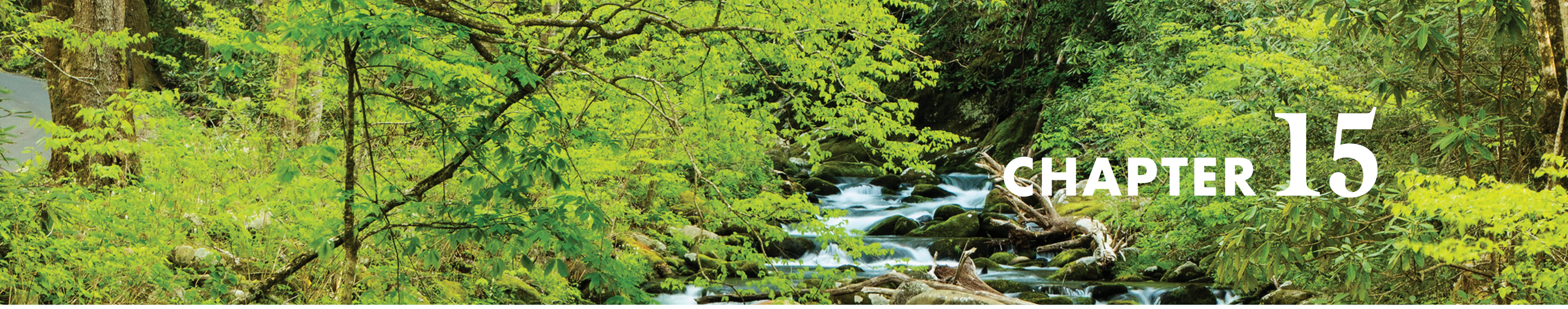

CHAPTER 15

SEMIAQUATIC ORTHOPTERA

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INTRODUCTION

With more than 28,000 extant species, Orthoptera is the most diverse order among the polyneopteran insect lineages (Cigliano *et al*. 2018). The order includes familiar singing insects, such as crickets and katydids, as well as often-devastating pests, such as grasshoppers and locusts. Orthopteran insects have diversified into numerous lineages that occupy every conceivable terrestrial habitat outside the polar regions and play integral roles in their ecosystems. Aquatic habitats have also been colonized by several orthopteran lineages, and some species even have unique morphological or behavioral adaptations that allow them to swim and breathe underwater. However, most of the species associated with aquatic habitats should be considered semiaquatic for they do not possess any traits that allow them to cope with water. Some semiaquatic species occur on or under wet substrates (damp sand, muck, organic litter, moss close to the ground). Others reside on emergent aquatic plants growing near the shoreline or throughout a body of water (bogs, fens, swamps, fresh and salt water marshes, ponds, lakes, streams). Some can readily dive into water and swim below the surface to feed on aquatic plants or algae. Additional species live on plants growing in wet soil (damp meadows) or near the edge of open water.

Within Orthoptera, Acrididae, Tetrigidae, Tridactylidae, and Anostostomatidae collectively include some of the most unusual aquatic species. Gryllidae and Tettigoniidae include a number of semiaquatic species that prefer to inhabit near the edges of aquatic habitats, but do not directly interact with water. Most of these orthopterans are known from the tropical regions around the world, and there is a relatively small number of species known from North America. Amédégnato and Devriese (2008) conducted a global survey of orthopterans associated with aquatic habitats and recognized that there are at least 188 species in 50 genera from Acrididae and Tetrigidae alone. The natural history of many orthopteran species is simply unknown so it is possible that there are more unusual species that have evolved adaptations to aquatic habitats. Within Acrididae, the most unusual aquatic grasshoppers are found in Marelliinae (*Marellia remipes* Uvarov, 1929) and Pauliniinae (*Paulinia acuminata* (De Geer, 1773)), both of which are monotypic and endemic to South America. These species live on broad, floating leaves of aquatic plants, feeding and ovipositing on them, and their entire life cycle takes place on these plants. Their hind femora are flat and dilated, which help them swim underwater (Carbonell 1957). *Cornops aquaticum* (Bruner, 1906) (Leptysminae) from the Neotropics and *Gesonula punctifrons* (Stål, 1861) (Oxyinae) from India and Southeast Asia have convergently evolved to feed on water hyacinth and oviposit endophytically (Amédégnato and Devriese 2008; Capello *et al*. 2012). Some members of Leptyminae, Copiocerinae, Oxyinae, Hemiacridinae, and Tropidopolinae prefer to feed on reed species in the riparian habitats. Many species within Tetrigidae are limno-terrestrial and capable of swimming, and often found at the margins of rivers and lakes. Within Tetrigidae, the subfamily Scelimeninae can be considered truly aquatic because they can dive under water to hide and to feed on algae that grow on the underside of boulders (Amédégnato and Devriese 2008). These insects have sharp spines protruding from pronotum, which are presumed to be a defensive structure against predatory fish. The members of Tridactylidae can often be found in the same habitats as Tetrigidae. These insects are very small, and have modifications to the legs for swimming and walking on the water surface. The most recently discovered aquatic orthopteran belongs to Anostostomatidae, which include king crickets and wetas (common name for these orthopteran species). In 1999, a new genus of cave cricket *Hydrolutos* Issa & Jaffe, 1999 was discovered in the cave systems of tepuis (flat table-top mountains) in Venezuela, and subsequently a total of seven species have been described. These insects are characterized by having a plastron-like structure on the pleurosternal area of the thorax and abdomen covered with fine microtrichia, which presumably holds an air bubble and allows them to be submerged and move about for 20 min (Issa and Jaffe 1999; Derka and Fedor 2010).

In North America, many orthopteran species are probably semiaquatic, but ecological studies on whether these species truly prefer to feed on aquatic plants or show clear habitat preferences are lacking. Certainly both tetrigids and tridactylids are associated with aquatic habitats, but other examples described in this chapter are based on unpublished observations. The most widely cited and the only empirical study of semiaquatic orthopterans in the United States is by Squitier and Capinera (2002) who examined host plant preference of six grasshopper species commonly encountered in aquatic habitats in Florida. They performed laboratory choice tests involving 19 semiaquatic plant species on two species in Leptyisminae, *Stenacris vitreipennis* (Marschall, 1836), *Leptysma marginicollis* (Serville, 1838), three species in Melanoplinae, *Gymnoscirtetes pusillus* Scudder, 1897, *Paroxya clavuliger* (Serville, 1838), *Paroxya atlantica* Scudder, 1877, and one species of Romaleidae, *Romalea microptera* (Palisot de Beauvois, 1817). They showed that both leptysmines showed a strong preference for aquatic grasses, while other species showed a mixed preference for both grasses and forbs associated with semiaquatic habitats.

GENERAL BIOLOGY

The order Orthoptera is characterized by the presence of a cryptopleuron, developed from the lateral extension of the pronotum over the pleural sclerites, and jumping hind legs (Kevan 1982). As in other polyneopteran insects, the orthopteran insects are fully winged (although microptery and aptery have evolved multiple times), have chewing mouthparts, and incomplete metamorphosis. The order consists of two suborders, Caelifera and Ensifera. The Caelifera includes grasshoppers, locusts, and their relatives, and can be characterized by antennae with less than 30 flagellomeres, asymmetrical mandibles each with a heavy molar, mostly exposed thoracic pleura, three or fewer tarsal segments, and abdominal tympana. The Ensifera includes crickets, katydids, wetas, and their relatives, and can be characterized by long and thread-like antennae that are usually longer than the body, symmetrical mandibles, thoracic pleura concealed by lateral pronotal lobes, three or four tarsal segments, and tympana often present on the front tibia. Many orthopterans are capable of producing sound and engage in acoustic communication between males and females. Katydids and crickets have a stridulatory apparatus at the base of the tegmina. To produce sound, the front wings are elevated and the inner edge at the base of one tegmen is rubbed against a toothed ridge at the base of the other tegmen. Grasshoppers in the subfamily Gomphocerinae rub a longitudinal ridge or a series of pegs on the inside of the hind femora across a raised vein on the tegmina. Those in the subfamily Oedipodinae can produce snapping sounds during flight, known as crepitation.

