The Great Lakes Entomologist

Volume 5
Number 2 -- The Singing Insects of Michigan -- Summer 1972 *Number 2 -- The Singing Insects of Michigan -- Summer 1972*

Article 1

July 2017

The Singing Insects of Michigan

Richard D. Alexander
The University of Michigan

Ann E. Pace
The University of Michigan

Daniel Otte
University of Texas, Austin

THE SINGING INSECTS OF MICHIGAN

Richard D. Alexander,[1] Ann E. Pace[1] and Daniel Otte[2]

INTRODUCTION

The so-called "singing" insects are all those that make loud, rhythmical noises. They include members of three groups of Orthoptera (Gryllidae, Tettigoniidae, and Acridoidea) and one family of Homoptera (Cicadidae). There are about 300 noisy species in these four groups in eastern North America, perhaps a thousand in all of North America, and 25-30 thousand in the entire world. Only about 1000 of the world species have been studied in any detail, mostly in North America, Europe, Japan, and Australia.

Michigan has 90 known species of singing insects, representing all four of the above groups and a variety of subfamilies and genera. Recently, the Michigan species in each of these groups have been listed, and maps of their distributions and dates indicating adult seasonality have been presented (Moore, 1966; Cantrall, 1968). Except for morphological notes by Moore on the ten Michigan species of cicadas, however, no keys or other adequate means of distinguishing the species have been available. In this paper we add three orthopterans to Cantrall's list, and we provide keys, illustrations, and other information that we hope will enable interested persons to identify any singing insects from Michigan, either from a specimen that has date and locality data, or from a song and a field observation. Brief seasonal, distributional, and other biological information is also provided. The bibliography at the end of the paper includes all recent papers and phonograph records dealing with Michigan singing insects. Because no keys to the sounds and associated behavior of locusts (Acrididae) are included in the present paper, discussions of these characteristics by Cantrall (1943, 1968) and Otte (1971) will be especially useful.

The common names used for these four groups have been almost unbelievably confused between Europe and North America. The word "cricket" is used for all Gryllidae, but it has also been used for another family, the Gryllacrididae (including Stenopelmatinae and Rhaphidophorinae), along with various qualifying adjectives such as "camel cricket," "cave cricket," "stone cricket," and "Jerusalem cricket." "Weta" is the common name used for Gryllacrididae in New Zealand, but there appears to be no universal common name among English-speaking people for members of this family. Both "grasshopper" and "locust" have been used for both Acrididae and Tettigoniidae. "Locust" and "harvest-locust" are commonly used for cicadas in North America, reputedly because early settlers likened their sudden emergences to Old World locust plagues. Another common name for cicadas, especially in the South, is "jarfly." Sometime during the 18th or 19th century in North America, the name "katydid" was derived for *Pterophylla camellifolia* because its call can easily be paraphrased "katy-did." The name has been expanded by American entomologists to include most or all subfamilies of Tettigoniidae, and various adjectives have been applied such as "true katydids" (Pseudophyllinae), "false katydids," (Phaneropterinae), and "shield-backed katydids" (Decticinae). Some North American Tettigoniidae have been commonly referred to as "long-horned grasshoppers," with the Conocephalinae becoming "meadow grasshoppers," the Copiphorinae becoming "coneheaded grasshoppers," etc. But this requires that the Acrididae be referred to specifically as "short-horned grasshoppers" (or locusts). In fact, Britishers refer to members of the Acridinae as "meadow grasshoppers" while we call members of the same genera "locusts," and a recent book on British Orthoptera refers to all Tettigoniidae as "bush crickets"!

It seems impossible to straighten out this colloquial nomenclature to everybody's satisfaction, but for simplicity in this paper we use the names "locust" and "grasshopper" only for Acrididae, "cicada" for Cicadidae, "cricket" for Gryllidae, and "katydid" for Tettigoniidae.

[1]Museum of Zoology and Department of Zoology, The University of Michigan, Ann Arbor, Michigan 48104

[2]Current address: Department of Zoology, The University of Texas, Austin, Texas 78712

In all known cases, the males of these groups are the predominant or the sole noise-makers, and most of the sounds–even such embellishments as aggressive, territorial, or male aggregation sounds–function in connection with pair formation, courtship, mating. Disturbance squawks, prevalent in cicadas, unusual in katydids, and virtually absent in crickets and locusts, may be secondary phenomena in all of the groups in which they are found. They are produced when the insect is startled or manhandled and probably function in connection with escape from predators, though this has not been proved in any natural situation.

As a consequence of the role of acoustical signalling in mating, and therefore indirectly in reproductive isolation among species, it is not surprising that, on a local basis, acoustical behavior has turned out to be essentially infallible in species recognition. In other words, no case has yet been discovered in which two species that are reproductively active in the same places at the same times have identical acoustical behavior. Sometimes the calling songs of two species are distinct and non-overlapping when analyzed by audiospectrograph or oscilloscope, but their differences are not distinguishable to the unaided human ear. In a few instances, closely related species that are temporally isolated (*Gryllus veletis* and *G. pennsylvanicus* here), ecologically isolated on different host plants (*Oecanthus quadripunctatus* and *O. pini* and *O. laricis* here), or geographically isolated (*O. pini* and *O. laricis* here or *G. firmus* on the Atlantic Coast and *G. bermudensis* on Bermuda) still have very similar or apparently identical acoustical behavior.

Crickets and katydids make their noises by rubbing the forewings together and hear with tympanal auditory organs located on the front legs (Figs. 10-14, 24-31, 37-40, 48). Band-winged locusts (Oedipodinae) make their noises by rubbing their hind legs against the forewings and by snapping their hind wings in flight (crepitation). Slant-faced locusts (Acridinae and Gomphocerinae) use only the first of these two methods, and both kinds of locusts have tympanal auditory organs on the sides of the abdomen near its base. Cicadas make their noises by popping in and out convex portions of the body wall (timbals) near the base of the abdomen (Figs. 5-7), and they hear with tympana located in the same general region. There are some exceptions to these rules–locusts that snap their mandibles or stamp their feet, cicadas that clack their wings together, and others–but they are relatively trivial for our purposes here.

In all of the cicadas and nearly all crickets, the males make all the noise and attract the females; the single exception in Michigan is that mole cricket females also stridulate, but the function of their sounds is unknown. In locusts and some katydids, male noises are answered by female noises, and the male then goes to the female, usually during an exchange of signals. In some cases the female approaches before answering the male. Locust and cicada males usually move around during their daily singing periods; cricket and katydid males are mostly more stationary, particularly the males of burrowing cricket species.

Pair formation is usually effected either by individual females going to individual, singing males (all crickets and some katydids and cicadas) or by females flying into "chorusing" aggregations of males (cicadas and probably some locusts). In some katydids and locusts females are attracted into the vicinity of the made by a long-range signal. Then the male approaches the female during an exchange of signals while male and female are a few feet or yards apart. Crickets have 1-6 known kinds of signals per species; katydids, 1-3; locusts, 1-5 (possibly more); cicadas, 1-4. Aside from calling (pair-forming) and courting (pre-copulatory) signals, there are post-copulatory (or inter-copulatory), aggressive, disturbance, and (evidently) some kind of "recognition" signals, the last only in parental species of crickets, such as *Neocurtilla hexadactyla,* which tend their offspring briefly.

The so-called "singing" insects are by no means the only insects in Michigan with special sound-producing devices. Thousands of species of beetles and bugs stridulate (DuMortier, 1963; Alexander, 1967a). Indeed, many waterbugs in the families Corixidae and Notonectidae make fairly intense, rhythmical noises that would qualify by our definitions as "songs." But they are not often heard unless the insects are kept in aquaria. The behavioral significance of some of these sounds has recently been examined

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

(Wilcox, 1969; Jansson, 1971). Probably most of the social insects (termites, ants, wasps, bees) use sounds in some fashion. Most people know about the piping signals of queen honeybees; and honeybees also make noises when they "dance" in the hive after visiting food or hive sites (Wenner, 1968). Flies and wasps often have specialized buzzing wing noises. Many of the tiny Homoptera related to cicadas (leafhoppers and spittlebugs) make a variety of soft noises (Moore, 1961). Most of the noises of these many sonifiers seem to function either in courtship or alarm situations. We exclude them here because their sounds are too soft to be heard except at very close range, or because the sounds are produced in such specialized situations that they are rarely heard.

A NOTE ON SIBLING SPECIES

The Orthoptera and Cicadas both include many pairs of species that are difficult to distinguish on morphological grounds alone, or by use of traditional key characters. Examples in the Michigan fauna are *Scudderia furcata** and *S. fasciata**, *Neoconocephalus lyristes* and *N. nebrascensis, Orchelimum concinnum* and *O. delicatum, Gryllus pennsylvanicus** and *G. veletis**, *Allonemobius allardi* and *A. tinnulus, Oecanthus pini** and *O. laricis**, *Oecanthus nigricornis* and *O. quadripunctatus, Magicicada cassini* and *M. septendecim, Okanagana canadensis* and *O. rimosa, Tibicen canicularis* and *T. linnei.*

It is easy to fall into the trap of believing that such populations are somehow different in their evolutionary status from species more unequivocally separable on conventional grounds. But morphological differences visible to biologists need not appear when speciation occurs. The pairs of sibling or cognate species listed above can be shown on other grounds to have attained status similar or equivalent to that of other pairs of species more easily distinguishable. In all of these cases but those asterisked(*) the songs are distinct; this together with geographic and ecological sympatry demonstrates that interbreeding is absent. *Gryllus pennsylvanicus* and *G. veletis* are inter-sterile (Alexander and Bigelow, 1960), their songs apparently having failed to diverge because their life history difference results in almost complete seasonal separation of adults. *Scudderia furcata* and *S. fasciata,* and *Oecanthus pini* and *O. laricis,* may have slight song differences, but these are probably not great enough for the insects to avoid mistakes by song responses alone. These species pairs represent unusual and interesting cases because they involve shifts in host-specificity which at least now render them ecologically isolated. The color differences by which they are most easily distinguished if the host is unknown have evidently evolved as a result of the value of cryptic coloration owing to bird predation. One might wonder if the slight color differences used in the key are simply local differentiations of populations that recently moved onto different hosts. Geographic patterns, however, indicate otherwise. *S. fasciata* and *O. pini* both occur on pines in southern and eastern Ohio, at Turkey Point and Point Pelee, Ontario, and in Berrien County, Michigan. They are absent from planted pines in other regions and from pines in northern and central Michigan, where their close relatives on other vegetation, *S. furcata* and *O. quadripunctatus* respectively, are abundant. Likewise, *O. laricis,* most likely sharing an exclusive common ancestor with *O. quadripunctatus, O. nigricornis,* or *O. pini,* is restricted to larch trees in northern Ohio and southeastern Michigan. These geographic patterns indicate ancient separations, and full species status. All of the various cases listed above together demonstrate that absence of known, non-overlapping morphological or behavioral differences is not a reliable indicator of species status, particularly in cases of geographic, ecological, or temporal separation.

SPECIES LIST

Order ORTHOPTERA

Family Tettigoniidae

Subfamily PHANEROPTERINAE (False Katydids)

1. *Amblycorypha oblongifolia* (De Geer) — Oblong-Winged Katydid
2. *Amblycorypha rotundifolia* (Scudder) — Round-Winged Katydid
3. *Microcentrum rhombifolium* (Saussure) — Angle-Winged Katydid
4. *Scudderia curvicauda* (De Geer) — Curve-Tailed Bush Katydid

5. *Scudderia fasciata* Beutenmuller	Hemlock Bush Katydid
6. *Scudderia furcata* Brunner	Fork-Tailed Bush Katydid
7. *Scudderia pistillata* Brunner	Broad-Winged Bush Katydid
8. *Scudderia septentrionalis* (Serville)	Northern Bush Katydid
9. *Scudderia texensis* Saussure and Pictet	Texas Bush Katydid

Subfamily COPIPHORINAE (Cone-Headed Katydids)

10. *Neoconocephalus robustus* (Scudder)[3]	Crepitating Conehead
11. *Neoconocephalus ensiger* (Harris)	Sword-Bearing Conehead
12. *Neoconocephalus lyristes* (Rehn and Hebard)	Slender Conehead
13. *Neoconocephalus nebrascensis* (Bruner)	Nebraska Conehead

Subfamily CONOCEPHALINAE (Meadow Katydids)

14. *Orchelimum campestre* Blatchley	Dusky-Faced Meadow Katydid
15. *Orchelimum concinnum* Scudder	Stripe-Faced Meadow Katydid
16. *Orchelimum delicatum* Bruner	Delicate Meadow Katydid
17. *Orchelimum gladiator* Bruner	Gladiator Meadow Katydid
18. *Orchelimum nigripes* Scudder	Black-Legged Meadow Katydid
19. *Orchelimum volantum* McNeill	Nimble Meadow Katydid
20. *Orchelimum vulgare* Harris	Common Meadow Katydid
21. *Conocephalus attenuatus* (Scudder)	Long-Tailed Meadow Katydid
22. *Conocephalus brevipennis* (Scudder)	Short-Winged Meadow Katydid
23. *Conocephalus fasciatus* (De Geer)	Slender Meadow Katydid
24. *Conocephalus nemoralis* (Scudder)	Woodland Meadow Katydid
25. *Conocephalus nigropleurum* (Bruner)	Black-Sided Meadow Katydid
26. *Conocephalus strictus* (Scudder)	Straight-Lanced Meadow Katydid
27. *Conocephalus saltans* (Scudder)	Prairie Meadow Katydid

Subfamily DECTICINAE (Shield-Backed Katydids)

28. *Atlanticus davisi* Rehn and Hebard	Davis' Shield-Bearer
29. *Atlanticus testaceus* (Scudder)	Short-Legged Shield-Bearer

Subfamily PSEUDOPHYLLINAE

30. *Pterophylla camellifolia* (Fabricius)	Northern True Katydid

Family Gryllidae

Subfamily GRYLLINAE (Field and House Crickets)

31. *Acheta domesticus* (Linnaeus)	House Cricket
32. *Gryllus pennsylvanicus* Burmeister	Fall Field Cricket
33. *Gryllus veletis* (Alexander and Bigelow)	Spring Field Cricket

Subfamily NEMOBIINAE (Ground Crickets)

34. *Allonemobius allardi* (Alexander and Thomas)	Allard's Ground Cricket
35. *Allonemobius fasciatus* (De Geer)	Striped Ground Cricket
36. *Allonemobius griseus* (Walker)	Gray Ground Cricket
37. *Allonemobius maculatus* (Blatchley)	Spotted Ground Cricket
38. *Allonemobius tinnulus* (Fulton)	Tinkling Ground Cricket
39. *Eunemobius carolinus* (Scudder)	Carolina Ground Cricket

[3]This species is the *N. crepitans* (Scudder) of Cantrall (1968) and other authors. Two species for which these names have been variously used overlap from southern Ohio to the Atlantic Coast (Alexander, unpubl.), but the types of *robustus* (Cape Cod, Mass.) and *crepitans* (Texas, Nebraska) are evidently both from outside the range of the eastern, unnamed species (Walker *et al*, in prep).

