

KATYDIDS OF COSTA RICA

Volume 1. Systematics and bioacoustics of the cone-head katydids
(Orthoptera: Tettigoniidae: Conocephalinae sensu lato)

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Katydid of Costa Rica

Volume 1: Systematics and bioacoustics of the cone-head katydids
(Orthoptera: Tettigoniidae: Conocephalinae *sensu lato*)

by

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ABSTRACT

Katydid (Orthoptera: Tettigoniidae) are some of the most conspicuous and abundant members of the Costa Rican insect fauna. Yet their biology and systematics still remain virtually unknown. This work, covering all Costa Rican taxa of the subfamily Conocephalinae *s. l.* (Conocephalinae + Agraeciinae + Copiphorinae), initiates a series of monographic treatments of the Tettigoniidae of this country.

Twenty genera and 52 species are described or redescribed. Four new genera and 21 species are described. The genera are: *Lipotactomimus* gen. n., *Metacaputus* gen. n., *Pluviasilva* gen. n., and *Podacanthophorus* gen. n. The new species are *Conocephalus magdalenae* sp. n., *Lipotactomimus rowelli* sp. n., *Copiphora hastata* sp. n., *C. ottei* sp. n., *Metacaputus brenesi* sp. n., *Erioloides longinoi* sp. n., *E. acutidentis* sp. n., *E. sikesi* sp. n., *E. laticobinus* sp. n., *Pluviasilva levis* sp. n., *Eriolus aculeus* sp. n., *E. penicillus* sp. n., *E. duplidentis* sp. n., *Podacanthophorus alas* sp. n., *P. vargasi* sp. n., *P. maylinae* sp. n., *P. nelciae* sp. n., *Subria sylvestris* sp. n., *S. crassicerca* sp. n., and *S. scutellaris* sp. n. One new subspecies (*Copiphora brevicauda costaricensis* ssp. n.) is also described. Holotypes of all new species are deposited at the Academy of Natural Sciences, Philadelphia, PA. Sixteen species and 1 subspecies appear to be endemic to Costa Rica, but it is likely that they also occur in Nicaragua and Panama.

Pictorial and tabular keys are provided for all genera and species of Costa Rican Conocephalinae *s. l.* and all species are fully illustrated. Costa Rican distribution maps are provided for all species. Sound data are provided for 25 species. Males of the genus *Copiphora* produce both airborne calls and substrate tremulations, while males of *Lirometopum coronatum* supplement their tremulations with drumming of their hind feet.

RESUMEN

Las esperanzas (Orthoptera: Tettigoniidae) son algunos de los miembros más conspicuos y abundantes de la entomofauna de Costa Rica. Pese a su importancia, la biología y la sistemática de este grupo todavía es prácticamente desconocida. Este trabajo, que incluye todos los taxos de una subfamilia Conocephalinae *sensu lato* de Costa Rica (Conocephalinae + Agraeciinae + Copiphorinae), es el primero de una serie de monografías sobre la familia Tettigoniidae de este país. Se describen o redescubren 20 géneros y 52 especies, de los cuales 4 géneros (*Lipotactomimus* gen. n., *Metacaputus* gen. n., *Pluviasilva* gen. n., *Podacanthophorus* gen. n.), 21 especies (*Conocephalus magdalenae* sp. n., *Lipotactomimus rowelli* sp. n., *Copiphora hastata* sp. n., *C. ottei* sp. n., *Metacaputus brenesi* sp. n., *Erioloides longinoi* sp. n., *E. acutidentis* sp. n., *E. sikesi* sp. n., *E. laticobinus* sp. n., *Pluviasilva levis* sp. n., *Eriolus aculeus* sp. n., *E. penicillus* sp. n., *E. duplidentis* sp. n., *Podacanthophorus alas* sp. n., *P. vargasi* sp. n., *P. maylinae* sp. n., *P. nelciae* sp. n., *Subria sylvestris* sp. n., *S. crassicerca* sp. n., *S. scutellaris* sp. n.), y 1 subespecie (*Copiphora brevicauda costaricensis* ssp. n.) son nuevos a la ciencia. Los holotipos de todas las nuevas especies se depositaron en la Academia de Ciencias Naturales de Philadelphia. Dieciséis especies y 1 subespecie parecen ser endémicas de Costa Rica, aunque su presencia en Nicaragua y Panamá también es probable.

En este trabajo se proporcionan las claves ilustradas y tabulares para todos los géneros y las especies de Conocephalinae *s. l.* de Costa Rica. Todas las especies se ilustran con detalle. También se proporcionan los mapas de la distribución en Costa Rica para todas las especies. Las descripciones de sonidos se proporcionan para 25 especies. Los machos del género *Copiphora* producen sonidos aerotransportados y vibraciones del sustrato, mientras que los machos del *Lirometopum coronatum* producen además tecló con sus patas traseras.

INTRODUCTION

Katydids (Tettigoniidae) are some of the most conspicuous and abundant members of tropical insect communities. The number of currently recognized species of the family Tettigoniidae exceeds 6200; presently these are assigned to over 1000 genera (Naskrecki and Otte 1999), most of them occurring in tropical and sub-tropical regions of the world. They can be found in a wide variety of habitats, ranging from the littoral zone of the seashore to grasslands, forests, and mountain tops, well above the tree line. Several species are some of the largest insects in the world, thus attracting much attention from both casual naturalists and professional entomologists. Many genera and species of Tettigoniidae have become model organisms for studies on mechanisms of speciation and species isolation (e. g. Bailey 1976, Barendse 1990, Dadour and Bailey 1990, Greenfield 1990), mate choice and male investment in offspring (e. g. Darwin 1871, Gwynne 1985, Gwynne and Bailey 1988, Simmons 1992), and anti-predator defense (Belwood and Morris 1987, Belwood 1990, Castner 1995, Castner and Nickle 1995, Nickle and Castner 1995). Katydids are also the subjects of a large body of research on insect bioacoustics and communication (e.g. Dadour and Bailey 1990, Heller and Helversen 1986, Heller 1990, Stiedl and Kalmring 1989, Morris et al. 1994, Walker and Greenfield 1983, Robinson 1990) as well as the physiology of hearing and signal perception (Kalmring et al. 1990). The importance of katydids as members of biological communities, both in the role of herbivores and predators, as well as the primary source of animal proteins for many vertebrates and invertebrates, is just beginning to be fully appreciated. For example, in the Panamanian rain forest, katydids may constitute up to 61% of the insects consumed by insectivorous bats (Belwood 1990), and they are also a major component of the diet of small primates, many birds, reptiles, and arthropods (Nickle 1992; Nickle and Heyman 1996).

What makes katydids such desirable objects of biological studies is their large size, their abundance, the ease with which they can be collected and observed, and the great variety of behavioral patterns, morphological forms, and ecological roles they play. It is not surprising that katydids are very popular study organisms among students of nature in Central America. Unfortunately, despite the recent upsurge of research involving Tettigoniidae of the Neotropical region, the state of our knowledge of the katydid fauna of the neotropics can only be described as rudimentary at best. A survey of over 30 papers that dealt with katydids, written by students participating in biological courses conducted by the Organization of Tropical Studies (OTS) in Costa Rica since

1964, revealed that the most precise identifications were "a brown katydid," "a green katydid," or "a katydid." Since no voucher specimens have been retained, it makes these otherwise valuable contributions, which span many different aspects of katydid ecology and behavior, practically useless for any future researchers, and demonstrates a clear need for a synthetic taxonomic treatment of the Costa Rican Tettigoniidae.

The first handful of species of neotropical katydids was described over 200 years ago by Linnaeus, Fabricius, and De Geer, and since then over 1800 species have been added to the list. It is quite likely, however, that this number represents only about 50%, or perhaps an even smaller portion of the actual number of species diversity of the Neotropical region. In this study alone, which covers only a very small geographic region of the neotropics, the country of Costa Rica, and only one subfamily of Tettigoniidae, over 40% of the species discussed below are new to science.

Several workers attempted to summarize different stages of knowledge of the neotropical Tettigoniidae. Redtenbacher (1891) and Brunner von Wattenwyl (1878, 1895) published world reviews of the subfamily Conocephalinae, and of subfamilies Phaneropterinae and Pseudophyllinae, respectively. These works included many neotropical taxa and presented keys to genera and species. Saussure and Pictet (1898) presented the most comprehensive review of Central American Orthoptera to date. Naturally, in the hundred years that have passed since its publication the review has become quite outdated. Bruner's (1915) work was the first, and the last effort to summarize taxonomic information on all genera of Tettigoniidae of the neotropical region (including Costa Rican taxa). However, this work, not exceptional for its quality to begin with because of the lack of even a single illustration, has also become outdated. At the beginning of this century, James G. Rehn and Morgan Hebard published a series of papers treating the Tettigoniidae of Costa Rica and Panama (Rehn 1905, 1906, 1917a, 1917b, 1918, 1944, 1946; Rehn and Hebard 1914, 1915; Hebard 1927, 1933, 1934). Since then, only a few additional papers dealing specifically with the Costa Rican katydid fauna have been published, and most of the new records are buried in taxonomic revisions of various neotropical taxa (e.g., Beier 1960, 1962; Grant 1964, Emsley 1969, 1970, Nickle 1984).

The most recent papers treating various aspects of the biology or taxonomy of selected species of Costa Rican Tettigoniidae are those by Toledo Piza (1974), Rentz (1975, 1976, 1983), Young (1977), Hogue (1979), Morris (1980),

genera of Conocephalinae *s.l.* represented in the Costa Rican fauna.

BIONOMICS AND DISTRIBUTION

Costa Rican Conocephalinae *s.l.* occupy a variety of habitats, ranging from open grasslands (*Conocephalus*, *Caulopsis*, *Pyrgocorypha*, *Neoconocephalus*) to semi-open, shrubby vegetation (*Orchelimum*, *Neoconocephalus*, *Lirometopum*) to dense primary and secondary wet forests (most genera). Forest members of the subfamily occur in all three major strata of the forest—the forest floor, the understory and the canopy level. Only species of the genus *Sphyrometopa* are known to be restricted to the ground level of the forest, with the adults spending most of their lives among fallen leaves on the forest floor, only occasionally ascending low, herbaceous plants. The understory level of both the primary and secondary wet forests is inhabited by a number of taxa, including most species of the genera *Copiphora*, *Lirometopum*, *Subria*, *Eriolus* and *Erioloides*. At least some species of the latter two genera, however, seem to be restricted to the canopy level and have only been collected by either canopy fogging or occasionally at lights. Also, at least one species of the genus *Copiphora*, (*C. brevicauda costaricensis*) has been observed and collected almost exclusively at the canopy level. The genera that seem to be entirely restricted to the canopy level of the forest include *Acantheremus*, *Podacanthophorus*, *Moncheca*, *Vestria*, and *Pluviasilva*. Individuals of these genera have only been collected by either canopy fogging, from freshly felled trees or by collecting directly in tree crowns. Clearings and swamps within lowland, both dry and wet forests are inhabited by members of the genera *Caulopsis*, *Neoconocephalus* and *Conocephalus*.

Costa Rican Copiphorinae *s.l.* occur at elevations ranging from sea level to 1700 m, although the presence of members of the subfamily (especially the genera *Conocephalus* and *Neoconocephalus*) above the elevation of 1700 m cannot be ruled out. Species of the genus *Erioloides* have been collected in montane wet forest of Monteverde (Puntarenas Prov.) at the elevation of 1700 m, while *Neoconocephalus triops* (L.) and *Moncheca pretiosa* (Walker) have been collected at the elevation of 1650 m on the slopes of Volcán Cacao (Guanacaste Prov.), and at the elevation 1670 m on Cerro Gemelo (Puntarenas Prov.). The remaining species of the subfamily seem to be restricted to lowland or mid-elevation sites not exceeding 700 m.

As in all other organisms, the pattern of distribution of katydid is dictated by a combination of many biotic and abiotic components. Costa Rican climate exhibits an amazing range of temperature and humidity, from 0°C on some peaks of the Talamanca Range to 30°C on the

dry lowlands of Guanacaste. Combined with the great geological diversity of the country, this results in the presence of a wide variety of habitats, supporting quite diverse floras and faunas. The diversity of the biota of Costa Rica has been studied by numerous scientists (for a summary see Janzen 1983). Several authors (Herrera-Soto and Gómez-Pignataro 1993, DeVries 1987) proposed systems of classifications of the Costa Rican biota, based mostly on the classification of life zones introduced by Holdridge (1967). DeVries (1987) introduced a system of six faunal zones of Costa Rica, which I will use below to discuss the distribution of Conocephalinae *s.l.* (for a detailed descriptions of the system consult his work). I also include some additional information on particular types of vegetation (after Herrera-Soto and Gómez-Pignataro 1993) found in each zone.

Isla del Coco, a small Pacific island under Costa Rican administration, is not included here. It has no close faunal affinities with the mainland, and no data on Conocephalinae *s.l.* of this island are available.

Pacific Slope

Pacific Lowland Deciduous Forest (“Guanacaste” forest zone) – This region stretches from Nicaragua south to the city of Puntarenas. The elevation ranges from 0 to 600 m and the dominant type of vegetation is tropical subhumid forest subject to 5-6 dry months (with patches of subtropical humid forest, with 5-6 dry months). Most of the species of Conocephalinae *s.l.* found in this area are graminivorous forms associated with open or semi-open habitats. They include species of the genera *Conocephalus*, *Orchelimum*, *Neoconocephalus*, *Bucrates*, *Pyrgocorypha*, *Metacaputis* and *Caulopsis*. The forest fauna include relatively few species (genera *Erioloides*, *Sphyrometopa*, *Moncheca*, and *Podacanthophorus*). Rare or absent are large, forest katydids of the genera *Lirometopum* and *Copiphora*. The only species of Conocephalinae *s.l.* known exclusively from this region are *Orchelimum fraternum* and *Metacaputis brenesi*.

Pacific Lowland Evergreen Forest – This region includes most of the Puntarenas Province south of the city of San Mateo and west of the Talamanca Range. The elevation gradient ranges from sea level to 800 m. The dry season is not nearly as pronounced here as it is in Guanacaste and northern Puntarenas, especially in the southern portion of the region (Osa Peninsula). In the northern portion the dominant vegetation type is tropical humid forest, subject to 3-4 dry months. The southern portion, which includes Osa Peninsula, is covered by wet forest with only 1-2 dry months. The katydid fauna here is extremely rich, and the cone-heads are represented by 30, mostly forest species. Several species, such as *Copiphora otti*, *Eriolus*

Morris and Beier (1982), Nickle (1983), Hayes and Rentz (1986), O'Donnell (1993), and Bowen-Jones (1994). None of these, however, provides either a key or a check-list of Costa Rican taxa. Nickle's (1992) treatment of katydids of Panama helped remedy the situation by providing the first key to many Central American Tettigoniidae. It included a number of genera and species common to both Panama and Costa Rica, and constitutes a valuable resource for students of Central American entomology. It also shows, however, how little we know about the faunal composition of the Tettigoniidae of Central America: only 18 of the 51 species of Costa Rican Conocephalinae *s.l.*, the main subject of the present work, can be identified using Nickle's key.

In order to improve the state of our knowledge of Central American Orthoptera, this book commences a series of monographic treatments dealing with all subfamilies of Tettigoniidae represented in Costa Rican fauna. The emphasis of this work has been put on reliable identification of species and presenting known fact about their biology and acoustic behavior. It makes no pretense of being comprehensive, and readers will quickly realize how little is known about the Tettigoniidae of this country, and yet, at the same time, how many interesting research opportunities they present.

TAXONOMIC SCOPE

The group of katydids treated in this work comprises genera collectively called "cone-head katydids," and traditionally placed in three subfamilies: Conocephalinae, Copiphorinae, and Agraeciinae. Some authors (e.g., Rentz 1979; Gorochoy 1988, 1995) opt for merging these subfamilies into a single, more inclusive taxon, the subfamily Conocephalinae, with tribes Conocephalini Kirby et Spence (= Xiphidiini Redtenbacher), Agraeciini Redtenbacher (= Eumegalodontinae Kirby) and Copiphorini Caudell (Gorochoy also included in Conocephalinae 5 additional tribes, known almost exclusively from the Old World and not covered in this work). Due to inherent problems with the currently adopted system of classification of Tettigoniidae (see Nickle and Naskrecki 1997 for a discussion), the latter, more inclusive approach seems more appropriate at this time. Currently, it is difficult, if not impossible, to provide phylogenetically sound, i.e. based exclusively on synapomorphic characters diagnoses for the three tribes of Conocephalinae. Therefore, all taxa covered in this work will be treated as members of the subfamily Conocephalinae *sensu lato*, without trying to assign them to tribes.

Of all three tribes of Conocephalinae *s.l.*, providing a diagnosis for the Agraeciini certainly proves to be the most problematic. Karny (1912) gave a diagnosis of the

tribe (regarded in his work as the subfamily Agraeciinae) but the characters listed as diagnostic overlap broadly with those of other groups of Tettigoniidae (especially Copiphorini). Most of Karny's characters are unreliable for higher taxonomic classification (e.g., coloration), and only one of the several characters listed, the pointed and ventrally unarmed fastigium of vertex, is relatively rare within the entire family Tettigoniidae (although a similar condition can be found in some members of Hetrodinae). To add to the confusion, many members of the tribe do not exhibit any of the characteristics considered diagnostic for Agraeciini, and are assigned to the tribe based only on the "taxonomic tradition." For example, genera *Eppia* Stål and *Sphyrmetopa* Carl have been traditionally assigned to Agraeciini although neither displays characteristics listed by Karny as diagnostic. The genus *Sphyrmetopa* was originally placed in the Conocephalini (Rehn 1905) (being "allied to *C. laticeps* Redtenbacher," now considered a member of Copiphorini) but then moved to Agraeciinae (Hebard 1927) because this and related genera were "best referred to this subfamily" (no other rationale was given by Hebard). This problem has already been recognized by other authors (Walker and Gurney 1972; Rentz 1976), but nevertheless the name still persists in the taxonomic literature.

Although undoubtedly certain groups of genera of Agraeciini form monophyletic units (e.g. *Agraecia* Serville and *Eschatoceras* Redtenbacher), the tribe as a whole, with all the genera currently assigned to it, is clearly an example of a metataxon – a widely accepted but not diagnosable assemblage of smaller taxa (but see Ingrisch 1998 for a different opinion). The relationships of a large group of genera of Agraeciini to other members of Tettigoniidae is currently a subject of an extensive cladistic analysis (Naskrecki, in prep.).

It is considerably easier to provide a description of the tribe Conocephalini than of Agraeciini, no attempts, however, have been made to test whether the character states diagnostic of Conocephalini (laterally flattened fastigium of vertex, pronotum with a "secondary tympanum," unarmed fore and mid femora) are indeed derived and unique within the Tettigoniidae and how this tribe is related to the Copiphorini. The latter is a large assemblage of genera, most of which share a greatly enlarged fastigium of vertex. But again, it is impossible to point out characters that are uniquely derived for the tribe and shared by all its members.

For all these reasons I refrain in this work from any further speculations about the validity and relationships of Agraeciini, Conocephalini and Copiphorini, leaving them for the above mentioned cladistic treatment of the entire family Tettigoniidae. Instead, I will focus on alpha taxonomic and biological descriptions of individual

Line illustrations included in this study were done as pencil sketches using a camera lucida Wild 308700 on a stereomicroscope Wild M8. These sketches were subsequently scanned into a Macintosh computer at the resolution 300 dpi, processed using a pixel editing application (Adobe Photoshop v. 5.0), and printed at the resolution 600 dpi. Scanning electromicrophotographs were taken using a Zeiss EM910 120 keV scanning electron microscope at the electron microscopy laboratory of the University of Connecticut.

MATERIAL DEPOSITORIES

ANSP	Academy of Natural Sciences, Philadelphia, PA
ANIC	Australian National Insect Collection, Division of Entomology, CSIRO, Canberra
BMNH	The Natural History Museum, London
BPBM	Bishop Museum, Honolulu, HI
EMEC	Essig Museum of Entomology, University of California, Berkeley, CA
EMUS	Entomological Museum, Utah State University, Logan, UT
GKM	Glenn K. Morris collection, Erindale College, University of Toronto, Mississauga, Ontario
INBio	Instituto Nacional de Biodiversidad, San José, Costa Rica
MCZC	Museum of Comparative Zoology, Harvard University, Cambridge, MA
MNHN	Museum National d'Histoire Naturelle, Paris
NHMW	Naturhistorisches Museum Wien, Vienna
UMMZ	Museum of Zoology, University of Michigan, Ann Arbor, MI
UNSM	University of Nebraska State Museum, Lincoln, NE
USNM	U. S. National Museum of Natural History, Washington, D. C.
ZMAN	Universiteit van Amsterdam, Instituut voor Taxonomische Zoologie, Amsterdam

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to use his unpublished recordings of Central American Tettigoniidae and shared with me his knowledge of the genus *Neoconocephalus*. Hugh F. Rowell kindly provided me with some of the most interesting specimens described in this work. Glenn K. Morris helped me to obtain type specimens of several species. Both Glenn and Dan Otte also made excellent companions on one of my collecting trips and I am grateful to them for sharing some of their knowledge with me. I also thank curators of all the museums and collections from which I borrowed specimens: Donald Azuma (Philadelphia), David C. F. Rentz (Canberra), Judith Marshall (London), David J. Preston (Honolulu), Cheryl B. Barr (Berkeley), Wilford J. Hanson (Logan), Angel Solis (San José), Christiane Amedegnato (Paris), Eugene Hall (Lincoln), and Ulrike Aspöck (Vienna). Robert K. Colwell helped me in more ways than can be listed here, but one of them was giving me the opportunity to work with the project ALAS, the first large scale inventory of tropical Arthropoda. I thank parataxonomists of the project ALAS, Danilo Brenes, Ronald Vargas, Maylin Paniagua, and Nelci Oconotrillo, for their expert help in collecting, preparing, and databasing insect material during my stays at La Selva Biological Station. Ángel Solis' help was invaluable during my visits to the Instituto Nacional de Biodiversidad (INBio, San José). My stays at Las Cruces Biological Station, which resulted in the collecting of several new species of Tettigoniidae, were made possible by Louís Diego Gomez. I thank the Costa Rican Ministry of Natural Resources, Energy, and Mining for giving me the permit to collect Tettigoniidae in this country. PCB Electronics donated the electronic equipment used in recording of substrate tremulation and drumming of several species described in this work. James S. Romanow's help was invaluable in capturing the SEM images presented in this work. David L. Wagner and Sacha Spector helped me with collecting specimens in Costa Rica and Francisca Massardo helped me with Spanish translations. I am greatly indebted to Evan Bowen-Jones and his family, who provided their support during my stay in London where I examined type specimens at the Natural History Museum. I also thank Derek S. Sikes for his help and criticism. And last but not least my sincere gratitude is extended to my wife Kristin M. Smith for her unconditional support and encouragement as well as for bravely enduring spider attacks and rough field conditions during our collecting trips in Costa Rica.

duplidentis, *Subria scutellaris* and *Subria crassicerca*, seem to be restricted to this region.

Pacific Mid-Elevation – This extremely diverse region, which spans elevations ranging from 700 to 1600 m, has been rather poorly explored with regards to the conocephaline fauna. It includes a wide array of life zones: tropical humid, premontane belt transition, lower montane humid, lower montane wet, premontane wet, premontane wet-rain transition, and premontane rain forest. Estación Cacao and Estación Pitilla have 10 and 18 species of Conocephalinae *s.l.*, respectively. Seven species have been collected from Monteverde, and one (*Erioloides sikesi*) may be endemic to this region.

High Elevation Pacific and Atlantic – So far, no specimens of Conocephalinae *s.l.* have been collected from this region, which spans elevations of 1600 - 3000 m. It is likely, however, that several species of the genera *Conocephalus* and *Neoconocephalus* will be found there, as some of them are known from the temperate zones of North America (e.g. *Conocephalus cinereus* and *Neoconocephalus triops*).

Atlantic Slope

Atlantic Lowland - This large region covers the area of Costa Rica east of the Cordillera Central and Cordillera de Talamanca, and stretches from Nicaragua south to the Panamanian border. It includes a great diversity of habitat types contained in the following zones: tropical wet, tropical moist, and premontane wet transition forests. These habitats do not dry out during the year and some areas (e.g. Tortuguero) include large patches of swamp forest. In terms of the amount of collected material and known species of Conocephalinae *s.l.*, this is certainly the best studied faunal region of Costa Rica. Thirty species are known from this region, most of which are forest species. Several species (*Eriolus penicillus*, *Podacanthophorus alas*, *P. vargasi*, *Sphyrometopa atlantica*) have not yet been collected outside this region. Most of the large, forest species of the genera *Lirimetopum* and *Copiphora* are common here.

Atlantic Mid-Elevation – This region, spanning the elevations 600-1500 m, covers the lower, eastern slopes of the Cordilleras. It contains a great diversity of habitats and remains wet throughout the year. The following life zones can be found there: tropical wet, premontane

transition, premontane wet, and premontane rain forest. Only Braulio Carillo N. P. has been relatively well explored in terms of its katydid fauna, and 10 species of Conocephalinae *s.l.* have been collected there. Other parts of this region remain poorly investigated but very promising, considering its great diversity of habitats.