Eggs are deposited in loose soil, stems, clumps of vegetation, burrows, or on the surface of leaves and twigs, depending on the species. Nymphs develop into adults through the process of incomplete metamorphosis. Most species occurring in temperate regions have a 1-year life cycle, although some in cold climates may require up to 3 years to become adults; in contrast, two generations per year may occur in the southern United States. All caeliferans are virtually phytophagous in a broad sense, although specific preferences on different plant types have evolved numerously throughout different lineages within Caelifera. Unlike caeliferans, ensiferans demonstrate incredible variety in their diet. Most crickets are omnivorous, feeding on detritus, dead insects, and plants. Many basal ensiferans, including the Anostostomatidae, Gryllacrididae, Rhaphidophoridae, and Stenopelmatidae, are scavengers or are predatory on small insects. While many katydids are herbivorous, some groups are predatory and others may feed on flowers, pollen, or nectar.

Grasshoppers (family Acrididae and Romaleidae) are characterized by short antennae and three-segmented tarsi; females have short, stout ovipositors. Approximately 26 out of some 630 species in North America north of Mexico are semiaquatic. Only a few species (e.g., *Leptysma marginicollis* (Serville, 1838), *Stenacris vitreipennis* (Marschall, 1836), *Metaleptea brevicornis* (Johannson, 1763), *Paroxya clavuliga* (Serville, 1838)) occur almost exclusively in wet areas. Habitats for semiaquatic grasshoppers include edges of bogs, fens, swamps, fresh and saltwater marshes, ponds, lakes and streams, as well as muck, wet meadows, peatlands, and tundra. In North America, the members of Acridinae, Gomphocerinae, and Oedipodinae prefer grasses, whereas other subfamilies feed on a wide variety of herbaceous plants. Most grasshoppers are polyphagous, although many species can be narrowly oligophagous (Chapman and Sword 1997).

Pygmy grasshoppers (family Tetrigidae) are small insects with a distinctive pronotum that extends backward to the tip of the abdomen or beyond. The tegmina are reduced to small pads but the hind wings are usually long and used for flying. Fourteen of the 27–30 species in North America north of Mexico are associated with wet habitats at ground level. They occur on damp sandy, mucky, muddy, and algae-covered edges of swamps, marshes, ponds, lakes, and streams, on mossy soils, and in damp meadows. Individuals may leap into water and swim short distances to submerged objects to evade capture. Tetrigids feed on mosses, algae, decaying organic matters, fungi, and low, succulent seedlings.

Pygmy mole crickets (family Tridactylidae) are small (4–10 mm in length) orthopterans with small eyes, prognathous mouthparts, front tibiae modified for digging. Their hind tibiae usually have long, slender, movable plates for swimming and walking on the water surface, and their hind femora are enlarged for jumping. Five of the seven tridactylid species in North America north of Mexico excavate and live in burrows along sandy banks of ditches, ponds, lakes, and streams. They feed on organic debris and algae.

Katydids (family Tettigoniidae) are characterized by tegmina that are held roof-like over the abdomen, a male subgenital plate with a pair of styles, a sword-like ovipositor in females, and four-segmented tarsi. Stridulation is achieved by rubbing the left tegmen over the right. Generally, katydids are the most commonly seen and heard of the orthopterans in semiaquatic environments. Most of the 35 semiaquatic species of katydids listed out of approximately 265 species in North America north of Mexico are more common in the wet, humid eastern half of the United States. They occur on vegetation on the edges of bogs, fens, swamps, ponds, lakes, and streams and the edges and interior of fresh and saltwater marshes. All are plant feeders although a few are predaceous on occasion (e.g., some *Orchelimum* species), and one (*Sphagniana sphagnorum* (Walker, 1869)) is presumed to be primarily predaceous on other insects. *Conocephalus* and *Orchelimum* species are particularly common in and around the edges of marshes. *Conocephalus spartinae* (Fox, 1912), *O. concinnum* Scudder, 1862, and *O. fidicinium* Rehn and Hebard, 1907 are major consumers of leaves, flowers, and seeds of dominant salt marsh perennials such as *Juncus* (rushes) and *Spartina* (grasses).

Crickets (family Gryllidae) are characterized by long antennae, a generally quadrate pronotum, tegmina positioned flat across the dorsum, long cerci, and a needle-like ovipositor. In many species, males produce melodic songs by rubbing scrapers on the left tegmen against stridulatory files on the right tegmen. Cricket wings have modified veins that form the mirror and harp, which function as resonators when stridulation takes place. Virtually all crickets stridulate by passing the right tegmen over the left. Crickets are omnivorous scavengers and typically nocturnal. About eleven species out of approximately 120 species in North America north of Mexico are semiaquatic. Semiaquatic crickets are found on the edges of bogs, fens, swamps (also under tidal litter of mangrove swamps), on grasses and reeds of fresh and saltwater marshes, and on edges of ponds, lakes, and streams.

Mole crickets (family Gryllotalpidae) are characterized by a small and conical head, legs modified for digging and burrowing, hind legs not modified for jumping, tegmina of males lacking a mirror, and a highly reduced ovipositor in females. They comprise seven species in North America north of Mexico, of which two live primarily in semiaquatic habitats. The two semiaquatic species among them frequent muck and wet sand on the edges of marshes, ponds, lakes, and streams. They feed on plant materials, insects, and other soil arthropods.

KEY TO FAMILIES OF ORTHOPTERA WITH SEMIAQUATIC SPECIES IN NORTH AMERICA

1. Antennae long and thread-like and usually longer than the body (Figs. 15.17–15.20, 15.26, 15.30); tympanum present on the front tibiae 2

1'. Antennae short and robust with less than 30 flagellomeres and usually shorter than the body (Figs. 15.1, 15.10, 15.16); tympanum not present on the front tibiae 4

2(1). All tarsi 4-segmented; tegmina held roof-like over the abdomen; a male subgenital plate with a pair of styles; a sword-like ovipositor in females (Figs. 15.17–15.20, 15.23–15.24) (katydids) . . . . ***TETTIGONIIDAE***

2'. All tarsi 3-segmented; tegmina positioned flat across the dorsum (Figs. 15.26, 15.30, 15.34); a male with long cerci; a needle-like or reduced ovipositor in females (Figs. 15.31–15.33) 3

3(2'). Head small and conical; front legs modified for digging and burrowing (Fig. 15.34); hind legs not modified for jumping; tegmina of males lacking a mirror, and a highly reduced ovipositor in females (mole crickets) . . . . ***GRYLLOTALPIDAE***

