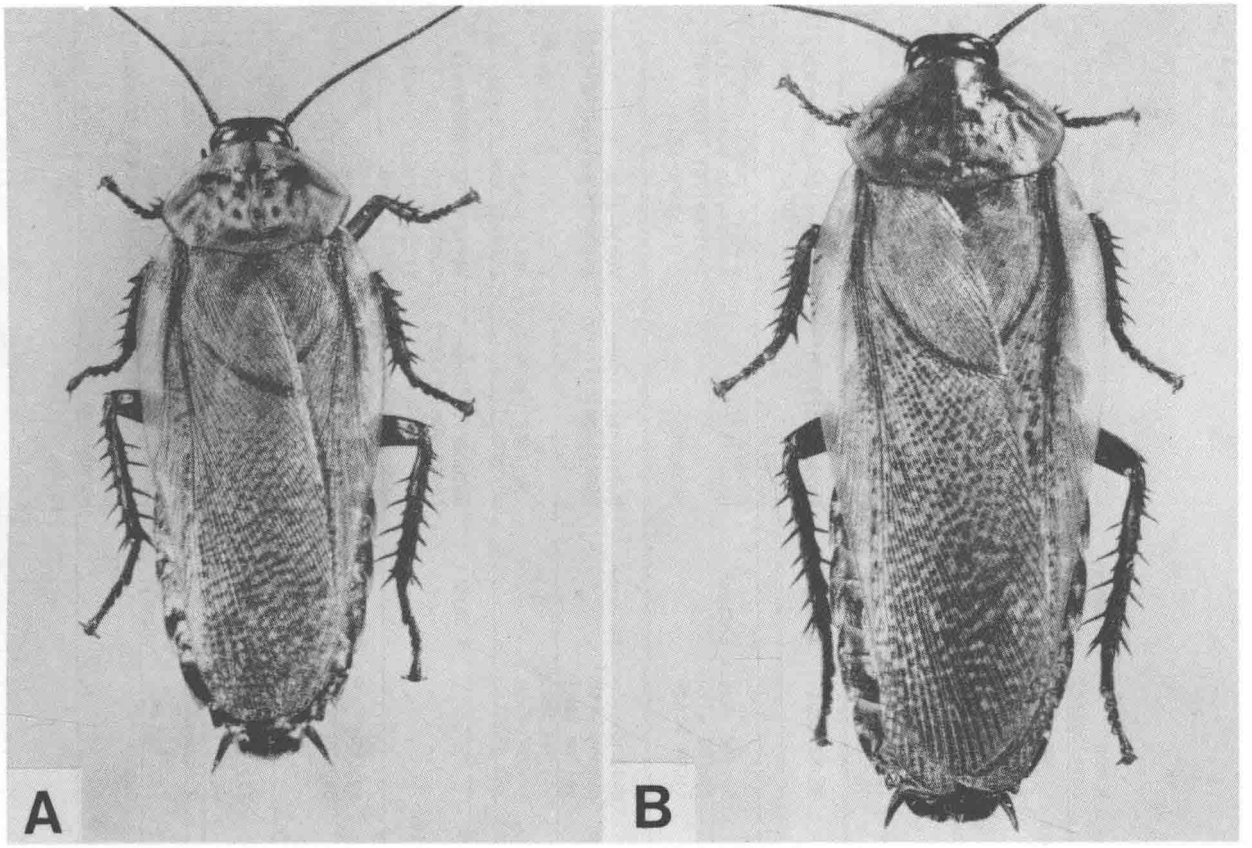

Fig. 1.8. Leucophaea maderae; (A) male (B) female.