MATERIAL AND METHODS

The material used in the present study comes from a number of institutions but the single largest source of specimens and information was Instituto Nacional de Biodiversidad in San José, Costa Rica. Other major sources of specimens include the Academy of Natural Sciences in Philadelphia, the U.S. National Museum of Natural History, and the Museum of Zoology at the University of Michigan. Types of most species discussed in this study have been located and examined. Only in a few cases were types not examined because they are either lost or the species is well known and its identity leaves no doubt.

In addition to museum specimens, this study is based on six years of field collecting and observations, conducted by parataxonomists and collaborators of the project ALAS at La Selva Biological Station and by me.

Primary types of all new species described here have been deposited in the insect collection of the Academy of Natural Sciences in Philadelphia. Other depositories are indicated by acronyms listed below.

Recordings presented here were made both in the field and under laboratory conditions. Most recordings were made with a Sony WM-D6C recorder, using a Sennheizer M66 directional microphone with a K6 powering module. In some cases recordings were made using a Uher 4200 reel-to-reel recorder. Recordings of substrate tremulations and drumming were done using a U352B5 accelerometer from PCB Piezoelectronics, with a power unit 480E09. The signal from the accelerometer was fed directly into a computer (Macintosh PPC 8600/300) and digitized at the rate of 44100Hz, 16 bit. The same sampling rate was applied for digitizing acoustic signals recorded on tape. All acoustic signals were analyzed using The Cornell Bioacoustic Workstation Canary v. 1.2.1. Whenever possible, multiple specimens of each species were recorded, although for some species only single individuals could be recorded.

CHECK-LIST OF CONOCEPHALINAE S. L. OF COSTA RICA

Genus: *Conocephalus* Thunberg, 1815

1. *Conocephalus (Xiphidion) angustifrons* (Redtenbacher, 1891)
2. *Conocephalus (Xiphidion) cinereus* Thunberg, 1815
3. *Conocephalus (Xiphidion) ictus* (Scudder, 1875)
4. *Conocephalus (Xiphidion) saltator* (Saussure, 1859)
5. *Conocephalus (Xiphidion) magdalenae* Naskrecki, sp. n.

Genus: *Orchelimum* Serville, 1839

6. *Orchelimum fraternum* Rehn and Hebard, 1915

Genus: *Lipotactomimus* Naskrecki, gen. n.

7. *Lipotactomimus rowelli* Naskrecki, sp. n.

Genus: *Copiphora* Serville, 1831

8. *Copiphora cochleata* Redtenbacher, 1891
9. *Copiphora cultricornis* Pictet, 1888
10. *Copiphora brevicauda costaricensis* ssp. n.
11. *Copiphora hastata* Naskrecki, sp. n.
12. *Copiphora rhinoceros* Pictet, 1888
13. *Copiphora ottei* Naskrecki, sp. n.

Genus: *Acantheremus* Karny, 1907

14. *Acantheremus colwelli* Naskrecki, 1997

Genus: *Lirometopum* Scudder, 1875

15. *Lirometopum coronatum* Scudder, 1875

Genus: *Neoconocephalus* Karny, 1907

16. *Neoconocephalus affinis* (Palisot de Beauvois, 1805)
17. *Neoconocephalus punctipes* (Redtenbacher, 1891)
18. *Neoconocephalus spiza* Walker and Greenfield, 1983
19. *Neoconocephalus triops* Linnaeus, 1758

Genus: *Pyrgocorypha* Stål, 1873

20. *Pyrgocorypha hamata* (Scudder, 1879)
21. *Pyrgocorypha rogersi* Saussure and Pictet, 1898

Genus: *Bucrates* Burmeister, 1838

22. *Bucrates capitatus* (De Geer, 1773)
23. *Bucrates clausus* (Scudder, 1878)

Genus: *Caulopsis* Redtenbacher, 1891

24. *Caulopsis cuspidata* (Scudder, 1878)

25. *Caulopsis microprora* Hebard, 1926

Genus: *Metacaputus* Naskrecki, gen. n.

26. *Metacaputus brenesi* Naskrecki, sp. n.

Genus: *Erioloides* Hebard, 1927

27. *Erioloides consobrinus* (Saussure and Pictet, 1898)
28. *Erioloides brevipennis* (Redtenbacher, 1891)
29. *Erioloides longipennis* (Redtenbacher, 1891)
30. *Erioloides macrocephalus* (Carl, 1908)
31. *Erioloides longinói* Naskrecki and Cohn, sp. n.
32. *Erioloides acutidentis* Naskrecki and Cohn, sp. n.
33. *Erioloides sikesi* Naskrecki and Cohn, sp. n.
34. *Erioloides laticobinus* Naskrecki and Cohn, sp. n.

Genus: *Eppia* Stål, 1876

35. *Eppia truncatipennis* Stål, 1876

Genus: *Sphyrometopa* Carl, 1908

36. *Sphyrometopa atlantica* Rentz, 1976
37. *Sphyrometopa femorata* Carl, 1908

Genus: *Pluviasilva* Naskrecki, gen. n.

38. *Pluviasilva levis* Naskrecki, sp. n.

Genus: *Eriolus* Bolivar, 1888

39. *Eriolus acutipennis* Saussure and Pictet, 1898
40. *Eriolus aculeus* Naskrecki, sp. n.
41. *Eriolus penicillus* Naskrecki, sp. n.
42. *Eriolus duplidentis* Naskrecki, sp. n.

Genus: *Podacanthophorus* Naskrecki, gen. n.

43. *Podacanthophorus alas* Naskrecki, sp. n.
44. *Podacanthophorus maylinae* Naskrecki, sp. n.
45. *Podacanthophorus vargasi* Naskrecki, sp. n.
46. *Podacanthophorus nelciae* Naskrecki, sp. n.

Genus: *Moncheca* Walker, 1869

47. *Moncheca pretiosa* (Walker, 1869)
48. *Moncheca elegans* (Giglio-Tos, 1898)

Genus: *Vestria* Stål, 1874

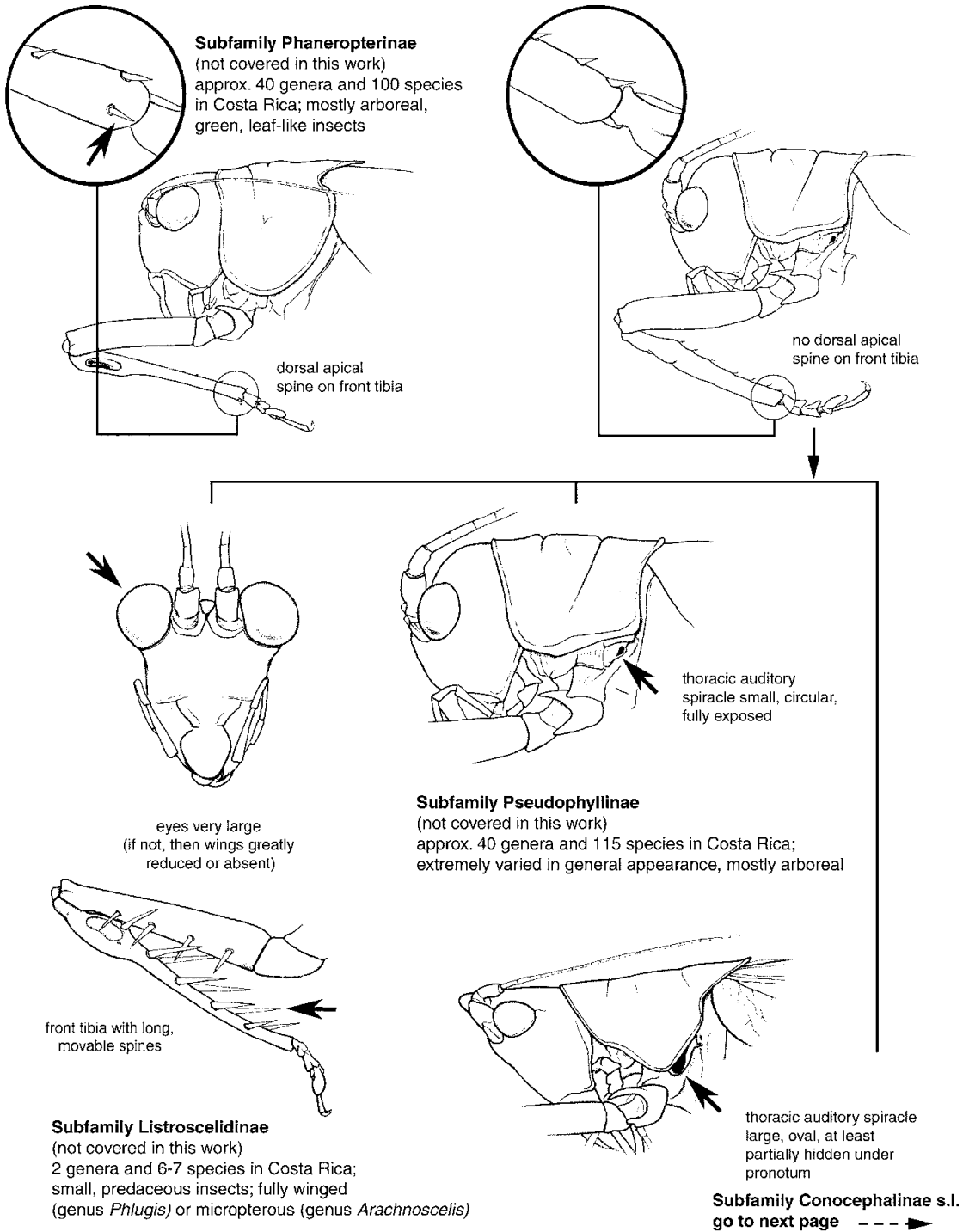
49. *Vestria punctata* (Redtenbacher, 1891)

Genus: *Subria* Stål, 1874

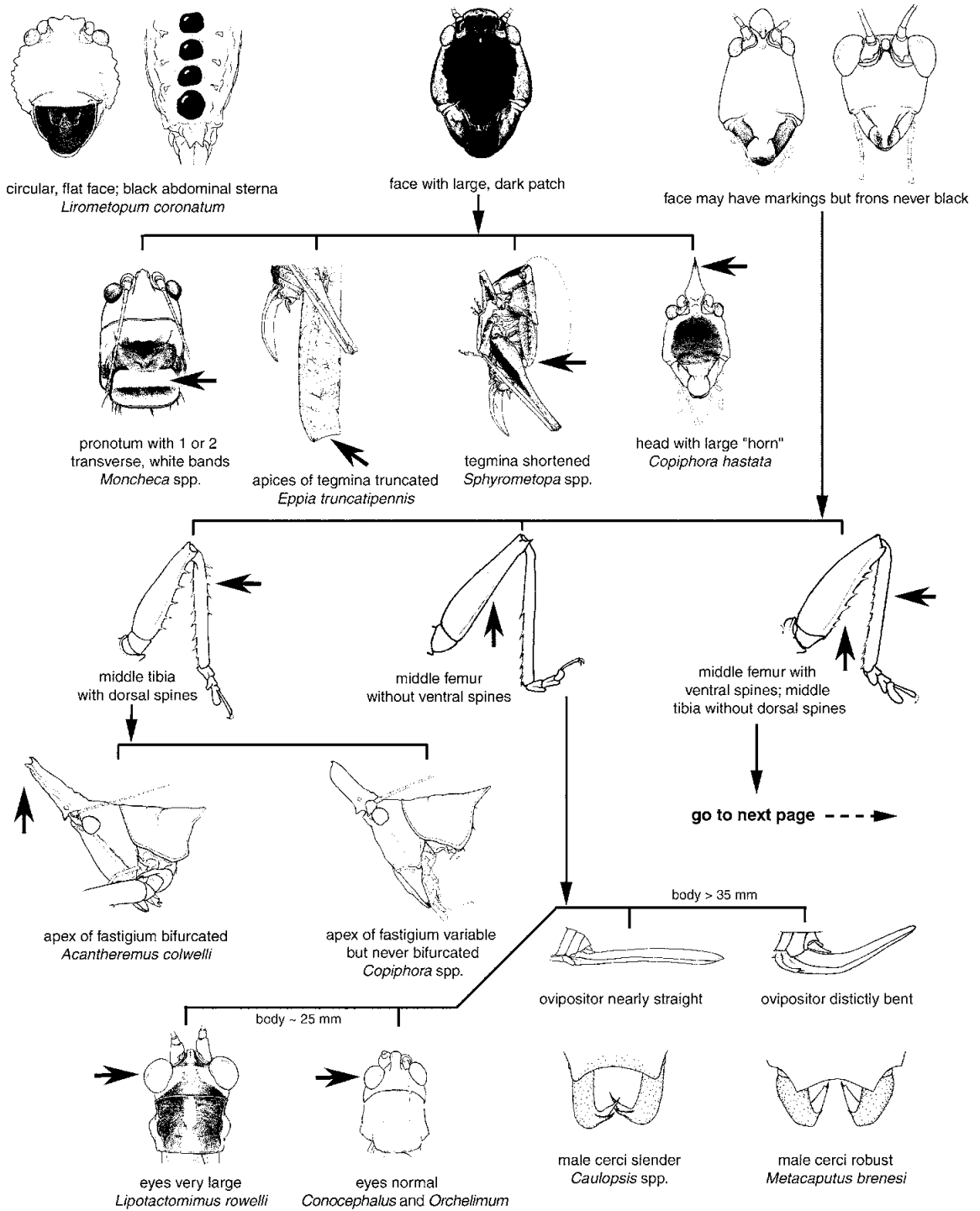
50. *Subria crassicerca* Naskrecki and Morris, sp. n.

GENERAL KEYS

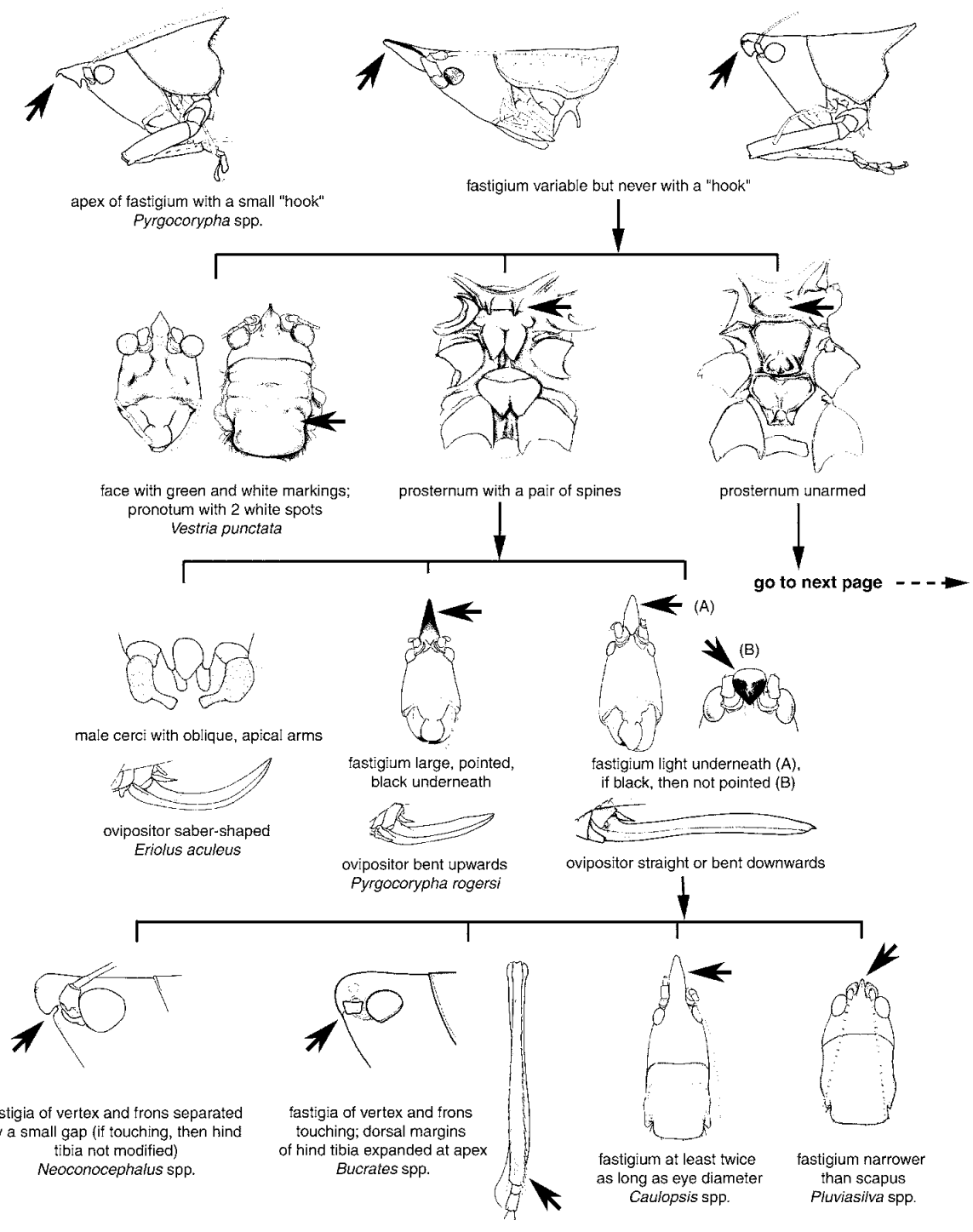
KEY 1. Key to subfamilies of Tettigoniidae represented in Costa Rica.



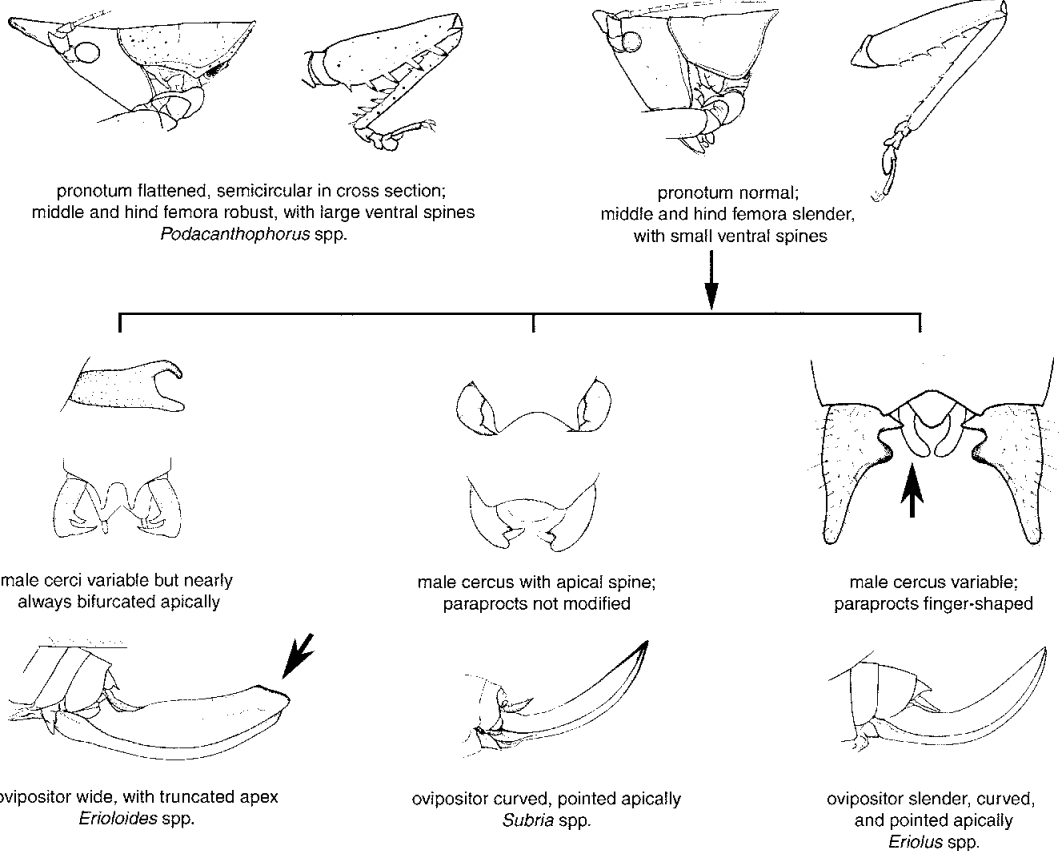
KEY 2. Key to genera and species of Conocephalinae *sensu lato* represented in Costa Rica.



KEY 2. Key to genera and species of Conocephalinae *sensu lato* represented in Costa Rica (continued).



KEY 2. Key to genera and species of Conocephalinae *sensu lato* represented in Costa Rica (continued).



Note: As with most taxonomic keys, the above key is not intended to reflect or illustrate phylogenetic relationships among the included taxa, and its sole purpose is to facilitate identification. Additional keys are included within the descriptions of individual genera.

TAXONOMIC DESCRIPTIONS

The taxonomic descriptions below cover 20 genera and 52 species of Conocephalinae *s.l.* known to occur in Costa Rica. Two other species recorded in the literature as present in this country are not included for the following reasons. The occurrence of *Copiphora cornuta* (De Geer), reported from Costa Rica by Redtenbacher (1891) could not be confirmed and is probably based on misidentification. This species is known only from South America (Colombia, Surinam, Brazil), and its presence in Central America is unlikely. The second species, *Neoconocephalus tristani* (Pictet and Saussure), was designated a *nomen dubium* by Walker and Greenfield (1983) as it proved impossible to identify.

In addition to species of Conocephalinae *s.l.* from Costa Rica, the section below includes a description of a new species from Mexico, as it represents the second known species of the new genus *Pluviasilva* gen. n. described in this work.

It is quite likely that the fauna of Costa Rica includes more species of Conocephalinae *s.l.* than presented here. I hope that this work will provide a starting point for a more comprehensive exploration of the katydid fauna of this extremely interesting country, and prove helpful in identifying both known and yet undiscovered members of the family Tettigoniidae.

CONOCEPHALUS Thunberg, 1815
Common Name: Meadow katydids

1815 Thunberg, Mem. Acad. St. Petersburg. 5: 214; type species: *Gryllus Tettigonia conocephalus* Linnaeus, 1767

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>references; types illustrated

[syn.] *Xyphidium* = 1853 Fieber, Lotos 3: 170; type species: unknown

[syn.] *Palotta* = 1869 Walker, Cat. Derm. Salt. Brit. Mus. 2: 249; type species: *Palotta inornata* Walker [syn. of *Conocephalus iris* (Serville)], by monotypy

[syn.] *Xiphidium* = 1838 Burmeister, Handb. Ent. 2: 707 >>Replacement name for *Xiphidium* Serville 1831.

Diagnosis

Body slender, small as for the family; macropterous, mesopterous, brachypterous or squamipterous (Figs. 1A, 2A, 36A, 37D); tegumen smooth. Fastigium of vertex laterally compressed, rounded apically, never cone-shaped; no traces of genal carinae present; mandibles and labrum symmetrical; eyes relatively large. Pronotum short, lat-

eral lobes approximately triangular, posterior edge of lobe with "secondary tympanum." Stridulatory file with peg like teeth. All legs slender, fore and mid femora unarmed on lower margins. Male cercus usually armed with one internal tooth, rarely unarmed; ovipositor straight to weakly curved, with upper and lower margins parallel.

Description (male except where specified)

Head.— Fastigium of vertex 0.75 to 1.5 times as wide as scapus (Figs. 1C-E), laterally compressed, rounded dorsally and apically, never hook- or cone-shaped, never projecting strongly in front of eyes; fastigium of vertex touching fastigium of frons. Eyes large relative to size of head, weakly protruding. Frons weakly convex, smooth; tegumen of head smooth, without traces of genal carinae; face slender. Mandibles and labrum symmetrical.

Thorax and wings.— Dorsal surface of pronotum smooth, flat or metazona slightly raised; anterior dorsal margin straight, posterior one straight or weakly convex; lateral lobes approximately triangular, with acute posterior angle; posterior edge of lateral lobe with "secondary tympanum" – a somewhat raised, narrowly elliptical area of thinner cuticle covering thoracic auditory spiracle; humeral sinus poorly developed or absent (Fig. 1A). Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle unmodified. Prosternum unarmed or armed with two thin, short spines (modified basisternum); meso- and metasternum with lateral lobes of basisterna small, triangular, their inner margins touching; posterior part of metasternum strongly compressed causing hind coxa to nearly touch each other.

Wings in both sexes either fully developed, well surpassing apices of hind femora, with hind wings usually distinctly longer than tegmina; or wings shortened, barely reaching apex of abdomen; or wings shortened not reaching apex of abdomen; or wings very short, not reaching middle of abdomen, squamipterous in females; often intermediate forms occur, and many species have both macro- and brachypterous forms; in macropterous forms tegmina slender, narrowly rounded apically (Fig. 2A). Stridulatory apparatus of male well developed; stridulatory area of left wing membranous, without a network of secondary veinlets; stridulatory file (vein AA₁—new vein homology after Kukalova-Peck, personal communication; male stridulatory file used to be homologized with the vein Cu₂) sinusoidal (Figs. 1B-F), teeth thick, peg-like, sparsely arranged, especially on distal end of file; mirror of right wing approximately rectangular, with

secondary veinlet next to AA₁ always well developed, divergent from AA₁.