ORTHOPTERA

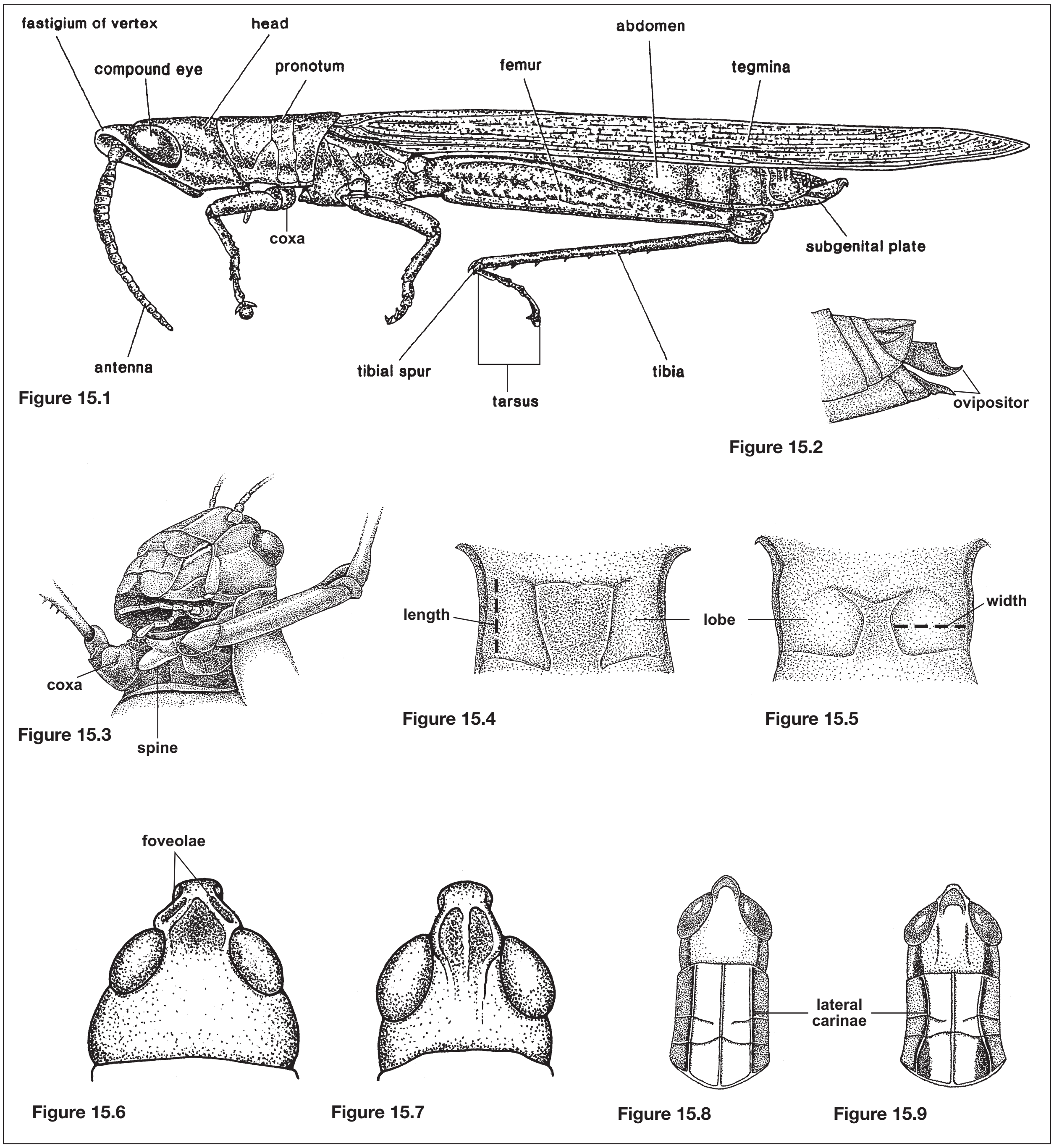

Figure 15.1 Male grasshopper, *Leptysma marginicollis* (Acrididae).
Figure 15.2 Ovipositor of a female grasshopper.
Figure 15.3 Prosternal spine between front coxae (Acrididae) (after Capinera *et al*. 2004).
Figure 15.4 Mesosternal lobes longer than wide (*Schistocerca*: Acrididae) (after Bland 2003).
Figure 15.5 Mesosternal lobes as wide as long (Acrididae) (after Bland 2003).
Figure 15.6 Lateral foveolae of vertex visible from above (Acrididae).
Figure 15.7 Lateral foveolae of vertex not visible from above (Acrididae).
Figure 15.8 Lateral carinae of pronotum straight (*Dichromorpha*: Acrididae) (after Capinera *et al*. 2004).
Figure 15.9 Lateral carinae of pronotum incurved in middle and diverging posteriorly (*Orphulella*: Acrididae) (after Capinera *et al*. 2004).

3'. Head not conical; front legs normal; hind legs modified for jumping; tegmina of males with a mirror; a needle-like ovipositor in females (Figs. 15.31–15.33) (crickets) . . . . ***GRYLLIDAE***

4(1'). Pronotum extended posteriorly to or beyond tip of abdomen (Fig. 15.10) (pygmy grasshoppers) . . . . ***TETRIGIDAE***

4'. Pronotum not extended posteriorly 5

5(4'). Size small (less than 1 cm); prognathous mouthparts; front legs well-modified for digging (Fig. 15.16) (pygmy mole crickets) . . . . ***TRIDACTYLIDAE***

5’. Size medium to large (more than 1 cm); hypognathous mouthparts; front legs normal (Fig. 15.1); tympanum present on the lateral sides of first abdominal segment; ovipositor of female stout, consisting of four short, curved projections at tip of abdomen (Fig. 15.2) 6

6(5'). External apical spur present on the hind tibiae; often large, sluggish, and colorful (lubber grasshoppers) . . . . ***ROMALEIDAE***

6'. External apical spur present on the hind tibiae; size and color highly variable (grasshoppers) . . . . ***ACRIDIDAE***

KEYS TO GENERA WITH SEMIAQUATIC SPECIES

Tettigoniidae

1. Front tibiae with three large dorsal spines; tegmina broad and usually short, covering half (males) to one-fourth (females) of abdomen; edges of sphagnum bogs and spruce swamps; southern half Canada from eastern British Columbia to western Quebec; one species, *sphagnorum* (Walker, 1869) (Fig. 15.17) . . . . ***Sphagniana*** Zeuner, 1941

1'. Front tibiae without three large dorsal spines, typically spineless dorsally; tegmina broad or narrow, if broad then longer than abdomen 2

2(1'). Prosternal spines between front coxae (cf. Fig. 15.3); tegmina narrow and sometimes do not extend beyond tip of abdomen; head conical on species longer than 24 mm 3

2'. No prosternal spines between front coxae; tegmina broad, long, extend beyond tip of abdomen; head rounded, not conical 6

3(2). Body length less than 17 mm excluding ovipositor; fresh and salt water marshes, swamps, edges of ponds, lakes, and streams; eastern half United States, TX, CA, southern Quebec and Ontario; nine species, *aigialus* Rehn and Hebard, 1915, *attenuatus* (Scudder, 1869) (Fig. 15.18), *brevipennis* (Scudder, 1862), *hygrophilus* Rehn and Hebard, 1915, *nigropleuroides* Fox, 1912, *nigropleurum* (Bruner, 1891), *spartinae* (Fox, 1912), *spinosus* (Morse, 1901), *stictomerus* Rehn and Hebard, 1915. . . . . ***Conocephalus*** Thunberg, 1815

3'. Body length usually 17 mm or longer excluding ovipositor. 4

4(3'). Body length 17–27 mm (rarely less than 17 mm) excluding ovipositor; head without conical projection; fresh and salt water marshes, swamps, edges of ponds, lakes, and streams; United States, southern fifth Canada; 12 species, *agile* (De Geer, 1773), *bradleyi* Rehn and Hebard, 1915, *bullatum* Rehn and Hebard, 1915, *campestre* Blatchley, 1893, *concinnum* Scudder, 1862 (Fig. 15.19), *delicatum* Bruner, 1892, *fidicinium* Rehn and Hebard, 1907, *gladiator* Bruner, 1891, *militare* Rehn and Hebard, 1907, *nigripes* Scudder, 1875, *pulchellum* Davis, 1909, *volantum* McNeill, 1891 . . . . ***Orchelimum*** Serville, 1838

4'. Body length 27 mm or more excluding ovipositor; head with conical projection (fastigium) (Figs. 15.20–15.22) 5