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

40. *Eunemobius melodius* (Thomas and Alexander) Melodious Ground Cricket
41. *Neonemobius palustris* (Blatchley) Marsh Ground Cricket

Subfamily OECANTHINAE (Tree Crickets)

42. *Neoxabea bipunctata* (De Geer) Two-Spotted Tree Cricket
43. *Oecanthus exclamationis* Davis Davis' Tree Cricket
44. *Oecanthus fultoni* T. J. Walker Snowy Tree Cricket
45. *Oecanthus pini* Beutenmuller Pine Tree Cricket
46. *Oecanthus laricis* T. J. Walker Tamarack Tree Cricket
47. *Oecanthus nigricornis* F. Walder Black-Horned Tree Cricket
48. *Oecanthus niveus* (De Geer) Narrow-Winged Tree Cricket
49. *Oecanthus quadripunctatus* Beutenmuller Four-Spotted Tree Cricket

Subfamily TRIGONIDIINAE (Sword-Bearing Crickets)

50. *Anaxipha exigua* (Say) Say's Bush Cricket

Subfamily GRYLLOTALPINAE (Mole Crickets)

51. *Neocurtilla hexadactyla* (Perty) Northern Mole Cricket

Subfamilies GOMPHOCERINAE AND ACRIDINAE (Slant-Faced Locusts)[4]

52. *Pseudopomala brachyptera* Scudder Bunch Grass Locus
53. *Metaleptea brevicornis* (Johannson) Short-horned Locust
54. *Syrbula admirabilis* (Uhler) Handsome Locust
55. *Orphulella speciosa* (Scudder) Pasture Locust
56. *Orphulella pelidna* (Burmeister) Spotted-Winged Locust
57. *Dicromorpha viridis* (Scudder) Short-Winged Locust
58. *Chloealtis conspersa* Harris Sprinkled Locust
59. *Chloealtis abdominalis* (Thomas) Rocky Mountain Sprinkled Locust
60. *Chorthippus curtipennis* (Harris) Meadow Locust
61. *Ageneotettix deorum* (Scudder) Sand Locust
62. *Stethophyma gracile* (Scudder) Northern Sedge Locust
63. *Stethophyma lineatum* (Scudder) Striped Sedge Locust

Subfamily OEDIPODINAE (Band-Winged Locusts)

64. *Arphia pseudonietana* (Thomas) Red-Winged Locust
65. *Arphia sulphurea* (Fabricius) Spring Yellow-Winged Locust
66. *Arphia xanthoptera* (Burmeister) Autumn Yellow-Winged Locust
67. *Chortophaga viridifasciata* (De Geer) Green-Striped Locust
68. *Encoptolophus sordidus* (Burmeister) Dusky Locust
69. *Camnula pellucida* (Scudder) Clear-Winged Locust
70. *Pardalophora apiculata* (Harris) Coral-Winged Locust
71. *Pardalophora haldemani* (Scudder) Haldeman's Locust
72. *Dissosteira carolina* (Linnaeus) Carolina Locust
73. *Spharagemon bolli* Scudder Boll's Locust
74. *Spharagemon collare* (Scudder) Mottled Sand Locust
75. *Scirtetica marmorata* (Harris) Northern Marbled Locust
76. *Trachyrhachys fuscifrons* (Stål) Ash-Brown Locust
77. *Psinidia fenestralis* (Serville) Long-Horned Locust

[4]Attempts to distinguish the various subfamilies of Acrididae have been controversial and inconclusive. Some authors would place *Metaleptea* and *Stethophyma* in the Acridinae. Jago (1971: Proc. Acad. Nat. Sci. Phila. 123) is the most recent author in the series; Uvarov (1966: *Grasshoppers and Locusts,* Cambridge Univ. Press) lists representative genera in the various subfamilies and most of the recent publications.

78. *Trimerotropis huroniana* E. M. Walker	Lake Huron Locust
79. *Trimerotropis interior* E. M. Walker	Seaside Locust
80. *Trimerotropis verruculata* (Kirby)	Cracker Locust

ORDER HOMOPTERA

Family Cicadidae (Cicadas)

81. *Diceroprocta vitripennis* (Say)	Green-Winged Cicada
82. *Magicicada cassini* (Fisher)	Cassin's 17-year Cicada
83. *Magicicada septendecim* (Linnaeus)	Linnaeus' 17-year Cicada
84. *Okanagana canadensis* (Provancher)	Canadian Cicada
85. *Okanagana rimosa* (Say)	Say's Cicada
86. *Tibicen auletes* (Germar)	Northern Dusk-Singing Cicada
87. *Tibicen canicularis* (Harris)	Dog-Day Cicada
88. *Tibicen chloromera* (Walker)	Swamp Cicada
89. *Tibicen linnei* (Smith and Grossbeck)	Linne's Cicada
90. *Tibicen lyricen* (De Geer)	Lyric Cicada

LEARNING THE SINGING INSECTS

Unless an expert is available to take one into the field and teach him how to recognize the species one by one, probably the best way to learn the singing insects quickly is to begin in May and take careful note of each new insect singer as the season progresses. By late July, when the main horde of noise-makers begins to fill the air with a really confusing chorus, several species will already have been identified, and the family or subfamily of most new singers will be recognizable just by sound or appearance. This is half the battle. One should learn when and where to listen and look, and try to identify each singer by catching it or watching it at close range. He should consider such questions as whether the sound is produced only by day (cicadas, grasshoppers), only by night (some crickets and katydids), or both day and night (some crickets and katydids). Is it coming from vegetation or from the ground? From bushes, trees, or herbs? Is it a clear, whistle-like sound (crickets) or a "noise" (buzz, click, rasp, whir, rattle, etc.) (all groups except crickets)? How far away is it audible? Is it abundant in lawns, or does it come only from woodlands, marshes, or some other special place? Once a species has been identified, the listener should expect it in the same kinds of places and be aware of the likelihood that species heard in quite different habitats may be something else.

THE EARLY SINGERS

JUVENILE-OVERWINTERERS: Late in April or early in May, the Green-Striped Locust (*Chortophaga viridifasciata*), first singing insect to mature in Michigan (after spending the winter as a partly-grown juvenile), begins its short, low, buzzing, daytime flights in pastures, lawns, and old fields. About two weeks later, the Spring Field Cricket (*Gryllus veletis*) adds a clear chirp from burrow entrances day and night in the same locations. Then the Spring Yellow-Winged Locust (*Arphia sulphurea*) starts its crackling, daytime flights in dry, upland pastures and fields. The Coral-Winged Locust (*Pardalophora apiculata*) and Haldeman's Locust (*P. haldemani*) are also spring species, which lack the noisy "crepitating" flights of the other spring locusts, but share with them the ability to signal by stridulating by rubbing the hind legs against the forewings or body while sitting in the grass.

There are five other early species, all cicadas which require many years to reach maturity. These five species, which begin song in late May or early June, are the 17-year *Magicicada* species, which last filled the daytime air with their choruses in 1970 in southern counties, the two *Okanagana* species, *rimosa* and *canadensis*, and the single *Diceroprocta* species, known only from Michigan's southwestern county (and the only known early cicada there). There is a third 17-year cicada, but it apparently does not get into Michigan (Alexander and Moore, 1962); the two species involved here can be

separated easily: *cassini,* which is rare in Michigan if it occurs there at all, is small and black underneath, and produces ticks followed by shrill buzzes, mostly in the afternoon; *septendecim* has much brownish color underneath and sings a low-pitched buzz that some people have paraphrased "phaar-oo-ah," beginning at dawn and dwindling in intensity by afternoon. The *Okanagana* species are generally more northern, but behave similarly, singing in noisy choruses. The Canadian Cicada (*O. canadensis*) buzzes more or less continually and evenly, while the Rimose Cicada (*O. rimosa*) delivers lisps slowly enough to be distinguished but too rapidly to be counted. These two species can otherwise be distinguished from *Magicicada* because their dorsum is usually marked with orange between the wings, while those of the *Magicicada* species are wholly black.

Aside from the five remaining cicadas (*Tibicen* species), the above ten species are the only native Michigan singing insects that do not overwinter solely in the egg stage. One European import, the House Cricket (*Acheta domesticus*), can sometimes be heard giving its weak chirp in and around buildings during winter as well as summer. This cricket, originally from tropical Asia, is reared and shipped extensively within the United States as fish bait and for laboratory use.

EARLY MATURING EGG-OVERWINTERERS: The Short-Legged Shield-Bearer (*Atlanticus testaceus*) hatches very early in woods and brushy areas, and usually matures and begins its soft, irregular, whispery, night-time buzzes in mid-June. Shortly afterward, the Gladiator Meadow Katydid (*Orchelimum gladiator*) starts its typical, meadow katydid "tick-and-buzz" kind of song along roadsides in low, marshy areas. These two are soon joined by the Carolina Ground Cricket (*Eunemobius carolinus*) with a vibrating, buzzy trill from the ground day and night in damp grass and tangled woodland areas. Eight more locust species begin to crepitate and stridulate between 20 June and 1 July. In early July, Linne's Cicada (*Tibicen linnei*) and the Dog-Day Cicada (*T. canicularis*) add to the growing din their very loud daytime buzzes—vibratory and smooth, respectively.

LATE SEASON REPLACEMENTS: The 24 species discussed above are the only "early season" singers. All but the first nine keep right on singing into the main season, which lasts from late July until frost. But three of them have "sing-alike" replacements in their habitats, which come along as they disappear in late July. The Fall Field Cricket (*Gryllus pennsylvanicus*) replaces the Spring Field Cricket; the Red-Winged Locust (*Arphia pseudonietana*) replaces the Spring Yellow-Winged Locust; and the Common Meadow Katydid (*Orchelimum vulgare*) replaces the Gladiator Meadow Katydid. The Common Meadow Katydid is heard in fields, pastures, and rarely in lawns, as well as in the marshy habitats to which the Gladiator Meadow Katydid is more or less restricted. It is not easy to distinguish these three pairs of seasonally isolated species except by the times of their appearance; but if one learns the three early species, he will recognize their later counterparts.

So nearly one-third of the 90 Michigan singing insects can be learned before late July when the main season for insect noise is just beginning. The following keys have been designed to identify all species, early or late. One simply chooses the proper alternative in each couplet and follows the numbers until he comes to a name. If the species finally reached doesn't seem to fit, decisions should be retraced until a doubtful one is discovered, and other alternatives tried until everything fits. Only a careful ear, a ruler, and rarely a hand lens, will be necessary. If either song or structure is not mentioned in separating two species, this means that they can be distinguished in that particular regard only by analyzing tape recordings or by using a microscope. The illustrations include a full view of one member of each major group and key characters that will distinguish the species of each group.

LIST OF KEYS

I. Keys for identifying Michigan's singing insects using a combination of songs, morphology, and distribution

A. Families and Subfamilies (page 40)

B. Cicadas (page 41)

C. Crickets (page 42)

D. True and False Katydids (page 43)
E. Coneheaded Katydids (page 44)
F. Shield-backed Katydids (page 44)
G. Meadow Katydids (page 44)

II. Keys for identifying Michigan's singing insects by specimen alone
H. Families (page 46)
I. Cicadas (page 46)
J. Crickets (page 47)
K. Katydids (page 49)
L. Locusts (page 52)

KEYS FOR IDENTIFYING MICHIGAN'S SINGING INSECTS USING A COMBINATION OF SONGS, MORPHOLOGY, AND DISTRIBUTION

A. IDENTIFYING FAMILIES AND SUBFAMILIES (see also H, page 46)

1. Loud, daytime buzzes from trees, less commonly from bushes or tall weeds; insects an inch or more long with beaks and transparent wings, and without enlarged jumping hind legs (Cicadas) . . . . . B, I (pages 41, 46)

1′. Either loud or soft nighttime noises, or else daytime noises from herbs, from the ground, or from flying insects with yellow- or red-flashing wings; insects more or less than an inch long, with enlarged jumping hind legs (Locusts, Crickets, Katydids) 2

2 (1′). Short, crackling or buzzing daytime noises made in flight by insects with colored wings ("crepitation" of Band-Winged Locusts). (Not all band-winged grasshoppers crepitate. Slant-faced grasshoppers in the genus *Orphulella* crepitate, but their hind wings are clear.). . . . . J (page 47)

2′. Any loud or soft, long or short noises produced day or night by stationary or walking insects (Crickets, Katydids, Slant-Faced Locusts, and Band-Winged Locusts) 3

3 (2′). Short, soft, rasping daytime noises from the ground in grass, weeds, or woodland leaf litter; insects with antennae shorter than body ("stridulation" of Slant-Faced Locusts and Band-Winged Locusts) . . . . . J (page 47)

3′. Either clear, (whistle-like) sound or else buzzing, rasping, clicking noises; day or night; on the ground or on any kind of vegetation; insects with antennae much longer than body (except mole crickets—singing only in swamps at night, also flying to lights); if song fits 3 above, then it never comes from the ground and for only a few species does it come from low vegetation (Crickets, Katydids) 4

4 (3′). Song clear (that is, resembling a police whistle, through usually higher- or lower-pitched); forewings either opaque or translucent, brownish or black, rarely greenish, and with the greatest part of its area horizontal (Crickets) . . . . . C, K (pages 42, 49)

4′. Song noise-like, not clear (buzzes, rasps, clicks, lisps, etc.); forewings opaque or partly translucent, often greenish, and either with greatest part of its area vertical or with a shield-like extension covering a third of the wings or more (Katydids) 5

5 (4′). Loud or soft noises, usually only at night; never continuous for long periods without perceptible breaks, but consisting of short phrases or notes; large green or brown insects with opaque forewings (True and False Katydids) . . . . . D, L (pages 43, 52)

5′. If loud, nighttime buzzes, then continuous for long periods without obvious breaks or regular breaks at 3 per five seconds (Cone-Headed Katydids); otherwise, either very soft noises or else "tick-buzz" songs produced both day and night (Meadow Katydids, Shield-Backed Katydids, one False Katydid) . . . 6

6 (5′). Loud, nighttime buzzes or very rapidly delivered lisps that continue for long periods without interruption, or else with regular breaks at 3 per five

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

seconds; usually on herbaceous vegetation 3-5 feet above the ground (Cone-headed Katydids). . . . . F, L (pages 44, 52)

6′. Loud or soft noises, usually from low vegetation, and usually composed of two parts, a tick series and a buzz series; or else very soft, continual buzzes; or else groups of short, irregular buzzes 7

7 (6′). Sounds produced day and night, usually from woodlands or brushy areas; groups of whispery, intense buzzes; insects brown with a shield covering a third or more of the very short forewings (Shield-Backed Katydids) . . . . . F, L (pages 44, 52)

7′. Sounds produced day or night; otherwise fitting 6′ above, except that buzzes are not noticeably grouped; insects brown or green, small or large, with pronotal shield covering much less than a third of the forewings (Meadow Katydids and one False Katydid, the Northern Bush Katydid) . . . . . D, G, L (pages 43, 44, 52)

B. IDENTIFYING CICADAS CHIEFLY BY SONG

1. Singing generally in large choruses in May and June; wing veins red or green; thorax black, black and red, or black and green. 2

1′. Usually singing alone or in small groups, early July until frost every year; wing veins green or brown; thorax green or brown and black 6

2 (1). Dorsal thorax black; emerging every 17 years 3

2′. Dorsal thorax with some reddish or greenish patterning; possibly emerging every four years 4