Legs.— All legs long and slender; fore coxa with an elongate, forward projecting spine dorsally. All femora unarmed dorsally; fore and mid femora unarmed ventrally, hind femora armed ventrally with relatively few minute spines or unarmed; genicular lobes of femora usually armed with short spines, sometimes only inner genicular lobes armed. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area weakly to distinctly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen.— Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite usually strongly sclerotized, with narrow apical incision, supraanal plate small, triangular. Male cercus variable but usually with one internal spine, sometimes unarmed or with apex of cercus modified into spine (Figs. 39A-H); female cercus, simple, slender and weakly incurved. Subgenital plate of male with a pair of styli, distinct median keel, truncated apically or with triangular apical emargination; female subgenital plate approximately triangular, rounded or shallowly emarginated apically. Concealed genitalia of male with paired, heavily sclerotized, hook-like titillators (Figs. 2G-K). Ovipositor narrow, straight to weakly curved; its length variable, from distinctly shorter to over twice as long as hind femur; both dorsal and ventral margins of ovipositor smooth, parallel; apex of upper valvula sharp (Figs. 2B-F).

Coloration.— General coloration usually green, sometimes straw brown, almost invariably with dark, wide stripe on head and pronotum (stripe black and extending along the dorsal side of the abdomen in nymphs of probably all species); abdomen usually green but often apical half of abdomen colored differently, yellow, orange, red or purple (especially in males); sometimes dorsal side of abdomen yellow, with dark, longitudinal stripes. Tegmina straw brown to light green; legs green to light brown.

Remarks.— The genus *Conocephalus*, with its 7 subgenera, is the largest genus of the Tettigoniidae, having at least 161 valid species, distributed on all continents. Most species of the genus are associated with open, grassy habitats. Both nocturnal and diurnal species are known, and both can occur within the same habitat. They are known to be herbivorous, omnivorous, or predominantly predaceous, and some can be of significant economic importance. Two species from New Guinea, *C.*

redtenbacheri (Bolivar) or *C. semivittatus vittatus* (Fabricius), have potential as biocontrol agents, being well-known predators of rice pests (Pitkin 1980). In Cuba, *C. fasciatus* (De Geer) and *C. brevipennis* (Scudder) were observed feeding on caterpillars of *Mocis* sp. (Lepidoptera, Noctuidae) (De Zayas 1974). The only Costa Rican species of the genus known to be beneficial is *C. saltator*, which is reported as a predator of pests in the sugar cane fields of the Hawaiian Islands (Zimmerman 1948). On the other hand, it can cause damage to rice (Grist and Lever 1969) as well as corn and pineapple (Zimmerman 1948). In the last case, the damage is caused by laying its eggs in the flowers of the plants rather than by feeding on them. Another species known from Costa Rica, *C. cinereus*, was listed as a pest of rice in Guyana and Surinam (Grist and Lever 1969). It has also been reported as injurious to tobacco seedlings in San Lorenzo, Puerto Rico (Wolcott 1950, in Gurney 1959). Gurney (1959) also reports that specimens of this species have been seen feeding on the banded cucumber beetle, *Diabrotica balteata* LeConte.

Costa Rican fauna of *Conocephalus* spp. is rather poorly known and requires additional, extensive collecting and studying. At least 5 species occur in this country, including 1 species new to science, described below. With the exception of *C. angustifrons*, all Costa Rican species seem to be chiefly diurnal. *Conocephalus angustifrons* is predominantly predaceous and individuals of this species have been observed capturing insects of the size equal to their own, including adult individuals of the predaceous katydid *Phlugis* sp. Little is known about the diet of the remaining species but they seem to feed on seeds and leaves of various grasses. Males of most species of *Conocephalus* produce continuous, high duty calls, which can be heard during the day in nearly all open, grassy areas of the country.

Conocephalus (Xiphidion) angustifrons (Redtenbacher, 1891)



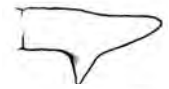



Figs. 1C, 2E, 2J, 36A, 39B, 39J, 52C-D, Map 1

1891 Redtenbacher, Monogr. Conoceph.: 498
>>*Xiphidium*; type locality: Colombia: Tolima and Sta Fe de Bogota; type depository: Naturhistorisches Museum, Vienna, Austria – male and female syntypes

1906 Kirby, Syn. Cat. Orth. 2: 282. >>*Anisoptera*
1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 260
>>*Conocephalus (Xiphidion)*

Diagnostic description.— General characteristics as described above; most individuals in the Costa Rican population mesopterous (Fig. 36A), rarely macropterous.

TABLE 1. Key for identification of Costa Rican species of *Conocephalus* and *Orchelimum*

Species	Male cerci	Left mirror area	Ovipositor	Coloration
<i>C. angustifrons</i>		small, shorter than eye diameter (Fig. 1C)	as long as 0.6-0.7 of hind femur (Fig. 2E)	body dark emerald green; apex of male abdomen red (Fig. 35A)
<i>C. cinereus</i>		small, shorter than eye diameter (Fig. 1E)	as long as 0.8-0.9 of hind femur (Fig. 2C)	body light green; apex of male abdomen yellow (Fig. 36D)
<i>C. ictus</i>		about as long as eye diameter (Fig. 1D)	as long as 0.8-0.9 of hind femur (Fig. 2D)	body pale green; apex of male abdomen yellow to reddish brown
<i>C. saltator</i>		about as long as eye diameter (Fig. 1B)	as long as 0.9 of hind femur (Fig. 2F)	body light green; apex of male abdomen reddish-yellow to yellowish-brown
<i>C. magdalenae</i>		large, distinctly longer than eye diameter (Fig. 1F)	as long as 0.6 of hind femur (Fig. 2B)	body green; abdomen in both sexes with yellow and black longitudinal stripes
<i>O. fraternum</i>		about as long as eye diameter (Fig. 3C)	as long as 0.6-0.7 of hind femur (Fig. 3F)	body pale green; dorsal surface of abdomen yellow

Stridulatory file of male 1.06 mm long, with 40 teeth, maximum width of file 50 μ m (Fig. 39J); teeth of file thick, peg-like, more densely arranged at proximal end of file. Left (upper) mirror of stridulatory apparatus as in Fig. 1C, shorter than eye diameter. Fastigium of 1/2 to 3/4 as wide as scapus. Outer ventral edge of hind femur armed with 1-4 minute, black spines. Male cercus as in Fig. 39B; ovipositor distinctly shorter than hind femur (ratio ovipositor/hind femur 0.62-0.71), weakly upcurved (Fig. 2E).

Coloration.— Coloration unique, in live individuals head and anterior portion of pronotum aquamarine green or teal, posterior part of pronotum, thoracic terga and first four abdominal terga emerald green; remaining portion of abdomen of male bright orange-red, that of female reddish-brown; all femora brown, hind knees dark brown; fore and mid tibia emerald green, hind tibia dark green to brown. Dorsum of head and pronotum with wide, dark band, typical of most species of the genus (Fig. 36A). Coloration deteriorates considerably in preserved specimens but most of them

still retain dark bluish-green coloration, unlike any other species of *Conocephalus*.

Measurements.— Table 2.

Bioacoustics.— The call of *C. angustifrons* consists of a series of short chirps, produced at the rate of about 1.4-2.0 per second (at 26°C) (Fig. 52C). Each chirp lasts 92-124 ms (avrg. 116 \pm 10.3, n=10) and consists of 3-4 wingstrokes (opening and closing), with the first wingstroke being incomplete (Fig. 52D). Typically of the genus, the call is low Q, with most energy within the audible part of the call allocated between 6.5-16 kHz.

Remarks.— This species is known from the Atlantic portion of Costa Rica (Map 1), Panama, and Colombia. It is one of the most distinctive species of the genus and cannot be confused with any other species of *Conocephalus* in Costa Rica. *Conocephalus angustifrons* seems to be active mostly at night although males also stridulate during the day. This species appears to be predaceous, suc-

cessfully hunting insects of nearly equal body size (e.g., katydids of the genus *Phlugis*).

Material examined. — **COSTA RICA: Cartago Prov.**, 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 5 males, 1 female (UMMZ); Monumento Nacional Guayabo, A.C.A.C. Amistad, 15 July 1994 (coll. G. Fonseca) - 1 male (INBio); Quebrada Segunda Ref., Nac. Fauna Silv. Tapantí, elev. 1250 m, 15 April 1992 (coll. R. Vargas) - 1 female (INBio); **Heredia Prov.**, Braulio Carillo N. P., Estac. El Ceibo, elev. 400 - 600 m, 15 December 1989 (coll. R. Aguilar and M. Zumbado) - 2 males (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 - 4 April 1994 (coll. P. Naskrecki) - 1 male (INBio); same locality, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 13 April - 10 May 1998 (coll. P. Naskrecki) - 2 males (INBio); **Limón Prov.**, Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 200 m, 15 December 1990 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 200 m, 15 April 1991 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 100 m, 15 June 1991 (coll. A. Moreno) - 1 female (INBio); same locality, elev. 100 m, 15 June 1991 (coll. G. Carballo) - 1 male, 1 female (INBio); Los Diamantes (1 km E of Guápiles), 26 - 27 January 1967 (coll. I.J. Cantrall) - 10 males, 6 females (UMMZ); Saturno Farm, Estrella Valley, elev. 30.48 m, 12 September 1923 - 2 males (ANSP); **PANAMA:** Canal Zone, Barro Colorado Island, 20 January 1967 (coll. I.J. Cantrall) - 1 female (UMMZ).

Conocephalus (Xiphidion) cinereus Thunberg, 1815
Figs. 1E, 2A, 2C, 2H, 37D, 39C, 40C, 52E-G, Map 1

1815 Thunberg, Mem. Acad. St. Petersb. 5: 27; type locality: Jamaica; type depository: Zoological Institute, University of Uppsala, Sweden - holotype female [syn.] 1875 Scudder, Proc. Boston Soc. Nat. Hist. 17: 459 >>*Orchelimum ortonii*; type locality: South America: Peru: Maranon; type depository: Academy of Natural Sciences, Philadelphia, PA, USA >>holotype female

Diagnostic description. — General characteristics as described above; most individuals in the Costa Rican population macropterous (Fig. 2A), rarely mesopterous (with tegmina hardly reaching apices of hind femora; in such individuals hind wings sometimes completely covered by tegmina). Stridulatory file of male 1.47 mm long, with 44-45 teeth, maximum width of file 66 µm (Figs. 40C); teeth of file thick, peg-like, more densely arranged at

proximal end of file. Left (upper) mirror of stridulatory apparatus as in Fig. 1E, shorter than eye diameter. Fastigium of vertex 2/3 to 3/4 as wide as scapus. Outer ventral edge of hind femur unarmed or armed with 1-2 minute, black spines. Male cercus as in Fig. 39C; ovipositor distinctly shorter than hind femur (ratio ovipositor/hind femur 0.76-0.87), nearly straight (Fig. 2C).

Coloration. — Coloration typical of the genus, light green, with brown stripe on top of head and pronotum; posterior half of abdomen in male bright yellow, cerci yellow to light brown; abdomen in females usually green or faintly yellowish (Fig. 37D).

Measurements. — Table 2.

Bioacoustics. — The call of *C. cinereus* has two repeating, distinct parts: a series of individual, short chirps, followed by a train of continuous buzz (Fig. 52E). At 27°C each series of chirps lasts 1.6-1.8 s, with chirps produced at the rate of 0.30-0.32/s, and each chirp lasting 32-37 ms (avg. 34±1.7 ms, n=10) (Fig. 52F). The continuous portion of the call lasts 0.86-1.1 s and consists of a train of short chirps produced at the rate of 39.5-40.2/s (Fig. 52G). Both parts can be repeated continuously for several minutes. Within the audible portion of the call most energy is allocated between 8 and 16 kHz.

Remarks. — *Conocephalus cinereus* is known from most of the Caribbean islands and a large portion of the continental Americas, from Florida in the US and Vera Cruz in Mexico, through Guatemala, Costa Rica (Map 1) and Panama, to French Guyana, Surinam and Peru. Older records (prior to Rehn and Hebard 1915b) should be treated with caution as this species has been frequently confused with *C. fasciatus* (De Geer). These two species can be separated based on the shape and coloration of male cerci (cerci green, apical part short and only weakly flattened dorso-ventrally in *C. fasciatus* [Fig. 38D], yellow, apical part more elongated and strongly flattened dorso-ventrally in *C. cinereus* [Fig. 38F]) as well as in the number of the stridulatory teeth (about 33 in *C. fasciatus*, 44-45 in *C. cinereus*). In addition, the apical portion of the fastigium of vertex in *C. cinereus* is usually slightly expanded laterally, whereas that of *C. fasciatus* has its sides parallel.

Material examined. — **COSTA RICA: Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 14 - 27 April 1994 (coll. K. Flores) - 1 male (INBio); same locality, elev. 20 m, 3 - 23 April 1995 (coll. R. Villalobos) - 1 male (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 1 male, 2 females (PN

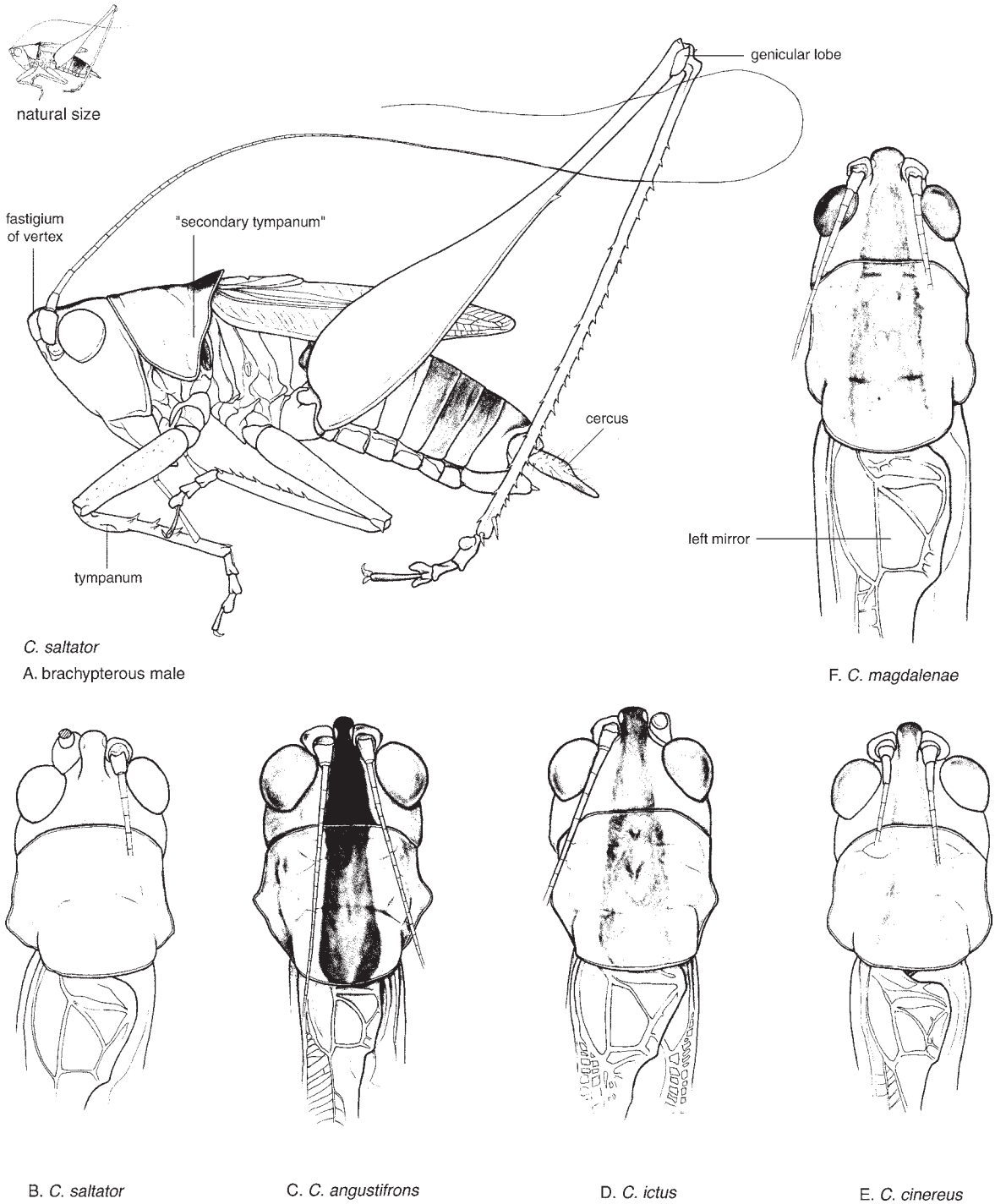


FIG. 1. Costa Rican *Conocephalus* spp. A. *C. saltator* - habitus; B-F: male pronotum, dorsal view. B. *C. saltator*, C. *C. angustifrons*, D. *C. ictus*, E. *C. cinereus*, F. *C. magdalena*.

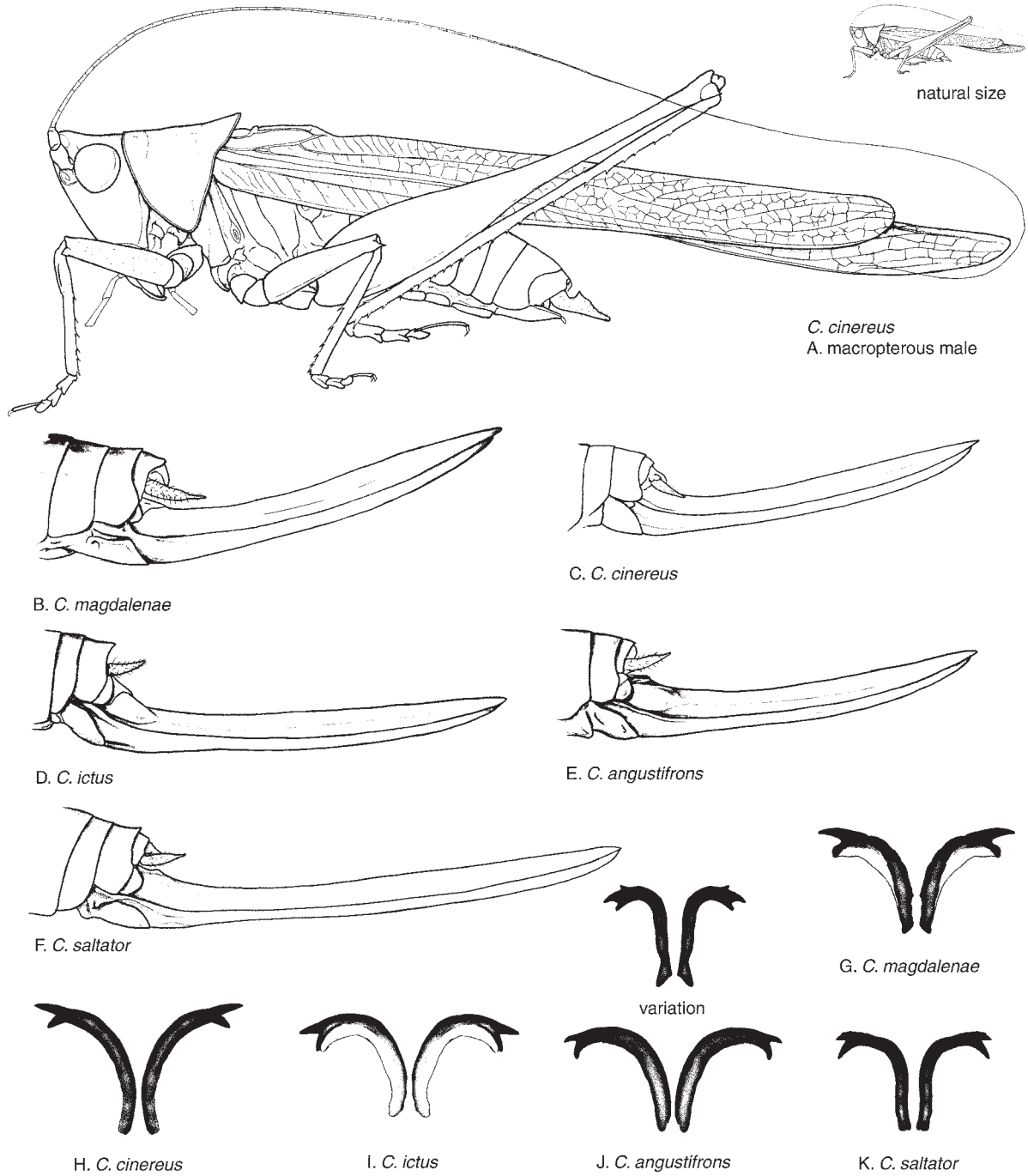


FIG. 2. Costa Rican *Conocephalus* spp. **A.** *C. cinereus* - habitus; **B-F:** ovipositors. **B.** *C. magdalenae*, **C.** *C. cinereus*, **D.** *C. ictus*, **E.** *C. angustifrons*, **F.** *C. saltator*; **G-K:** titillators. **G.** *C. magdalenae*, **H.** *C. cinereus*, **I.** *C. ictus*, **J.** *C. angustifrons*, **K.** *C. saltator*

collection); **Guanacaste Prov.**, Estac. Murciélago, 8 km SO de Cuajiniquil, elev. 100 m, 6 - 24 January 1994 (coll. F. Quesada) - 1 male (INBio); Palo Verde N. P., Palo Verde Biological Station, 5 February 1994 (coll. P. Naskrecki) - 3 males (PN collection); **Heredia Prov.**, Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 - 4 April 1994 (coll. P. Naskrecki) - 1 female (PN collection); same locality, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 male, 1 female (INBio, PN collection); **Limón Prov.**, Aurora Farm, Estrella Valley, elev. 30.48 m, 11 September 1923 - 1 female (ANSP); Siquirres, 3 August 2003 (coll. M.A. Carriker, Jr.) - 1 male (ANSP); **Puntarenas Prov.**, 4 km NW of San Vito de Java (jct. of road and Río Java), elev. 910 m, 20 January 1967 (coll. I.J. Cantrall) - 1 male (UMMZ); Estac. Aguias, Río Aguias, Frente a la Estac., elev. 300 m, 1 - 7 December 1997 (coll. A. Azofeifa) - 2 males (INBio); Est Esquinas, Península de Osa, elev. 0 m, 15 January 1993 (coll. F. Quesada) - 1 male (INBio); Estación Altamira, ACLA, PILA, elev. 1450 m, 1 - 28 January 1996 (coll. R. Vilalobos) - 1 male (INBio); Finca Cafrosa, Estac. Las Mellizas, P.N. Amistad, elev. 1300 m, 15 April 1989 (coll. M. Ramirez and G. Mora) - 1 male (INBio); Península de Osa, Estac. Esquinas, A.C. Osa, elev. 200 m, 15 January 1994 (coll. M. Segura) - 1 male (INBio); Puntarenas, 1 - 28 February 1907 (coll. P. Biolley) - 1 female (ANSP); Rancho Quemado Península de Osa, elev. 200 m, 15 October 1990 (coll. F. Quesada) - 1 male (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 2 males, 1 female (PN collection); **COLOMBIA**: Boca Murindo, Choco, 9 November 1918 (coll. M.A. Carriker, Jr.) - 1 female (ANSP); **CUBA**: Havana, - 1 male (ANSP); **GUATEMALA**: Petén Poptún, 15 April 1956 (coll. Hubbell-Cantrall) - 1 male (UMMZ); **PANAMA**: Canal Zone, Barro Colorado Island, 2 January 1967 (coll. I.J. Cantrall) - 1 male (UMMZ); Colón, 1 - 20 August 1963 (coll. J.L. Lawrence) - 1 female (UMMZ).

Conocephalus (Xiphidion) ictus (Scudder, 1875)

Figs. 1D, 2D, 2I, 39C, 40B, Map 2

1875 Scudder, Proc. Boston Soc. Nat. Hist. 17: 461
 >>*Xiphidium*; type locality: Mexico; type depository:
 Academy of Natural Sciences, Philadelphia -
 syntypes, males and females
 1906 Kirby, Syn. Cat. Orth. 2: 281. >>*Anisoptera*
 1912 Karny, Genera Insectorum 135: 8 >>*Conocephalus*
 (*Neoxiphidion*) *ictus*
 1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 250
 >>*Conocephalus (Xiphidion)*

[syn.] *mexicanum* = 1875 Saussure, Rev. Mag. Zool. 2 ser
 11: 208 >>*Xiphidium*; type locality: Central America:
 Mexico; type depository: Geneva
 1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 250
 >> syn. of *C. ictus*

Diagnostic description. — General characteristics as described above, body quite robust as for the genus; most individuals in Costa Rican population brachy- to mesopterous, less frequently fully macropterous. Stridulatory file of male 1.63 mm long, with 61 teeth, maximum width of file 68.5 μ m (Fig. 40B); teeth of file thick, peg-like, nearly uniformly spaced along entire file. Left (upper) mirror of stridulatory apparatus as in Fig. 1D, as long as or slightly longer than eye diameter. Fastigium of vertex as wide as 3/4 of scapus, its sides slightly divergent towards apex. Outer ventral edge of hind femur unarmed or armed with 1-3 minute, black spines. Male cercus as in Fig. 39C; ovipositor only slightly shorter than hind femur (ratio ovipositor/hind femur 0.79-0.89), straight (Fig. 2D).

Coloration. — General coloration pale green, dorsal band on head and pronotum very dark, often nearly black, bordered by two thin, lighter stripes; posterior half of abdomen in male yellow to reddish-brown, cerci yellow to light brown; abdomen in females usually green or faintly yellowish.

Measurements. — Table 2.