ORTHOPTERA

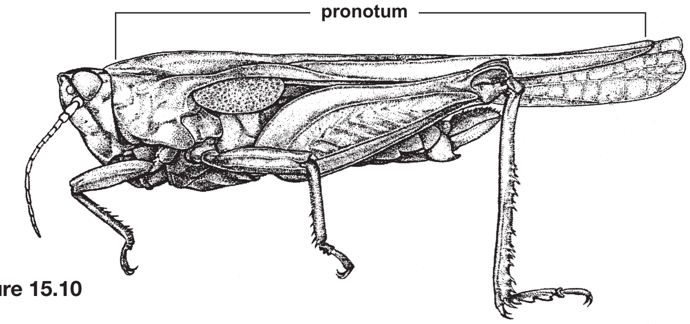

Figure 15.10

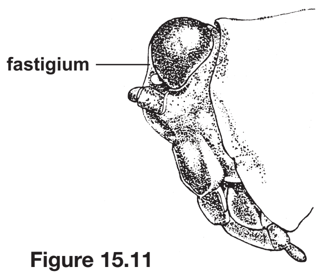

Figure 15.11

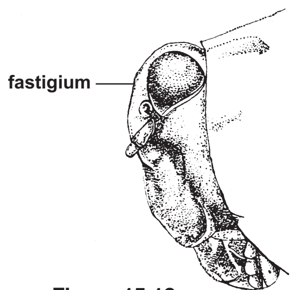

Figure 15.12

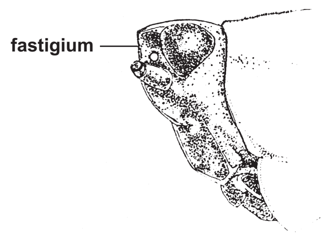

Figure 15.13

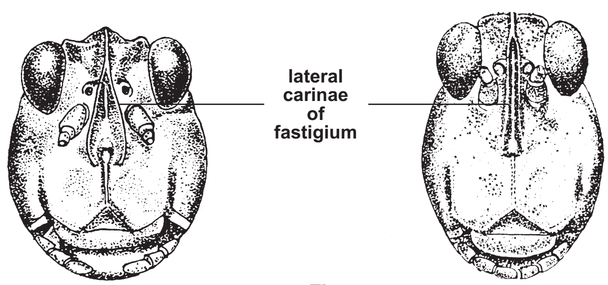

Figure 15.14

Figure 15.15

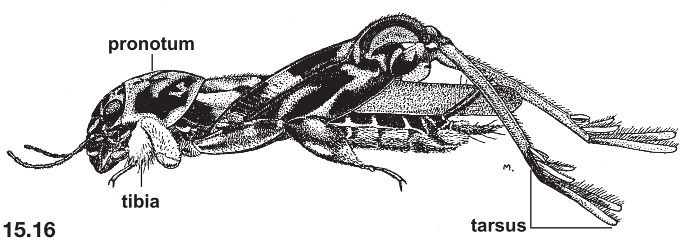

Figure 15.16

Figure 15.10 Female pygmy grasshopper, *Tetrix subulata* (Tetrigidae) (after Rehn and Grant 1961).
Figure 15.11 Fastigium of vertex slightly extended in front of eyes (*Paratettix cucullatus*: Tetrigidae) (after Rehn and Grant 1961).
Figure 15.12 Fastigium of vertex greatly extended in front of eyes and broadly arched in profile (*Neotettix femoratus*: Tetrigidae) (after Rehn and Grant 1961).
Figure 15.13 Fastigium of vertex greatly extended in front of eyes and angular in profile (*Tetrix subulata*: Tetrigidae) (after Rehn and Grant 1961).
Figure 15.14 Lateral carinae of frontal costa strongly divergent ventrally (*Neotettix femoratus*: Tetrigidae) (after Rehn and Grant 1961).
Figure 15.15 Lateral carinae of frontal costa slightly divergent ventrally (*Tetrix subulata*: Tetrigidae) (after Rehn and Grant 1961).
Figure 15.16 Male pygmy mole cricket, *Ellipes minutus* (Tridactylidae) (after Hebard 1934).

5(4'). Fastigium with a broad tooth beneath, large gap between lower face of fastigium and median facial ridge (Fig. 15.21); edges of bogs, fens, fresh and saltwater marshes; eastern two-thirds United States, southern Ontario; six species, *caudellianus* (Davis, 1905), *exiliscanorus* (Davis, 1887), *lyristes* (Rehn and Hebard, 1905) (Fig. 15.20), *melanorhinus* (Rehn and Hebard, 1907), *palustris* (Blatchley, 1893), *retusus* (Scudder, 1878) . . . . ***Neoconocephalus*** Karny, 1907

5'. Fastigium without a broad tooth beneath, narrow or no gap between lower face of fastigium and median facial ridge (Fig. 15.22); fresh and salt water marshes; Atlantic and Gulf coasts, AR; one species, *malivolans* (Scudder, 1878) . . . . ***Bucrates*** Burmeister, 1838

6(2'). Tegmina distinctly broader in middle; fastigium about twice as wide as first antennal segment; edges of marshes, swamps, ponds, and lakes; eastern two-thirds United States, southern Quebec; one species, *oblongifolia* (De Geer, 1773) (Fig. 15.23) . . . . ***Amblycorypha*** Stål, 1873

6'. Tegmina not distinctly broader in middle, tegmina narrow and elongated; fastigium about same width as first antennal segment. 7

7(6'). Tegmina green, strikingly marked with black and brown, sometimes as stripes; cypress swamps; southeastern United States, Gulf Coast states to LA, north to IL; three species, *strigata* (Scudder, 1898), *taxodii* Caudell, 1921, *walkeri* Hebard, 1925. . . . . ***Inscudderia*** Caudell, 1921

7'. Tegmina without striking black and brown markings 8

8(7'). Male subgenital plate long, upwardly curved (Fig. 15.24); male supra-anal plate (Fig. 15.24) elongate and notched at apex (Fig. 15.25); front and middle femora not spined below; edges of marshes, swamps, and lakes; United States except northwestern and southwestern regions; one species, *texensis* Saussure and Pictet, 1897 (Fig. 15.24) . . . . ***Scudderia*** Stål, 1873

8'. Male subgenital plate short, broad, not curved upward; male supra-anal plate triangular, without apical notch; front and middle femora strongly spined below; swamps, on water hyacinth; southern United States north to IN and MD; one species, *modesta* (Brunner von Wattenwyl, 1878) . . . . ***Montezumina*** Hebard, 1925

Gryllotalpidae

1. Front tibiae with two dactyls (blade-like claws or finger-like projections); wet sand or muck on edges of ponds and streams; southern United States; one species, *borellii* (Giglio-Tos, 1894). . . . . ***Neoscapteriscus*** Cadena-Castañeda, 2015

1'. Front tibiae with four dactyls (Fig. 15.34); wet sand or muck on edges of marshes, ponds, lakes, and streams; eastern two-thirds United States, southern Ontario; one species, *hexadactyla* (Perty, 1832) (Fig. 15.34) . . . . ***Neocurtilla*** Kirby, 1906

*Gryllidae**

1. Ventral side of second tarsal segment of hind tarsi with a brush-like pad (Fig. 15.27); edges of fresh and saltwater marshes, mangrove and other swamps, lakes, and streams; eastern two-thirds United States, southern Ontario; four species, *delicatula* (Scudder, 1878), *exigua* (Say, 1825) (Fig. 15.26), *litarena* Fulton, 1956, *scia* Hebard, 1915 . . . . ***Anaxipha*** Saussure, 1874

*Recently, the subfamily Trigonidiinae, which includes all of the genera covered in this key, was elevated to the family Trigonidiidae. However, this change is not yet widely accepted, and thus we follow the traditional family concept, Gryllidae, here.