3 (2). Ventral abdomen usually entirely black; song a series of high-pitched ticks followed by a sibilant buzz, produced mostly after noon; very rare in Michigan, if at all present. . . . . *Magicicada cassini*

3′. Ventral abdomen brown or brown and black; song a series of buzzes that drop in pitch at their ends, beginning at dawn; sounding like "Phaaaroah!" . . . . *Magicicada septendecim* (Fig. 1)

4 (2′). Berrien County only; wing veins greenish. . . . . *Diceroprocta vitripennis* (Fig. 3)

4′. Known only from Washtenaw County and Berrien County and north from Clare County; wing veins reddish 5

5 (4′). Song a steady fast buzz in which the pulses are delivered far too fast to be individually audible; 2nd and 8th dorsal abdominal segments red and black; Lower Peninsula (LP) and Upper Peninsula (UP) . . *Okanagana rimosa* (Fig. 2)

5′. Song a series of lisps delivered slowly enough to hear but too fast to count; 2nd and 8th dorsal abdominal segments usually all black; UP only . . . . . *Okanagana canadensis*

6 (1′). Song very loud, produced in choruses mostly around dusk, individually at other times, sounding something like roller skates stroked regularly against a sidewalk; generally restricted to oak woods in sandy areas in the LP; wing length over 40 mm . . . . . *Tibicen auletes*

6′. Not necessarily as above; wing length under 40 mm 7

7 (6′). Song smooth without easily discernible vibrato 8

7′. Song with obvious vibrato (actually an intensity, not a frequency, modulation) during its most intense portion 9

8 (7). Song a completely smooth whining buzz sounding like a miniature buzz saw, rarely lasting more than a minute . . . . . *Tibicen canicularis*

8′. Song rather coarse in quality, a rough buzz often lasting more than a minute . . . . . *Tibicen lyricen* (Fig. 4)

9 (7′). Vibratory portions of song usually lasting 15-25 seconds, produced mostly in afteroon, nearly always from trees (common and widespread). . *Tibicen linnei*

9′. Vibratory portions of song usually lasting 8-13 seconds, produced mostly in morning, usually from bushes or tall weeds in low, swampy areas (rare in Michigan) . . . . . *Tibicen chloromera*

C. IDENTIFYING CRICKETS CHIEFLY BY SONGS

1. On vegetation; head much narrower than forewings; blackish-green, whitish-green, or else reddish- or yellowish-brown (Tree Crickets, Sword-Tailed Crickets) 2

1′. On the ground or in burrows or buildings, head usually about as wide as forewings or else forelegs enlarged and shovel-like; black, brown, or gray (Field, House, Ground, Mole Crickets) 10

2 (1′). Song an extremely high-pitched, continuous trill heard day and night from low herbs only in damp areas; body less than 1/2 inch long; forewings pale brown. . . . . *Anaxipha exigua* (Fig. 11)

2′. Song not necessarily as above; body more than 1/2 inch long; forewings not pale brown; otherwise not fitting above description 3

3 (2′). Songs continuous without perceptible breaks, heard day and night on herbs and small shrubs, never in trees 4

3′. Songs always with regularly or irregularly spaced breaks (songs of individuals must be heard); at night, only in bushes and trees, never on herbs 5

4 (3). On coarse weeds and woody plants; body suffused with black; usually more than three feet above the ground (almost any old field, especially marshy places) . . . . . *Oecanthus nigricornis* (Fig. 14)

4′. On grasses and fine-stemmed, soft weeds, within three feet of the ground; body never suffused with black (almost any old field, especially upland fields) . . . . . *Oecanthus quadripunctatus*

5 (3′). Song composed of chirps delivered at such a rate that the number in 15 seconds + 40 gives the approximate air temperature in Fahrenheit degrees . . . . . *Oecanthus fultoni*

5′. Song composed of trills a second or more in length 6

6 (5′). On conifers in southern Michigan; body green with brownish or blackish coloration on head and pronotum 7

6′. Very rarely on conifers; body pale-green or reddish 8

7 (6). On tamarack or in plantations of pine and spruce in southeastern and south-central Michigan; body dark green, about the color of tamarack needles, with blackish markings, especially on head and pronotum . . . . *Oecanthus laricis*

7′. On pines in southwestern Michigan; body the color of pine needles with brownish or reddish markings, especially on head and pronotum. . . *Oecanthus pini*

8 (6′). Wings and body with reddish markings . . . . . *Neoxabea bipunctata*

8′. Wings and body whitish-green 9

9 (8′). Wings about 1/4 as wide as body length; first antennal segment with a straight black mark underneath . . . . . *Oecanthus exclamationis*

9′. Wings about 1/3 as wide as body length, first antennal segment with a J-shaped black mark underneath . . . . . *Oecanthus niveus*

10 (1′). Song made up of countable chirps which are multipulse and sometimes buzzy. 11

10′. Song a trill or else (in woods only) made up of barely countable, clearly one-pulse "tink" sounds 15

11 (10). Usually one chirp per second or slower; body straw-colored; more than 1/2 inch long; always in or near buildings. . . . . *Acheta domesticus*

11′. Usually more than one chirp per second; body dark brown or black; in grassy places, rarely inside buildings 12

12 (11′). Chirps clear-sounding and loud without any buzzy quality; body more than a half inch long. 13

12′. Chirps buzzy-sounding, soft, carrying only a few yards; body less than 1/2 inch long (lawns, pastures, fields) . . . . . *Allonemobius fasciatus*

13 (12). Very low-pitched chirps at 1-3 per second, delivered with considerable regularity from marshes at night; may be mistaken for a frog; a large, cylindrical, velvety, burrowing insect with a pointed head. *Neocurtilla hexadactyla* (Fig. 10)

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

13′. The most common loud cricket chirp around lawns; a large black or brown cricket not fitting above description. 14
14 (13′). May to late July . . . . . *Gryllus veletis*
14′. Late July until heavy frosts . . . . . *Gryllus pennsylvanicus* (Fig. 13)
15 (10′). Only in sandy areas; body and wings gray without reddish-brown coloration . . . . . *Allonemobius griseus*
15′. In woods, pastures, lawns, sphagnum bogs, or marshes; body and wings reddish-brown or dark brown or black 16
16 (15′). Very abundant in pastures and lawns; song a slow trill with occasional breaks . . . . . *Allonemobius allardi* (Fig. 12)
16′. In woods, sphagnum bogs, marshes, and (less often) lawns (if in lawns, then song a very fast, buzzy pulsating trill) 17
17 (16′). In dry woods; song a slow, continual "tink-tink-tink-etc."; body and wings reddish-brown, sometimes rather pale . . . . . *Allonemobius tinnulus*
17′. In marshes, bogs, damp woods, or (rarely) lawns 18
18 (17′). In any kind of moist area; song usually with obvious rhythmical pulsations in intensity and without breaks . . . . . *Eunemobius carolinus*
18′. In bogs, marshes, or woods; song without obvious pulsations in intensity, but with either regular, rapid, or else irregular, infrequent breaks 19
19 (18′). In bogs and marshes; song with irregular, obvious breaks every few seconds . . 20
19′. In woods; song with regular, momentary breaks ("catches") recurring several times a second; grayish, spotted species . . . . . *Allonemobius maculatus*
20 (19). In bogs throughout the state; body length under 6 mm; song rather soft and buzzy . . . . . *Neonemobius palustris*
20′. Only known in Berrien County; body length 8-10 mm; song a succession of rather loud, clear trills with occasional separated single pulses audible . . . . . *Eunemobius melodius*

D. IDENTIFYING TRUE AND FALSE KATYDIDS CHIEFLY BY SONG

1. A very loud, harsh, 2- to 3-pulse phrase delivered steadily at about one phrase per second at night from trees; a large, green, convex-winged kitydid . . . . . *Pterophylla camellifolia* (Fig. 24)
1′. Song not as above; if a large, green insect, then with vertical part of forewings flat, not convex (False Katydids) 2
2 (1′). A series of 20-40 loud sharp ticks, repeated rapidly at rates of 3-10 per second, becoming louder and faster as the series progresses, ending abruptly; usually at night only from trees; a large, green katydid (See couplet 4 for this species' other song) . . . . . *Microcentrum rhombifolium* (Fig. 25)
2′. Not fitting above description 3
3 (2′). Simple lisps repeated continually from trees, bushes, or weeds 4
3′. Multi-pulse phrases, buzzes, or rattles from weeds or bushes 6
4 (3). Loud lisps from trees, usually at night only, delivered 2-3 in five seconds; usually from high in trees (See also couplet 2) . . . . . *Microcentrum rhombifolium* (Fig. 25)
4′. Rather soft lisps delivered much more slowly, day or night; a slender green katydid 1/2 inch long 5
5 (4′). Hemlock trees and other conifers . . . . . *Scudderia fasciata*
5′. Bushes and weeds in dry upland areas . . . . . *Scudderia furcata* (Fig. 29)
6 (3′). Groups of rattly buzzes or phrases, 5-15 phrases per group with one long phrase near the end of the group lasting about five seconds; at night in old fields or along woodland borders about 4-5 feet up on weeds and bushes; a small green katydid with a brown basal patch on its forewings . . . . . *Amblycorypha rotundifolia* (Fig. 27)
6′. Single, ragged phrases delivered at a fairly regular pace, or else groups of soft lisps with one phrase much longer than any other 7

7 (6′). A non-uniform phrase beginning with a long pulse that speeds up toward its end, the whole phrase sounding like "zzzzzz-zik-zik" and repeated every few seconds with some regularity; in weeds and bushes at night, usually 4-8 feet above the ground; a large green katydid with a brown basal patch on its forewings . . . . . *Amblycorypha oblongifolia* (Fig. 26)

7′. Not as above; discernible pulses all about alike; no brown patch on forewings, 2-5 feet above ground on weeds and in bushes; slender green katydids . . . 8

8 (7′). Several 1- to 3-pulse phrases spaced about five seconds apart; the pulses in each phrase repeated slowly as if with deliberation at a rate of 2-3 per second (if imagined to be repeated continuously); an individual may start with a 1-pulse phrase then follow with several 2- and 3-pulse phrases . . . . . *Scudderia curvicauda*[5] (Fig. 31)

8′. Individual pulses in each phrase delivered much more rapidly, usually running together 9

9 (8′). 5-8 (uncountable) pulses per phrase, delivered so rapidly that the phrase sounds like one rough note; phrase louder toward its end . . . . . *Scudderia pistillata*[5] (Fig. 30)

9′. 3-21 (usually 3-4) (almost countable) pulses per phrase, delivered rapidly so that the phrase sounds like a pulse series rather than a single rough phrase; seemingly louder toward end of phrase . . . . . *Scudderia texensis*[5]

E. IDENTIFYING CONE-HEADED KATYDIDS CHIEFLY BY SONG

1. Rapidly delivered lisps from old fields; underside of cone on head with only tip and sides black (almost any roadside). . . *Neoconocephalus ensiger* (Fig. 48)

1′. Continuous or broken buzzing; underside of cone on head either nearly all black or all green 2

2 (1′). Buzz broken regularly about three times every five seconds (rare outside Berrien County); underside of cone nearly all black . . *Neoconocephalus nebrascensis*

2′. Buzzes continuous 3

3 (2′). Very loud buzzing; cone all green underneath; rather common along roadsides . . . . . *Neoconocephalus robustus*

3′. A fine, thin buzz from marshes only; underside of cone all black (rare) . . . . . *Neoconocephalus lyristes*

F. IDENTIFYING SHIELD-BACKED KATYDIDS CHIEFLY BY SONG

1. Groups of soft buzzes, the buzzes irregular in length, lasting from 1/2 second up to several minutes; generally distributed across the state; singing from early June to mid-September . . . . . *Atlanticus testaceus* (Fig. 37)

1′. Groups of soft buzzes, the buzzes about 1/2 second long and delivered about one per second at 80°F; known only from several countries north of the Thumb on the Lower Peninsula; singing from July 13 to September 11 . . . . . *Atlanticus davisi*

G. IDENTIFYING MEADOW KATYDIDS CHIEFLY BY SONG

NOTE: The Northern Bush Katydid, because of its complicated "tick-buzz" song, keys out here in the key to subfamilies. It may be identified by the following: a soft, complicated phrase lasting 10-30 seconds a composed of a series of 3-8 clicks followed by a series of "zeeps," beginning in early July, just before

[5]Some bush katydids change their songs under conditions not yet understood, and on occasion one may make a noise very similar to that of another species. These variations are associated with the fact that the females make soft noises back at the males and the males go to the females rather than vice versa (Spooner, 1968).

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

the true katydid, and coming from trees at night; a dark green, small, slender katydid (also see Fig. 28).

NOTE: We have not heard the song of the Prairie Meadow Katydid, *Conocephalus saltans.*

1. Soft, seedy, continuous buzzes audible only a few feet away from grasses and weeds about one foot above the ground; no ticks 2

1′. Either ticks and buzzes or else short phrases; not continuous buzzes; 1-6 feet above the ground 4

2 (1). Buzz changing speed, alternately slowing and speeding up about every 15-30 seconds; in grassy and weedy areas; a tiny greenish or brownish insect. . . . . *Conocephalus strictus*

2′. Buzz not changing speed, but continuing uniformly for indefinite periods; only around marshes 3

3 (2′). Strikingly marked in black and yellowish . . . . . *Conocephalus nigropleurum*

3′. Tan-colored or brownish . . . . . *Conocephalus attenuatus*

4 (1′). Song definitely composed of ticks delivered slowly enough to be counted (or at least clearly distinguished) and buzzes that last one second or more 5

4′. Song composed either of buzzes without ticks, or of buzzes with ticks attached to their front ends, the ticks delivered so rapidly that they can barely be distinguished from the regular part of the buzz; 2-6 buzzes per five seconds 11

5 (4). Usually 2-4 ticks per buzz; buzzes lasting less than five seconds; in marshy areas, two feet above the ground 6

5′. More than 4 ticks per buzz, buzzes lasting more than five seconds; in marshes, fields, pastures, lawns; 2-6 feet above the ground 8

6 (5). 3-5 complete phrases in five seconds; very soft sound usually less than a foot above the ground in pastures, lawns, fields; insect tiny with forewings not reaching tip of abdomen . . . . . *Conocephalus brevipennis* (Fig. 39)

6′. Complete phrases each lasting more than two seconds; usually about two feet above the ground in marshy areas; forewings usually reaching beyond tip of abdomen 7

7 (6′). Face usually green laterally and with a red center stripe. *Orchelimum concinnum*

7′. Face usually green without a stripe . . . . . *Orchelimum delicatum*

8 (5′). Loud sounds, noticeable several yards away; usually more than two feet above the ground 9

8′. Soft sound, noticeable only a few feet away; usually less than two feet above the ground; 10-30-second buzzes, with 10-25 ticks between them; a tiny, slender, long-winged insect . . . . . *Conocephalus fasciatus* (Fig. 40)

9 (8). Buzzes lasting 15-30 seconds; often several buzzes repeated without intervening ticks; only in marshy areas; face splotched with red, but central part usually pale . . . . . *Orchelimum campestre*

9′. Buzzes never much over five seconds in length; usually ticks between buzzes every time; face green 10

10 (9′). Beginning in late June or early July; in marshy areas only; buzzes not noticeably louder toward their ends, Males may omit the ticks from their songs at night. . . . . *Orchelimum gladiator*