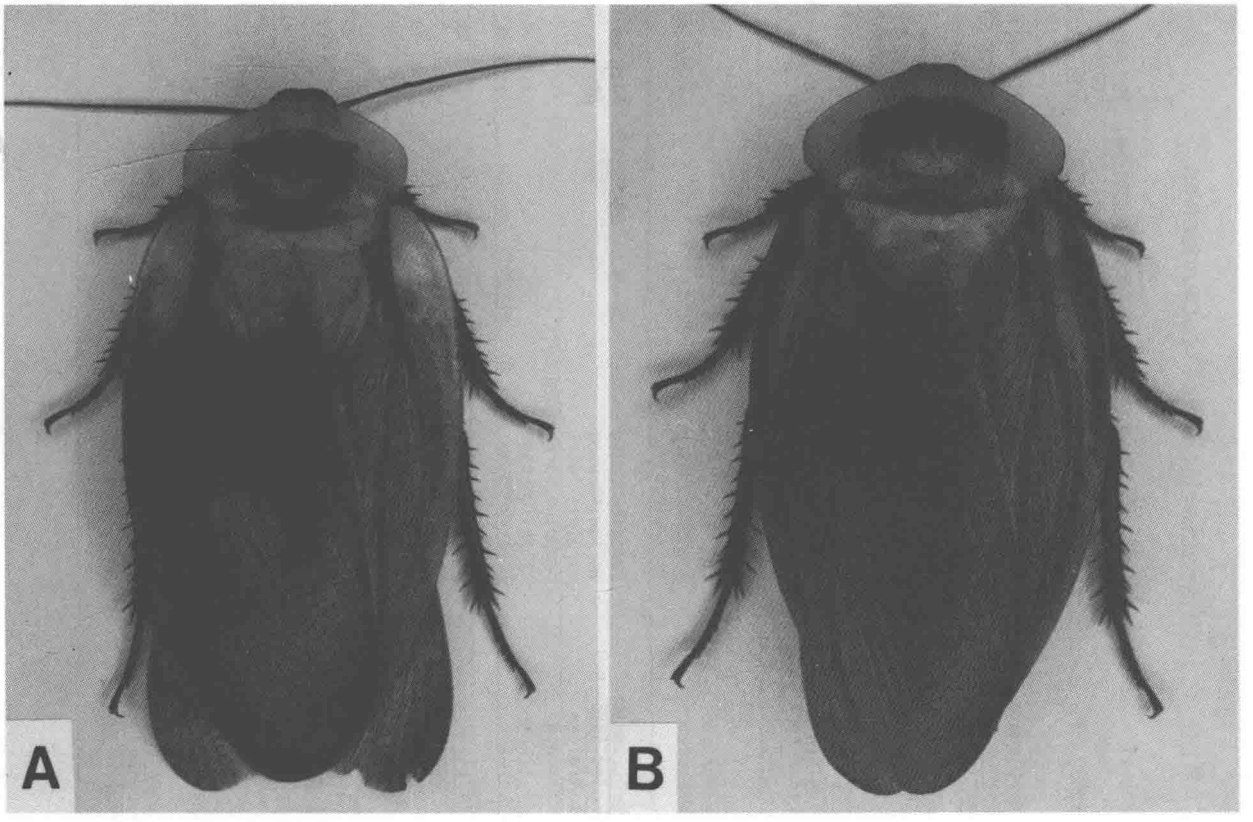

Fig. 1.7. Blaberus craniifer; (A) male (B) female.

TABLE 1. Characteristics of cockroaches

Scientific name and common name	Morphological Characteristics	Body Length (mm) Male	Female	Egg case; Reproduction Characteristics	Nymph development	Interval between egg cases	Habitat	Geographical distribution
Periplaneta americana American cockroach	Reddish-brown; full wings	36-44	29-37	8x5 mm, dark brown; Oviparous	6-12 mo.	5-6 days	Domiciliary, caves, outdoors	World-wide (temperate, subtropical, tropical)
Blatta orientalis Oriental cockroach	Black to very dark brown; females wingless, males reduced wings	17-29	20-27	10x5 mm, dark brown to black; Oviparous	5-7 mo.	6-8 days	Domiciliary	World-wide (temperate, subtropical, tropical)
Blattella germanica German cockroach	Tan or pale yellowish brown; full wings	10-13	12-15	8x3 mm, tan; Oviparous	36-63 days	22 days	Domiciliary	World-wide (temperate, subtropical, tropical)
Supella longipalpa Brown-banded cockroach	Tan and brown; lighter margins on pronotum, wings; full wings	13-15	10-12	4x2.5 mm, reddish-brown; Oviparous	54-100 days; nymphs with light bands	6 days?	Domiciliary	World-wide (temperate, subtropical, tropical)
Periplaneta australasiae Australian cockroach	Reddish-brown; yellowish wing margins; dark pronotum surrounded by by yellow edges; full wings	36-44	29-37	10x5 mm, dark brown; Oviparous	6-12 mo; nymphs with yellow bands	10 days	Outdoors; sometimes domiciliary	World-wide (subtropical, tropical)
Periplaneta brunnea brown cockroach	Reddish-brown; dark pronotum surrounded by tan edges; full wings	34-42	27-35	12-16 mm, reddish-brown, securely glued to substrate; Oviparous		4 days	Outdoors; sometimes domiciliary	World-wide (temperate, subtropical)
Periplaneta fuliginosa smoky brown cockroach	Brownish black	36-44	29-37	10-13 mm; Oviparous	179-586 days	11 days	Outdoors; sometimes domiciliary	World-wide (subtropical)
Pycnoscelus surinamensis surinam cockroach	Brownish black; light wing margins; full wings	18-24		Ovoviviparous	127-184 days		Outdoors, greenhouses	World-wide (subtropical, tropical)
Leucophaea maderae Madeira cockroach	Olive; full wings mottled with dark lines	40-44	42-50	Ovoviviparous	127-150 days		Domiciliary, agricultural products; warehouses	World-wide (subtropical, tropical)

Scientific name and common name	Morphological Characteristics	Body Length (mm) Male	Female	Egg case; Reproduction Characteristics	Nymph development	Interval between egg cases	Habitat	Geographical distribution
Nauphoeta cinerea Lobster cockroach	Ash colored with blotchy pattern on pronotum; wings shorter than abdomen	25-29		Ovoviviparous	72-94 days		Outdoors; sometimes domiciliary	World-wide (subtropical, tropical)
Blaberus craniifer	Blackish brown, pronotum elliptical and ornamented with design in center; full wings	48-50	54-57	Ovoviviparous			Outdoors, sometime domiciliary	Central and S. America West Indies (subtropical, tropical)
Eurycotis floridana	Reddish brown to black; wingless	31-35	30-40	14-16 mm, black; Oviparous	100 days; nymphs with yellow bands		Outdoors, shelters, stumps	Central and S. America, West Indies (subtropical, tropical)
Parcoblatta sp. Wood roaches (5 species)	Yellowish brown to black			Oviparous			Woodlands, grasslands	U.S. (temperate)
Cryptocercus punctulatus	Homogeneous black; wingless			Oviparous			Woodlands	U.S. (temperate)
Ectobius sp. (3 species)	Yellowish brown to brown	6-11		Oviparous			Woodlands, grasslands	Europe (temperate)
Arenivaga sp. Desert cockroach	Light tan			Oviparous			Desert	U.S. (temperate)
Blattella vaga Field cockroach	Tan; longitudinal dark band on pronotum; full wings	9-10	8-10	Oviparous	45-90 days	24 days	Sometimes domiciliary, grasslands, desert	World wide (temperate, subtropical)