1'. Ventral side of second tarsal segment of hind tarsi without a brush-like pad 2

2(1'). Hind tibiae with three spines on each upper margin; mangrove swamps; south FL coast; one species, *alleni* (Morse, 1905) . . . . ***Hygronemobius*** Hebard, 1913

2'. Hind tibiae with four spines on each upper margin 3

3(2'). Paired disto-ventral spurs of hind tibiae about equal in length (Fig. 15.28); end of ovipositor with coarse teeth dorsally and very fine teeth ventrally (Fig. 15.31); edges of bogs, fens, marshes, mangrove and other swamps, lakes, and streams; United States, southeastern Canada; two species, *carolinus* (Scudder, 1877), *melodius* (Thomas and Alexander, 1957) . . . . ***Eunemobius*** Hebard, 1913

3'. Paired disto-ventral spurs of hind tibiae distinctly unequal in length (Fig. 15.29); end of ovipositor with fine teeth dorsally and no teeth ventrally (Figs. 15.32–15.33). 4

4(3'). Body length of males less than 9 mm; ovipositor gently curved upward (Fig. 15.32) and not more than two-thirds length of hind femora; edges of bogs (especially sphagnum bogs), fens, and mangrove and other swamps; eastern half of United States, southern Canada; two species, *cubensis* (Saussure, 1874), *palustris* (Blatchley, 1900) . . . . ***Neonemobius*** Hebard, 1913

4'. Body length of males usually greater than 9 mm; ovipositor nearly straight (Fig. 15.33), at least three-fourths length of hind femora; edges of bogs, fresh and saltwater marshes, mangrove and other swamps, ponds, lakes, and streams; northern half United States, Midwest south to TX, southern third Canada; 2 species, *fasciatus* (De Geer, 1773) (Fig. 15.30), *sparsalsus* (Fulton, 1930). . . . . ***Allonemobius*** Hebard, 1913

Tetrigidae

1. Less than 15 antennal segments; front femora with distinct dorso-longitudinal ridge 2

1'. More than 15 antennal segments; front femora with a shallow, broad, dorso-longitudinal groove 4

2(1). Fastigium of vertex slightly or not extended in front of eyes in profile (Fig. 15.11); edges of coastal marshes, swamps, ponds, lakes, and streams, on mats of algae; United States, southern Ontario; four species, *aztecus* (Saussure, 1861), *cucullatus* (Burmeister, 1838), *mexicanus* (Saussure, 1861), *rugosus* (Scudder, 1862) . . ***Paratettix*** Bolívar, 1887

2'. Fastigium of vertex greatly extended in front of eyes in profile (Figs. 15.12–15.13). 3

3(2'). Frontal costa with lateral carinae strongly divergent ventrally (Fig. 15.14); fastigio-facial angle distinctly and broadly arched in profile (Fig. 15.12); edges of salt marshes and swamps; NY to southeastern United States, west to IN and TX; one species, *femoratus* (Scudder, 1869). . . . . ***Neotettix*** Hancock, 1898

3'. Frontal costa with lateral carinae only slightly divergent ventrally (Fig. 15.15); fastigio-facial angle angular or weakly rounded in profile (Fig. 15.13); edges of bogs, marshes, ponds, and streams; Alaska, Canada, United States; three species, *arenosa* Burmeister, 1838, *ornata* (Say, 1824), *subulata* (Linnaeus, 1758) (Fig. 15.10) . . . . ***Tetrix*** Latreille, 1802

4(1'). Body distinctly swollen; front half of pronotum moderately arched in profile; wet meadows and woods, edges of ponds; southeastern United States west to LA; one species, *obesa* (Scudder, 1877) . . . . ***Paxilla*** Bolívar, 1887

4'. Body weakly swollen, relatively slender; front half of pronotum not arched in profile; edges of bogs, fresh and salt water marshes, swamps, wet woods, and ponds; eastern two-thirds United States, southeastern Canada; four species, *acuta* Morse, 1895, *armata* Morse, 1895, *lateralis* (Say, 1824), *prorsa* Scudder, 1877 . . . . ***Tettigidea*** Scudder, 1862

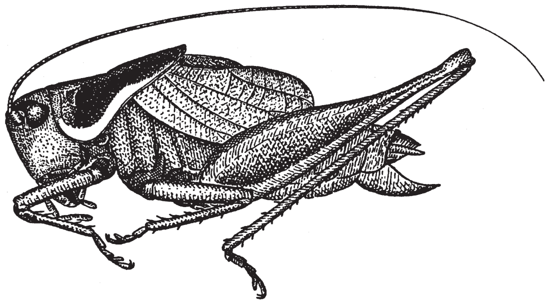

Figure 15.17

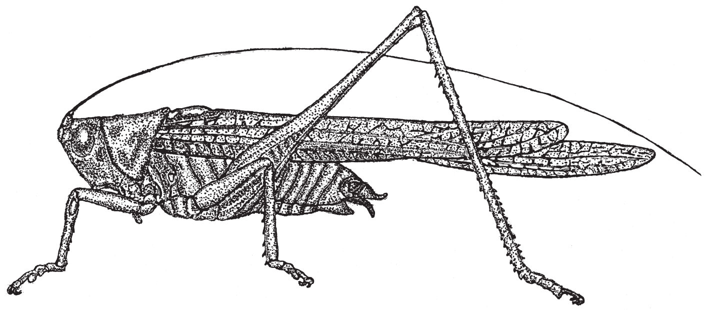

Figure 15.18

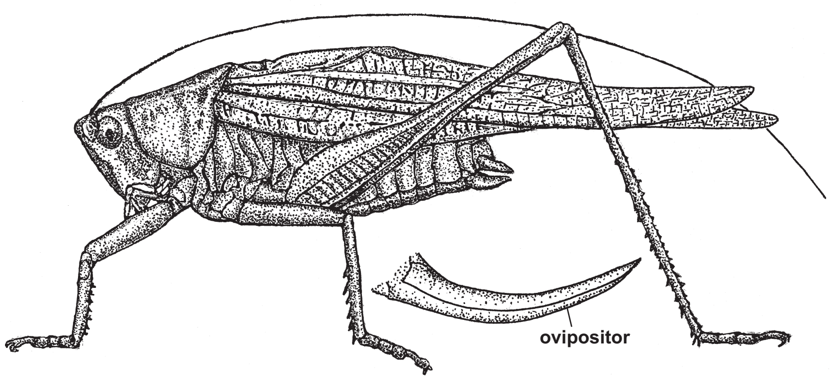

Figure 15.19

Figure 15.17 Male katydid, *Sphagniana sphagnorum* (Tettigoniidae) (after Helfer 1987).
Figure 15.18 Male katydid, *Conocephalus attenuatus* (Tettigoniidae).

Figure 15.19 Male katydid, *Orchelimum concinnum*, and ovipositor of a female (Tettigoniidae).