10′. Beginning in late July; in grassy, weedy, marshy areas; buzzes noticeably getting louder toward their ends . . . . . *Orchelimum velgare* (Fig. 38)

11 (4′). Each buzz slowing toward its end; in marshes only. . . . . *Orchelimum volantum*

11′. Buzzes not noticeably slowing toward their ends 12

12 (11′). Soft buzzes from about one foot above the ground in or near woodland; a tiny, brown, short-winged insect; some buzzes with a slightly noticeable preface of ticks so rapidly delivered that the buzz sounds like the roll of a miniature drum. . . . . *Conocephalus nemoralis*

12′. Louder buzzes, each prefaced by 2-3 very rapidly delivered ticks; in marshy areas; insect blue-green with blackish hind legs . . . . . *Orchelimum nigripes*

KEYS FOR IDENTIFYING MICHIGAN'S SINGING INSECTS BY SPECIMEN ALONE

H. IDENTIFYING FAMILIES BY SPECIMENS ALONE

1. Enlarged jumping hind legs; no beak; wings usually opaque or translucent (Orthoptera) 2
1′. Hind legs similar in size to others; beak extending from back of head ventrally; wings largely transparent (Cicadas) . . . . . I (page 46)
2 (1). Antennae with fewer than 30 segments and usually less than half body length; cerci (hind end feelers) very short and not obvious; tarsi 3-segmented (Locusts) . . . . . L (page 52)
2′. Antennae with more than 30 segments and (except in mole crickets) longer than body; cerci either long, pointed, tactual devices or forceps-like; tarsi 3- or 4-segmented 3
3 (2′). Tarsi 3-segmented; cerci long, pointed, tactual devices with knobbed setae internally near their bases; most of forewings horizontal (Crickets). J (page 47)
3′. Tarsi 4-segmented; cerci forceps-like without knobbed setae; usually most of forewings vertical (Katydids) . . . . . K (page 49)

I. IDENTIFYING CICADA SPECIMENS

1. Wing veins reddish; body black and reddish; timbals (dark-ribbed convex sound-producing organs on sides of abdomen) of males exposed (Fig.5) 2
1′. Wing veins and body greenish or brown and black; timbals of male covered . . 5
2 (1). Pronotum, viewed from above, all black except for lateral margins (Fig. 1); eyes reddish 3
2′. Pronotum, viewed from above, usually with some pale (orange or reddish) marking, especially along rear border (Fig. 2); eyes dark, not reddish 4
3 (2). Ventral abdomen usually all black (rare if present at all in Michigan) . . . . . *Magicicada cassini*
3′. Ventral abdomen always marked with reddish or brownish . . . . . *Magicicada septendecim* (Fig. 1)
4 (2′). UP only; male with 10-11 timbal ribs (Figs, 5-6); second abdominal segment black dorsally . . . . . *Okanagana canadensis*
4′. Up and LP; male with 7-8 (rarely 9) timbal ribs (Fig. 7); second abdominal segment red dorsally . . . . . *Okanagana rimosa* (Fig. 2)
5 (1′). Body length 33-38 mm; first cross-vein in forewing originating 1/3-1/2 of the way out on first marginal cell; known only from Berrien County. . . . . *Diceroprocta vitripennis* (Fig. 3)
5′. Body length 37-72; first cross-vein in forewing originating about 1/4 of the way out on first marginal cell; not restricted to Berrien County 6
6 (5′). Wing length over 45 mm; pronotal collar brown; abdomen more or less unicolorous beneath, often pruinose (covered with a grayish "bloom"). . . . . *Tibicen auletes*
6′. Wing length under 45 mm; pronotal collar black, brown, or green; abdomen beneath with or without a dark mid-line 7
7 (6′). Pronotal collar largely or entirely black 8
7′. Pronotal collar brown or green. 9
8 (7). Abdomen beneath with mid-line only slightly darker than rest, sometimes only at base of each sternite; pronotal shoulder patches large, solid green; mesonotum largely black . . . . . *Tibicen chloromera*
8′. Abdomen beneath with a broad, shining black stripe down mid-line; shoulders and pronotum largely black or mesonotum heavily patterned with green or brown . . . . . *Tibicen lyricen* (Fig. 4)
9 (7′). Wing length usually over 40 mm; costal (anterior) margin or forewing decidedly more bent near its center than elsewhere, so that, if vein M + R is projected

by holding a ruler over it, it crosses SC before SC coalesces with C near the tip of the wing (Fig. 8) . . . . . *Tibicen linnei*

9′. Wing length usually under 40 mm; costal margin of forewing only slightly curved and forming a nearly symmetrical arc, so that ruler held to projected vein M + R passes behind the coalescence of SC and C near tip of wing (Fig. 9) . . . . . *Tibicen canicularis*

J. IDENTIFYING CRICKET SPECIMENS

1. Front legs enlarged and shovel-like, much stouter than middle legs; head horizontal, much narrower than pronotum and narrowing anteriorly toward mouthparts . . . . . *Neocurtilla hexadactyla* (Fig. 10)

1′. Front legs not enlarged and shovel-like not noticeably stouter than middle legs; otherwise not necessarily as above. 2

2 (1′). Hind tarsus with the long basal segment having a false joint about midway, giving the impression that the tarsus is 4-segmented (Fig. 14); head more or less horizontal, longer than pronotum when viewed from above; foretibiae with large oval tympana on both internal and external faces, the inner one a little longer 3

2′. Hind tarsus without a false joint on the basal segment and clearly only 3-segmented; otherwise not necessarily as above 12

3 (2). Hind tibiae with apical spurs only; first antennal segment not marked with black ventrally and with a small prominent tubercle on distal border. . . . . *Neoxabea bipunctata*

3′. Hind tibiae with several non-apical long spurs and many shorter spines; first antennal segment frequently marked with black ventrally and without a prominent tubercle on distal border. 4

4 (3′). Inner edge of ventral face of first antennal segment with a pale swelling marked with black (Figs. 15-17); stridulatory file with fewer than 30 teeth per mm of length 5

4′. Inner edge of ventral face of first antennal segment without a pale swelling but segment marked with black (Figs. 18-23); stridulatory file frequently with more than 30 teeth per mm of length 7

5. Black mark on first antennal segment round or oval (occasionally a second black mark near distal border of segment); second antennal segment usually with a similar mark (Fig. 15); width of dorsal field of male forewings more than four-tenths of length; more than 35 teeth in stridulatory file. . . . . *Oecanthus fultoni*

5′. Black mark on first antennal segment neither round nor oval; second segment with an elongate black mark; width of dorsal field of male forewings frequently less than four-tenths of length; fewer than 35 teeth in stridulatory file 6

6 (5′). Mark on first antennal segment straight (rarely slightly curved) (Fig. 16); no prominent orange markings on vertex; length of male forewings 12-15 mm; file teeth more widely spaced (19-23.4 teeth per mm). . . . . *Oecanthus exclamationis*

6′. Mark on first antennal segment strongly curved toward the inner side or J-shaped (Fig. 17); vertex yellow or orange (in fresh specimens); length of male forewings 9.8-12.2 mm; file teeth less widely spaced (23.7-29.7 teeth per mm) . . . . . *Oecanthus niveus*

7 (4′). Pronotum black or with one, two, or three black or suffused-blackish longitudinal stripes; venter and distal portions of legs and antennae black . . . . . *Oecanthus nigricornis* (part)

7′. Pronotum never black, never with black or suffused-blackish stripes (except that *laricis* may have brown stripes with the lateral ones somewhat blackish); venter and distal portions of legs and antennae sometimes suffused-blackish or brown but never black 8

8 (7′). Head, pronotum, and legs largely brownish or blackish; forewings a contrasting bright green or dark green in fresh specimens; found only in or (rarely) beneath conifers 9

8′. Head, pronotum, and legs without much brown pigment and not contrasting in color with the forewings; almost never found in conifers 10

9 (8). In larches and planted conifers in southeastern and south central Michigan; dark coloration blackish . . . . . *Oecanthus laricis*

9′. In pines in Berrien County only; dark coloration reddish-brown . . *Oecanthus pini*

10 (8′). Black marks on second antennal segments confluent, contiguous, or separated by no more than one-third the width of the inside mark (Fig. 22); may be found in Michigan through no records yet exist. . . . . *Oecanthus argentinus*

10′. Black marks on second antennal segment separated by more than one-third the width of the inside mark 11

11 (10′). Outside marks on first and second antennal segments usually less heavily pigmented than inside marks (sometimes they are missing, and rarely they are as heavily pigmented as the inside marks); outside mark on first segment often round (Fig. 23); tibiae and apex of hind femur usually without conspicuous dark markings; more than 47 teeth in stridulatory file. . . . . *Oecanthus quadripunctatus*

11′. Outside marks on first and second antennal segments as heavily pigmented as inside ones; outside mark on first segment never round (Figs. 18-19); tibiae and apex of hind femur usually with conspicuous dark markings; fewer than 47 teeth in stridulatory file . . . . . *Oecanthus nigricornis* (part)

12 (2′). Head with prominent dorsal bristles; spurs of hind tibiae long, slender, hairy, usually cylindrical; in most species some non-apical spurs are nearly as long as basal tarsal segment; body length usually under 10 mm 13

12′. Head without prominent dorsal bristles; spurs of hind tibiae are not as above, but stout, often emarginate, and none approaching length of basal tarsal segment; body length usually over 10 mm 21

13 (12). Second tarsal segment depressed and with a prominent adhesive pad (Fig. 11); hind tibia as long as hind femur or longer . . . . . *Anaxipha exigua* (Fig. 11)

13′. Second tarsal segment compressed and without a noticeable adhesive pad (Fig. 12); hind tibia shorter than hind femur 14

14 (13′). Ventral apical internal and external spurs of hind tibiae equal or nearly equal in length; spurs of hind tibiae without teeth on their ventral margins; ovipositor of female with teeth on the ventral valve 15

14′. Ventral apical internal and external spurs of hind tibiae unequal in length; spurs of hind tibiae with rows of tiny teeth on their ventral margins; ovipositor of female without teeth on the ventral value 16

15 (14). Male with fewer than 75 teeth on the stridulatory file; female with ovipositor less than 3.5 mm long. . . . . *Neonemobius carolinus*

15′. Male with more than 100 teeth on the stridulatory file; female with ovipositor more than 4.5 mm long. . . . . *Neonemobius melodius*

16 (14′). Size larger, hind femora of males 4.8-7.6 mm, females, 4.9-8.0 mm; face or dorsal head nearly always with distinct markings; ovipositor of female straight, nearly as long as or longer than the hind femora 17

16′. Size smaller, hind femora of males 3.9-5.8 mm, females 4.0-6.7 mm; face and dorsal head nearly always unicolorous; ovipositor of female gently curved, no more than 2/3 as long as hind femora . . . . . *Neonemobius palustris*

17 (16). Face below the antennae shining black; general color with a grayish suffusion; lateral margins of dorsal field of male tegmina narrowly yellow . . . . . *Allonemobius griseus*

17′. Face below the antennae not a shining black; general color without a noticeable grayish suffusion 18

18 (17′). Black markings, especially in females, scattered to give a mottled appearance . . . . . *Allonemobius maculatus*

18′. Black markings of body not scattered in blotches and dashes to give a mottled appearance. 19

19 (18′). Head and pronotal coloration usually a strong patterning of dark brown or black with light yellowish; dorsal head well-rounded and full; pronotum in short-winged specimens barrel-shaped, so that head and front edge of pronotum are usually as wide as or wider than rear edge of pronotum; hind wings either long or short; ovipositor of females 5.9-10.0 mm in length, over 7.5 mm only in the specimens with head width behind eyes over 2.6 mm; stridulatory vein on right forewing of male bearing only 100-150 teeth and with portion inside ulnar vein (a lateral longitudinal vein, connecting to the stridulum from behind) less than 1.0 mm long and less than one-third as long as width of head behind eyes . . . . . *Allonemobius fasciatus*

19′. Head and pronotal color either sandy-reddish or dark reddish-brown or black; dorsal head striping faint or absent; head narrow and restricted; pronotum in both long-winged and short-winged specimens trapezoidal, narrower in front so that head and front of pronotum are noticeably narrower than rear edge of pronotum; ovipositor of females 6.0-10.3 mm in length; head width behind eyes in females not over 2.8 mm; stridulatory vein on right forewing of male bearing more than 160 teeth, and with portion inside ulnar vein rarely under 1.0 mm in length and more than two-fifths as long as width of head behind eyes 20

20 (19′). General coloration pale and reddish, especially dorsal surface of head; specimens with long hind wings extending beyond tips of forewings are not known; in woodlands and leaf litter . . . . . *Allonemobius tinnulus*

20′. General coloration red-brown to black; dorsal head striping usually faintly visible, and head sandy-reddish only in some specimens from sandy areas around the Great Lakes; with hind wings long or short; in grasslands . . . . . *Allonemobius allardi* (Fig. 12)

21 (12′). General coloration yellowish or brown with a dark transverse bar between the compound eyes; only in or near houses . . . . . *Acheta domesticus*

21′. General coloration black, head black, nearly always without noticeable markings; forewings sometimes brown, appendages and face sometimes with pale markings, in grassy fields 22

22 (21′). Adult from May to middle or late July; overwintering as a half-grown, juvenile; female ovipositor averaging shorter, but overlapping that of following species . . . . . *Gryllus veletis*

22′. Adult from late July until frost; overwintering as an egg; female ovipositor averaging longer but overlapping that of previous species . . . . . *Gryllus pennsylvanicus* (Fig. 13)

K. IDENTIFYING KATYDID SPECIMENS

1. Dorsal surface of first tarsal segment laterally grooved; usually with spines between bases of forelegs; front wings about as long as or longer than hind wings 2

1′. Dorsal surface of first tarsal segment smoothly rounded; no spines between bases of forelegs; hind wings longer than front wings, or front wings obliquely truncate at apex 3

2 (1). Pronotum about as long as wide, and with two transverse grooves; front wings usually broadly oval and convex; mesal (inner) margins of antennal sockets elevated and ridgelike, and extending nearly or quite to dorsal surface of vertex . . . . . *Pterophylla camellifolia* (Fig. 24)

2′. Pronotum longer than wide, and with only one transverse groove or none; shape of forewings variable, but usually not broadly oval and convex; mesal margins of antennal sockets not particularly ridgelike, and rarely approaching dorsal part of vertex 11

3 (1′). Forewings broad, 7/22 as wide as long or wider; top of head and face forming an obtuse angle; space between bases of antennae usually twice or more than twice as wide as first antennal joint 4

3′. Forewings long, narrow, 5/19 as wide as long or narrower; top of head and face forming an acute angle; space between bases of antennae scarcely or not wider than basal joint of antennae 6

4 (3). Hind femora not reaching beyond apical third of forewings; fore and middle tibiae smooth and rounded above without angular margins; ovipositor short, bent abruptly upward, finely or not at all serrate. . . . . *Microcentrum rhombifolium* (Fig. 25)

4′. Hind femora reaching to or beyond apical fourth of forewings; fore and middle tibiae flat or angled above, their margins raised, acute; ovipositor long, curved gradually upward, usually strongly serrate on both edges 5

5 (4′). Forewings 30-40 mm long, lobes between bases of hind legs longer than broad, their hind margins narrowly rounded or pointed . . . . . *Amblycorypha oblongifolia* (Fig. 26)