Bioacoustics. — The call of *C. ictus* is similar to that of *C. cinereus*, and consists of two parts: a train of continuous buzz followed by a series of short, individual chirps (in *C. cinereus* the sequence is reversed and the buzz always follows the individual chirps) (Fig. 51A-B). At 32°C the continuous buzzes last 1.68-13.86 s (avrg. 6.15 \pm 4.05, n=17) and consist of pulses (chirps) produced at the rate of 18-19/s, with each pulse lasting 50-54 ms (avrg. 51.2 \pm 0.7, n=30). The slow series last 0.57-2.79 s (avrg. 1.64 \pm 0.68, n=13) and consist of 3-6 individual pulses produced at the rate of 2.8-3/s. Within the audible part of the call most energy is allocated between 10 and 17 kHz.

Distribution. — This species has been recorded from most of Mexico, Guatemala, Nicaragua, and northern Costa Rica (Map 2).

Material examined. — **COSTA RICA: Alajuela Prov.**, 11.5 mi. NE Esparta on Pan. Amer. Hwy., 5 October 1961 (coll. Hubbell, Cantrall, Cohn) - 6 males (UMMZ); **Guanacaste Prov.**, 15.3 mi. SE Las Cañas on Pan. Amer. Hwy., 5 October 1961 (coll. Hubbell, Cantrall, Cohn) - 3 males (UMMZ); Estac. Cacao, SW side Volcán Cacao, elev. 1000

- 1400 m, 15 March 1988 (coll. GNP Biodiv. Survey) - 1 male (INBio); same locality, elev. 1000 - 1400 m, 15 April 1988 (coll. GNP Biodiv. Survey) - 1 male (INBio); Los Almendros, P.N. Guanacaste, 8 - 20 November 1993 (coll. E. Lopez) - 1 male (INBio); Area de Conservacion Guanacaste, Santa Rosa National Park, 21 - 24 August 1999 (coll. P. Naskrecki, D. Otte, G. Morris) - 1 male (PN collection); **GUATEMALA**: San Marcos, Finca La Paz near La Reforma, elev. 1280 m, 3 May 1956 (coll. T.H. Hubbell) - 1 male, 1 female (UMMZ); same locality, elev. 1054 m, 5 May 1956 (coll. T.H. Hubbell) - 1 male (UMMZ); Honduras: Progreso, 19 March 1923 (coll. T.H. Hubbell) - 1 male (UMMZ); **MEXICO**: - 2 males, 2 females (ANSP, UMMZ); Sinaloa, Los Mochis, 2 - 10 December 1917 (coll. J.A. Kusche) - 1 male (ANSP); same locality, 21 December 1917 (coll. J.A. Kusche) - 1 male (ANSP); Venvidio, 15 August 1918 (coll. J.A. Kusche) - 1 female (ANSP); Villa Union, 27 September 1918 (coll. J.A. Kusche) - 1 female (ANSP).

Conocephalus (Xiphidion) saltator (Saussure, 1859)
Figs. 1A-B, 2F, 2K, 39A, 39I, 52A-B, Map 2

1859 Saussure, Rev. et Mag. Zool. [2]11: 208 >>*Xiphidium*;
type locality: Guyana; type depository: Museum d'Histoire Naturelle, Geneva, Switzerland - holotype female
1906 Kirby, Syn. Cat. Orth. 2: 276. >>*Anisoptera*
1912 Karny, Genera Insectorum 135: 9 >>*Conocephalus (Xiphidion)*
[syn.] *brachypterus* = 1891 Redtenbacher, Monogr. Conoceph.: 498, 523; type locality: Brazil, Colombia, Venezuela, Peru; type depository: Natural History Museum, Vienna—lectotype male >>*Xiphidium*
1906 Kirby, Syn. Cat. Orth. 2: 281. >>*Anisoptera*
1912 Karny, Genera Insectorum 135: 9 >>*Conocephalus (Neoxiphidion)*
1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 269 >>Syn. of *saltator*
1980 Pitkin, Bull. Br. Mus. nat. Hist. (Ent.) 41: 347 >>Lectotype designated
[syn.] *meridionalis* = 1875 Scudder, Proc. Boston Soc. Nat. Hist. 17: 460; type locality: Brazil, type depository: Acad. Nat. Sci. Philadelphia—holotype female >>*Xiphidium*
1906 Kirby, Syn. Cat. Orth. 2: 281. >>*Anisoptera*
1912 Karny, Genera Insectorum 135: 9 >>*Conocephalus (Neoxiphidion)*
1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 269 >>Syn. of *saltator*
[syn.] *propinquus* = 1891 Redtenbacher, Monogr. Conoceph.: 498, 522; type locality: St. Vincent, type

depository: The Nature History Museum, London >>*Xiphidium*
1906 Kirby, Syn. Cat. Orth. 2: 281. >>*Anisoptera*
1912 Karny, Genera Insectorum 135: 9 >>*Conocephalus (Neoxiphidion)*
1915b Rehn and Hebard, Trans. Amer. Ent. Soc. 41: 269 >>Syn. of *saltator*
1980 Pitkin, Bull. Brit. Mus. Nat. Hist. 41(5): 347 >>Lectotype designated
[syn.] *varipennis* = 1905 Swezey, Rep. Exp. Stat. Hawaii 1: 216; type locality: Hawaii, type depository: Honolulu - lectotype male >>*Xiphidium*
1912 Karny, Genera Insectorum 135: 10 >>*Conocephalus (Xiphidion)*
1980 Pitkin, Bull. Brit. Mus. Nat. Hist. 41(5): 347 >>syn. of *saltator*

Diagnostic description.— General characteristics as described above; most individuals in Costa Rica meso- or brachypterous (Fig. 1A) but macropterous individuals often occur within the same populations. Stridulatory file of male 1.34 mm long, with 55 teeth, maximum width of file 57.8 µm (Fig. 39I); teeth of file thick, peg-like, more densely arranged at proximal end of file. Left (upper) mirror of stridulatory apparatus as in Fig. 1B, distinctly longer than eye diameter. Fastigium of vertex as wide as 3/4 of scapus, its sides slightly diverging towards apex. Outer ventral edge of hind femur unarmed or armed with 2-4 minute, black spines. Male cercus as in Fig. 39A; ovipositor nearly as long as hind femur (ratio ovipositor/hind femur 0.87-0.90), straight (Fig. 2F).

Coloration.— Coloration typical of the genus, light green, with brown stripe on top of head and pronotum; posterior half of abdomen in male reddish-yellow to yellowish-brown, cerci light brown; upper surface of abdomen in females usually brownish, lower surface green.

Measurements.— Table 2.

Bioacoustics.— Males of *C. saltator* produce continuous, soft, rattling trains, with individual chirps produced at the rate of 23-24/s (at 27°C) (Figs. 52A-B). Most of the energy of the call is allocated between 10 and 16 kHz.

Distribution.— This species is widely distributed in Central and South America, stretching from Guatemala in the north to Rio de Janeiro in Brazil. It also occurs in Hawaiian Islands as well as several other Pacific Islands (Pitkin 1980). In Costa Rica it is rather common throughout the entire country (Map 2).

TABLE 2. Body measurements of Costa Rican species of *Conocephalus* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>angustifrons</i>					
male	13.4-14.9, 14±0.6	7.7-9.4, 8.3±0.8	3-3.5, 3.2±0.2	12.4-14.2, 13.3±0.7	na
female	16.1-16.1, 16.1±0	8.5-9.1, 8.8±0.4	3.4-3.4, 3.4±0	14.5-15, 14.8±0.4	9.3-10.3, 9.8±.7
<i>cinereus</i>					
male	15.9-26.5, 22.4±3.5	11.3-19.8, 16.6±2.8	2.8-3.4, 3±0.2	10.4-13.1, 11.8±0.9	na
female	21.7-27.4, 24.8±2.9	17.4-19.5, 18.1±1.2	3-3.4, 3.2±0.2	12.6-14, 13.2±0.7	9.6-12.2, 10.5±1.4
<i>ictus</i>					
male	12.2-26.9, 16±5.1	6.6-17.4, 8.9±3.9	3-3.9, 3.5±0.4	10.7-14.4, 12.7±1.6	na
female	13.9-29.4, 19.9±8.3	5.5-19.6, 11.6±7.3	3.4-4.1, 3.8±0.4	12.8-15.2, 14.2±1.2	10.1-13.2, 12.1±1.7
<i>saltator</i>					
male	13.9-27.7, 18.5±5.6	6.5-22.6, 10.9±7	2.9-3.7, 3.3±0.3	12.6-14.7, 13.7±0.8	na
female	14-29.8, 21.9±8.5	3.9-24.4, 14.2±11.1	3.2-3.5, 3.4±0.1	12.2-15, 14.1±1.3	11-13.3, 12.5±1.1
<i>magdalenae</i>					
male	26.6-29.8, 28.1±1.6	18.4-21.3, 20±1.5	4-4.2, 4.1±0.1	14.7-15.1, 14.9±0.3	na
female	26.9-31.8, 29.3±1.6	18.4-22.7, 20.8±1.5	3.9-4.4, 4.1±0.2	14.9-17.5, 15.7±0.9	8.7-10, 9.5±0.5

Material examined.— **COSTA RICA: Cartago Prov.**, 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 5 males, 3 females (UMMZ); **Guanacaste Prov.**, Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, elev. 700 m, 15 August 1988 (coll. GNP Biodiversity Survey) - 2 males (INBio); same locality, elev. 700 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, elev. 700 m, 15 October 1988 (coll. C. Chaves and M. Espinoza) - 1 male (INBio); same locality, elev. 700 m, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, elev. 700 m, 15 January 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 16 August 1997 (coll. C.H.F. Rowell) - 1 female (PN collection); Finca Taboga (6 mi S and 6 mi W of Las Cañas), elev. 12 - 40 m, 10° 19' N, 89° 9' W, 3 - 5 February 1967 (coll. I.J. Cantrall) - 1 male (UMMZ); **Heredia Prov.**, Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 13 April - 10 May 1998 (coll. P. Naskrecki) - 9 males, 3 females (INBio, PN collection); Sarapiquí, 25 October 1960 (coll. E. Morales) - 1 male, 2 females (UMMZ); **Limón Prov.**, Cerro Tortuguero, Tortuguero N. P., elev. 0 - 120 m, 1 - 30 April 1991 (coll. J. Solano) - 1 male (INBio); Cuatro Esquinas, P. N. Tortuguero, elev. 0 m, 15 April 1989 (coll.

R. Aguilar and J. Solano) - 1 male (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 100 m, 15 June 1991 (coll. A. Moreno) - 1 male (INBio); same locality, elev. 100 m, 15 July 1991 (coll. G. Carballo) - 1 female (INBio); same locality, elev. 100 m, 15 July 1991 (coll. A. Moreno) - 1 male (INBio); Los Diamantes (1 km E of Guápiles), 26 - 27 January 1967 (coll. I.J. Cantrall) - 6 males, 1 female (UMMZ); Puerto Limón, 7 July 1966 (coll. T.H. Hubbell) - 2 males (UMMZ); **Puntarenas Prov.**, 4 km NW of San Vito de Java (jct. of road and Río Java), elev. 910 m, 20 January 1967 (coll. I.J. Cantrall) - 15 males (UMMZ); AC. Osa, Bosque Esquinas, elev. 200 m, 15 June 1994 (coll. M. Segura) - 1 male (INBio); Cañas Gordas (Finca Loma Linda), elev. 1170 m, 7 June 1964 (coll. C.F. Walker and J.M. Savage) - 4 males, 1 female (UMMZ); Estac. San Miguel, Send. El Mirador, elev. 100 m, 29 September - 1 October 1997 (coll. F. Alvarado) - 1 male (INBio); Finca Cafrosa, Estac. Las Mellizas, P.N. Amistad, elev. 1300 m, 15 April 1989 (coll. M. Ramirez and G. Mora) - 2 males (INBio); Osa Peninsula, 5 mi. SW Rincón, elev. 30 m, 11 November 1964 (coll. T.F. Hubbell) - 3 males (UMMZ); Osa Peninsula, Rincón, elev. 75 - 240 m, 9 November 1964 (coll. T.F. Hubbell) - 7 males (UMMZ); Rancho Quemado, Pen. Osa, 1 November 1990 (coll. B. Apu) - 1 male (INBio); Rancho Quemado Península de Osa, elev. 200 m, 15 October 1990 (coll. F. Quesada) - 1 male, 1 female (INBio); Rincón, Osa Peninsula, 25 - 27 July 1966 (coll. C.F. Walker

- 1 male (UMMZ); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 1 female (PN collection).

Conocephalus (Xiphidion) magdalenae Naskrecki, sp. n.
Figs. 1F, 2B, 2G, 39C, 40A, Map 3

Type locality: Costa Rica, Guanacaste Prov., Finca Jenny, 31 km N Liberia, elev. 300 m; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— General characteristics as described above; all individuals collected so far macropterous. Stridulatory file of male 1.70-1.72 mm long, with 54-58 teeth, maximum width of file 69-72 μm (Fig. 40A); teeth of file thick, peg-like, nearly uniformly arranged along entire length of file. Left (upper) mirror of stridulatory apparatus as in Fig. 1F, at least 1.5 times longer than eye diameter. Fastigium of vertex about as wide as scapus, its sides slightly diverging towards apex. Outer ventral edge of hind femur unarmed. Male cercus as in Fig. 39C; ovipositor short (ratio ovipositor/hind femur 0.56-0.64), straight (Fig. 2B).

Coloration.— General coloration green but abdomen strikingly marked with dark brown and yellow longitudinal, parallel stripes on its dorsal surface; dark brown band on dorsal surface of head and pronotum bordered with thin, yellow stripes.

Measurements.— Table 2.

Bioacoustics.— Typical of the genus, the call of *C. magdalenae* is high duty and low Q. It consists of a regular series of paired buzzes (pulse train groups) produced every 0.26-0.96 s (avrg. 0.43 ± 0.18 s, $n=26$) at 34°C (Fig. 51C-D). Each pair lasts 0.44-0.86 s (avrg. 0.68 ± 0.09 s, $n=60$). The first pulse train group in a pair is usually longer (avrg. 0.34 ± 0.06 s, $n=20$) than the second one (avrg. 0.27 ± 0.05 s, $n=20$). The audible part of the call has most of its energy allocated between 8 and 16 kHz.

Distribution.— In Costa Rica *C. magdalenae* is so far known only from Guanacaste Prov. (Map 3) but it also has been collected in several southern states of Mexico (Jalisco, Oaxaca, Veracruz), and it is not unlikely that this species will be eventually found also in Guatemala and Nicaragua.

Remarks.— This new species is easily recognizable among other Costa Rican species of the genus by its larger size, unique shape of male cerci, large (compared to the diameter of eyes) mirror on the left tegmen, and the relatively very short ovipositor. *C. magdalenae* seems to be most closely related to *C. occidentalis* (Morse) from California and *C. strictus* (Scudder) from the eastern USA. Males of *C. magdalenae* differ from both species in the shape and size of the mirror of left tegmen (mirror shorter or at most as long as eye diameter and proportionately wider in *C. occidentalis* and *strictus*) and the shape of cerci. Females differ in the length of the ovipositor, which is much shorter than in these two species. All three species share similar shape of the male cerci and fastigium of vertex, the absence of spines on the outer ventral edge of hind femora, and a very similar pattern of coloration.

Material examined.— **COSTA RICA:** Guanacaste Prov., Cerro El Hacha, 12 km SE Las Cruz, elev. 300 m, 1 - 30 September 1991 (coll. E. Lopez and R. Espinoza) - 1 female (paratype) (INBio); Finca Jenny, 30 km N Liberia, elev. 240 m, 1 - 30 September 1997 (coll. F. Araya) - 2 females (allotype and paratype) (ANSP and INBio); Finca Jenny, 31 km N Liberia, elev. 300 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 1 male (holotype) (ANSP); Area de Conservacion Guanacaste, Santa Rosa National Park, 21 - 24 August 1999 (coll. P. Naskrecki, D. Otte, G. Morris) - 1 male, 2 females (PN collection); **MEXICO:** Jalisco, 59 mi NE Autlan, oak woodland with grasses and shrubs, 11 September 1981 (coll. Otte) - 1 female (paratype) (ANSP); Autlan, oak woodland with grasses and shrubs, 11 September 1981 (coll. Otte) - 1 female (paratype) (ANSP); N side Río Verde (N Guadalajara) on rd to Zacatecas, 12 September 1981 (coll. Otte) - 1 female (paratype) (ANSP); Oaxaca, 7 mi S Oaxaca Rd. to Pto. Ángel, short grass and shrub clumps, 1 September 1981 (coll. Otte, Azuma, Newlin) - 1 female (paratype) (ANSP); 46 mi W Jalapa del Marquez, at Portillo Nejapam pass, pine and oak woodland, 31 October 1981 (coll. Otte, Azuma, Newlin) - 1 male, 1 female (paratypes) (ANSP); Veracruz, few mi N jct 105-127 near Tempoalp, palm and secondary forest, 21 October 1981 (coll. Otte, Azuma, Newlin) - 1 male (paratype) (ANSP).

Etymology.— Named after my sister Magdalena Naskrecka, an ardent insect collector and a great companion during some of my earliest entomological endeavors.

Conocephalus sp. cf. *spinosus*

Fig. 39H

Rehn and Hebard (1915b) reported from Costa Rica (Puntarenas) a single male of *C. spinosus* (Morse), a species otherwise known from salt marshes of California and northern Mexico. After examining the specimen and comparing it to the type specimens of *C. spinosus*, I came to the conclusion that the two are not conspecific. Despite general similarity, they differ considerably both in the shape of cerci (Figs. 39G-H) and the arrangement of teeth on the stridulatory file. It is possible that the Costa Rican specimen represents a yet undescribed species of *Conocephalus*, but until more material is collected, its status remains uncertain.

ORCHELIMUM Serville, 1839

Common Name: Meadow katydid

1839 Serville, Hist. nat. Ins., Orthopt.: 522

1915a Rehn & Hebard, Trans. Amer. Ent. Soc. 41: 11-83
>>revision

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM)
>>references; types illustrated

Note: The genus *Orchelimum* is an example of a group maintained in the taxonomic literature by tradition rather than actual diagnostic characteristics that can identify it as a natural, monophyletic assemblage. Rehn and Hebard (1915a) present a combination of characters that supposedly identify *Orchelimum* as a genus distinct from *Conocephalus*, but even they admit that none of the characters is unique to *Orchelimum* and all of them occur, albeit less frequently, in *Conocephalus*. The only relatively consistent characteristics of *Orchelimum* spp. are their more robust appearance and larger body form, but even these characters broadly overlap with some species of *Conocephalus*. There are no consistent differences between the two genera either in the male or female genitalic structures, the male stridulatory apparatus, wing venation, leg armature, or any other structures considered diagnostic for Tettigoniidae.

Glenn K. Morris (personal communication) provides two behavioral characters that may indicate a degree of separateness of the two genera. The dominant spectral peak of the male's call in *Orchelimum* is in the acoustic range (about 18 kHz) whereas in *Conocephalus* (where unfortunately only a small fraction of species have ever been recorded) the dominant spectral peak is in the ultrasonic range (30 kHz and above). Morris notes, however, that "this song parameter is of course not unrelated to size, though it is not fair to say that frequency is sim-

ply dictated by size". The second behavioral character apparently unique to *Orchelimum* is high incidence of male fighting, and many of the species known to fight do it by grappling. The latter is unknown to occur in males of *Conocephalus*. These observations, however, are based on a very limited number of species.

Despite the lack of strong support for the separate status of the genus *Orchelimum*, it seems unwise to synonymize the two genera at this point as both names are well established in taxonomic literature and many species of *Orchelimum* are easily recognizable based on their larger size and sometimes distinct coloration. For the purpose of this review *Orchelimum* is treated as a separate, yet very closely related to *Conocephalus* genus of Conocephalinae s.l.

Diagnosis

Body slender to robust, small to medium size as for the family; macropterous or mesopterous (Figs. 3A); tegumen smooth. Fastigium of vertex laterally compressed, rounded apically, never cone-shaped; no traces of genal carinae present; mandibles and labrum symmetrical; eyes relatively large. Pronotum short, lateral lobes approximately triangular, humeral sinus weak to well developed, posterior edge of lobe with well developed "secondary tympanum." Stridulatory file with peg like teeth, strongly sinusoidal. All legs slender, fore and mid femora unarmed on lower margins. Male cercus always armed with one internal tooth; ovipositor weakly to distinctly curved, lower and upper edges of ovipositor parallel to divergent midlength.

Description (male except where specified)

Head. — Fastigium of vertex 0.75 to 1.4 times as wide as scapus (Figs. 3B-C), laterally compressed, rounded dorsally and apically, never hook- or cone-shaped, never projecting strongly in front of eyes; fastigium of vertex touching fastigium of frons. Eyes large relative to size of head, weakly protruding. Frons weakly convex, smooth; tegumen of head smooth, without traces of genal carinae; face slender to moderately wide. Mandibles and labrum symmetrical.

Thorax and wings. — Dorsal surface of pronotum smooth, flat or metazona slightly raised; anterior dorsal margin straight, posterior one straight or weakly convex; lateral lobes approximately triangular, with acute posterior angle; posterior edge of lateral lobe with "secondary tympanum" — a somewhat raised, narrowly elliptical area of thinner cuticle covering thoracic auditory spiracle; humeral sinus poorly to well developed (Fig. 3A). Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle unmodified. Prosternum armed with two

thin, short spines (modified basisternum); meso- and metasternum with lateral lobes of basisterna small, triangular, their inner margins touching; posterior part of metasternum strongly compressed causing hind coxa to nearly touch each other.

Wings in both sexes fully developed, surpassing apices of hind femora, rarely somewhat shortened and not reaching hind knees; hind wings usually distinctly longer than tegmina. Stridulatory apparatus of male well developed; stridulatory area of left wing membranous, without a network of secondary veinlets; stridulatory file (vein AA1—new vein homology after Kukalova-Peck, personal communication; male stridulatory file used to be homologized with the vein Cu2) sinusoidal (Fig. 41A), teeth thick, peg-like, sparsely arranged, especially on distal end of file; mirror of right wing approximately rectangular, with secondary veinlet next to AA1 always well developed, divergent from AA1.

Legs.— All legs long and slender; fore coxa with an elongate, forward projecting spine dorsally. All femora unarmed dorsally; fore and mid femora unarmed ventrally, hind femora armed ventrally with relatively few minute spines or unarmed; genicular lobes of femora usually armed with short spines. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area weakly to distinctly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen.— Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite usually strongly sclerotized, with narrow apical incision, supraanal plate small, triangular. Male cercus always with one internal spine, often accompanied by more or less developed dorsal, sinusoid groove (Fig. 41C); female cercus, simple, slender and weakly incurved. Subgenital plate of male with a pair of styli, distinct median keel, truncated apically (Fig. 3D) or with triangular apical emargination; female subgenital plate approximately triangular, rounded or shallowly emarginated apically. Concealed genitalia of male with paired, heavily sclerotized, hook-like titillators (Fig. 3E). Ovipositor narrow, straight to distinctly curved; its length variable, from less than half the length to almost as long as hind femur; both dorsal and ventral margins of ovipositor smooth, parallel to divergent midlength; apex of upper valvula sharp (Fig. 3F).

Coloration.— General coloration green to brown, almost invariably with dark, wide stripe on head and pronotum; head sometimes red dorsally (*O. erythrocephalum* Davis)

or face with median brown stripe (*O. concinnum* Scudder); abdomen green or yellow; sometimes dorsal side of abdomen yellow, with dark, longitudinal stripes. Tegmina straw brown to light green; legs green to light brown.

Remarks.— The genus *Orchelimum* includes 23 described species, distributed from south-eastern Canada, throughout eastern United States, Mexico to northern Costa Rica. Most species occur in moist freshwater habitats among sedges or reeds, along streams or margins of ponds. Some species occur in less typical habitats such as dry weedy fields, salt marshes, and two species are arboreal. The only Costa Rican species of the genus, *O. fraternum*, occurs on tall grassy vegetation along edges of the dry forest of Guanacaste as well as in open, savanna-like grasslands. It is a diurnal species, with males singing all day from tall vegetation. Nothing is known of their natural diet but in captivity they accepted grass seeds and various vegetables and fruits.

Orchelimum fraternum Rehn and Hebard, 1915
Figs. 3A-F, 41A-C, 51E-F, Map 3

1915a Rehn & Hebard, Trans. Amer. Ent. Soc. 41: 22, 79
>>*O. (Metarhoptrum)*; type locality: Mexico: Jalisco, Guadalajara; type depository: Academy of Natural Sciences, Philadelphia, PA, USA >>holotype male

1932 Hebard, Trans. Amer. Ent. Soc. 58: 334

Diagnostic description.— General characteristics as described above; mesopterous, with tegmina surpassing apex of abdomen but not reaching apices of hind femora (Fig. 3A). Stridulatory file of male 1.62 mm long, with 68 primary teeth (see Fig. 41A-B), maximum width of file 72.9 µm; teeth of file thick, peg-like, more densely arranged at ends of file than in its middle portion. Left (upper) mirror of stridulatory apparatus as in Fig. 3C, about as long as eye diameter. Fastigium of 1.2 times wider than scapus. Ventral edges of hind femur unarmed. Male cercus as in Fig. 41C; ovipositor distinctly shorter than hind femur (ratio ovipositor/hind femur 0.6-0.7), weakly upcurved (Fig. 3F).