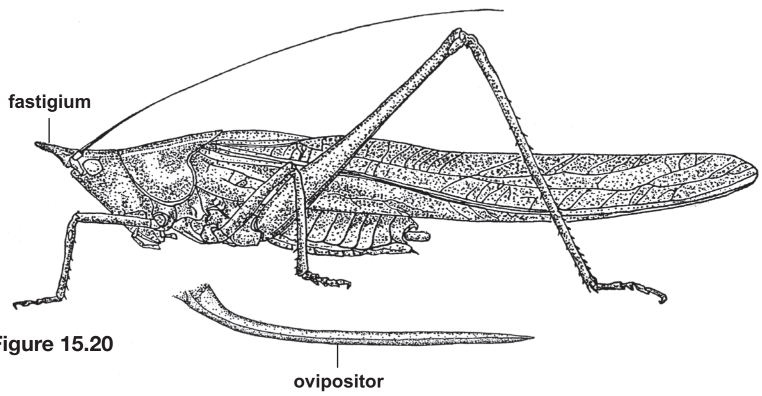

Figure 15.20

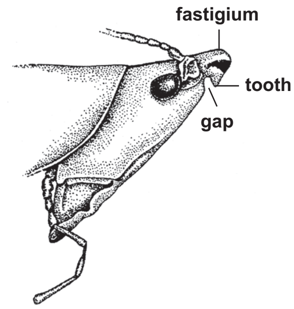

Figure 15.21

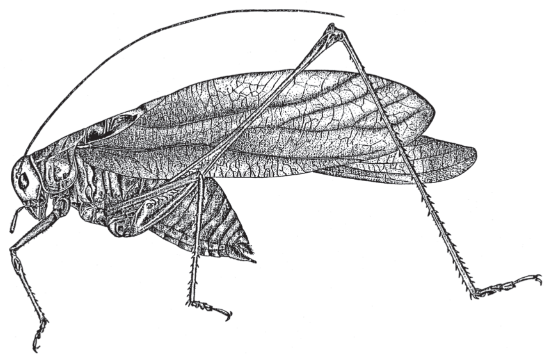

Figure 15.23

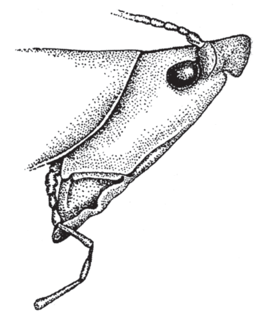

Figure 15.22

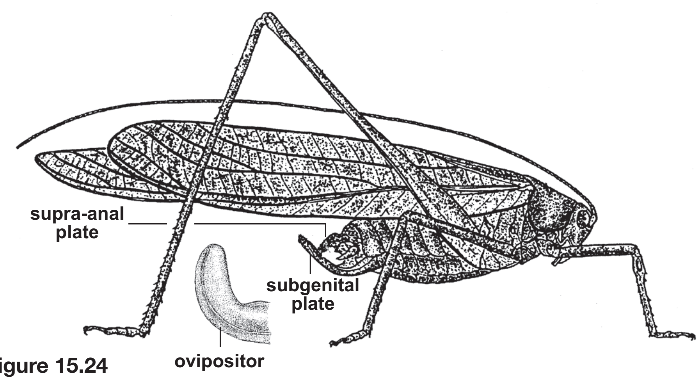

Figure 15.24

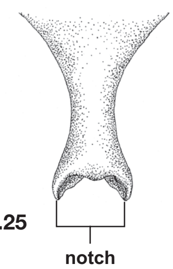

Figure 15.25

Figure 15.20 Male katydid, *Neoconocephalus lyristes*, and ovipositor of a female (Tettigoniidae) (modified after Vickery and Kevan 1986).

Figure 15.21 Fastigium with a broad tooth and wide gap between lower face and median facial ridge (*Neoconocephalus*: Tettigoniidae) (after Capinera *et al*. 2004).

Figure 15.22 Fastigium without a broad tooth and with a narrow gap or no gap between lower face and median facial ridge (*Bucrates*: Tettigoniidae) (modified after Capinera *et al*. 2004).

Figure 15.23 Male katydid, *Amblycorypha oblongifolia* (Tettigoniidae) (after Vickery and Kevan 1986).

Figure 15.24 Male katydid, *Scudderia texensis*, and ovipositor of a female (Tettigoniidae) (modified after Bland 2003).

Figure 15.25 Male supra-anal plate (dorsal view) with broad apical notch (*Scudderia texensis*: Tettigoniidae) (after Bland 2003).

Tridactylidae

1. Body length usually less than 5.5 mm; prosternum without a conical protuberance; tarsus of hind leg absent; wet, sandy banks of ponds, lakes, and streams; eastern two-thirds United States, southwestern United States, CA, southern Quebec, Ontario, and Manitoba; four species, *gurneyi* Günther, 1977, *minimus* Bruner, 1916, *minuta* (Scudder, 1862) (Fig. 15.16), *monticolus* Günther, 1977 . . . . ***Ellipes*** Scudder, 1902

1'. Body length usually more than 5.5 mm; prosternum with a conical protuberance; tarsus of hind leg present; habitats same as *Ellipes*; eastern half United States, southwestern United States, southern Quebec, Ontario, and Manitoba; 1 species, *apicialis* (Say, 1825). . . . . ***Neotridactylus*** Günther, 1972

Romaleidae

1. Hind tibiae with immovable apical spine on outside surface; short hind wings are pinkish red; large, stout grasshopper; color varying from orange yellow to black, edges of marshes and ponds, on water hyacinth; southeastern United States; one species, *microptera* (Palisot de Beauvois, 1817). ***Romalea*** Serville, 1831

Acrididae

1. Prosternum with a prominent cylindrical spine (prosternal process) between front coxae (Fig. 15.3). 2

1'. Prosternum without a prominent cylindrical spine between front coxae 10

2(1). Male cerci vertically hooked; lower external lobe of the hind knee angular; second tarsal segment of the hind legs very short; face strongly angled backwards in profile (Fig. 15.1) 3

2'. Male cerci triangular, quadrate, or variable shape, but not vertically hooked; lower external lobe of the hind knee round; second tarsal segment of the hind legs not short; face nearly vertical or slightly angled backwards in profile. 4

3(2). Head as long as or longer than pronotum; fastigium of vertex (Fig. 15.1) with a deep median groove; edges of bogs, marshes, ponds, lakes, and streams; southern half United States southwest to CA; one species, *marginicollis* (Serville, 1838) (Fig. 15.1) . . . . ***Leptysma*** Stål, 1873

3'. Head shorter than pronotum; fastigium of vertex without a median groove; edges of bogs, marshes, ponds, lakes, and streams; southeast and Gulf Coast states; one species, *vitreipennis* (Marschall, 1836) . . . .***Stenacris*** Walker, 1870

4(2'). Mesosternal lobes longer than wide with rectangular inner angle (Fig. 15.4); edges of bogs, fresh and saltwater marshes, ponds, and lakes; eastern half United States; one species, *alutacea* (Harris, 1841) . . . . ***Schistocerca*** Stål, 1873

4'. Mesosternal lobes as wide as or wider than their length with round inner angle (Fig. 15.5). 5

5(4'). Tegmina reduced to small pads or completely absent 6

5'. Tegmina and hind wings fully developed 9

6(5). Tegmina reduced to slender pads or round pads 7

6'. Tegmina and hind wings completely absent 8

7(6). Tegmina modified as slender pads; green, with two white stripes running laterally from head to thorax; edges of fresh and salt water marshes; southern U.nited States; one species, *sphenarioides* Scudder, 1878 . . . . . ***Aptenopedes*** Scudder, 1878

7'. Tegmina modified as round or elongate-oval pads; pronotum tectiform; edges of marshes; eastern half United States; two species, *palustris* Morse, 1904, *signatus* Scudder, 1897 . . . . ***Eotettix*** Scudder, 1897