5′. Forewings 23-27 mm long, lobes between bases of hind legs broader than long, their hind margins rather broadly rounded. . . . . *Amblycorypha rotundifolia* (Fig. 27)

6 (3′). Last dorsal abdominal segment of male slightly produced centrally, without a central notch or fork (Fig. 32); cerci tapering more or less smoothly toward tip; forewings rather broad, dull, with swollen veinlets; ovipositor with both margins curved, not bent, more than 1-1/2 times length of pronotum. . . . . *Scudderia septentrionalis* (Fig. 28)

6′. Last dorsal abdominal segment of male with a long median process notched or forked at tip; cerci with a thickened region, not tapering smoothly; ovipositor bent as well as curved, less than 1-1/2 times length of pronotum . . 7

7 (6′). Apical fork of dorsal abdominal process of male with fork much wider than deep with a central tooth (Fig. 33) . . . . . *Scudderia texensis*

7′. Apical fork of dorsal abdominal process of male U-shaped or V-shaped and as deep as wide or deeper, with no central teeth 8

8 (7′). Dorsal abdominal process of male with arms of apical fork about as long as central basal portion, notch U-shaped (Fig. 34) 9

8′. Dorsal abdominal process of male with arms of apical fork shorter than central basal portion, notch V-shaped (Figs. 35-36) 10

9 (8). Known only from Berrien County; living chiefly in coniferous trees; forewings with a blackish stripe along the upper (medial) edge, sometimes with blackish or purplish regions elsewhere on the wings and body . . . *Scudderia fasciata*

9′. Known throughout the state; living in weeds and deciduous trees; forewings without blackish stripes, more or less uniform green . . . . . *Scudderia furcata* (Fig. 29)

10 (8′). Lobes or lateral projections of dorsal abdominal process (each side of notch), viewed from above, narrow and distinctly tapering apically (Fig. 35); forewings not over four times longer than wide . . . *Scudderia pistillata* (Fig. 30)

10′. Lobes or lateral projections of dorsal abdominal process, viewed from above, rounded (Fig. 36); forewings about five times longer than wide or longer . . . . . *Scudderia curvicauda* (Fig. 31)

11 (2′). Head between bases of antennae forming a long tapering cone, extending well beyond basal antennal segment 12

11′. Head between bases of antennae usually not conical and not extending beyond basal antennal segment in any case 15

12 (11). Lower surface of cone without black coloration or black only at tip (Fig. 49). . . . . *Neoconocephalus robustus*

12′. Lower surface of cone either almost entirely black, or black at tip and along margins (Figs. 50-52) 13

13 (12′). Lower surface of cone black only at tip and along margins (Fig. 50) . . . . . *Neoconocephalus ensiger* (Fig. 48)

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

13′. Lower surface of cone wholly or nearly wholly black (Figs. 51-52) 14

14 (13′). First ten teeth on lateral end of male stridulatory file nearly as widely spaced as next ten, occupying 0.4-0.5 mm; forewing 3.57 to 4.21 times as long as wide . . . . . *Neoconocephalus nebrascensis*

14′. First ten teeth on lateral end of stridulatory file much more closely spaced than next ten teeth, occupying about 0.25 mm; forewing 4.23 to 4.65 times as long as wide . . . . . *Neoconocephalus lyristes*

15 (11′). One or more spines on dorsal surface of front tibia; pronotum extending back to abdomen; hind wings usually greatly reduced; forewings usually gray, brown, or spotted and never reaching tip of abdomen 16

15′. No spines on dorsal surface of front tibia; pronotum never extending back to abdomen; hind wings always well developed; forewings usually green and in most species reaching beyond tip of abdomen 17

16 (15). Exposed part of male forewings, as viewed from above, more than half length of pronotum; the two lateral portions of subgenital plate of female almost semicircular, not triangular . . . . . .*Atlanticus testaceus* (Fig. 37)

16′. Exposed part of male forewings, as viewed from above, less than half length of pronotum; the two lateral portions of subgenital plate of female somewhat triangular. . . . . *Atlanticus davisi*

17 (15′). Body usually more than 18 mm in length; forewings reaching past tip of abdomen; spines between bases of forelegs rather long, cylindrical, slender; ovipositor stouter, usually distinctly scimitar-shaped, or upcurved 18

17′. Body usually less than 17 mm in length; forewings shorter than abdomen in most species; spines between bases of forelegs very short or absent; ovipositor slender, straight or nearly so 24

18 (17). Apical portion of male cercus behind the median tooth not much if any longer than the basal portion in front of it (Fig. 41-43); ovipositor in the majority of the species not distinctly more than half as long as hind femur and (except in *gladiator*) with upper margin always evidently and regularly curved 19

18′. Apical portion of male cercus behind the tooth distinctly longer than the portion in front of it (Fig. 44); ovipositor (except rarely in *concinnum*) distinctly more than half as long as hind femur, its upper margin either straight or curved 21

19 (18). Tibiae blackish; upper surface of male cercus with a distinct obtuse sinuate carina (Fig. 41) . . . . . *Orchelimum nigripes*

19′. Tibiae not blackish; upper surface of male cercus without a distinct sinuate carina 20

20 (19′). Tooth of male's cercus shorter than apical half of shaft (Fig. 42); ovipositor less than half the length of hind femur, its upper margin distinctly curved . . . . . .*Orchelimum vulgare* (Fig. 38)

20′. Tooth of male's cercus as long as apical half of shaft (Fig. 43); ovipositor almost two-thirds as long as hind femur, its upper margin nearly straight . . . . . *Orchelimum gladiator*

21 (18′). Apical portion of male's cercus distinctly and strongly tapering to a narrow but not sharp tip; upper margin of ovipositor straight or nearly so . . . . . *Orchelimum volantum*

21′. Apical portion of male cercus not strongly tapering to a sharp tip; upper margin of ovipositor (except in *delicatum*) regularly and evenly curved 22

22 (21′). Face green with few or no reddish markings except scattered tiny flecks of reddish and rarely a brownish central area . . . . . .*Orchelimum delicatum*

22′. Face with prominent red central stripe or prominent network of red lines laterally or both 23

23 (22′). Face with a central red stripe and otherwise without prominent reddish areas on the face . . . . . *Orchelimum concinnum*

23′. Face with prominent networks of red lines at sides, central part usually unmarked, rarely a red vertical mark. . . . . .*Orchelimum campestre*

24 (17′). Hind tibia with one pair of apical spurs; prosternum without spines; forewings pad-like, scarcely longer than pronotum; hind femora unarmed beneath; face with a medium reddish-brown stripe or blotch . . . . . *Conocephalus saltans*

24′. Hind tibia with two or three pairs of apical spurs; prosternum with two spines; forewings (except in female of *strictus*) always distinctly longer than the pronotum 25

25 (24′). Male cercus swollen at middle and armed on underside with a slender tooth, the base of which is scarcely visible from above (Fig. 45); apical portion of cercus strongly flattened; hind femora very rarely unarmed beneath. 26

25′. Male cercus armed in inner margin near middle with a stout tooth, the base of which is plainly visible from above; hind femora very rarely armed beneath 27

26 (25). Sides of abdomen shining black . . . . . *Conocephalus nigropleurum*

26′. Sides of abdomen not shining black . . . . . *Conocephalus attenuatus*

27 (25′). Apical portion of male cercus dished out, i.e., with dorsal surface concave in cross-section (Fig. 46); ovipositor shorter than body and with upper margin straight. 28

27′. Apical portion of male cercus somewhat flattened and upturned, but with dorsal surface convex in cross-section (Fig. 47); ovipositor either longer than body or, if shorter, with upper margin curved 29

28 (27). Forewings longer than abdomen; hind wings longer than forewings . . . . . *Conocephalus fasciatus* (Fig. 40)

28′. Forewings and hind wings both shorter than abdomen . . . . . *Conocephalus brevipennis* (Fig. 39)

29 (27′). Ovipositor shorter than hind femur; male cercus with flattened apical portion no longer than tooth; general color smoky or greenish brown . . . . . *Conocephalus nemoralis*

29′. Ovipositor much longer than hind femur, male cercus with flattened apical portion 1 1/2 - 2 times length of tooth (Fig. 47); general color green . . . . . *Conocephalus strictus*

L. IDENTIFYING LOCUST SPECIMENS

1. Pronotum covering abdomen (no prominently acoustical species) . . . Tetrigidae

1′. Pronotum not covering abdomen (Acrididae) 2

2 (1′). Ventral surface of first thoracic segment (prosternum) with a prominent spine (no prominently acoustical species) . . . Cyrtacanthacridinae and Melanoplinae

2′. Ventral surface of first thoracic segment without a prominent spine (Band-winged grasshoppers and Slant-faced grasshoppers) 3

3 (2′). Face in lateral view slanting backwards forming an acute angle with the dorsum; posterior margin of pronotum centrally rounded, truncate, or very obtusely angulate (Fig. 54) (Slant-faced grasshoppers) 4

3′. Face in lateral view rounded and not strongly slanted backwards, face above antennae forming approximately a right angle with top of head, or an obtuse angle; posterior margin of pronotum usually forming a right or acute angle (Fig. 53) (Band-winged grasshoppers) 15

4 (3). Lateral carinae of pronotum, viewed from above, straight and parallel 5

4′. Lateral carinae of pronotum, viewed from above, not straight and parallel, at least slightly incurved in middle, and often strongly divergent posteriorly. . 7

5 (4). Third antennal segment about as broad as first segment 6

5′. Third antennal segment distinctly narrower than first segment . . . . . *Dichromorpha viridis*

6 (5). Forewings not extending beyond end of abdomen, usually much shorter; body color brown . . . . . *Pseudopomala brachyptera*

6′. Forewings extending beyond end of abdomen; dorsal surfaces of male distinctly lighter than lateral surfaces, usually green . . . . . *Metaleptea brevicornis*

7 (4′). Lower surfaces of hind femora bright red and hind tibiae yellow 8

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

7′. Lower surfaces of hind femora not bright red, if reddish, then hind tibiae are equally red 9

8 (7). Lower edge of folded forewing with light yellow or yellowish-green stripe . . . . . *Stethophyma lineatum*

8′. Lower edge of folded forewing without distinct light stripe, tegmina uniformly colored . . . . . *Stethophyma gracile*

9 (7′). Vertex, viewed from above, having two lateral carinae, one on each side, converging anteriorly 10

9′. Vertex, viewed from above, apparently with four lateral carinae, two on each side, converging anteriorly, so as to frame a small oblong depression in front of each compound eye 14

10 (9). Antennae broad and flattened; third antennal segment broader than second though usually not as broad as the first segment; males distinctly smaller than females 11

10′. Antennae nearly filiform, only slightly flattened; third antennal segment no broader than second and distinctly narrower than first; sexes about equal in size 13

11 (10). Hind tibia with 18 or more spines on outer margin. . . . . *Syrbula admirabilis*

11′. Hind tibia with 15 or fewer spines on outer margin 12

12 (11′). Both sexes usually with shiny black patch on abdomen around area of tympanum; male with lateral lobes of pronotum uniformly black and with antennae at least 1 1/2 times length of head and pronotum together . . . . . *Chloealtis conspersa*

12′. Neither sex with shiny black patch around tympanum; male with lateral lobes of pronotum brown dorsally, usually lighter below and with antennae only 1/3 longer than head and pronotum together . . . . . *Chloealtis abdominalis*

13 (10′). Lateral carinae of pronotum only slightly incurved, smallest distance between them more than 2/3 greatest distance (Fig. 55) . . . . . *Orphulella speciosa*

13′. Lateral carinae of pronotum strongly incurved, smallest distance between them less than 2/3 greatest distance (Fig. 56) . . . . . *Orphulella pelidna*

14 (9′). Hind femur more than five times as long as wide, and without dark markings near tip; body color greenish. . . . . *Chorthippus curtipennis* (Fig. 54)

14′. Hind femur less than five times as long as wide and with dark markings on lateral and dorsal surfaces; body color grayish, speckled with black . . . . . *Ageneotettix deorum*

15 (3′). Median ridge of pronotum without a notch or with only one notch (very rarely with two notches) 16

15′. Median ridge of pronotum with two notches, the posterior one usually more distinct. 28

16 (15). Dorsolateral margin of folded forewing with a pale stripe; tegmen otherwise speckled or spotted 17

16′. Dorsolateral margin of folded forewing usually without a pale stripe; or when it has one, lateral surface is dorsally brown and ventrally green, or else solid brown 19

17 (16). Hind wings colored red or yellow (*Pardalophora*) 18

17′. Hind wings clear 27

18 (17). Forewing with five or more large, fairly distinct spots; hind tibiae usually red or orange . . . . . *Pardalophora haldemanii*

18′. Forewing indistinctly spotted, at most with three or fewer large spots; hind tibiae usually yellow, rarely reddish . . . . . *Pardalophora apiculata*

19 (16′). Hind wings black with a pale border . . . . . *Dissosteira carolina*

19′. Hind wings yellow, orange, or red (rarely clear) with a dark border 20

20 (19′). Hind tibiae wholly or partially red or orange (in old faded specimens yellowish); head and pronotum mottled 21

20′. Hind tibiae without any red or orange; head and pronotum usually uniformly dark 23

21 (20). Rear margin of pronotum forming a right or obtuse angle; most specimens strikingly mottled with ivory and black; head in side view higher than pronotum; hind tibia banded with reddish, black, and yellowish . . . . . *Scirtetica marmorata*

21′. Rear margin of pronotum forming an acute angle; mottling usually not so striking, in yellowish and dark brown; hind tibia not necessarily as above .22

22 (21′). Hind tibia banded with reddish, black, and yellowish . . . . . *Spharagemon bolli*

22′. Hind tibia orange or reddish, without black band . . . . . *Spharagemon collare*

23 (20′). Hind wing with a yellow, orange, or red proximal portion and a very distinct outer dark band; lateral surface of folded forewing unicolorous, without broad light and dark areas 24

23′. Hind wing with a pale, greenish-yellow proximal region and without a distinct outer band; lateral surface of folded forewing with dark markings or with distinct light and dark areas 26

24 (23). Facial ridge between antennae (frons) narrowing slightly or not at all above the antennae, at narrowest point more than half its width between the antennae (Fig. 57); adult season 10 July - 28 September 25

24′. Facial ridge between antennae narrowing sharply above the antennae, at narrowest point less than half its width between the antennae (Fig. 58); adult season 9 May - 2 August . . . . . *Arphia sulphurea*

25 (24). Median carina of pronotum high, sharp, its silhouette rounded in side view and lacking any notch, though sometimes slightly sinuate; proximal portion of hind wing yellow (never red). . . . . *Arphia xanthoptera*

25′. Median carina of pronotum low, not very prominent, its silhouette in side view with a notch just before the halfway point; proximal portion of hind wing usually red (rarely yellow) . . . . . *Arphia pseudonietana*

26 (23′). Hind margin of pronotum forming an acute angle (viewed from above); width of pronotum less than the length . . . . . *Chortophage viridifasciata*

26′. Hind margin of pronotum forming a right angle or an obtuse angle; width of pronotum equal to or greater than the length of the pronotum . . . . . *Encoptolophus sordidus*

27 (17′). Lateral surfaces of head, pronotum, and folded forewings with large, dark blotches; hind margin of pronotum forming an obtuse angle. . *Camnula pellucida*

27′. Lateral surfaces of head, pronotum, and forewings without conspicuous large dark blotches, hind margin of pronotum forming an acute angle . . . . . *Chortophaga viridifasciata*

28 (15′). Top of head in lateral view much higher than top of pronotum 29

28′. Top of head in lateral view nearly level with top of pronotum 30

29 (28). Proximal area of hind wing reddish orange . . . . . *Psinidia fenestralis*

29′. Proximal area of hind wing yellow . . . . . *Trachyrhachys kiowa*

30 (28′). Cells in tip of hind wing darkly pigmented . . . . . *Trimerotropis verruculata*

30′. Cells in tip of hind wing clear 31

31 (30′). Proximal half of inside of hind femur entirely dark; distal half with one or two narrow light bands . . . . . *Trimerotropis huroniana*

31′. Proximal quarter of inside of hind femur distinctly lighter than the rest of the proximal half; distal half with two wide light bands (wider than the dark bands) . . . . . *Trimerotropis maritima interior*

DISCUSSION BY R.D.A. OF SOME PREVIOUSLY PUBLISHED DISTRIBUTION RECORDS

1. Although specimens of *Neoconocephalus nebrascensis* have been taken in Michigan only from Berrien County (Cantrall, 1968), I have on two occasions, and Dr. Charles F. Walker of the University of Michigan Museum of Zoology (pers. comm.) has on one occasion, heard single males singing in or near Ann Arbor, Washtenaw County, in August. The song is unmistakable and was clearly heard by me on both occasions. These are almost surely flying immigrants that have failed so far to establish breeding

colonies; one of the males I heard was singing on a pole below a street light in downtown Ann Arbor. If Berrien County is the nearest Michigan population, then these individuals seem most likely to be immigrants from Ohio or eastern Indiana populations.