Coloration.— Coloration light green; dorsum of head and pronotum with wide, dark band border with thin, yellow stripes (Fig. 3C). Abdomen yellow dorsally, male cerci dark yellow, with reddish tips.

Measurements (mm).— Measurements (4 males, 5 females). — body with wings: male 22.6-24.4, female 23-23.1; pronotum: male 4.9-5.1, female 5-5.4; tegmen: male 16.5-17.3, female 15-16; hind femur: male 18.7-19, female

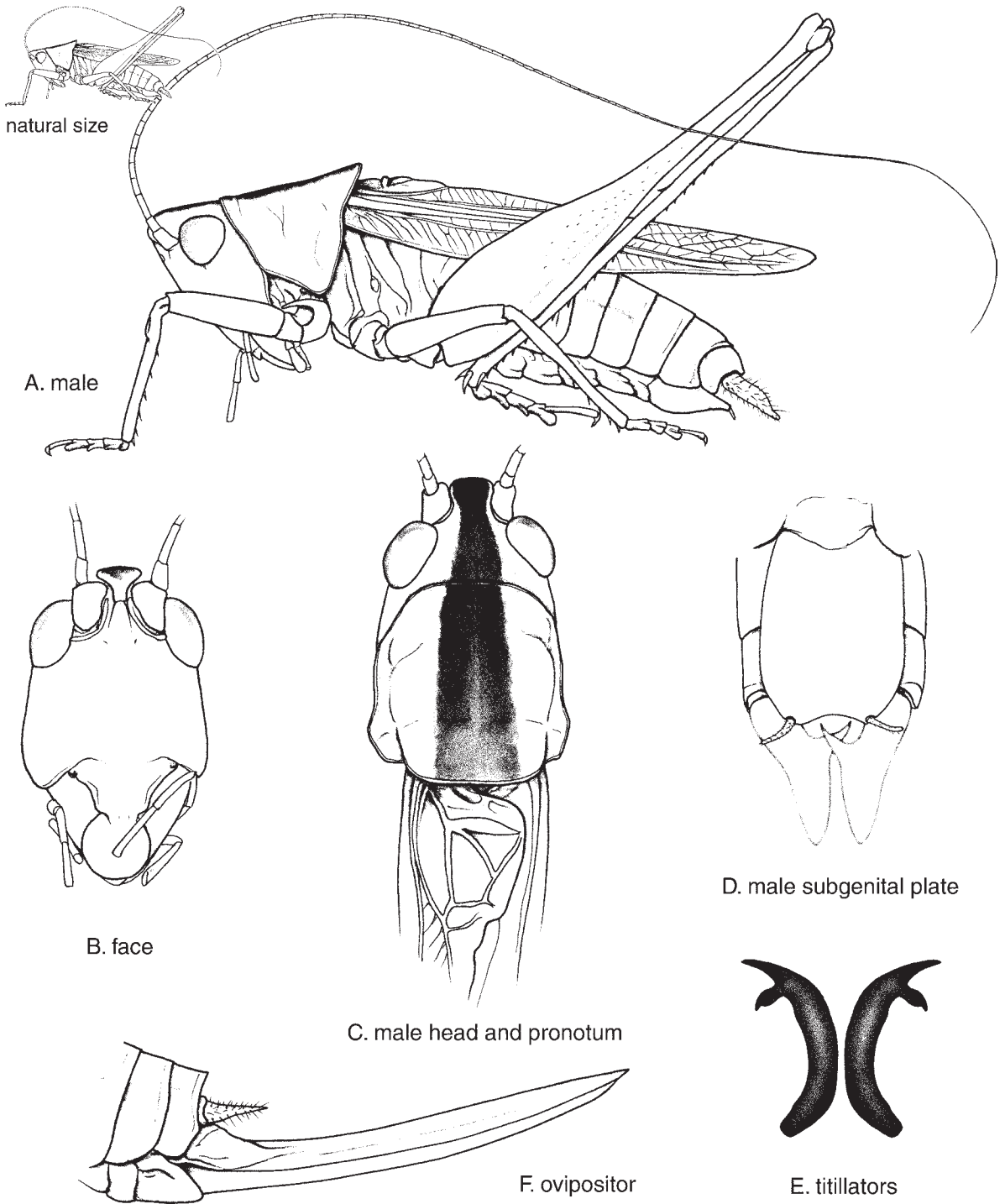


FIG. 3. *Orchelimum fraternum*. A. male - habitus, B. male face, C. male head and pronotum, dorsal view, D. male subgenital plate, ventral view, E. titillators, F. ovipositor.

18.7-18.7; ovipositor: female 11.1-12.4.

Bioacoustics. — The call of *O. fraternum* consists of regular series of short buzzes, each lasting 0.49-0.77 s (at 28°C) and separated by 0.6-0.77 s of silence (Fig. 51E-F). Each buzz has two pulse train groups. The first group consists of 6-7 pulse trains produced at a slow rate (24.5-28.5/s), with trains separated by 7-14 ms (avrg. 11.26±2.4, n=19) of silence. The second, faster (47-48.2/s) and longer group consists of 11-25 train groups separated by only 1-3 ms (avrg. 1.8±0.5, n=18) of silence. Individual train groups are of similar length in both the slow and fast pulse train groups, and last 19-26 ms (avrg. 21±2.3, n=17). The call is low Q, with most energy apparently allocated between 9 and 16 kHz.

Material examined. — **COSTA RICA: Guanacaste Prov.,** Area de Conservacion Guanacaste, Santa Rosa National Park, 21 - 24 August 1999 (coll. P. Naskrecki, D. Otte, G. Morris) - 4 males, 5 females (GKM, PN collection); **Mexico: Jalisco, Guadalajara,** (coll. Crawford) - 1 male (holotype) (Philadelphia).

LIPOTACTOMIMUS Naskrecki, gen. n.

Type species: *Lipotactomimus rowelli* sp. n., here designated

Diagnosis (female)

Body small, stout; female mesopteroous (Fig. 4A); tegumen smooth, shiny. Fastigium of vertex 0.5 times as wide as scapus, small, knob-like; eyes large, strongly protruding; pronotum wider than long. Hind femur stocky; ovipositor shorter than hind femur, distinctly upcurved.

Description (female; male unknown)

Head. — Fastigium of vertex small, knob-like, as wide as 1/2 of scapus, with longitudinal furrow dorsally (Fig. 4C); fastigium of vertex separated from fastigium of frons by small gap. Eyes very large relative to head size, strongly protruding; frons flat; tegumen of head smooth, shiny; face approximately triangular. Mandible and clypeus symmetrical (Fig. 4B).

Thorax and wings. — Dorsal surface of pronotum smooth and shiny; metazona distinctly raised; both anterior and posterior dorsal margins of pronotum straight; lateral lobes about as long as high, without humeral sinus. Thoracic auditory spiracle large, elliptical, nearly completely exposed. Prosternum unarmed, simple; mesosternum with lateral lobes of basisterna triangular, their inner margins touching;

metasternum reduced to small, transverse plate.

Wings somewhat shortened, most likely barely reaching end of abdomen (abdomen shrunken in holotype).

Legs. — All legs stout; fore coxa with short, forward projecting spine dorsally. Fore and mid femora completely unarmed; hind femora very stout, armed with minute spines on anterior ventral margins only; all genicular lobes of femora armed with short spines. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 diameter of tibia; hind tibia armed on dorsal margins along their entire length, and on ventral margins in apical fourth; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified; 10th tergite simple; cercus conical, simple; subgenital plate about as long as wide, with shallow apical emargination. Ovipositor distinctly upcurved; 1/2 as long as hind femur, gradually narrowing towards apex; apex acute.

Coloration. — Coloration striking, with contrasting green, yellow and brown elements. Face creamy-pink, with wide, yellow circles around compound eyes, occiput dark brown. Pronotum dark brown, with bright green stripe along the middle and yellowish-green, elongate patches along posterior edge of lateral lobes. Tegmina green, hind wings black. Legs green, except for black hind knees and brownish hind tibia. Abdomen yellow, ovipositor yellowish-brown. (Note: this description is based on a dried specimen, live individuals are more brightly colored).

Remarks. — This unusual new genus in its general appearance strongly resembles members of the south-east Asian genus *Lipotactes* Brunner von Wattenwyl (Lipotactinae). *Lipotactomimus* differs from members of Lipotactinae in the structure of thoracic sterna (prosternum armed, and meso- and metasternum with stout cylindrical processes in *Lipotactes*; no such modifications in *Lipotactomimus*), lack of a process on hind coxa (present in *Lipotactes*), and shorter and wider pronotum. Also, females are either squamipteroous or apteroous in all known species of Lipotactinae (female mesopteroous in *Lipotactomimus*).

Lipotactomimus seems to be most closely related to genera traditionally placed in Conocephalinae, especially to the genus *Fatuhivella* Hebard from Marquesas Islands, from which it differs in thicker and shorter legs as well as larger, more prominent compound eyes.

Etymology. — The generic epithet indicates the superficial similarity of the new genus to the south-east Asian genus *Lipotactes*.

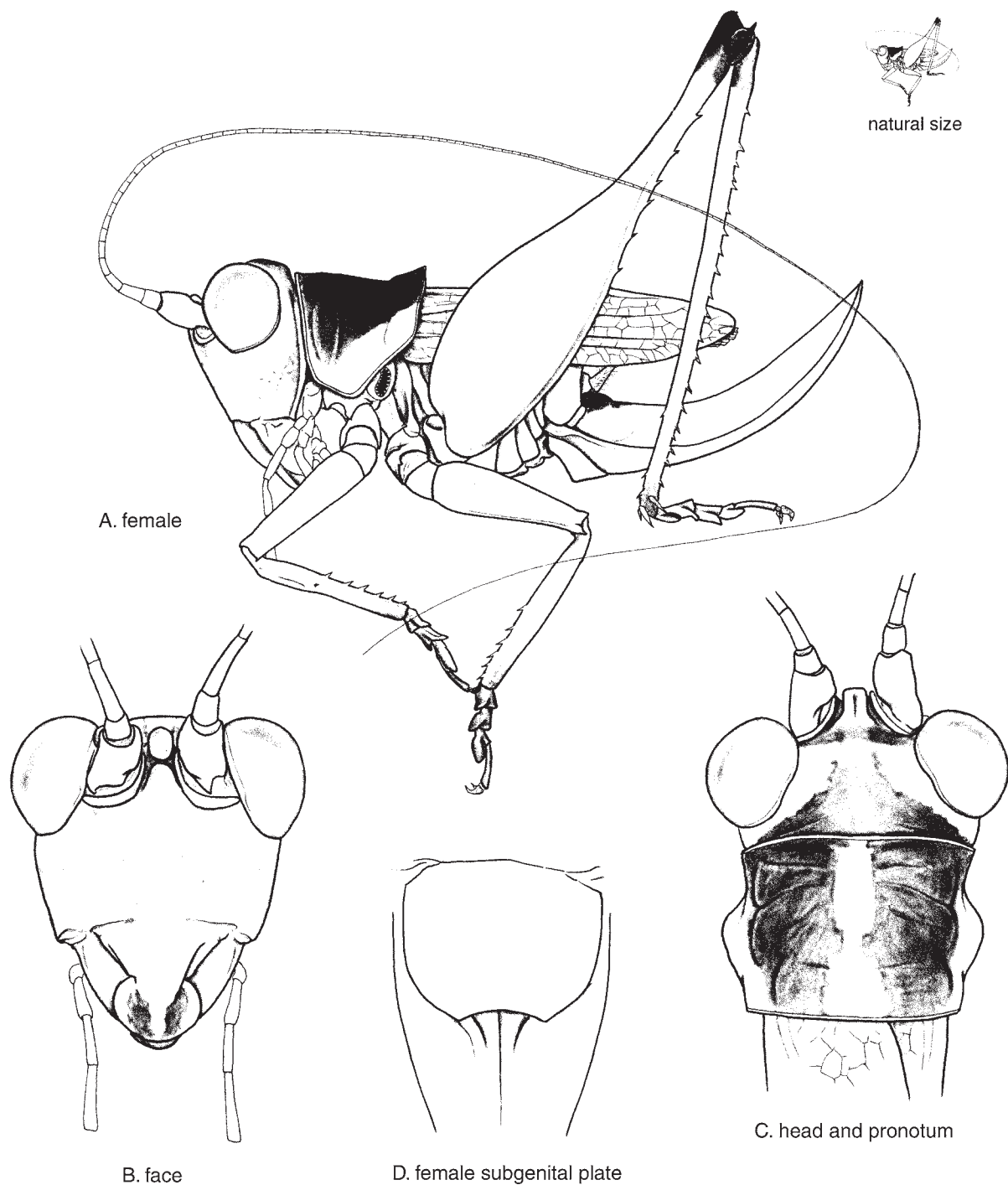


FIG. 4. *Lipotactomimus rowelli*. A. female - habitus, B. female face, C. female subgenital plate, D. female head and pronotum, dorsal view

Lipotactomimus rowelli Naskrecki, sp. n.
Figs. 4A-D, Map 3

Type locality: Costa Rica, San José Prov., Ciudad Colón, Hda. El Rodeo, Fila Diamante; type depository: Academy of Natural Sciences, Philadelphia – holotype female

Diagnostic description. — As described above. Ovipositor (Fig. 4A) shorter than hind femur - ratio ovipositor/hind femur 0.6.

Measurements (female holotype) (mm). — body with wings 10; pronotum 2.5; tegmen 6.3; hind femur 9.3; ovipositor 5.

Material examined. — COSTA RICA: San José Prov., Ciudad Colón, Hda. El Rodeo, Fila Diamante, elev. 1025 m, 21 Aug. 1997, coll. C.H.F. Rowell - 1 female (holotype) (ANSP).

Etymology. — Named after C. Hugh Fraser Rowell, a prominent orthopterist and neurobiologist, as well as the collector of the only specimen of this new species.

COPIPHORA Serville, 1831
Common name: Spear bearers

1831 Serville, Ann. Sci. nat. Paris 22:147; type species:

Locusta cornuta De Geer, 1773

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>references; types illustrated

[syn.] *Copidophora* = 1846 Agassiz, Zool. Nomencl. Ind. Univ.: 98

[syn.] *Copiophora* = 1838 Burmeister, Handb. Ent. 2: 702

Diagnosis

Slender to robust; both sexes macropterous (Figs. 5A, 9A). Head with fastigium of vertex strongly produced, 2-3.5 times as long as diameter of eye, sharply conical (Fig. 5A) or laterally flattened (Fig. 8C), rarely fastigium short (Fig. 9A). Head robust, frons flat or weakly convex; genae with moderately to strongly developed lateral carinae; eyes globular, moderately protruding. Mid tibia armed dorsally. Male cerci thick, blunt apically, with one or two inner spines; ovipositor straight or weakly downcurved, sometimes extremely long.

Description (male except where specified)

Head. — Fastigium of vertex strongly produced, 1.5 to 5.5 times as long as diameter of eye (Figs. 5A, 8C, 9A); fastigium sharply conical, laterally flattened, or dorso-

ventrally expanded subapically; rarely fastigium short, trituberculate; fastigium usually with well developed ventral keel; dorsal surface of fastigium smooth or tuberculate; fastigium without well developed lateral carinae; lateral ocelli well developed, sometimes very prominent, situated on large protuberances; apex of fastigium sharply tapered or with small hook, rarely blunt; basal portion of fastigium of vertex with a prominent knob ventrally, well separated from fastigium of frons. Antennal sockets separated by distance equal to 0.6-1.0 diameter of eye. Eyes globose, moderately projecting; frons flat or weakly convex; genae with well developed, granulose lateral carinae. Labrum and mandibles symmetrical.

Thorax and wings. — Dorsal surface of pronotum smooth to weakly rugose, flat or metazona weakly raised; anterior margin of pronotum straight, posterior margin straight or weakly convex; lateral lobes with posterior angle rounded, with weakly developed humeral sinus. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobes of pronotum. Prosternum unarmed, mesosternum with a pair of small, widely separated, vertical spine-like lobes; metasternum unarmed.

Wings in both sexes fully developed, surpassing apices of hind femora. Stridulatory apparatus of male well developed; stridulatory file straight or weakly curved (Figs. 40B-G, 43A-C), teeth variable, from thin and wide to thick and narrow, sometimes both types of teeth present in file; stridulatory area of left wing covered with secondary venation; mirror of right wing approximately rectangular to nearly circular, with or without thin veinlet parallel to AA₁. Posterior margin of front wing straight or weakly convex; apex of front wing narrowly to broadly rounded.

Legs. — Fore coxa with an elongate, sometimes laterally flattened, forward projecting spine dorsally; middle and hind coxa without spine; all trochanters unarmed. All femora unarmed dorsally but with prominent spines on anterior ventral margins, posterior ventral margins unarmed; sometimes femoral spines large, triangular, nearly lobe-like; genicular lobes of all femora armed with long spines, sometimes posterior lobes of fore and/or mid femora unarmed. Front tibia unarmed dorsally, both ventral margins with short, immovable spines; tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area moderately swollen; middle tibia armed dorsally with 1-3 dorsal spines, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of hind tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with surface smooth, its

TABLE 3. Key for identification of Costa Rican species of *Copiphora*







Species	Fastigium	Face	Ovipositor	Femoral spines
<i>rhinoceros</i>	long, pointed horn; bright yellow 	face green; clypeus, labrum and outer portions of man- dibles yellow; inner portions of man- dibles black	very long 2.3-2.5 times as long as hind femur	large, flat, triangu- lar, contrastingly white
<i>cochleata</i>	strongly dilated apically; yellow, apex brown 	face green; clypeus, labrum and outer portions of man- dibles yellow; inner portions of man- dibles black	long 1.7 times as long as hind femur	long, conical, white
<i>cultricornis</i>	laterally flattened, slightly dilated apically; yellow 	entirely yellow, with 4 or 6 small black dots	extremely long 3-3.4 times as long as hind femur	small, thin, green
<i>hastata</i>	laterally flattened, slightly dilated apically; yellow 	central portion of face with large, dark brown patch; sides of face yellow	extremely long 3.3-3.5 times as long as hind femur	small, green
<i>brevicauda</i>	short, somewhat flattened laterally at apex; yellow 	bright yellow, with contrastingly black clypeus, labrum and mandibles	long 1.9-2.1 times as long as hind femur	small, blue
<i>ottei</i>	very short, with prominent lateral ocelli 	yellowish-orange to pinkish-brown, with 4 or 6 tiny black dots	medium length 1.4-1.6 times as long as hind femur	small, very thin, green

TABLE 4. Body measurements of species of *Copiphora* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>rhinoceros</i>					
male	61.6-70.6, 65±3	44.8-50.8, 48.4±1.9	9.6-11.1, 10.5±0.5	20.9-24.4, 23±1.2	na
female	69.4-76.5, 73±2.7	53.3-57.2, 55±1.6	9.9-10.7, 10.4±0.3	25.3-26.6, 26.1±0.5	61.3-64.1, 62.4±1.1
<i>cochleata</i>					
male	68	48.3	9.8	23	na
female	69.1	50.2	9.3	24.7	41.8
<i>cultricornis</i>					
male	56.5-67.7, 63.9±6.4	44.3-50, 47.4±3	9.2-11, 10.1±0.9	19.9-23.4, 21.9±1.6	na
female	70.7-79.4, 74.4±4	53.7-58.4, 55.6±2.2	10-10.9, 10.4±0.4	22.7-27.4, 24.7±2	74.1-87.6, 79.6±6.5
<i>hastata</i>					
male	55.4-61.7, 59±2.6	41.2-47.6, 44.7±2.2	8.1-9.8, 9.1±0.6	19.1-20.7, 19.7±0.5	na
female	62.9-69.3, 66.7±2.6	47.9-53.4, 51.1±1.7	9.1-10.2, 9.8±0.4	21.2-23.1, 22.3±0.7	71.8-79.4, 74.7±3.2
<i>b. brevicauda</i>					
male	52.5-64.2, 57.7±4.8	39.7-48.2, 44.3±3.7	7.3-8.9, 8.1±0.6	17-20, 19.1±1.3	na
female	53.5-64, 59.6±3.3	43.5-48.1, 45.8±1.6	8-9.1, 8.4±0.3	18.7-21.8, 20.4±1.1	33.1-41.3, 37.5±3.1
<i>b. costaricensis</i>					
male	57-59.9, 58.5±2.1	44-47, 45.5±2.1	8.5-9.4, 9±0.6	18.4-19.4, 18.9±0.7	na
female	57.5-65.1, 61.9±3.9	47.4-51.2, 49.1±1.9	8.9-9.1, 9±0.1	20.1-21.6, 20.9±0.8	41.6-42.8, 42.2±0.8
<i>ottei</i>					
male	38.3	26.3	17.3	8.6	na
female	38.4-39.9, 39.4±0.7	26.2-27.8, 27.2±0.7	8.1-8.6, 8.4±0.2	18-18.9, 18.5±0.4	26.3-29.7, 28.5±1.5

posterior margin weakly to distinctly emarginated; supraanal plate in both sexes small, broadly rounded apically; male cercus stout, blunt apically, usually with one, blunt, subapical internal spine (Figs. 5E-F, 6D-E); sometimes apex of cercus with sharp, heavily sclerotized, triangular lobe ventrally (Fig. 7D); paraprocts unmodified; female cercus, simple, narrowly conical. Subgenital plate of male with a very shallow apical emargination; styli short, 1.5-2.0 times as long as thick, to very short, peg-like; female subgenital plate with triangular apical incision or nearly straight apically. Male internal genitalia with weakly sclerotized inner margins of phallic lobes but without well developed titillators (Figs. 5D, 7E). Ovipositor narrow, straight or slightly downcurved, its margins parallel; both dorsal and ventral margins of ovipositor smooth; ovipositor often exceedingly long, ratio ovipositor/hind femur 1.4 - 3.5.

Coloration.— General coloration light to dark green (Figs. 36E, G); facial markings variable and often species-specific; fastigium of vertex often bright yellow.

Dorsum of the head and pronotum sometimes with darker, brown or reddish markings. Sometimes posterior margins of tegmina red, resulting in distinct red dorsal stripe; stridulatory file and femoral spines often contrastingly white.

Remarks.— The genus *Copiphora* currently includes 24 described species, distributed throughout Central and South America [*C. subulata* (Stoll) described from South Africa undoubtedly belongs to a different genus]. Two additional new species and one subspecies from Costa Rica are described below.

Members of the genus *Copiphora* are some of the most spectacular katydids in Central America. Some species of the genus possess large, horn-like fastigia, which gave rise to the common name “rhinoceros katydids.” Females of many species also possess some of the longest ovipositors among the Tettigoniidae, and for this reason I propose a common name “spear bearers” for such species.

All Costa Rican species of *Copiphora* are forest insects,

occurring primarily in the canopy and high understory levels. *Copiphora rhinoceros*, *C. cultricornis*, and *C. hastata* frequently descend to low, shrubby vegetation, and females of probably all species come to the ground to lay eggs. At La Selva Biological Station, females of *C. rhinoceros* have been repeatedly observed laying eggs in the fronds at the base of the palm *Calyptrogyne ghiesberghiana* (Linden and H.A. Wendl.) H.A. Wendl. *Copiphora brevicauda costaricensis* seems to be restricted to the canopy level and has never been seen on lower vegetation. All species of the genus are strictly nocturnal. They feed on a variety of organic material, including seeds, fruits, and insects. *Copiphora hastata* seems to specialize on hard seeds but has also been seen feeding on flowers and fruits of a palm *Calyptrogyne ghiesberghiana*, caterpillars, and egg clutches of a frog *Agalychnis callidryas* (Cope). The closely related *C. cultricornis* has not been seen feeding in the wild, but in captivity individuals of this species accepted both insects (although they seemed incapable of catching live, fast moving insects) and various fruits, seeds, and vegetables (including leaves of lettuce, not accepted by any other species of the genus). *Copiphora rhinoceros* has been seen feeding on fruits of *Psychotria* sp. (Rubiaceae), *C. ghiesberghiana*, unidentified alate seeds of several tree species, several species of caterpillars (including ones covered with dense, urticating hairs), snails (Fig. 36G), other katydids, and even small lizards (*Norops* sp.). *Copiphora brevicauda costaricensis* seems to be primarily predaceous, actively hunting and capable of capturing even such fast moving prey as cockroaches. Upon seeing an insect, they jump on it, using the first two pairs of legs to grasp the victim, at the same time inflicting damaging bites with their extremely powerful mandibles.

Copiphora rhinoceros Pictet, 1888

Common name: Rhinoceros spear bearer

Figs. 5A-F, 36G, 43B-C, Map 5

1888 Pictet, Mem. Soc. Geneve 30 (6): 48; type locality: Nicaragua; type depository: Museum d'Histoire Naturelle, Geneva

Diagnostic description. — Body large, with broad wings, in both sexes extending well beyond apex of abdomen (Fig. 5A). Fastigium of vertex forming large, sharply pointed horn, straight or somewhat curved, 5-5.5 times as long as eye diameter (Fig. 5B); basal, dorsal part of fastigium granulate (Fig. 5C). Face convex; genal carinae of head well developed, granulate. Pronotum smooth, shiny; metazona slightly raised; both anterior and posterior margins straight; lateral lobe of pronotum

1.8 times longer than high. Male stridulatory file weakly curved, 3.8 mm long, 345 μ m wide, with 219 very closely spaced, wide, lamelliform teeth (Fig. 43B-C); mirror approximately rectangular but with sides somewhat convex; small, parallel vein next to AA₁ present.