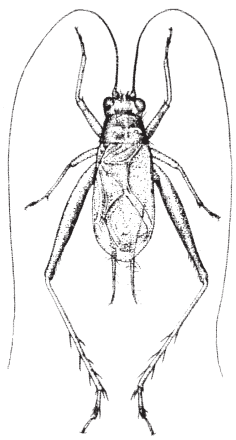

Figure 15.26

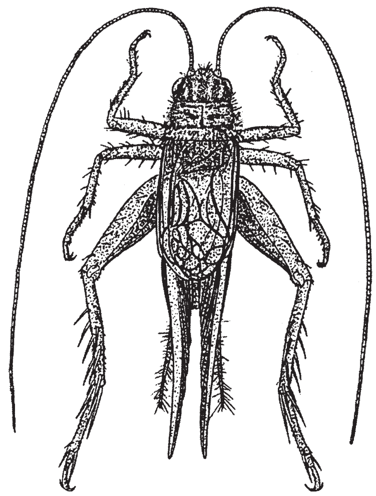

Figure 15.30

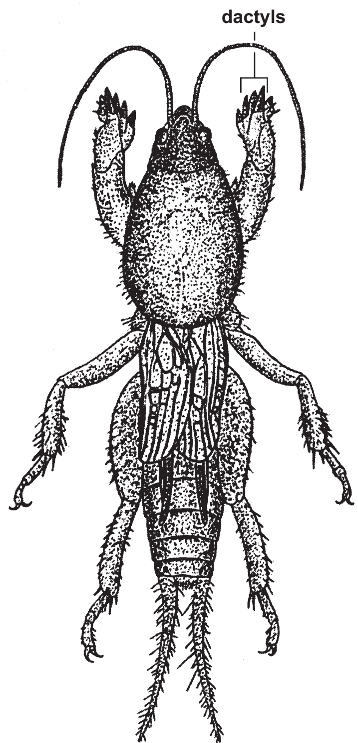

Figure 15.34

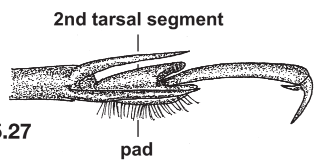

Figure 15.27

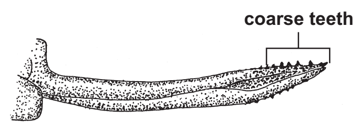

Figure 15.31

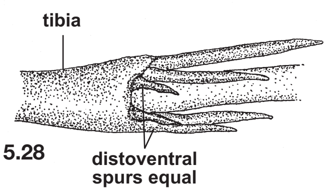

Figure 15.28

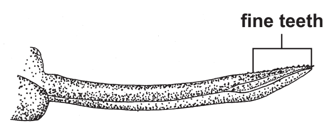

Figure 15.32

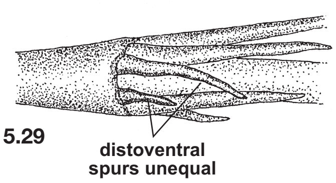

Figure 15.29

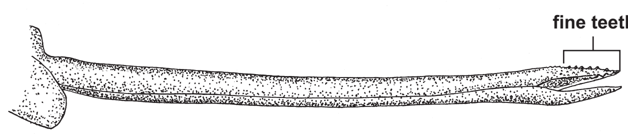

Figure 15.33

Figure 15.26 Male cricket, *Anaxipha exigua* (Gryllidae) (after Froeschner 1954).
Figure 15.27 Brush-like pad on ventral side of second tarsal segment (*Anaxipha*: Gryllidae) (after Bland 2003).
Figure 15.28 Paired distoventral spurs of hind tibiae nearly equal in length (*Eunemobius*: Gryllidae) (after Bland 2003).
Figure 15.29 Paired distoventral spurs of hind tibiae distinctly unequal in length (*Neonemobius*, *Allonemobius*: Gryllidae) (after Bland 2003).
Figure 15.30 Male cricket, *Allonemobius fasciatus* (Gryllidae).
Figure 15.31 Short, slightly curved cricket ovipositor with coarse dorsal teeth apically (*Eunemobius*: Gryllidae) (modified after Vickery and Kevan 1986).
Figure 15.32 Short, slightly curved cricket ovipositor with fine dorsal teeth apically (*Neonemobius*: Gryllidae) (after Vickery and Kevan 1986).
Figure 15.33 Long, nearly straight cricket ovipositor with fine dorsal teeth apically (*Allonemobius*: Gryllidae) (after Vickery and Kevan 1986).
Figure 15.34 Male mole cricket, *Neocurtilla hexadactyla* (Gryllotalpidae).

8(6'). Brownish green body, dark ivory patch on side of pronotum; bogs, fens; North Central states, southern Ontario; two species, *glacialis* (Scudder, 1862), *variegata* (Scudder, 1897) . . . . **Booneacris** Rehn and Randell, 1962

8'. Greenish or brownish yellow or gray body, longitudinal dull black stripe on side of body; edges of bogs and marshes; southern U.S.; two species, *morsei* Hebard, 1918, *pusillus* Scudder, 1897 . . . . **Gymnoscirtetes** Scudder, 1897

9(5'). Dorsal surface of pronotum twice as long as average width; antennae much longer than head and pronotum combined; edges of bogs, fresh and saltwater marshes, ponds, and lakes; eastern third United States, southern Ontario; three species, *atlantica* Scudder, 1877, *clavuligera* (Serville, 1838), *hoosieri* (Blatchley, 1892) . . . . **Paroxya** Scudder, 1877

9'. Dorsal surface of pronotum less than twice as long as average width; antennae as long as or shorter than head and pronotum combined; tundra, peatlands, edges of bogs and streams; Alaska, Canada, northern third United States, southwestern United States; two species, *borealis* (Fieber, 1853), *herbaceus* Bruner, 1893 . . . .**Melanoplus** Stål, 1873

10(1'). Lateral foveolae or foveolar area of vertex visible from above (Fig. 15.6) 11

10'. Lateral foveolae or foveolar area of vertex not visible from above (Fig. 15.7) 12

11(10). Dorsum of pronotum without dark lateral markings posteriorly; tegmina reach much beyond tip of abdomen; underside of hind femora usually reddish, sometimes yellowish; edges of bogs, marshes, swamps, wet meadows, lakes, and streams; Alaska, Canada, northern half United States except Pacific Coast states, CO, OK, southeastern U.nited States; three species, *celatum* Otte, 1979, *gracile* (Scudder, 1862), *lineatum* (Scudder, 1862). . . . . **Stethophyma** Fischer, 1853

11'. Dorsum of pronotum with dark lateral markings posteriorly; tegmina often short, extending about two-thirds of distance to tip of abdomen but sometimes beyond abdomen; underside of femora pale brown or yellowish; tundra, wet meadows, edges of bogs, fens, marshes, and lakes; N. America except southernmost areas; one species, *curtipennis* (Harris, 1835) . . . . . . **Pseudochorthippus** Defaut, 2012

12(10'). Antennae flattened, sword-shaped (ensiform), basal third slightly to greatly widened 13

12'. Antennae threadlike (filiform), basal third may be slightly flattened but not wider than distal segments 15

13(12). Head longer than pronotum; front of face strongly slanted backward and concave in profile; tegmina shorter than abdomen; body very slender; wet meadows, edges of fresh and salt water marshes and ponds; southeastern United States to FL; one species, *carinatum* (Walker, 1870) . . . .**Achurum** Saussure, 1861

13'. Head equal to or shorter than pronotum; face moderately slanted, not concave in profile; tegmina longer than abdomen; body not highly slender. 14

14(13'). Tegmina rounded apically; in males, a stridulatory file consisting of a row of pegs along the inside of each hind femur present, dark dorso-longitudinal stripe; wings rounded apically; edge of marshes; coastal region from NJ to FL; one species, *intertexta* Scudder, 1899 . . . . **Mermiria** Stål, 1873

14'. Tegmina nearly square (truncated) apically; in males, a stridulatory file consisting of a row of pegs along the inside of each hind femur absent; wet meadows, edges of fresh and salt water marshes, swamps, ponds, lakes, and streams; eastern half United States, southern Ontario; one species, *brevicornis* (Johannson, 1763). . . . . **Metaleptea** Brunner von Wattenwyl, 1893

15(12'). Lateral carinae of pronotum straight and nearly parallel in dorsal view (Fig.15.8); edges of marshes, swamps, ponds and lakes; eastern half U.S. southwest to NM; two species, *elegans* (Morse, 1896), *viridis* (Scudder, 1862) . . . . **Dichromorpha** Morse, 1896

15'. Lateral carinae of pronotum distinctly incurved in middle and diverge posteriorly in dorsal view (Fig. 15.9); wet meadows, muck, fresh and salt water marshes; United States, southern Canada; one species, *pelidna* (Burmeister, 1838) . . . ***Orphulella*** Giglio-Tos, 1894

ADDITIONAL TAXONOMIC REFERENCES

General

Blatchley (1920); Capinera *et al*. (2004); Rehn and Grant (1961); Triplehorn and Johnson (2005).