2. Moore (1966) gives Genesee County as the southermost record for *Okanagana rimosa* in the eastern Lower Peninsula, but on 24 June 1967, I heard two males near my home (5530 Warren Road) eight miles northeast of Ann Arbor, Michigan, and collected one male, deposited in the the University of Michigan Museum of Zoology. On 6 June 1971 I heard two males in Superior Township, Washtenaw County, Michigan, on the southwest corner of the junction of Cherry Hill and Harris Roads. These isolated records may be owing to nymphs transported on nursery stock. A nursery is located about a mile east of the second locality, and several balled spruce trees had been set out near the first site two years earlier. Moore also lists a Berrien County record. The basis for this isolated record is not clear; if it is a song record, some doubt must exist, in the absence of an analyzable tape recording, because of the similarity between the song and this species and that of *Diceroprocta vitripennis.*
3. Moore (1966) lists *Magicicada cassini* on the basis of a single specimen "found amid several quarts of specimens collected 21 June 1936 in Ann Arbor (Brood X) by I. J. Cantrall." Cantrall collected these specimens in Eberwhite Woods. In 1970 this population appeared to be extinct, and the specimen identified as *cassini* by Moore is apparently lost from the collection at the UMMZ. Visits by Moore and me to numerous populations of *M. septendecim* around Ann Arbor during the 1970 emergence of Brood X gave no indication, by song listening or examination of specimens, that *cassini* is present in this locale. This record seems doubtful, and *cassini* may be absent from Michigan.
4. *Tibicen chloromera* is recorded by Moore (1966) from three countries in southeastern Michigan: Lenawee, Washtenaw, and Ingham. A single male is present in the UMMZ collection, labelled Washtenaw County, July 1962, H. Westers. This specimen, according to Moore (pers. comm.) was submitted in a student collection, taken from inside an automobile by a resident of the Whitmore Lake region, on the west side of the lake. This specimen seems old, and it has apparently been hollowed out by dermestids, and possibly relabelled. Though I have lived in Washtenaw County for 13 years, I have not heard this species in Michigan. On the basis of these data, I am inclined to doubt that breeding colonies exist in the state, at least north of Lenawee County.

NEW MICHIGAN RECORDS

All of the following records are from trips made by R. D. Alexander.

1. On 28 August 1971, Warren Dunes State Park in Berrien County, Michigan, was visited in late afternoon before and just after sundown. In a small population of young white pines down the slope from larger pines (probably jack pines), males of *Oecanthus pini* were heard singing within a few minutes after arrival, sporadically in the daylight. One tree in which a male was heard was climbed, and the male was eventually located on the main trunk of the tree and collected. On 3 September this locale was revisited. Again, *pini* was heard within a few minutes in late afternoon, though sporadically until dark. After dark two males and two females were collected, and two other males and female seen and missed. A katydid species tentatively identified as *Scudderia fasciata* was abundant, one juvenile and two adults being collected before dark (juvenile later matured in laboratory). Where this specimens are actually conspecific with New York, Ohio, and Ontario specimens is problematical; but the presence of *Oecanthus pini* in all three locations along with pine-inhabiting *Scudderia* suggests that this is the case.
2. On 28 August 1971, a bog west of Coloma, Michigan, in Berrien County was visited after dark. A single large white pine on the slope along the west side of the bog had no *O. pini* singing in it during about 15 minutes of listening. A clump of tamarack trees out

in the bog had no *O. laricis* singing in it during about 20 minutes of listening. *Eunemobius melodius* was heard on the sphagnum in the bog and two males and a juvenile female (later natured in the laboratory) were collected. Except for Clare and Roscommon Counties in central Michigan, this was the only locality in which white pine and tamarack were examined in close proximity.

3. On 29 August 1971 between late afternoon and about 11 PM, a listening trip was made through the coniferous forests of Clare and Roscommon Counties, Michigan, extending approximately 25 miles from the first tamaracks a few miles north of the I-75-27 interchange north of Clare north along Old Route 27. The northward half of the trip took place largely before dark, the return trip all after dark. Listening speed was 20-30 miles per hour, slow enough to distinguish small populations of *Oecanthus nigricornis* singing in alders 100 feet from the highway from *O. quadripunctatus* singing on low weeds nearer the highway, and slow enough to detect single individuals of *O. quadripunctatus* several times singing in herbaceous vegetation under conifers back inside the woods 50-100 feet. No tree crickets were heard in white pine, spruce, tamarack, jack pine, red pine, hemlock, white cedar, or red cedar. Neither were tree crickets heard singing in the deciduous trees in these forests, only the herb-inhabiting species, *O. nigricornis* and *O. quadripunctatus.* Tamaracks were inspected in both bogs and on upland sites.
4. On 6 September 1971, four medium-sized tamaracks at the west end of Coldwater Lake in Branch County, Michigan were inspected in late afternoon on a cloudy warm day (5:30-6 PM) No *O. laricis* was heard or seen.
5. On 6 September 1971, ten medium-sized tamarack trees in the large bog along the east side of Highway I-69 in Calhoun County, Michigan, south of Battle Creek were inspected in late afternoon (6:10-6:30 PM) on a cloudy day after a rain. One male was heard, beginning about ten minutes after the tamaracks were approached. None was collected. The listening record seemed absolutely certain, as the cricket (1) was definitely traced to a high tamarack branch, (2) sang with the slow trill of *O. laricis,* clearly distinct from *O. nigricornis* in the area, and (3) interrupted its trill at intervals in the manner of both *O. pini* and *O. laricis.*

ACKNOWLEDGMENTS

We thank Drs. Irving J. Cantrall, Theodore H. Hubbell, Thomas E. Moore, and Thomas J. Walker for criticisms of the manuscript, and we are particularly grateful to Martha B. Lackey for preparing the excellent illustrations.

PHONOGRAPH RECORDS OF THE SONGS OF MICHIGAN INSECTS

Alexander, R. D. and D. J. Borror. 1956. The songs of insects. Calls of the Common Crickets, grashoppers, and cicadas of the eastern United States. Ithaca, N.Y.: Cornell Lab. Ornith., 40 species, 29 minutes.

Taxonomic work since 1956 has resulted in the following nomenclatural alternations for species represented on this record:

1) *Acheta assimilis = Gryllus pennsylvanicus,* 2) *Nemobius fasciatus fasciatus = Allonemobius allardi,* 3) *Nemobius fasciatus tinnulus = Allonemobius tinnulus,* 4) *Nemobius fasciatus socius = Allonemobius fasciatus,* 5) *Nemobius maculatus = Allonemobius maculatus,* 6) *Nemobius carolinus = Eunemobius carolinus,* 7) *Nemobius confusus = Eunemobius confusus,* 8) *Oecanthus angustipennis = Oecanthus niveus,* 9) *Oecanthus niveus = Oecanthus fultoni,* 10) *Gryllotalpa hexadactyla = Neocurtilla hexadactyla,* 11) *Neoconocephalus robustus crepitans = Neoconocephalus robustus.*

Alexander, R. D. 1960. Demonstration record accompanying Lanyon, W. E. and W. N. Tavalga (eds). Animal Sounds and Communication AIBS Publ. 7. Five selections including repertoires of *Gryllus pennsylvanicus, Magicicada septendecim* and *M. cassini, Microcentrum rhombifolium, Pterophylla camellifolia,* and *Amblycorypha rotundifolia* and its undescribed southern sibling.

RECENT PUBLICATIONS DEALING WITH MICHIGAN SINGING INSECTS

Alexander, R. D. 1957. The song relationships of four species of ground crickets (Orthoptera: Gryllidae: *Nemobius*) Ohio Journ. Sci. 57:153-163, 13 figs.

———— 1967a. Acoustical communication in arthropods. Ann. Rev. Entomol. 12:495-526.

———— 1967b. Singing insects: Four case histories in the study of animal species. Rand-McNally Patterns of Life Series: 1-86, 30 figs.

————1968. Arthropods. *In*: Sebeok, T. A. Animal communication: Techniques of Study and results of research. Bloomington, Indiana Univ. Press. 167-216, 19 figs.

———— and R. S. Bigelow. 1960. Allochronic speciation in field crickets, and a new species, *Acheta veletis.* Evolution 14:334-346, 5 figs.

———— and G. H. Meral. 1967. Seasonal and daily chirping cycles in the northern spring and fall field crickets, *Gryllus veletis* and *G. pennsylvanicus.* Ohio Jour. Sci. 67:200-209, 6 figs.

———— and T. E. Moore. 1962. The evolutionary relationships of 17-year and 13-year cicadas, and three new species (Homoptera, Cicadidae, *Magicicada*). Univ. Mich. Mus. Zool. Misc. Publ. 121:1-59, 10 figs. 2 tab.

————, T. E. Moore, and R. E. Woodruff. 1963. The evolutionary differentiation of stridulatory signals in beetles (Insecta: Coleoptera) Animal Behaviour 11:111-115.

———— and E. S. Thomas. 1959. Systematic and behavioral studies on the crickets of the *Nemobius fasciatus* group (Orthoptera: Gryllidae:Nemobiinae). Ann. Entomol. Soc. Amer. 52:591-605. 9 figs.

Cantrall, I. J. 1943. The ecology of the Orthoptera and Dermaptera of the George Reserve, Michigan Univ. Mich. Mus. Zool. Misc. Publ. 54:1-182, 3 figs., 10 plates, 16 tab., 2 maps.

———— 1968. An annotated list of the Dermaptera, Dictyoptera, Phasmatoptera, and Orthoptera of Michigan. The Mich. Entomol. 1:299-346, 142 figs.

———— 1970. Appalachian orthopteron relicts in Michigan. Mich. Entomol. 3:84-89, 4 figs.

DuMortier, B. 1963. Chapters 11, 12, 21; pp. 277-373, 583-654. *In*: Busnel, R. (ed.) Acoustic behavior of animals. NY: Elsevier.

Hubbell, T. H. 1929. The distribution of the beach-grasshoppers *Trimerotropis huroniana* and *Trimerotropis maritima interior* in the Great Lakes Region (Orthoptera: Acrididae). Jour. N. Y. Entomol. Soc. 37:31-39, 1 plate.

Jansson, A. 1970. Sound production and associated behavior in Corixidae. Ph. D. Dissertation, Univ. of British Columbia.

Moore, T. E. 1961. Audiospectrographic analysis of sounds of Hemiptera and Homoptera. Ann. Entomol. Soc. Amer. 54:273-291.

———— 1966. The cicadas of Michigan (Homoptera: Cicadidae). Papers Mich. Acad. Sci. Arts, and Letters 51:75-94, 23 figs.

Otte, D. 1971. A comparative study of communicative behavior in grasshoppers. Univ. Mich. Mus. Zool. Misc. Publ. 141:1-168, 20 figs., 22 tab.

Spooner, J. 1968. Pair forming acoustic systems of phaneropterine katydids (Orthoptera, Tettigoniidae). Animal Behaviour 16:197-212.

Thomas, E. S. and R. D. Alexander. 1957. *Nemobius melodius,* a new species of cricket from Ohio (Orthoptera, Gryllidae). Ohio. J. Sci. 57:148-152.

———— 1962. Systematic and behavioral studies on the meadow grasshoppers of the *Orchelimum concinnum* group (Orthoptera: Tettigoniidae). Univ. Mich. Mus. Zool. Occ. Pap. 626: 1-31, 9 figs., 1 plate.

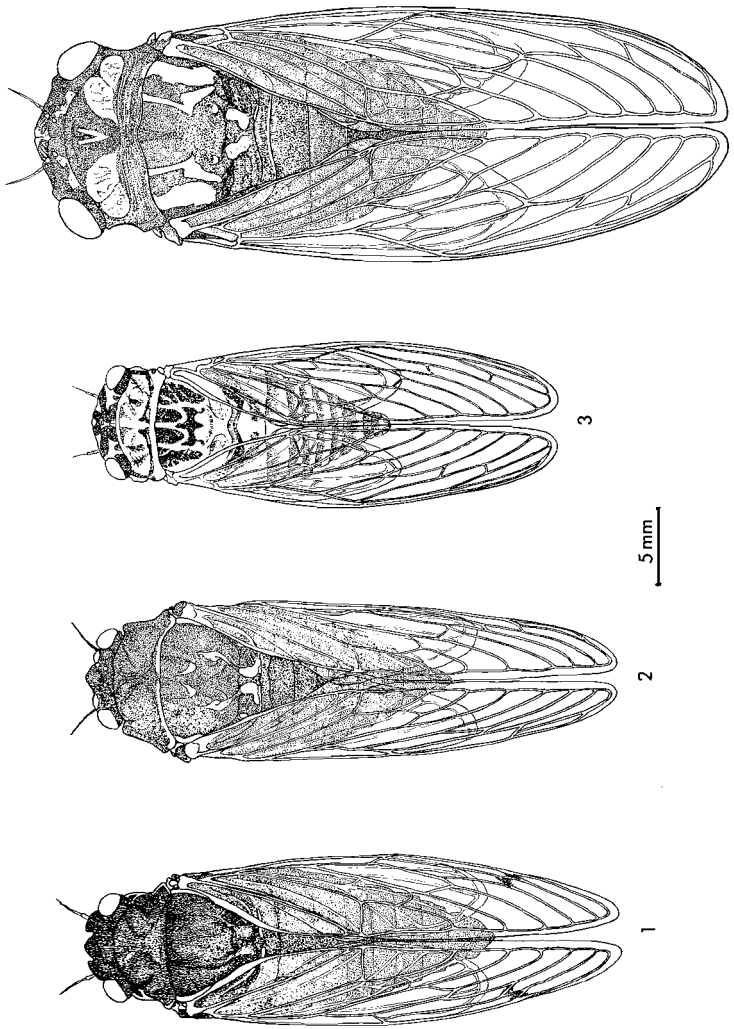
Vickery, V. R. and D. E. Johnstone. 1970. Generic status of some Nemobiinae (Orthoptera: Gryllidae) in northern North America. Ann. Entomol. Soc. Amer. 63:1740-1749.