Ventral spines of femora large, triangular, usually contrastingly white; all genicular lobes armed with long, sharp spines. Male cercus thick, blunt, and strongly incurved, thicker at apex than at base; ventral, subapical spine of cercus short and invisible from above (Figs. 5E-F). Female cercus simple, elongately conical, somewhat curved. Male subgenital plate narrowed toward apex, apex with shallow incision; styli short, about 1.2 times as long as wide. Female subgenital plate approximately triangular but apical portion more narrowed than its basal part, and with small apical incision. Ovipositor very long, straight, more than twice as long as hind femur (ratio ovipositor/hind femur 2.3-2.5) (Fig. 5).

Coloration. — General coloration bright green. Fastigium of vertex bright yellow, sometimes with black tip; face bright green, clypeus, labrum and outer parts of mandibles yellow; inner parts of mandibles black (Fig. 36G). Pronotum green, with diffuse yellow band at posterior edge of metazona. Tegmina green, densely mottled with regularly arranged pale brown dots; posterior margin of tegmina purple-red, resulting in a conspicuous dorsal stripe when wings are folded; male stridulatory file usually bright white. Legs green, with white femoral spines; often tarsi bright green with black metatarsus. Abdominal terga green, sterna yellow.

Measurements. — Table 4.

Bioacoustics and biology. — The call of *C. rhinoceros* is one of the dominant night calls in many lowland wet forests of Costa Rica. In fact, it is one of the very few species of Central American forest Tettigoniidae that have a nearly continuous, loud, and easily perceptible call. It was described in great detail by Morris (1980), therefore I give only a brief description here. The call consists of a rapid succession of short buzzes, each lasting about 0.5 to 10 s (Fig. 54F). The buzz is composed of paired, clearly defined pulses ("phonatomes" of Morris and Walker 1976). The first, minor, pulse in each pair has a low amplitude and lasts only 14-25 ms. This pulse is followed by a longer, 25-41 ms, and much louder major pulse. The paired pulses are produced at the rate of 16/s at 26 °C (14/s at 24°C) (Fig. 54G).

The call is high Q, with most energy concentrated around 9.5 kHz. Morris (1980) measured the energy peak at 8.7 kHz, and detected first and second harmonics at 17.4 kHz and 26.1 kHz, respectively.

In addition to the airborne sound during their calling activity males of *C. rhinoceros* produce short bouts of rapid tremulations. Females respond with similar tremulations but of lower intensity and regularity. The bouts of males last about 2.5 s and consist of about 5 tremulations (Morris measured the rate of tremulations at 3.1 tremulations per bout).

Females of this species have been observed laying eggs in fronds of the palm *Calyptrogyne ghiesberghiana*. Eggs are creamy-white, elongate, about 8.7 mm long, with one end distinctly more narrowed (Fig. 38A). The chorion of the eggs has a characteristic, reticulate pattern.

Distribution. — *C. rhinoceros* is known from Nicaragua, Costa Rica and Panama. In Costa Rica it has not yet been recorded from the Península de Nicoya (Map 5).

Material examined. — **COSTA RICA:** Lower Río Reventazon, Castila Farm, 24 July 1936 (coll. C.W. Dodge) - 1 female (ANSP); (no more details), 15 July 1934 - 1 nymph (USNM); Pozo Azul, (coll. C.F. Underwood) - 1 female (ANSP); **Alajuela Prov.**, Estac. San Ramón Oeste, elev. 620 m, 19 April 1994 (coll. F. Quesada) - 4 males, 3 nymphs (INBio); Río San Lorencito, elev. 800 m, 18 July 1997 (coll. I.A. Chacón) - 1 female (INBio); Sect. San Ramón de Dos Rios, 1.5 km NO Hda. Nueva Zelandia, elev. 620 m, 12 - 21 July 1996 (coll. F.A. Quesada) - 1 female (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 2 nymphs (PN collection); **Cartago Prov.**, Caché, 16 October 1916 (coll. Lankester) - 1 male, 1 female (ANSP); 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 29 - 30 September 1961 (coll. Hubbell, Cantrall, Cohn) - 4 males, 1 female (UMMZ); same locality, 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 4 males, 2 females (UMMZ); Juan Vinas, 15 March 1920 (coll. L. Bruner) - 1 male (ANSP); near Tuis, elev. 910 m, 16 - 22 July 1993 (coll. S. Keller) - 1 female (EMUS); Peralta, 15 May 1923 (coll. Lankester) - 1 male (ANSP); Turrialba, 6 June 1951 (coll. O.L. Cartwright) - 1 male (USNM); same locality, 21 July 1957 (coll. A. Starrett) - 1 male (UMMZ); Turrialba, Agr. Sta., 10 February 1966 (coll. H.R. Roberts) - 1 male (ANSP); Turrialba, CATIE, 26 - 29 June 1986 (coll. W. Hanson, G. Bohart) - (EMUS); Turrialba (near bdlgs. of IAPI), 15 February 1966 (coll. M. Crosby) - 1 female (UMMZ); **Guanacaste Prov.**, 15 June 1903 (coll. C.F. Underwood) - 2 males (ANSP); 3 km SE R. Naranjo, 15 - 22 October 1991 (coll. F.D. Parker) - 1 male (EMUS); same locality, 1 November 1991 (coll. F.D. Parker) - 1 male (EMUS); same locality, 10 - 23 January 1992 (coll. F.D. Parker) - 1 female (EMUS); Estac. Cacao, Lado SO Vol. Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 4 May 1993 (coll. D.H. Janzen) - 1 male (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 June 1994 (coll. C. Moraga)

- 1 female (INBio); same locality, 1 - 31 August 1997 (coll. C. Moraga and P. Rios) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 October 1992 (coll. C. Moraga) - 1 male (INBio); **Heredia Prov.**, Carillo, 15 August 1903 (coll. C.F. Underwood) - 1 male, 1 female (ANSP); Estac. Magsasay, P. N. Braulio Carillo, elev. 200 m, 15 June 1991 (coll. A. Fernández) - 1 male (INBio); La Selva, 1 July - 31 August 1991 (coll. J. Doubles) - 1 female, 1 nymph (UMMZ); Los Arbolitos, Sarapiquí, elev. 10 - 30 m, 27 March 1993 (coll. F. Araya) - 1 male, 1 female (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 31 July 1969 - 1 female (USNM); same locality, 24 - 30 August 1988 (coll. W.J. Hanson) - 1 male (EMUS); same locality, 17 - 22 February 1994 (coll. P. Naskrecki) - 1 male, 2 females (PN collection); same locality, 15 March 1994 (coll. P. Naskrecki) - 4 females (PN collection); same locality, 1 - 4 April 1994 (coll. P. Naskrecki) - 9 males, 2 females, 3 nymphs (PN collection); same locality, 7 - 10 December 1995 (coll. P. Naskrecki) - 1 female (PN collection); same locality, 8 March 1967 (coll. H.R. and E.H. Roberts et al.) - 1 male (ANSP); **Limón Prov.**, 7 km W Guápiles at Río Toro Amarillo, 19 August 1964 (coll. S.P. Hubbell) - 1 female (UMMZ); Amubri, Talamanca, elev. 70 m, 14 January 1992 (coll. M.M. Chavarría) - 1 male (INBio); Cerro Tortuguero, Tortuguero N. P., elev. 0 - 120 m, 15 June 1990 (coll. M. Barrelier) - 1 male (INBio); Estac. Aquas Frías, elev. 10 - 20 m, 1 - 30 September 1997 (coll. E. Rojas) - 1 female (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 100 m, 20 June 1992 (coll. F.A. Quesada) - 1 male (INBio); same locality, elev. 200 m, 16 September 1993 (coll. G. Carballo) - 1 male, 1 nymph (INBio); Estac. Miramar, Res. Biol. Hitoy Cerere, Río Cerere, elev. 500 m, 15 July 1993 (coll. G. Carballo) - 1 female (INBio); Estrella Valley, 100-150 ft., north end of Suretka trail, along Duroy River, elev. 30 - 45 m, 9 September 1927 (coll. J.A.G. Rehn) - 1 male, 1 female, 1 nymph (ANSP); Guápiles, elev. 300 m, 12 September 1927 (coll. J.A.G. Rehn) - 1 male (ANSP); La Emilia, near Guápiles, elev. 300 m, 24 August 1923 - 1 female (ANSP); La Lola (0.5 mi. W Madre de Dios), 2 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 female (UMMZ); Los Diamantes (1 km E of Guápiles), 26 - 27 January 1967 (coll. I.J. Cantrall) - 1 male, 1 female (UMMZ); Río Sardinas, R.N.F.S. Barra del Colorado, elev. 10 m, 15 September 1992 (coll. F. Araya) - 1 female (INBio); same locality, 24 July 1993 (coll. F. Araya) - 2 males (INBio); same locality, elev. 50 m, 1 - 31 May 1994 (coll. F. Araya) - 1 female (INBio); same locality, elev. 50 m, 20 August 1994 (coll. F. Araya) - 1 male (INBio); same locality, elev. 50 m, 11 September 1994 (coll. F. Araya) - 1 female (INBio); Sardinas, Barra del Colorado, elev. 15 m, 13 - 17 March 1995 (coll. F. Araya) - 1 female (INBio); Siquirres, 3 July 1903 - 1 male (ANSP); **Puntarenas Prov.**,

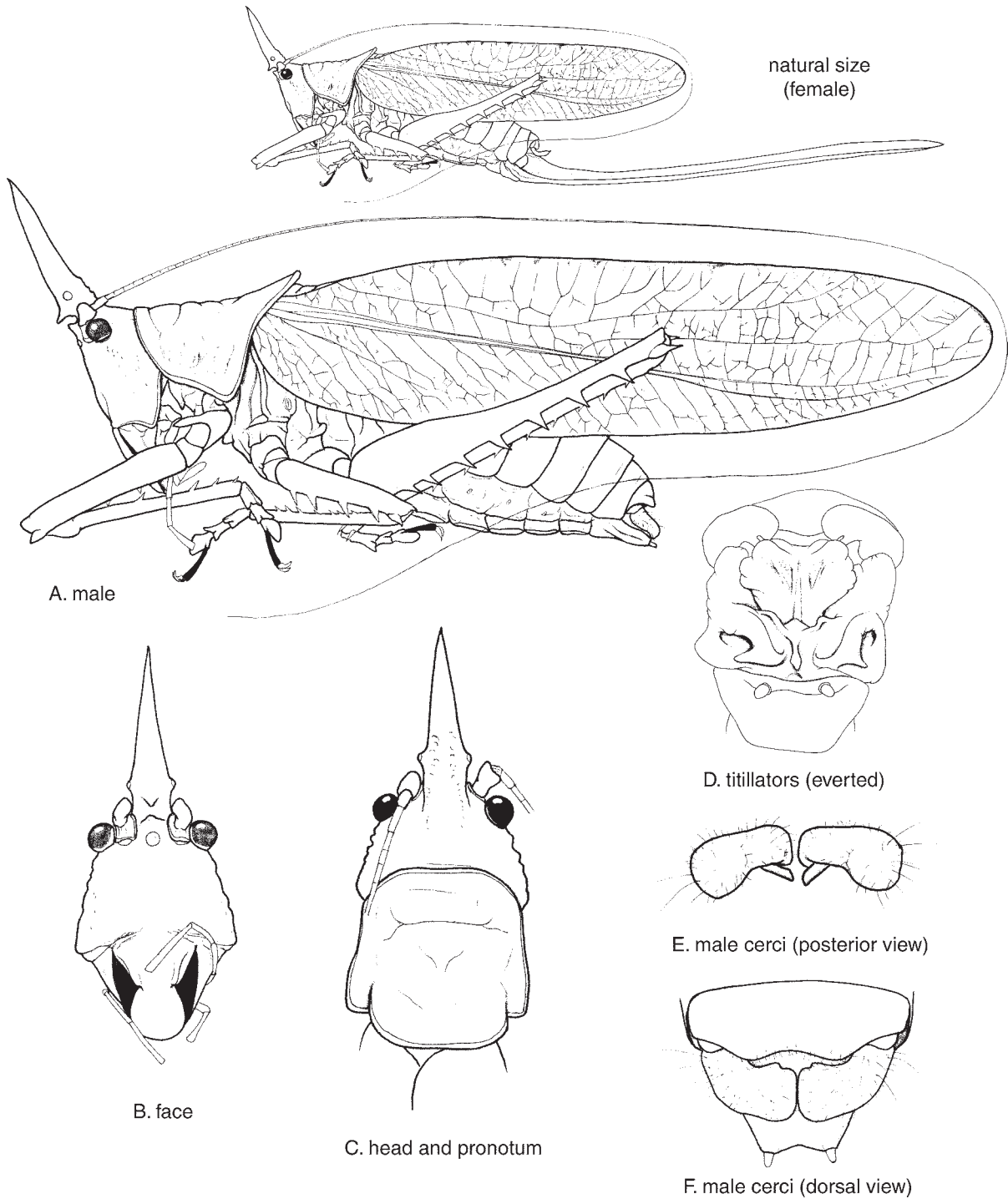


FIG. 5. *Copiphora rhinoceros*. A. male - habitus, B. male face, C. male head and pronotum, dorsal view, D. titillators, posterior view (everted), E. male cerci, posterior view, F. male cerci, dorsal view.

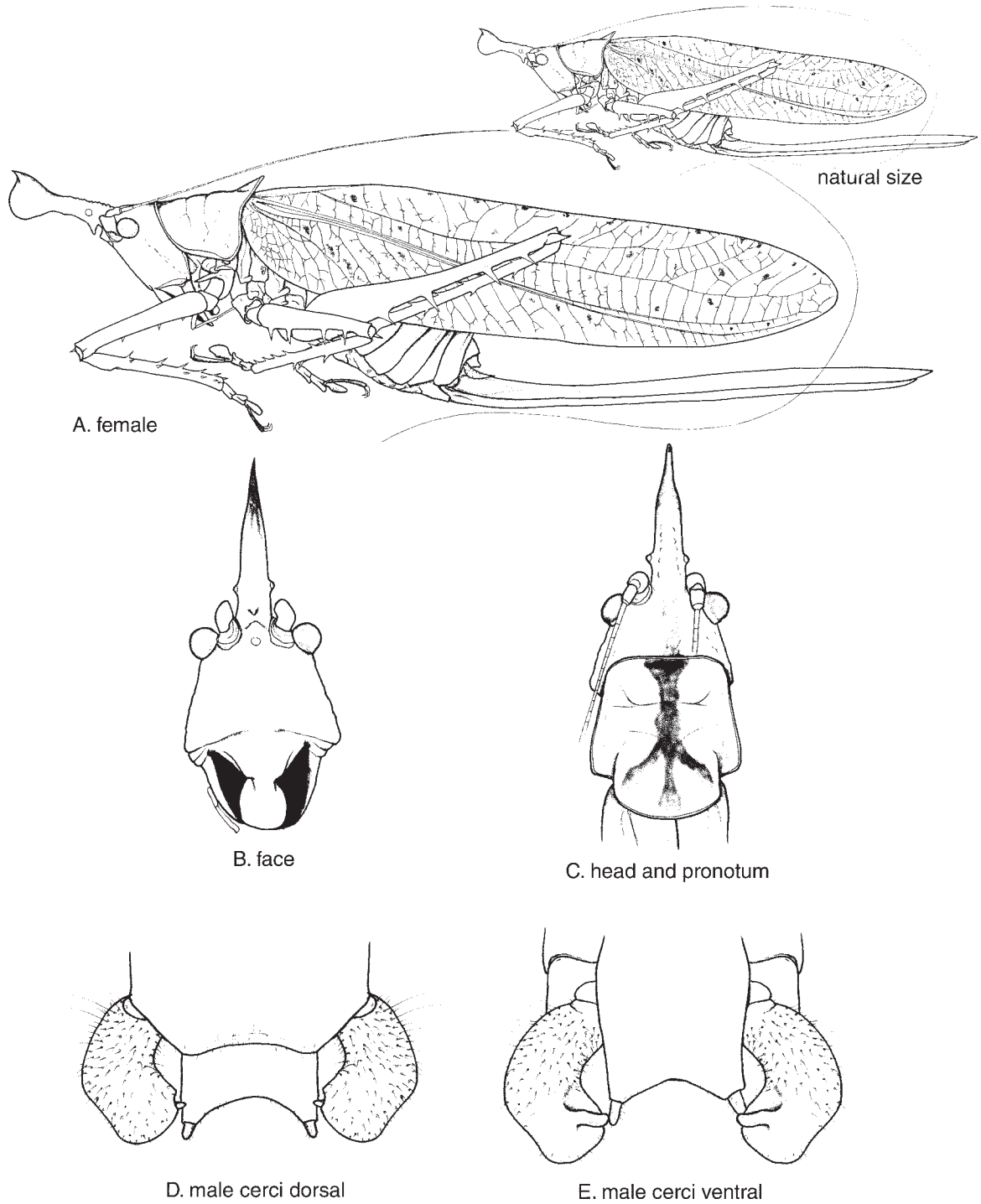


FIG. 6. *Copiphora cochleata*. **A.** female - habitus, **B.** female face, **C.** female head and pronotum, dorsal view, **D.** male cerci, dorsal view, **E.** male cerci, ventral view.

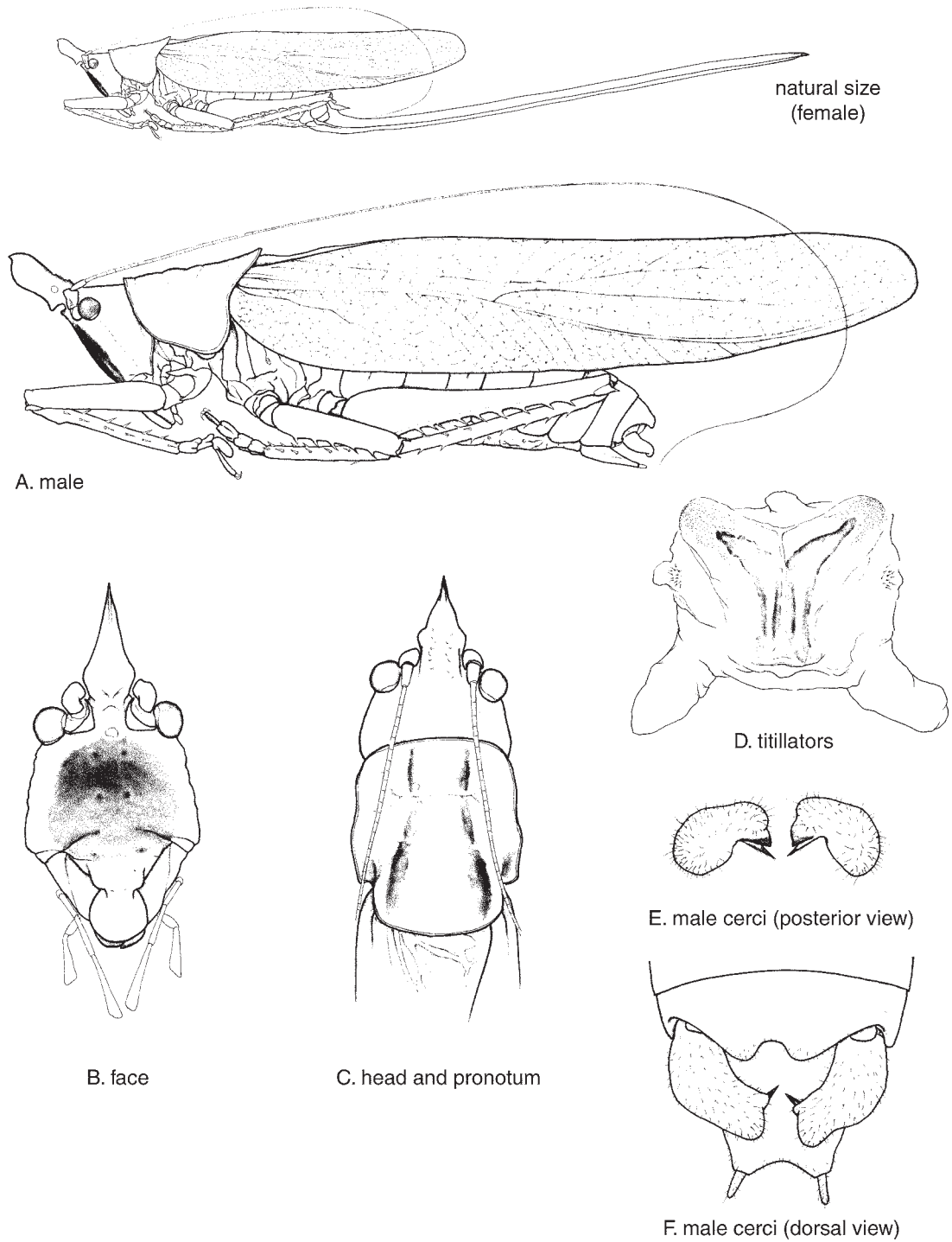


FIG. 7. *Copiphora hastata*. **A.** male - habitus, **B.** male face, **C.** male head and pronotum, dorsal view, **D.** titillators, posterior view (everted), **E.** male cerci, posterior view, **F.** male cerci, dorsal view.

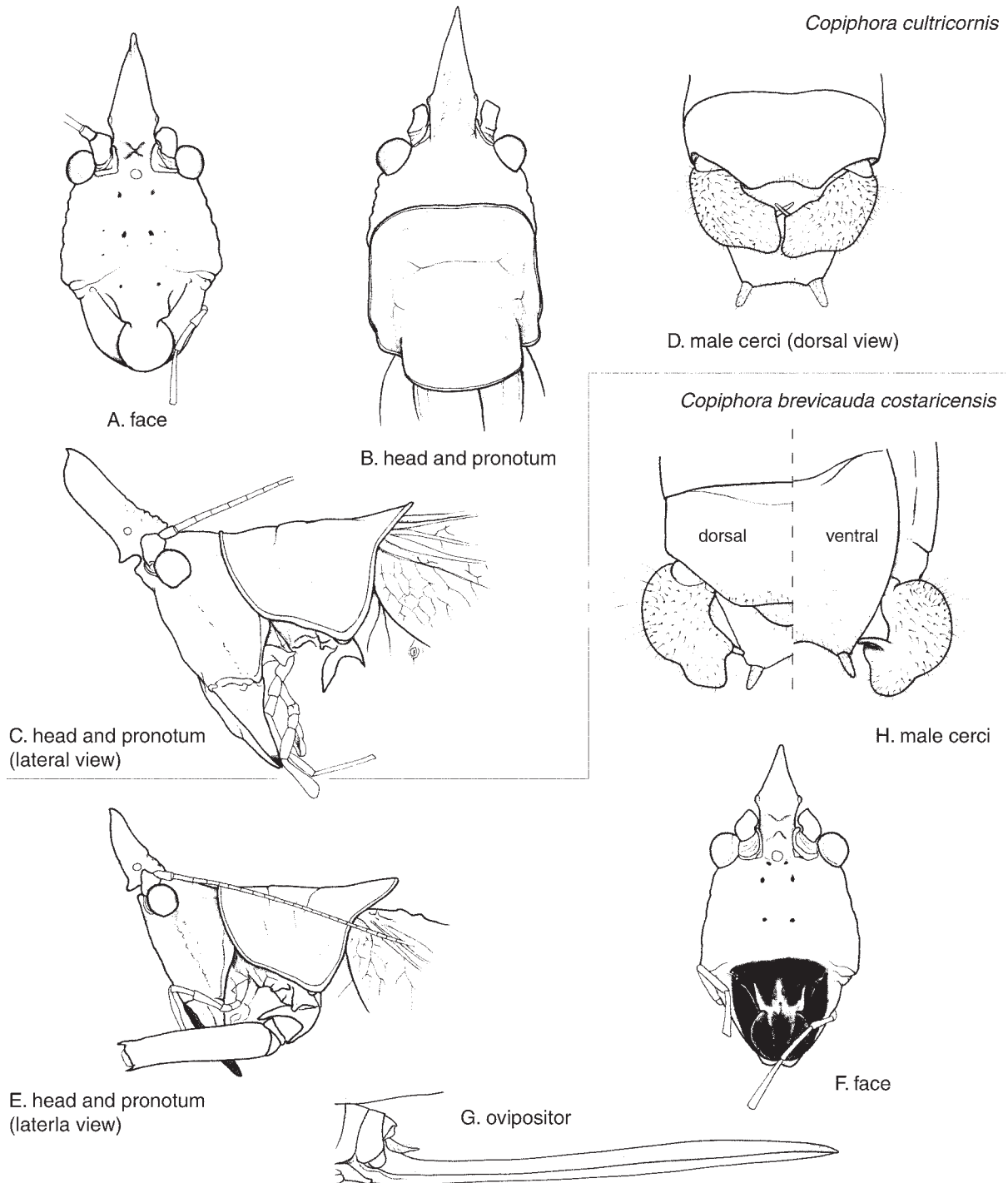


FIG. 8. Costa Rican *Copiphora* spp. **A-D:** *C. cultricornis*; **A.** male face, **B.** male head and pronotum, dorsal view, **C.** male head and pronotum, lateral view, **D.** male cerci, dorsal view; **E-H:** *C. brevicauda costaricensis*; **E.** male head and pronotum, lateral view, **F.** male face, **G.** ovipositor, **H.** male cerci.