Taxonomic treatments at the family and generic levels

Acrididae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Dakin and Hays (1970); Helfer (1987); Otte (1981); Otte *et al*. (2001); Rehn and Eades (1961); Strohecker *et al*. (1968); Vickery and Kevan (1986).

Gryllidae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Dakin and Hays (1970); Fulton (1956); Otte *et al*. (2001); Vickery and Johnstone (1970); Vickery and Kevan (1986); Walker and Moore (2005).

Gryllotalpidae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Otte *et al*. (2001); Vickery and Kevan (1986); Walker and Moore (2005).

Tetrigidae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Dakin and Hays (1970); Helfer (1987); Otte *et al*. (2001); Rehn and Grant (1961); Strohecker *et al*. (1968).

Tettigoniidae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Dakin and Hays (1970); Hebard (1925); Helfer (1987); McCafferty and Sein (1976); Otte *et al*. (2001); Rehn and Hebard (1915a,b,c); Thomas and Alexander (1962); Vickery and Kevan (1986); Walker (1971); Walker and Moore (2005).

Tridactylidae: Bland (2003); Blatchley (1920); Capinera *et al*. (2004); Dakin and Hays (1970); Günther (1975); Helfer (1987); Otte *et al*. (2001); Vickery and Kevan (1986).

Table 15A Summary of ecological and distributional data for semiaquatic Orthoptera (grasshoppers, crickets, etc.) (For definition of terms see Tables 6A-6C; table prepared by R. G. Bland, K. W. Cummins, R. W. Merritt, and M. B. Berg.)

Taxa (number of species in parentheses)							
Order	Family	*Genus*	Habitat	Habit	Trophic Relationships	North American Distribution	Ecological References**
Orthoptera - Grasshoppers, Locusts and Crickets							
	Acrididae (26) - Short-Horned Grasshoppers		Lentic—vascular hydrophytes (emergent zone, margins)	Skaters; "swimmers"; climbers	Shredders—herbivores (chewers)		535, 525, 532, 885, 1317, 3734, 5797, 6177, 6050, 2515, 1993, 4478, 4479, 2491
	Acridinae	*Metaleptea* (1)				Eastern half U.S., southern Ontario	4478
		Stethophyma (3)				Alaska, Canada, northern half U.S. except Pacific Coast states	4478
	Cyrtacanthacridinae	*Schistocerca* (1)				Eastern half U.S.	
	Gomphocerinae	*Achurum* (1)				Southeastern U.S. to Florida	4478
		Chorthippus (1)				N. America except southernmost areas	4478
		Dichromorpha (2)				Eastern half U.S. southwest to New Mexico	4478
		Mermiria (1)				Coastal region New Jersey to Florida	4478
		Orphulella (1)				U.S., southern Canada	4478
	Leptysminae	*Leptysma* (1)				Southern half U.S. southwest to California	4897
		Stenacris (1)				Southeast and Gulf Coast states	4897, 5028
	Melanoplinae	*Aptenopedes* (1)				Southern U.S.	

**Emphasis on trophic relationships

(continued)

Table 15A Continued

Taxa (number of species in parentheses)							
Order	**Family**	***Genus***	**Habitat**	**Habit**	**Trophic Relationships**	**North American Distribution**	**Ecological References****
		Eotettix (2)				Eastern half U.S.	
		Gymnoscirtetes (2)				Southern U.S.	123
		Melanoplus (2)				Alaska, Canada, northern third and southwestern U.S.	
		Paroxya (3)				Eastern third U.S., southern Ontario	123
	Podisminae	*Booneacris* (2)				North Central states, southern Ontario	
	Romaleinae	*Romalea* (1)				Southeastern U.S.	
	Tetrigidae (14) - Pygmy Grasshoppers		Lentic—vascular hydrophytes (emergent zone, margins)	Sprawlers	Generally shredders—herbivores; collectors—gatherers		535, 4898, 525, 532, 885, 1317, 5797, 6177, 6050, 2515, 1993, 4479, 2491
	Batrachideinae	*Tettigidea* (4)				Eastern two-thirds U.S., southeastern Canada	
	Tetriginae	*Neotettix* (1)				New York to southeastern U.S., west to Indiana and Texas	
		Paratettix (4)				U.S., southern Ontario	322
		Paxilla (1)				Southeastern U.S. west to Louisiana	

**Emphasis on trophic relationships

Table 15A Continued

Taxa (number of species in parentheses)							
Order	Family	*Genus*	Habitat	Habit	Trophic Relationships	North American Distribution	Ecological References**
		Tetrix (4)				Alaska, Canada, U.S.	
	Tridactylidae (5)		Lentic or lotic margins, near quiet water, away from wave or splash zone	Burrowers; skaters; swimmers	Generally shredders—herbivores; collectors—gatherers		535, 4898, 532, 885, 6177, 6050, 2515, 1993, 4479, 2491
	Tridactylinae	*Ellipes* (4)				Eastern two-thirds and southwestern U.S., California, southern Quebec, Ontario, and Manitoba	
		Neotridactylus (1)				Eastern half and southwestern U.S., southern Quebec, Ontario, and Manitoba	2291
	Tettigoniidae (35) - Katydids		Lentic (occasionally lotic)—vascular hydrophytes (emergent zone, margins)	Generally climbers; swimmers	Generally shredders—herbivores (chewers); some predators (engulfers)		6177, 532, 885, 1317, 3896, 6050, 2515, 1993, 6247, 535, 4479, 2491
	Conocephalinae	*Bucrates* (1)				Atlantic and Gulf Coast states, Arkansas	
		Conocephalus (9)				Eastern half U.S., Texas, California, southern Quebec and Ontario	4901, 477, 4528
		Neoconocephalus (6)				Eastern two-thirds U.S., southern Ontario	
		Orchelimum (12)				U.S., southern fifth Canada	4899, 4900, 5961, 6246, 4528, 5502
	Phaneropterinae	*Amblycorypha* (1)				Eastern two-thirds U.S., southern Quebec	

**Emphasis on trophic relationships

(continued)

Table 15A Continued

Taxa (number of species in parentheses)							
Order	**Family**	***Genus***	**Habitat**	**Habit**	**Trophic Relationships**	**North American Distribution**	**Ecological References****
		Insudderia (3)				Southeastern U.S., Gulf Coast states to Louisiana, north to Illinois	2490
		Montezumina (1)				Southern U.S. north to Indiana and Maryland	
		Scudderia (1)				U.S. except northwestern and southwestern regions	
	Tettigoniinae	*Metrioptera* (1)				Southern half Canada from eastern British Columbia to western Quebec	
	Gryllidae (11) - True Crickets		Generally lentic—vascular hydrophytes (emergent zone, margins)	Sprawlers	Generally shredders—herbivores (chewers); collectors—gatherers; some predators (engulfers)		535, 6176, 525, 532, 885, 1993, 3734, 6177, 6247, 6050, 2515, 1317, 4479, 2491
	Nemobiinae	*Allonemobius* (2)				Northern half U.S., Midwest south to Texas, southern third Canada	
		Eunemobius (2)				U.S., southeast Canada	
		Hygronemobius (1)				South Florida coast	
		Neonemobius (2)				Eastern half U.S., southern Canada	
	Trigonidiinae	*Anaxipha* (4)				Eastern two-thirds U.S., southern Ontario	2022
	Gryllotalpidae (2) - Mole Crickets		Lentic and lotic—margins (near quiet water away from wave or splash zone)	Burrowers	Collectors—gatherers; predators (engulfers)		535, 1520, 532, 885, 6177, 6247, 6050, 2515, 1993, 4479, 2491
	Gryllotalpinae	*Neocurtilla* (1)				Eastern two-thirds U.S., southern Ontario	5397
		Scapteriscus (1)				Southern U.S.	

**Emphasis on trophic relationships