Walker, T. J. 1962. The taxonomy and calling songs of United States tree crickets (Orthoptera: Gryllidae: Oecanthinae) I. The genus *Neoxabea* and the *niveus* and *varicornis* groups of the genus *Oecanthus.* Ann. Entomol. Soc. Amer. 55:303-322, 17 figs.

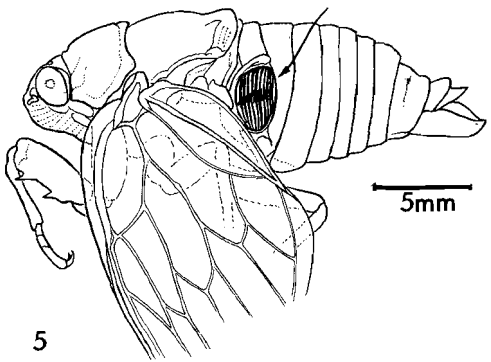
———————— 1963. Ibid II. The *nigricornis* group of the genus *Oecanthus*. Ann. Entomol. Soc. Amer. 56:772-789.

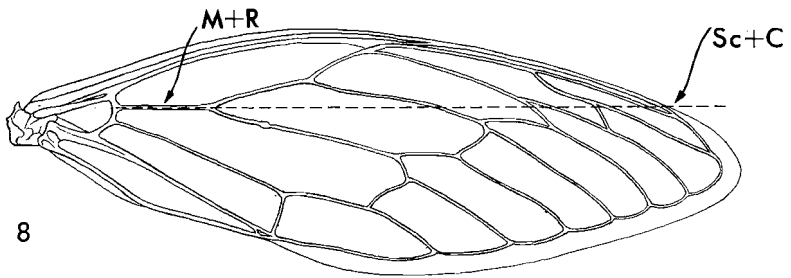
Wenner, A. M. 1968. Honeybees. *In*: Sebeok, T. A. Animal Communication. Bloomington: Indiana Univ. Press, pp. 217-243.

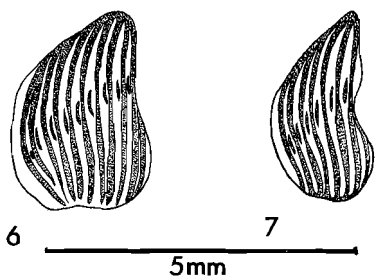
Wilcox, R. S. 1969. Acoustical behavior, sound-producing structures and biology of *Buenoa* (Hemiptera, Notonectidae). Ph. D. Dissertation, The Univ. of Mich. vi + 271 pp., 43 figs.

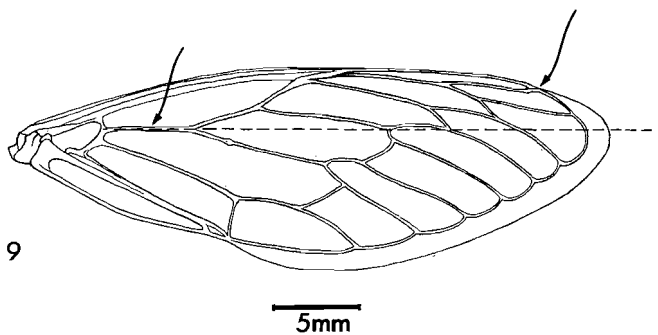


Figs. 1-4 Dorsal views of examples of four cicada species representing the four genera occurring in Michigan: Fig. 1, *Magicicada septendecim;* Fig. 2. *Okanagana rimosa;* Fig. 3, *Diceroprocta vitripennis;* Fig. 4, *Tibicen lyricen.*



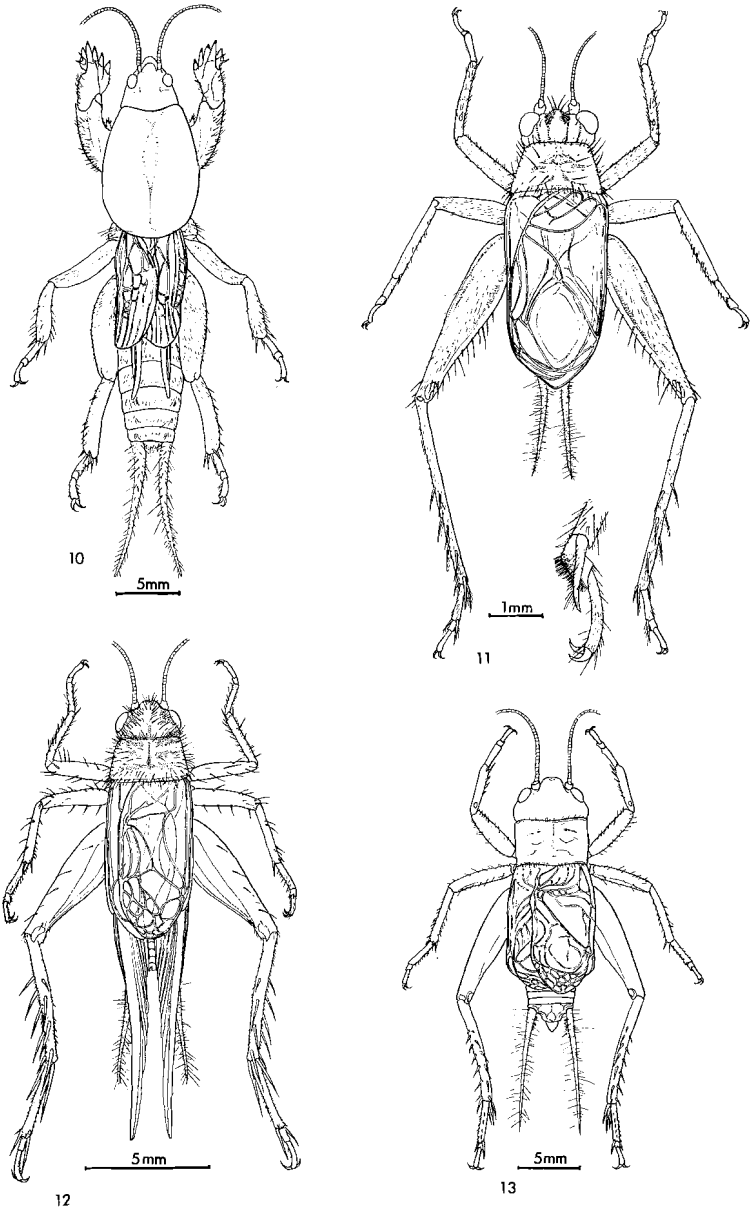




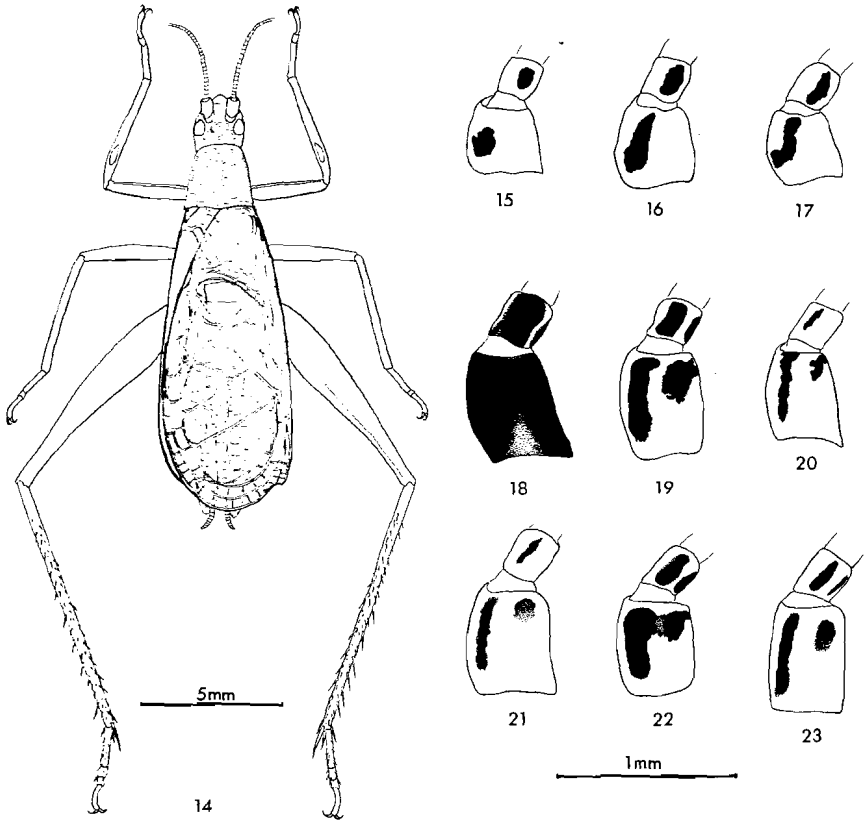


Figs. 5-9 Some distinguishing characteristics of cicadas: Fig. 5, side view of *Ōkanagana canadensis* showing location of timbal; Fig. 6, timbal of *O. canadensis;* Fig. 7, timbal of *O. rimosa;* Fig. 8, forewing of *Tibicen linnei;* Fig. 9, forewing of *T. canicularis.*

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

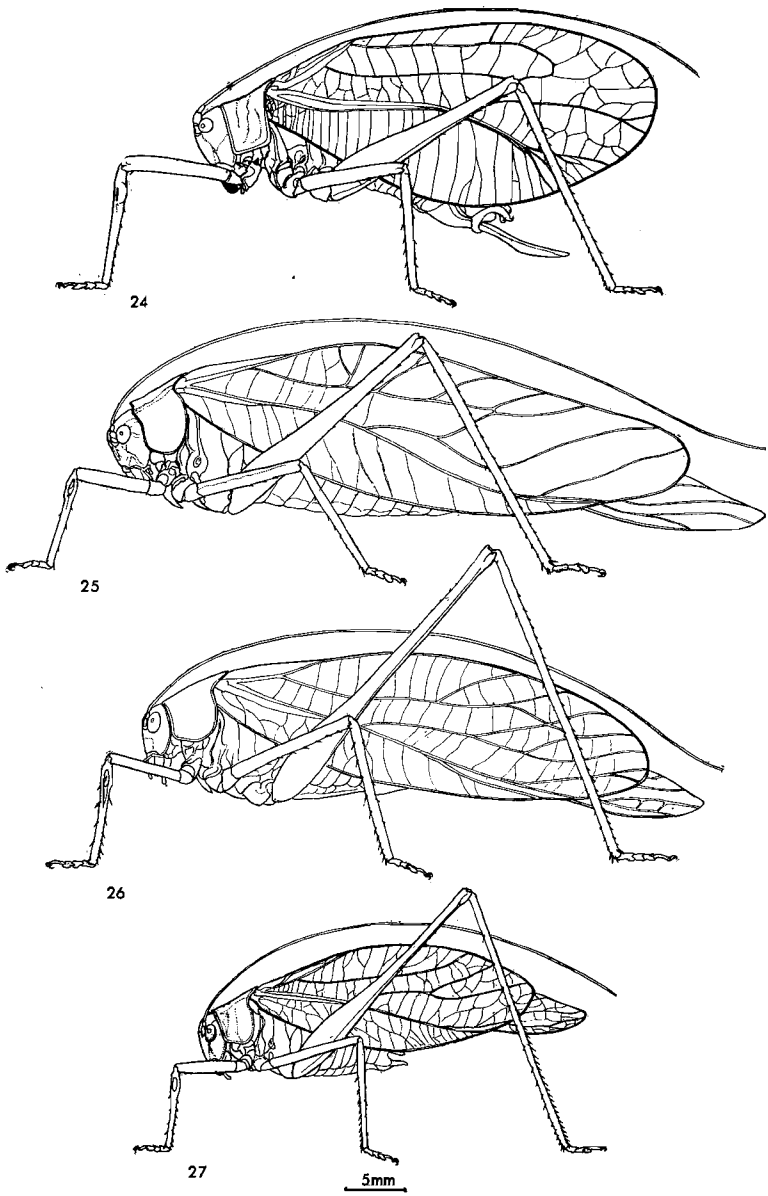


Figs. 10-13 Dorsal views of male examples of four cricket species representing four Michigan genera in different subfamilies: Fig. 10, *Neocurtilla hexadactyla* (Gryllotalpinae); Fig. 11, *Anaxipha exigua* (Trigonidiinae) (inset is side view of tarsus showing depressed middle segment with adhesive pad and brush); Fig. 12, *Allonemobius allardi* (Nemobiinae); Fig. 13, *Gryllus pennsylvanicus* (Gryllinae).

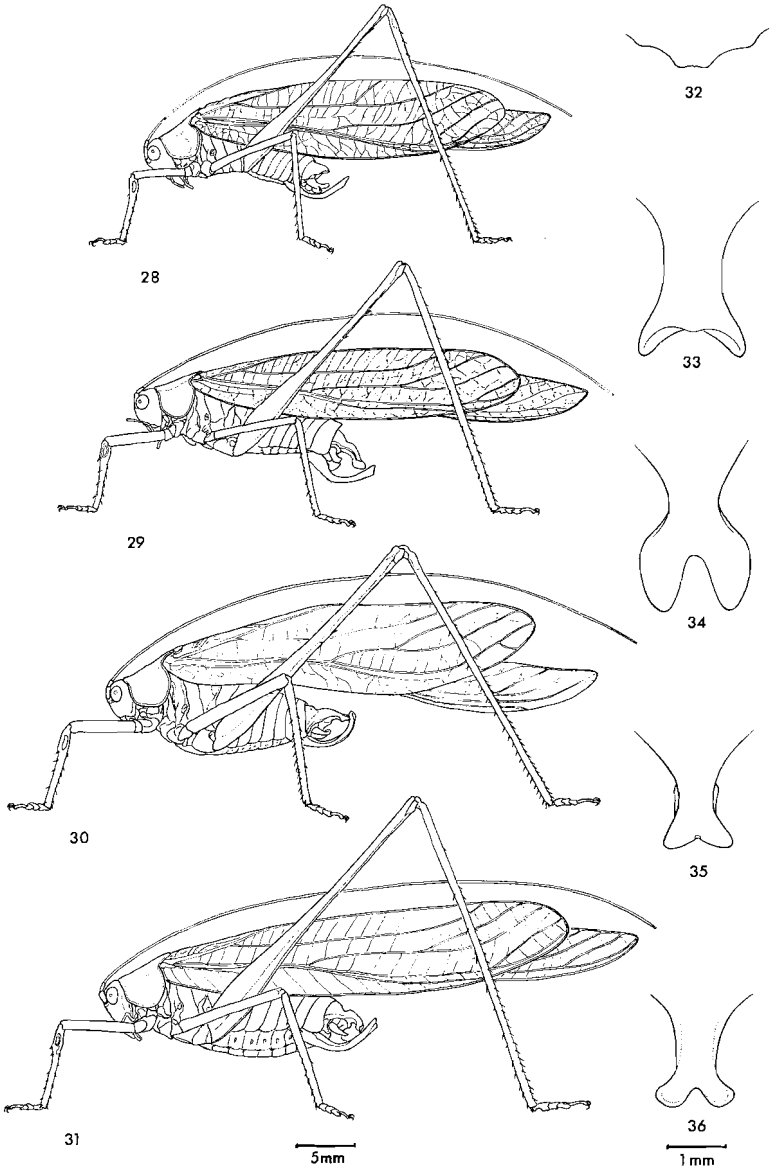


Figs. 14-23 Tree crickets: Fig. 14, dorsal view of *Oecanthus nigricornis;* Figs. 15-23: ventral views of basal antennal segments of *Oecanthus* species: Fig. 15, *O. fultoni;* Fig. 16, *O. exclamationis;* Fig. 17, *O. niveus;* Figs. 18-19, *O. nigricornis;* Fig. 20, *O. laricis;* Fig. 21, *O. pini;* Fig. 22, *O. argentinus;* Fig. 23, *O. quadripunctatus.*