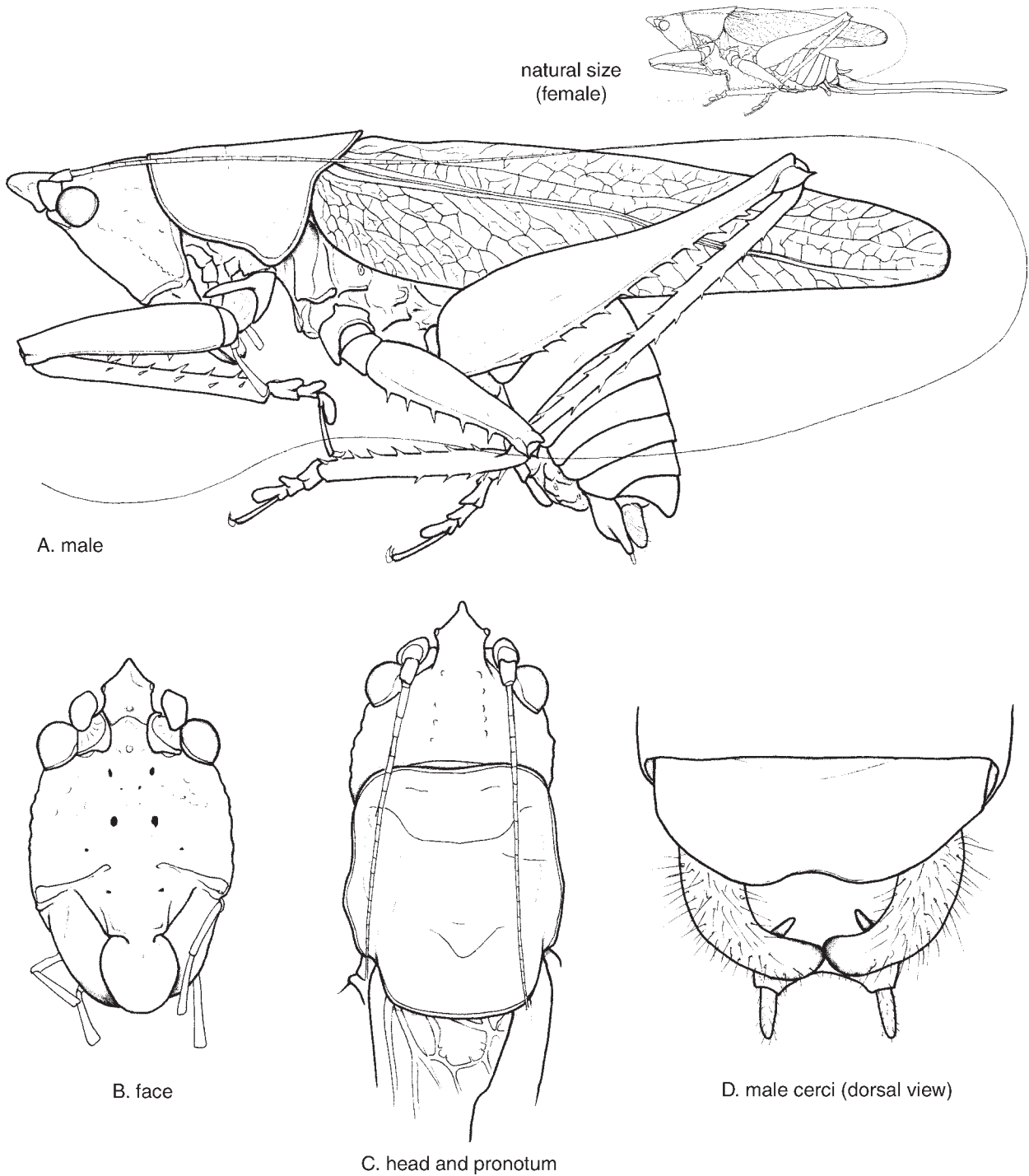


FIG. 9. *Copiphora ottei*. A. male - habitus, B. male face, C. male head and pronotum, dorsal view, D. male cerci, dorsal view.

Cañas Gordas (Finca Loma Linda), elev. 1170 m, 7 June 1964 (coll. C.F. Walker and J.M. Savage) - 1 female (UMMZ); Estac. Biol. Las Alturas, Coto Brus, elev. 1500 m, 15 June 1991 (coll. Aguilar, Greeney and Zumbado) - 1 female (INBio); same locality, elev. 1500 m, 21 March 1992 (coll. M.A. Zumbado) - 1 male (INBio); Estac. La Casona, Res. Biol. Monteverde, elev. 1520 m, 15 May 1991 (coll. N. Obando) - 1 female (INBio); Estación Altamira, 1 km S del Cerro Biolley, elev. 1450 m, 28 July - 7 August 1995 (coll. R. Vilalobos) - 1 female (INBio); nr. San Vito de Java, 24 February 1970 (coll. M. Kosztarab) - 1 male (USNM); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 1 male (PN collection); **San José Prov.**, Estac. Santa Elena, Sendero La Fila, elev. 1300 - 1600 m, 11 June 1997 (coll. E. Alfaro) - 1 female (INBio).

Copiphora cochleata Redtenbacher, 1891

Common name: Spoon-horn

Figs. 6A-E, 43A, Map 5

1891 Redtenbacher, Monogr. Conoceph.: 341; type locality: Panama, Chiriquí; type depository: Naturhistorisches Museum, Vienna - lectotype male.

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>lectotype illustrated

Diagnostic description. - Body large, with wings in both sexes extending well beyond apex of abdomen (Fig. 6A). Fastigium of vertex forming large horn, with conspicuous, round dilatation below apex, apex sharply pointed; fastigium about 5 times as long as eye diameter; dorsal part of fastigium granulose (Fig. 6B-C). Face convex; genal carinae of head well developed, granulose. Pronotum smooth, shiny; metazona slightly raised; anterior dorsal margin straight, posterior one convex; lateral lobe of pronotum 1.8 times longer than high. Male stridulatory file nearly straight, 2.1 mm long, 156 µm wide, with 206 closely spaced, wide, lamelliform teeth (Fig. 43A); mirror approximately rectangular but with sides somewhat convex; small, parallel vein next to AA₁ present.

Ventral spines of femora long, conical, usually contrastingly white; all genicular lobes armed with long, sharp spines. Male cercus thick, blunt, and somewhat incurved, slightly thicker at apex than at base; ventral, subapical spine of cercus short and thick (Figs. 6D-E). Female cercus simple, elongately conical, somewhat curved. Male subgenital plate only weakly narrowed toward apex, apex with shallow incision; styli short, about twice as long as wide (Fig. 6E). Female subgenital plate approximately triangular, with small apical incision.

Ovipositor long, straight, less than twice as long as hind femur (ratio ovipositor/hind femur 1.7) (Fig. 6A).

Coloration. - General coloration green. Fastigium of vertex yellow, its dilated apical portion reddish brown; face green, clypeus, labrum and outer parts of mandibles yellow; inner parts of mandibles black. Pronotum green, with a contrasting red, hourglass-shaped pattern, continuous with red stripe on the head and fastigium of vertex. Tegmina green, densely mottled with brown dots; posterior margin of tegmina purple-red, resulting in conspicuous dorsal stripe when wings are folded; male stridulatory file usually bright white. Legs green, with white femoral spines. Abdomen green.

Measurements. - Table 4.

Bioacoustics. - Call unknown.

Distribution. - In Costa Rica *C. cochleata* is known only from the Osa Peninsula (Map 5). It also occurs in Panama (Chiriquí). Another, undescribed species of *Copiphora* with a similar, spoon-shaped fastigium of vertex occurs in Coclé Province, Panama.

Material examined. - **COSTA RICA: Puntarenas Prov.**, Península de Osa, 2.5 mi SW Rincón, 08°42'N, 83°29'W, March 1973 (coll. Chadab) - 1 male; Península de Osa, Estac. Esquinas, elev. 200 m, 15 September 1993 (coll. M. Segura) - 1 female (INBio); **PANAMA: Chiriquí**, (coll. Staudinger) - 1 female (allolectotype) (NHMW); same locality, 1 - 30 April 1878 - 1 male (lectotype) (NHMW).

Copiphora cultricornis Pictet, 1888

Common name: Yellow-faced spear bearer

Figs. 8A-D, 42C, 55A-C, Map 6

1888 Pictet, Mem. Soc. Geneve 30 (6): 47; type locality: Panama; type depository: Museum d'Histoire Naturelle, Geneva

Diagnostic description. - Body large, with wings in both sexes extending well beyond apex of abdomen. Fastigium of vertex forming large horn, somewhat flattened laterally, especially in its apical part, sometimes fastigium somewhat dilated subapically (Fig. 8C); fastigium 3.5-4 times as long as eye diameter; dorsal part of fastigium granulose (Fig. 8B). Face convex; genal carinae of head well developed, granulose. Pronotum smooth, flat dorsally; anterior dorsal margin straight, posterior one weakly convex; lateral lobe of pronotum 1.6 times longer than high. Male stridulatory file nearly straight, 3.5 mm long, 270 µm wide, with 164 teeth; teeth in proximal half

of file wider, thinner and more densely arranged, transition between the two types sudden (Fig. 42B); mirror approximately oval, with small, parallel vein next to AA₁.

Ventral spines of femora relatively short and thin, green; all genicular lobes armed with sharp spines, sometimes spine on anterior lobes of fore femora obtuse. Male cercus thick, blunt, and somewhat incurved, slightly thicker at midlength than at base; ventral, subapical spine of cercus long and thin (Fig. 8D); apex of cercus with sharply triangular lobe underneath. Male subgenital plate narrowed toward apex, apex straight; styli short, about 2.5 times as long as wide. Female subgenital plate approximately triangular, with distinct, triangular apical incision. Ovipositor extremely long, straight, more than 3 times as long as hind femur (ratio ovipositor/hind femur 3-3.4).

Coloration. — General coloration light green. Fastigium of vertex yellow and remainder of head yellow; face yellow with 4 or 6 small black dots (Fig. 8A). Pronotum green, with four white spots (2 in prozona, 2 in metazona). Tegmina green, occasionally mottled with few, small brownish dots; male stridulatory file usually green; legs green, with green femoral spines. Abdomen green.

Measurements. — Table 4.

Bioacoustics. — The call of this species is low duty and relatively high Q, with a clear energy peak around 9.3 kHz (although higher harmonics may occur in the ultrasonic frequency range). It consists of irregular, widely spaced series of chirps (Fig. 55A). Individual chirps last 91.9-117.2 ms, and consist of 5-6 pulses (Fig. 55B).

Both males and females tremulate during courtship, although female tremulations are both shorter and weaker than those of males. Each bout of male tremulation lasts 7-8 s (at 26°C) and consists of about 25 individual pulses (Fig. 55C).

Distribution. — In Costa Rica, this species seems to be restricted to the Pacific Lowland Evergreen Forest zone (southern Puntarenas Prov.) (Map 6). It is also known from Chiriquí, Panama.

Material examined. — **COSTA RICA: Puntarenas Prov.**, Albergue, Cerro de Oro, 5-9 May 1995 (coll. B. Gamboa) - 1 male (INBio); same locality, elev. 150 m, 30 August 1995 (coll. B. Gamboa) - 1 female (INBio); Dominical, approx. 27 km SW San Isidro del General, 1-5 May 1998

(coll. P. Naskrecki) - 2 males, 1 female; Corcovado N. P., Península de Osa, 11 March 1979 (coll. D.H. Janzen) - 2 females (INBio); same locality, 22 March 1979 (coll. D.H. Janzen) - 1 female (INBio); Est. Esquinas, Península de Osa, elev. 0 m, 15 May 1993 (coll. F. Quesada) - 1 female (INBio); Estac. Queb. Bonita, Res. Biol. Carara, elev. 50 m, 15 June 1990 (coll. E. Bello) - 1 female (INBio); Fila Guerra, Península de Osa, elev. 1 - 100 m, 15 March 1991 (coll. J. Quesada) - 1 female (INBio); Golfito, 17 July 1957 (coll. A. Menke) - 1 female (Bishop Museum, Honolulu); Osa, Palmar Norte, Caña Blanca, elev. 30 m, 13 - 15 February 1996 (coll. A.M. Maroto) - 1 female (INBio); P. N. Manuel Antonio, Quepos, elev. 80 m, 15 March 1991 (coll. R. Zuniga) - 1 male (INBio); same locality, elev. 80 m, 15 April 1991 (coll. R. Zuniga) - 2 males, 1 female (INBio); Península de Osa, Corcovado N. P., elev. 10 - 100 m, 25 March 1977 (coll. D.H. Janzen) - 1 male, 2 females (INBio); same locality, elev. 10 - 100 m, 7 July 1977 (coll. D.H. Janzen) - 1 male (INBio); same locality, elev. 10 - 100 m, 23 March 1978 (coll. D.H. Janzen) - 2 females (INBio); same locality, elev. 10 - 100 m, 27 March 1982 (coll. D.H. Janzen and W. Hallwachs) - 1 male (INBio); Península de Osa, Corcovado N. P., Estac. Sirena, 27 March 1981 (coll. D.H. Janzen and W. Hallwachs) - 3 males, 4 females (INBio); Península de Osa, Corcovado N. P., Sirena, 7 - 14 March 1994 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); Península de Osa, Estac. Esquinas, elev. 200 m, 15 September 1993 (coll. M. Segura) - 1 male (INBio); Peninsula de Osa, Rancho Quemado, elev. 200 m, 31 March 1992 (coll. A. Marín) - 1 male (INBio); same locality, elev. 200 m, 15 April 1992 (coll. D. Brenes) - 1 female (INBio); Rancho Quemado, Península de Osa, elev. 200 m, 24 July 1992 (coll. M.A. Zumbado) - 1 female (INBio); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 April 1989 (coll. R. Blanco and G. Fonseca) - 1 male, 2 females (INBio); same locality, elev. 0 - 100 m, 15 November 1989 (coll. G. Fonseca) - 1 female (INBio); same locality, elev. 0 - 100 m, 15 November 1990 (coll. J.C. Saborio) - 1 female (INBio); same locality, elev. 0 - 100 m, 15 November 1990 (coll. G. Fonseca) - 1 male (INBio); same locality, elev. 0 - 100 m, 15 April 1992 (coll. G. Rodríguez) - 1 male, 1 female (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 1 nymph (PN collection); **PANAMA:** Chiriquí, (coll. Staudinger) - 1 female (NHMW).

Copiphora hastata Naskrecki, sp. n.

Common name: Brown-faced spear bearer
Figs. 7A-E, 36E, 42C, 55D-E, Map 6

Type locality: Costa Rica: Heredia Prov., La Selva
Biological Station; type depository: Academy of
Natural Sciences, Philadelphia – holotype male

Diagnostic description. — Body large, with wings in both sexes extending well beyond apex of abdomen (Figs. 7A, 36E). Fastigium of vertex forming large horn, somewhat flattened laterally, especially in its apical part, fastigium always slightly dilated subapically, about 3 times as long as eye diameter; dorsal part of fastigium strongly granulose (Fig. 7C). Face convex; genal carinae of head well developed, granulose. Pronotum smooth, flat dorsally; anterior dorsal margin straight, posterior margin weakly convex; lateral lobe of pronotum about 1.6 times longer than high. Male stridulatory file weakly curved, 3.2 mm long, 275 μ m wide, with 147 teeth; teeth in proximal half of file wider, thinner and more densely arranged, transition between two types sudden (Fig. 42C); mirror approximately oval; small, parallel vein next to AA₁ present.

Ventral spines of femora relatively short and thin, green; all genicular lobes armed with sharp spines, sometimes spine on anterior lobes of fore femur obtuse. Male cercus thick, blunt, and somewhat incurved, slightly thicker at midlength than at base; ventral, subapical spine of cercus long, thin and pointed; apex of cercus with sharply triangular lobe underneath (Fig. 7D). Male subgenital plate narrowed toward apex, apex straight; styli short, about 2.5 times as long as wide. Female subgenital plate approximately triangular, with distinct, triangular apical incision. Ovipositor extremely long, straight, more than 3 times as long as hind femur (ratio ovipositor/hind femur 3.3-3.5) (Fig. 7).

Coloration. — General coloration light green (Fig. 36E). Fastigium of vertex yellowish-brown; face with large, oval, brown spot covering most of the frons, upper portion of the clypeus, and mandibles (Fig. 7B); remainder of head yellow. Pronotum green, with two dark brown to dark olive green stripes along lateral dorsal edges of pronotum. Tegmina green, never mottled with dots; edges of tegmina, especially in their apical portions, red; male stridulatory file usually green; legs green, with green femoral spines. Abdomen green.

Measurements. — Table 4.

Bioacoustics. — *Copiphora hastata* has a call similar to that of *C. cultricornis*, although the series of chirps are shorter and the intervals between individual chirps are much shorter. Also, each chirp consists of a much higher num-

ber of pulses than that of *C. cultricornis*. Individual series of chirps last about 3.5 s and are separated by several seconds to several minutes of silence (Fig. 55D). Each chirp lasts 153.2 - 241.5 ms and their length increases towards the end of the series. The chirps consist of 5 - 14 pulses, and the amplitude increases towards the end of each pulse (Fig. 55E). Most of the energy of the call is allocated between 8.6 and 11.6 kHz.

Typical of the genus, the airborne signals of *C. hastata* are accompanied by substrate tremulations. They are produced both in the absence of the female as well as after the female approaches the male. The substrate signals are similar to those observed in other species of *Copiphora*, and consist of rapid, shaking movements of the entire body, and unlike *Lirometopum coronatum*, lack any percussive behavior. Tremulations are produced in series of bouts at 26 Hz. After the initial contact with the female, the male almost entirely ceases to produce airborne signals and switches to tremulations. Females respond with nearly identical tremulations but of much lower amplitude.

Remarks. — This new species is widely distributed in Costa Rica, with the exception of the southern portion of Puntarenas Prov., where it is replaced by the closely related *C. cultricornis* (Map 6). It has also been collected in Nicaragua.

C. hastata can be easily identified among Costa Rican members of the genus by the presence of a dark brown patch covering most of the face, and the shape of the fastigium of vertex. Females of this new species as well as those of *C. cultricornis* have consistently the longest ovipositors among all *Copiphora* spp. in Costa Rica (and, in fact, all Tettigoniidae). From the closely related *C. cultricornis* it differs in the coloration of the face (yellow in *C. cultricornis*) and tegmina (posterior edges of tegmina reddish in *C. hastata*, green in *C. cultricornis*), shape of the fastigium of vertex (distinctly longer and more flattened laterally in *C. cultricornis*), characteristics of the male's stridulatory file (file with more teeth in *C. cultricornis*) as well as the characteristics of the male's call (Figs. 55D-E). Tremulations of these two species, however, are virtually identical, suggesting that they play little or no role in species recognition.

Material examined. — COSTA RICA: Alajuela Prov., 2 km S Pital, 5 - 28 September 1988 (coll. F.D. Parker) - 1 male, 1 female (paratypes) (EMUS); Estac. San Ramón Oeste, elev. 620 m, 19 April 1994 (coll. F. Quesada) - 1 female (paratype) (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 1 nymph (PN collection); Cartago Prov., Monumento Nacional Guayabo, A.C.A.C. Amistad, 15 July 1994 (coll. G. Fonseca) - 1 female (paratype) (INBio); Turrialba, 4

June 1951 (coll. O.L. Cartwright) - 1 female (paratype) (PN collection); same locality, 5 June 1951 (coll. O.L. Cartwright) - 1 female (paratype) (PN collection); **Guanacaste Prov.**, 2 km N Colonia Blanca, P. N. Rincón de la Vieja, elev. 800 m, 28 June 1992 (coll. III curso Parataxon.) - 1 male (paratype) (INBio); 14 km S Cañas, 15 - 20 October 1990 (coll. F.D. Parker) - 1 male (paratype) (EMUS); Estac. Cacao, 2 km SW del Cerro Cacao, elev. 1000 - 1400 m, 12 - 17 February 1995 (coll. S. Avila) - 1 male (paratype) (INBio); Estac. Cacao, Lado suroeste del Volcán Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 15 June 1990 (coll. II curso Parataxon) - 1 female (paratype) (INBio); Estac. Maritza, lado O Vol. Orosí, elev. 600 m, 10 March 1992 (coll. K. Taylor) - 1 female (paratype) (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 18 - 23 July 1993 (coll. C. Moraga) - 1 female (paratype) (INBio); same locality, 15 May 1994 (coll. C. Moraga) - 1 female (paratype) (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 July 1988 (coll. GNP Biodiversity Survey) - 1 male (paratype) (INBio); same locality, 15 August 1988 (coll. GNP Biodiversity Survey) - 1 nymph (INBio); same locality, 15 June 1989 (coll. GNP Biodiversity Survey) - 1 male (paratype) (INBio); same locality, 18 August 1993 (coll. P. Rios) - 1 female (paratype) (INBio); same locality, 1 - 30 June 1996 (coll. P. Rios) - 1 female (paratype) (INBio); Estac Cacao, SW side Volcán Cacao, elev. 1000 - 1400 m, 1 December 1989 (coll. R. Blanco and C. Chávez) - 1 female (paratype) (INBio); Estac. Mengo, SW side Volcán Cacao, elev. 1100 m, 15 February 1989 (coll. GNP Biodiversity Survey) - 1 female (paratype) (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 March 1989 (coll. GNP Biodiversity Survey) - 1 nymph (INBio); Finca Pasmompa Estación Pitilla, 5 km SW Santa Cecilia, elev. 400 m, 15 May 1989 (coll. GNP Biodiversity Survey) - 1 female (paratype) (INBio); **Heredia Prov.**, Braulio Carillo N. P., Estac. El Ceibo, elev. 400 - 600 m, 15 November 1989 (coll. R. Aguilar and M. Zumbado) - 1 male (paratype) (INBio); Estac. Magsasay, P.N. Braulio Carillo, elev. 200 m, 15 November 1990 (coll. M.A. Zumbado) - 1 male (paratype) (INBio); same locality, elev. 200 m, 15 May 1991 (coll. M.A. Zumbado) - 1 female (paratype) (INBio); same locality, elev. 200 m, 15 July 1991 (coll. A. Fernández) - 1 male (paratype) (INBio); Finca La Selva (on Río Puerto Viejo just above jct. with Río Sarapiquí), 3 August 1962 (coll. C.F. Walker) - 1 female (paratype) (UMMZ); La Selva, 1 July - 31 August 1991 (coll. J. Doubles) - 1 male (paratype) (UMMZ); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 March 1992 (coll. S. Cunningham) - 1 male (paratype) (PN collection); same locality, 15 March 1994 (coll. P. Naskrecki) - 3 females (paratypes) (PN collection); same locality, 1 - 4 April 1994 (coll. P. Naskrecki) - 4 males, 1 female (holotype male, allotype female, paratypes) (ANSP); same locality, 7 - 10 December 1995 (coll. P.

Naskrecki) - 1 female (paratype) (PN collection); **Limón Prov.**, Cuatro Esquinas, P. N. Tortuguero, elev. 0 m, 15 April 1989 (coll. R. Aguilar and J. Solano) - 1 female (paratype) (INBio); Cuatro Esquinas, Tortuguero N. P., 15 September 1989 (coll. J. Solano) - 1 male, 1 female (paratypes) (INBio); same locality, 15 November 1989 (coll. J. Solano) - 1 female (paratype) (INBio); Estac. Cuatro Esquinas, Tortuguero N. P., 15 June 1990 (coll. E. Quesada) - 1 female (paratype) (INBio); same locality, elev. 0 - 120 m, 16 July 1990 (coll. E. Quesada) - 1 male (paratype), 2 nymphs (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 200 m, 15 September 1990 (coll. G. Carballo) - 1 male (paratype) (INBio); same locality, elev. 100 m, 15 June 1991 (coll. G. Carballo) - 1 nymph (INBio); same locality, elev. 100 m, 15 June 1992 (coll. G. Carballo) - 2 females (paratypes) (INBio); same locality, elev. 100 m, 15 July 1992 (coll. G. Carballo) - 2 females (paratypes) (INBio); Hamburg Farm, (coll. C.W. Dodge) - 1 female (paratype) (MCZC); same locality, (coll. C.W. Dodge) - 1 male (paratype) (MCZC); Manzanillo, RNFS Gandoca y Manzanillo, elev. 0 - 100 m, 13 October 1992 (coll. K. Taylor) - 1 female (paratype) (INBio); **NICARAGUA**: Zelaya el Recreo, 1 - 31 October 1984 (coll. Foret) - 1 male, 2 females (paratypes) (MNHN).

Copiphora brevicauda Karny, 1907

Note: A comparison of the type specimens of *C. brevicauda*, along with a series of specimens from Venezuela and Ecuador, with those collected in Costa Rica, reveals small but consistent difference between the two populations. The differences relate mostly to the size of the stridulatory file and the number of stridulatory teeth, along with minor differences in the shape of the fastigium of vertex and coloration. Because I have sound recordings of only the Costa Rican individuals of the species, it is impossible to say to what extent these morphological differences are reflected in the acoustic properties of the calling behavior, and whether the two populations are reproductively isolated (although, based purely on the fact that physical properties of the stridulatory file in Tettigoniidae are strongly correlated with the physical properties of the sound, such differences undoubtedly exist). Therefore, it seems more advisable at this time to acknowledge these differences by giving the Costa Rican population a subspecific status, instead of elevating them to a full species.