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

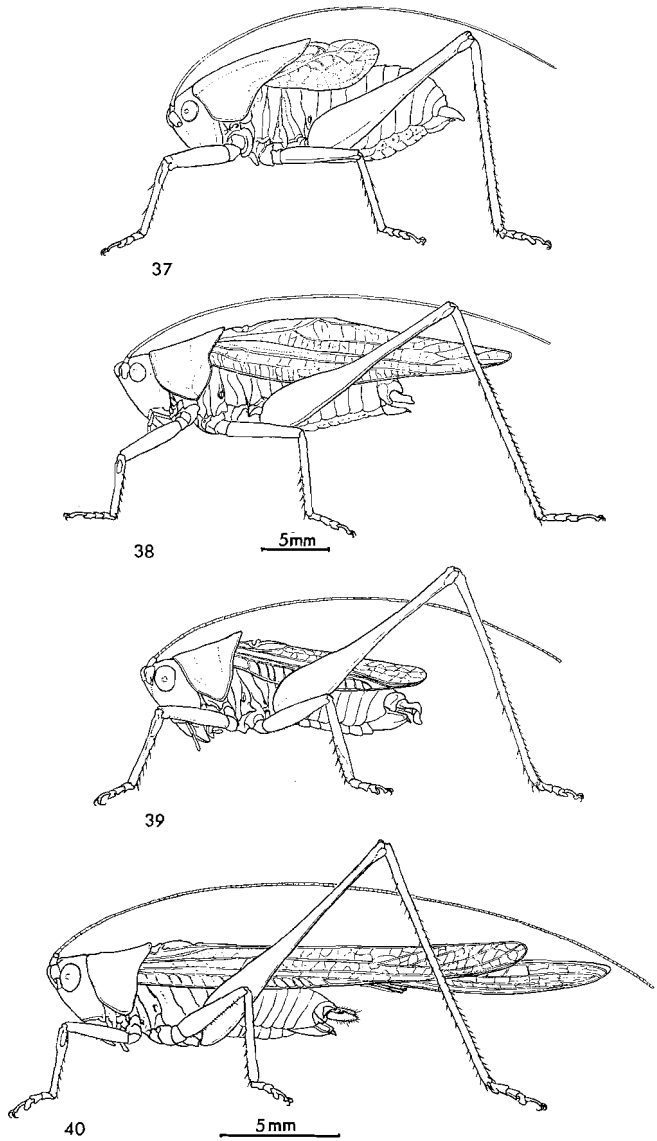


Figs. 24-27 Side views of male representatives of true and false katydids: Fig. 24, *Pterophylla camellifolia;* Fig. 25, *Microcentrum rhombifolium;* Fig. 26, *Amblycorypha oblongifolia;* Fig. 27, *A. rotundifolia.*

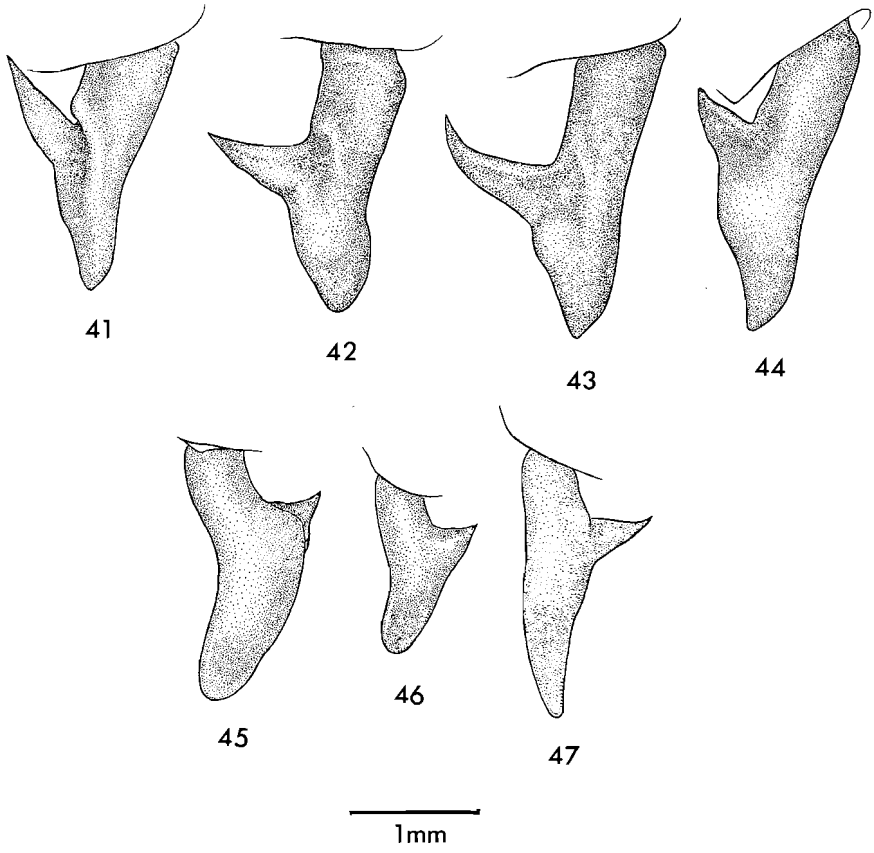


Figs. 28-36 False katydids. Figs. 28-31, side views of male respresentatives of four *Scudderia* species: Fig. 28, *S. septentrionalis;* Fig. 29, *S. furcata;* Fig. 30, *S. pistillata;* Fig. 31, *S. curvicauda;* Figs. 32-36, dorsal views of dorsal processes of male terminalia: Fig. 32, *S. septentrionalis;* Fig. 33, *S. texensis;* Fig. 34, *S. furcata;* Fig. 35, *S. pistillata;* Fig. 36, *S. curvicauda.*

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

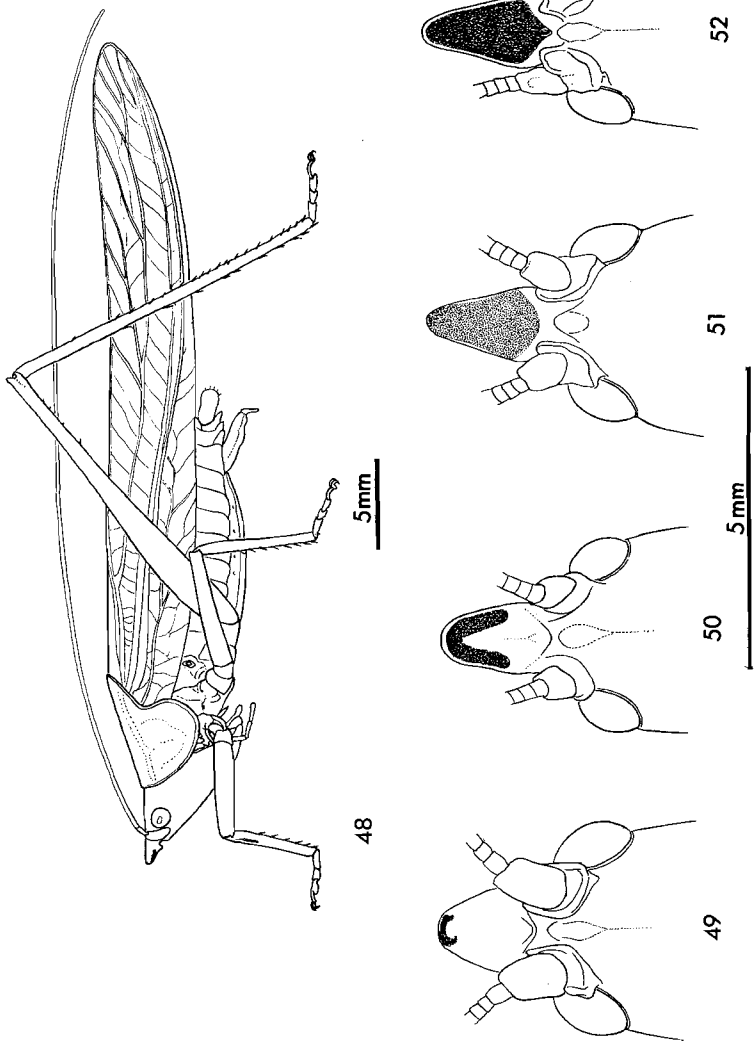


Figs. 37-40 Side views of male representatives of katydids: Fig. 37, *Atlanticus testaceus;* Fig. 38, *Orchelimum vulgare;* Fig. 39, *Conocephalus brevipennis;* Fig. 40, *C. fasciatus.*

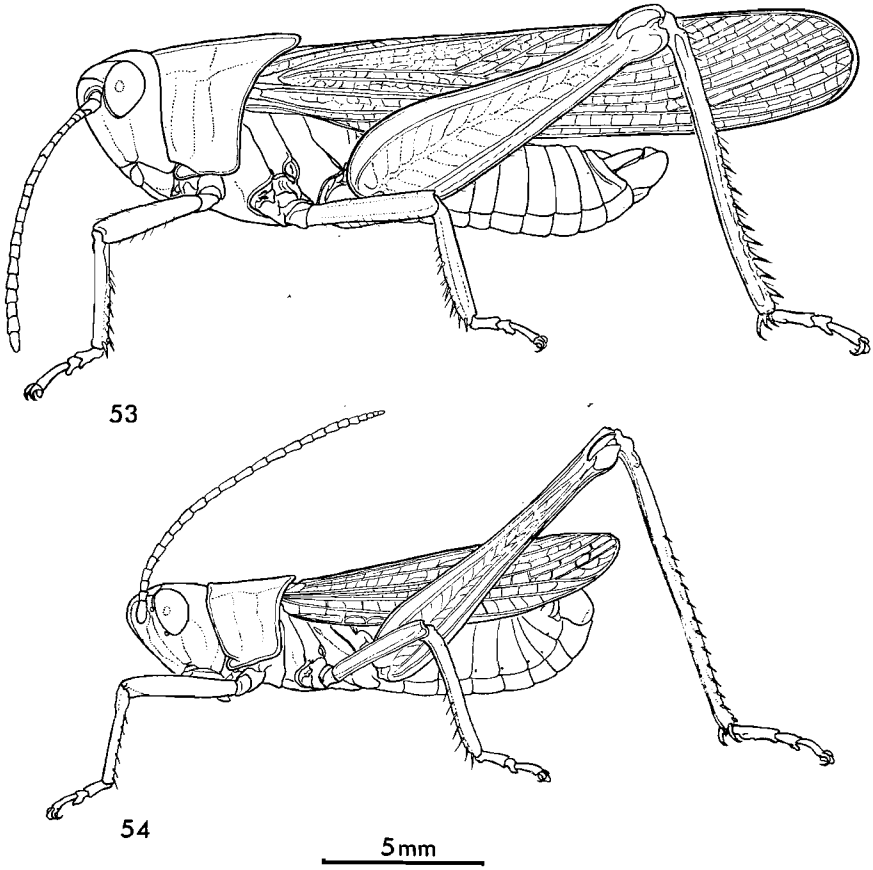


Figs. 41-47 Dorsal views of cerci of meadow katydids: Fig. 41-44, right cerci of *Orchelimum* species: Fig. 41, *O. nigripes:* Fig. 42, *O. vulgare;* Fig. 43, *O. gladiator;* Fig. 44, *O. volantum.* Figs. 45-47, left cerci of *Conocephalus* species: Fig. 45, *C. nigropleurum;* Fig. 46, *C. fasciatus;* Fig. 47, *C. strictus.*

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165

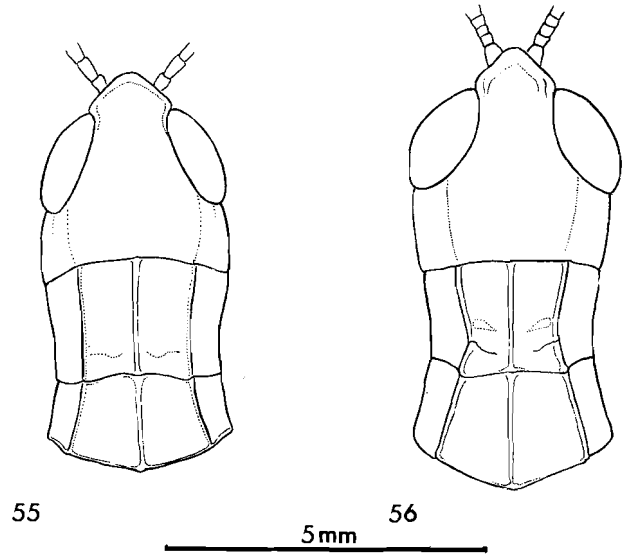


Figs. 48-52 Coneheaded katydids: Fig. 48, side view of male *Neoconocephalus ensiger*. Figs. 49-52, ventral views of cones on heads: Fig. 49, *N. robustus;* Fig. 50, *N. ensiger;* Fig. 51, *N. nebrascensis;* Fig. 52, *N. lyristes.*

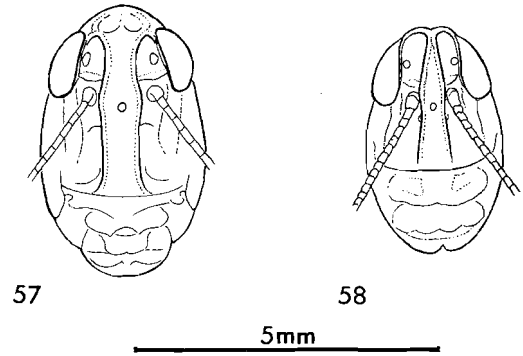


Figs. 53-54 Side views of two grasshoppers respresening different subfamilies: Fig. 53, *Chortophaga viridifasciata* (Oedipodinae); Fig. 54, *Chorthippus curtipennis* (Gomphocerinae).

https://scholar.valpo.edu/tgle/vol5/iss2/1
DOI: 10.22543/0090-0222.1165



Figs. 55-56 Dorsal views of pronota of *Orphulella* species showing key difference in shapes of lateral carinae: Fig. 55, *O. speciosa;* Fig. 56, *O. pelidna.*



Figs. 57-58 Faces of *Arphia* species, showing key differences in shape of facial ridge between antennae: Fig. 57, *A. xanthoptera;* Fig. 58, *A. sulphurea.*