Diagnostic description.— Body of medium size as for the genus, with wings in both sexes extending well beyond apex of abdomen. Fastigium of vertex forming relatively small horn, usually conical, but sometimes with ventral keel slightly expanded and not narrowing gradu-

ally towards apex; fastigium 2.5 times as long as eye diameter; dorsal part of fastigium granulose. Face convex; genal carinae of head well developed, granulose. Pronotum smooth, flat dorsally; anterior dorsal margin straight, posterior one straight to weakly convex; lateral lobe of pronotum 1.8 times longer than high. Male stridulatory file nearly straight, 1.7-2.7 mm long, 150-200 μ m wide, with 154-214 teeth (Figs. 42D-E); mirror approximately rectangular; vein AA₁ very thick, small, parallel vein next to AA₁ present.

Ventral spines of femora relatively short and thin; all genicular lobes armed with sharp spines, sometimes spine on anterior lobes of fore femora obtuse. Male cercus thick, blunt, and somewhat incurved, distinctly constricted below apex; ventral, subapical spine of cercus long and thin; apex of cercus with sharply triangular lobe underneath (Fig. 7I). Male subgenital plate narrowed toward apex, apex weakly emarginated; styli short, about 2.5 times as long as wide. Female subgenital plate approximately triangular, with distinct, triangular apical incision. Ovipositor long, straight, 1.6-2.1 times as long as hind femur.

Coloration.— General coloration light green. Fastigium of vertex yellow; face bright yellow, sometimes with 2, 4 or 6 small black dots; clypeus, labrum and mandibles black; occiput and genae green. Pronotum green; tegmina green, occasionally mottled with few, small brownish dots; male stridulatory file green; legs green, with blue femoral spines (green or yellow in poorly preserved specimens); hind femora usually with well developed reticulate pattern on their outer surfaces. Abdominal terga green, sterna yellow; in live individuals abdominal spiracles surrounded by blue circles.

Copiphora brevicauda brevicauda Karny, 1907
Fig. 42D

1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 7; type locality: Ecuador, Cachabi; type depository: Naturhistorisches Museum, Vienna – lectotype male
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>lectotype illustrated

Diagnostic description.— Fastigium of vertex forming relatively small horn, with poorly developed ventral keel. Stridulatory file 1.75 mm long, with 210-214 lamelliform teeth, evenly distributed (Fig. 42D). Ratio ovipositor/hind femur 1.6-1.9. Tegmina mottled with numerous brown dots.

Measurements.— Table 4.

Bioacoustics.— Call unknown.

Distribution.— This subspecies is known Colombia (F. Monteallegre, pers. comm.), Ecuador and Venezuela.

Material examined.— **ECUADOR:** Cachabi, elev. 152.4 m, 1 - 30 November 1896 (coll. Rosenberg) - 1 male (lectotype), 1 female (allolectotype) (NHMW); Guayaquil (with bananas), 23 May 1950 - 2 females (USNM); same locality, 23 May 1950 - 1 female (USNM); Santo Domingo de los Colorados, (coll. F. Campos) - 1 female; Tonchique, 1 - 31 May 1964 - 1 male (USNM); Esmeraldas Prov., El Placer, elev. 675 m, 25 - 31 July 1987 (coll. G.S. Glenn) - 1 male (ANSP); Galápagos Islands, St. Cruz, 3 km W Bellavista, Finca Vilema, elev. 210 m, 19 April 1992 (coll. S. Peck) - 1 male (S. Peck collection); St. Cruz, Sta. Rosa, Tortoise Reserve, elev. 180 m, 7 February 1989 (coll. S. Peck) - 1 male (S. Peck collection); Los Rios Prov., Río Palanque Science Cent., ca 47 km S Santo Domingo de los Colorados, 9 - 10 October 1988 (coll. J.L. Castner) - 2 females (USNM); **VENEZUELA:** Río Chacaito, Edo. Miranda, elev. 980 m, 18 September 1939 (coll. G.V. Berthier) - 1 male (ANSP).

Copiphora brevicauda costaricensis sp. n.
Common name: Costa Rican spear bearer
Figs. 8F-I, 42F, 55F-G, Map 5

Type locality: Costa Rica, Heredia Prov., La Selva Biological Station; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— Fastigium of vertex forming relatively small horn, with well developed ventral keel, keel often slightly expanded subapically (Fig. 8F). Stridulatory file 2.7 mm long, with 154 teeth, teeth in distal half of file distinctly thicker and less densely distributed (Fig. 42F). Ovipositor relatively short compared to other members of the genus, ratio ovipositor/hind femur 1.9-2.1 (Fig. 8H). Tegmina never mottled with brown dots.

Measurements.— Table 4.

Bioacoustics.— *C. brevicauda costaricensis* produce low duty, relatively high Q calls, consisting of irregular series of long chirps. Individual series of chirps last about 2.6 s (at 25°C) and are produced after intervals of several minutes of silence. Each series has 5-7 chirps, with each chirp lasting 185.3-269.1 ms (n=7), and consisting of 8-13 individual pulses. Most

energy of the call is allocated between 9.2 and 11.8 kHz.

Distribution.— This subspecies seems to be endemic to Costa Rica.

Material examined.— **COSTA RICA: Cartago Prov.**, Chitaria, elev. 500 m, 9 June 1929 (coll. M. Valerio) - 1 male (paratype) (ANSP); **Heredia Prov.**, Chilamate, 24 - 30 July 1993 (coll. S. Keller) - 1 female (paratype) (EMUS); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 3 November 1994 (coll. ALAS) - 1 male (paratype) (ALAS); same locality, 1 October 1995 (coll. P. Naskrecki) - 1 female (allotype) (ANSP); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 male (holotype), 1 female (paratype) (ANSP); **Puntarenas Prov.**, Estac. Aguias, Río Agujas, Sendero Purruja, elev. 300 m, 1 - 6 September 1997 (coll. A. Azofeifa) - 1 female (paratype) (INBio); Península de Osa, Rancho Quemado, elev. 200 m, 15 August 1992 (coll. F. Quesada) - 1 male (paratype) (INBio).

Copiphora ottei Naskrecki, sp. n.
Common name: Otte's spear bearer
Figs. 9A-D, 42F, Map 6

Type locality: Costa Rica: Puntarenas Prov., Golfito;
type depository: Academy of Natural Sciences,
Philadelphia - holotype male

Diagnostic description.— Body small compared to other members of the genus, with wings in both sexes extending beyond apex of abdomen by only about 1/4 of their length (Fig. 9A). Fastigium of vertex forming small, trituberculate horn, with lateral ocelli situated on conspicuous lateral protuberances; fastigium about as long as eye diameter; dorsal part of fastigium smooth or with two rows of poorly developed, small tubercles (Fig. 9C). Face flat; genal carinae of head well developed, granulose. Pronotum smooth, flat dorsally; anterior dorsal margin straight to weakly concave, posterior one weakly convex; lateral lobe of pronotum about 1.8 times longer than high. Male stridulatory file nearly straight, 2.3 mm long, 223 µm wide, with 214 thin, wide, and evenly distributed teeth (Fig. 42F); mirror nearly circular; small, parallel vein next to AA₁ reduced to hardly discernible fold.

Ventral spines of femora relatively short and thin, green; all genicular lobes, except for posterior lobe of fore

femora, armed with sharp spines. Male cercus thick (although not as much as in other species of the genus), blunt, and distinctly incurved; ventral, subapical spine of cercus long, blunt apically (Fig. 9D). Male subgenital plate weakly narrowed toward apex, apex weakly emarginated; styli short, about 3 times as long as wide. Female subgenital plate approximately triangular, with minute, triangular apical incision. Ovipositor long, straight, ratio ovipositor/hind femur 1.4-1.6 (Fig. 9).

Coloration.— General coloration light olive green. Fastigium of vertex, face and mouthparts yellowish-orange to pinkish-brown, face often with 4 or 6 small, dark dots (Fig. 9B). Pronotum brown to dark olive green. Tegmina green, with conspicuous yellow venation; edges of tegmina red, especially in their apical portions; male stridulatory file green; legs brown, with green femoral spines; hind femora usually with well developed reticulate pattern on their outer surfaces. Abdomen green.

Measurements.— Table 4.

Bioacoustics.— Call unknown.

Distribution.— This new species seems to be restricted in its distribution to the southernmost portion of Puntarenas Prov. (Osa Peninsula and adjacent areas) (Map 6). It is possible, however, that this species also occurs in the north-western part of Panama.

Material examined.— **COSTA RICA: Puntarenas Prov.**, Corcovado N. P., Península de Osa, 14 August 1978 (coll. D.H. Janzen) - 1 female (paratype) (INBio); Estac. Aguias, Río Agujas, Sendero Ajo, elev. 300 m, 5 August 1997 (coll. A. Azofeifa) - 1 female (paratype) (INBio); Estac. Aguias, Río Agujas, Sendero Purruja, elev. 300 m, 1 - 6 September 1997 (coll. A. Azofeifa) - 1 female (paratype) (INBio); Golfito, 9 August 1957 (coll. A. Menke) - 1 male (holotype) (ANSP); Península de Osa, Corcovado N. P., Estac. Sirena, 13 August 1980 (coll. D.H. Janzen and W. Hallwachs) - 1 female (allotype) (ANSP).

Etymology.— This new species is named in honor of Daniel Otte, for his prodigious contributions to biology, and to entomology in particular.

ACANTHEREMUS Karny, 1907

1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 8; type species: *Acantheremus elegans* Karny, by original designation

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>references; types illustrated

Diagnosis

Slender to moderately robust; both sexes macropterous. Head with fastigium of vertex strongly produced into sharp cone, 2-3.5 times as long as diameter of eye; apex of fastigium blunt or ending in one or two small spines. Head robust, frons flat or weakly convex; genae with strongly developed lateral carinae, continuous with carinae on fastigium of vertex. Eyes globular, moderately protruding. Ovipositor straight or weakly curved; apex slightly thickened, minutely serrate, distinctly darker than remaining portion of ovipositor.

Description (male except where specified)

Head. — Fastigium of vertex produced into prominent, slender cone, 2 to 3.5 times as long as diameter of eye; dorsal surface of fastigium smooth or tuberculate; fastigium with well developed lateral carinae; lateral ocelli situated at bases of carinae; apex of fastigium blunt, or with one or two small apical spines; basal portion of fastigium of vertex with a prominent knob ventrally, well separated from fastigium of frons. Antennal sockets separated by distance equal to 0.6-1.0 diameter of eye. Eyes globose, moderately projecting; genae smooth or with two parallel rows of small tubercles. Frons flat or weakly convex; genae with strongly developed lateral carinae, continuous with those on fastigium of vertex.

Thorax and wings. — Dorsal surface of pronotum smooth or finely tuberculate, flat; anterior margin of pronotum straight, posterior margin straight or weakly convex; lateral lobes with posterior angle rounded or acute. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobes of pronotum. Prosternum unarmed, mesosternum unarmed or with a pair of small, widely separated, vertical spine-like lobes; metasternum unarmed.

Wings in both sexes fully developed, surpassing apices of hind femora. Stridulatory apparatus of male well developed; stridulatory file straight or weakly curved, with very high number (124-585) of narrow, lamelliform, very closely spaced teeth; stridulatory area of left wing covered with archdictyon or almost devoid of secondary venation; mirror of right wing about as long as wide, with or without veinlet parallel to AA₁. Posterior margin of front wing straight or weakly concave; apex of front wing narrowly rounded.

Legs. — Fore coxa with an elongate, sometimes laterally flattened, forward projecting spine dorsally; middle and hind coxa without spine; all trochanters unarmed. Fore femur dorsally unarmed, anterior (inner) margin of femur with 4-5 spines; middle femur unarmed dorsally, anterior (outer) margin of femur with 4-5 spines; hind femur unarmed dorsally, anterior (outer) ventral margin armed with 7-11 spines, inner margin unarmed; genicular lobes of all femora armed with long spines, outer (anterior) spine usually slightly longer than inner (posterior) one. Front tibia unarmed dorsally, both ventral margins with short, immovable spines; tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area moderately swollen; middle tibia unarmed dorsally or with 3-4 dorsal spines, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with surface smooth, its posterior margin weakly to distinctly emarginated; supraanal plate in both sexes small, broadly rounded apically; male cercus variable, either short and robust, with or without apical spine, and with a large inner spine, or laterally flattened, unarmed; paraprocts unmodified; female cercus, simple, narrowly conical. Subgenital plate of male variable, either broadly triangular, with a very shallow apical emargination, or almost parallel-sided, with very deep apical incision; styli short, 1.5-2.0 times as long as thick; female subgenital plate either triangular, with triangular apical incision, or with two widely divergent, upcurved lobes. Male internal genitalia with weakly sclerotized inner margins of phallic lobes but without well developed titillators. Ovipositor narrow, its margins parallel, straight or slightly curved upwards; both dorsal and ventral margins of ovipositor smooth; apex of ovipositor slightly but noticeably thickened laterally, darker than remaining part of ovipositor and slightly serrated on both upper and lower valvulae. Length of ovipositor from 0.6 to approximately 1.6 times length of hind femur.

Coloration. — General coloration green; frons green, clypeus and labrum sometimes yellow; scapus, lateral carinae of fastigium of vertex and genae yellow, sometimes with red edges; thorax and abdomen green or yellowish; legs green, femoral spines often yellow or pink; tegmina green with hind margins sometimes with narrow red and yellow edge, sometimes tegmina with widely scattered dark dots, hind wings transparent. Dried specimens in entomological collections usually turn yellow with time.

Remarks. — The genus, which includes 9 described species was recently revised by Naskrecki (1997).

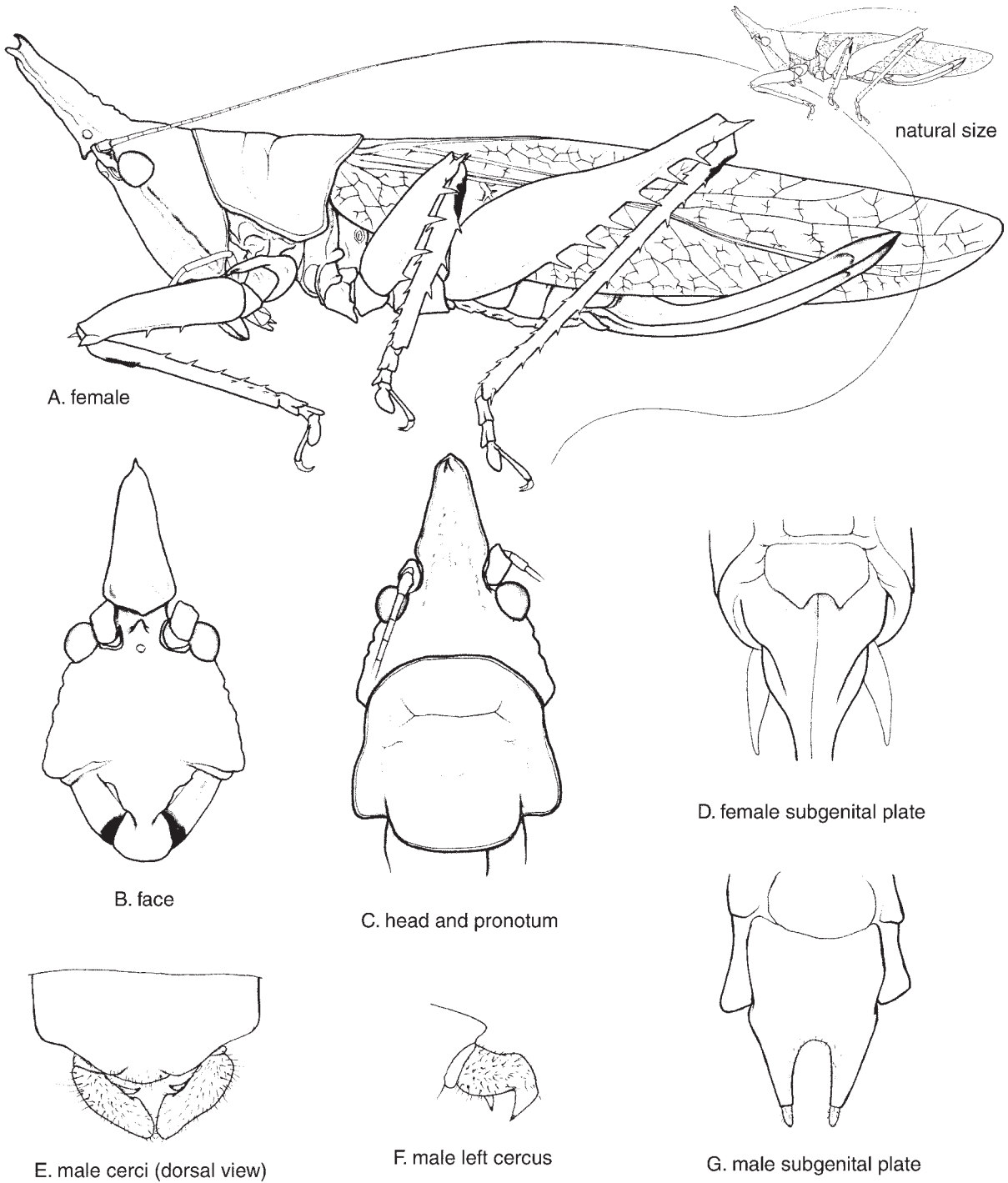


FIG. 10. *Acantheremus colwelli*. **A.** female - habitus, **B.** female face, **C.** female head and pronotum, dorsal view, **D.** female subgenital plate, ventral view, **E.** male cerci, dorsal view, **F.** male left cercus, lateral view, **G.** male subgenital plate, ventral view.

Acantheremus species range from southern Central America (Costa Rica, Panama), to the Caribbean (Dominica) and to South America (Colombia, Surinam, Guyana, Venezuela, Brazil, Peru).

Unlike members of the closely related *Copiphora*, which inhabit primarily the understory vegetation or even the ground level of the forest, species of *Acantheremus* seem to be restricted to the canopy level and never descend to the ground. This, combined with the apparent rarity of these insects, makes field observations extremely difficult and few conclusions can be drawn about the biology of *Acantheremus*.

Modifications of the apical part of the ovipositor suggest that females of all *Acantheremus* spp. deposit eggs in plant tissues, rather than in the ground, where at least some members of the genus *Copiphora* oviposit. The minutely toothed edges of the apical portions of both upper and lower valvulae suggest that females make incisions in plant tissues. A female of *A. colwelli* was seen depositing eggs in a stem of an unidentified vine. This species was also collected from the following tree species: *Virola koschnyi* Warb. (Myristicaceae), *Dendropanax arboreus* (L.) Decne. and Planch. (Araliaceae) and *Pentaclethra macroloba* (Gavilán) (Mimosaceae).

Probably all species of *Acantheremus* are predominantly predaceous. In captivity, nymphs of *A. colwelli* readily accepted both live and dead insects and rather reluctantly consumed plant material. Live insects, such as nymphs of other katydids and small moths, were swiftly captured with the fore legs and crushed with the powerful mandibles typical of the genus. Gut content analysis of other species revealed numerous cuticular elements of insect bodies, such as parts of mandibles and compound eyes of beetles and wing scales of Lepidoptera.

Little is known about the acoustic behavior of *Acantheremus* spp., and only *A. colwelli* has been recorded (see below for the song description).

Acantheremus colwelli Naskrecki, 1997

Common name: Colwell's horned katydid
Figs. 10A-G, 36C, 43D-E, 54D-E, Map 4

1997 Naskrecki Trans. Amer. Entomol. Soc. 123(3): 152;
type locality: Costa Rica: Guanacaste Prov.,
Estación Pitilla, 9 km S Santa Cecilia, elev. 700 m;
type depository: Instituto Nacional de
Biodiversidad, San José, Costa Rica – holotype
male

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD
ROM) >>holotype illustrated

Diagnostic description.— Body small, with wings in both sexes slightly surpassing apices of hind femora (Figs. 10A, 36C). Fastigium of vertex about 2.5-3 times as long as

eye diameter; triangular when viewed in front; apex bifurcated (Figs. 10B-C). Pronotum granulate; both anterior and posterior margins straight; lateral lobe of pronotum 1.8 times longer than high. Male stridulatory apparatus well developed; stridulatory file straight, 1.15 mm long, 0.17 mm wide, with 358 very closely spaced, lamelliform teeth (Figs. 43D-E); transparent area between M+CuA and mirror in shape of equilateral triangle, mirror about as long as high.

Caudal margin of male 10th tergite weakly emarginated. Male cercus almost straight when seen from above, its apex strongly bent downward, ending in sharp spine; inner, ventral part of cercus with short spine (Figs. 10E-F). Female cercus simple, elongately conical. Male subgenital plate about 1.3 times as long as wide, distinctly narrowed toward apex, apex with narrow, almost parallel sided incision, reaching past 1/3 of length of plate; styli short, about 1.8 times as long as wide (Fig. 10G). Female subgenital plate about 1.5 times as wide as long, apical part of plate narrowed and shallowly incised (Fig. 10D). Ovipositor shorter than hind femur, ratio tegmen/hind femur 0.9, distinctly upcurved in its basal part (Fig. 10A).

Coloration.— General coloration green (Fig. 36C) (yellow in old museum specimens). Lateral carinae on the head, knees, and cubital veins of tegmina yellow with red edges; femoral spines often red; proximal end of middle tibia with dark brown, longitudinal spot; apex of ovipositor dark brown.

Measurements (mm).— Body (excl. tegmina): male 26, female 26-30; body (incl. tegmina): male 30, female 36-40; pronotum: male 7, female 7.5-8; tegmen: male 19, female 25-28; hind femur: male 12, female 14.5-16, ovipositor 13-14.

Bioacoustics.— The call of *A. colwelli* consists of irregular series of short, buzzing trains, lasting 0.50-1.28 s, separated by 233-262 ms long pauses (at 25°C). Each train consists of 34-89 individual wingstrokes (Figs. 54D-E). The call is low Q, without a clearly defined energy peak. It is likely, however, that most energy is allocated in ultrasonic frequencies, which I was unable to record due to the technical constraints of the recording equipment.

Distribution.— *C. colwelli* is so far known only from a handful of localities in northern and central Costa Rica (Map 4).

Material examined.— **COSTA RICA: Guanacaste Prov.**, Estación Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 September 1989 (coll. C. Moraga and P. Rios)—male (holotype) (INBio); 3 km SE R. Naranjo, 16-31 January 1993 (coll. F.D. Parker)—male (EMUS); **Heredia Prov.**, Braulio Carillo N. P., Estac. El Ceibo, elev. 400-600 m, 15 Septem-

ber 1995 (coll. R. Aguilar and M. Zumbado)—female (alotype) (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 15 August 1976 (coll. G.K. Morris)—female (ANSP); same locality, 4 Oct. 1993 (coll. ALAS)—nymph; same locality and collector, CES 350, ex *Dendropanax arboreus* 12 Nov. 1994—nymph; same locality and collector, CC 400 m, ex *Pentaclethra macroloba* 9 Oct. 1994—nymph; same locality and collector, CC 50 m, 14 Oct. 1994—nymph; same locality and collector, CCC 400 m, ex *Virola koschnyi* 20 Oct. 1994; same locality and collector, CEN 550 m, 15 Nov. 1994—nymph; same locality and collector, 7 Jan 1994—nymph; same locality and collector, Sura 1100 m, 3 Nov. 1994—nymph; same locality, 10 May 1998, coll. K.M. Smith and P. Naskrecki - 1 male (INBio); **Cartago Prov.**, Turrialba, 6 March 1965 (coll. S.S. and W.D. Duckworth)—female (USNM); Turrialba, Agr. Sta., 10 February 1966 (coll. H.R. Roberts)—female (ANSP).

LIROMETOPUM Scudder, 1875

Common name: Pitbull katydids

1875 Scudder, Proc. Boston Soc. Nat. Hist. 17: 60. type species: *Lirometopum coronatum* Scudder, 1875
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>references; types illustrated

Diagnosis

Body very robust, of medium size; both sexes macropterous (Fig. 11A); tegumen smooth. Face nearly circular to moderately elongate; fastigium of vertex 3-5 times broader than scapus, short, with 3 tubercles apically, continuous with fastigium of frons; genal carinae extremely well developed; face flat. All femora armed on lower margins with spines. Male cercus stout, armed with blunt, ventral, subapical spine; ovipositor straight, with upper and lower margins parallel.

Description (male except where specified)

Head. — Fastigium of vertex 3 to 5 times as wide as scapus, as long as or shorter than diameter of eye, its apex with 3 horizontally arranged tubercles; fastigium of vertex touching fastigium of frons. Eyes small relative to size of head, weakly protruding. Head proportionately large to very large; face oval to nearly circular; frons flat, usually covered with large, irregular protuberances; genal carinae usually extremely well developed, consisting of semicircle of more or less conspicuous tubercles. Mandibles and clypeus symmetrical.

Thorax and wings. — Dorsal surface of pronotum smooth, flat; anterior dorsal margin straight, posterior

one straight to weakly convex; lateral lobes with posterior angle broadly rounded; humeral sinus weakly indicated. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle unmodified. Prosternum unarmed; mesosternum with lateral lobes forming vertical or oblique, short and widely separated spines; metasternum short and wide, unarmed.

Wings in both sexes fully developed, surpassing hind knees by 1/4 to 1/2 of their length (Fig. 11A); tegmina relatively narrow to wide, sometimes nearly elliptical in outline. Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network of secondary veinlets; stridulatory file (vein AA₁) straight; mirror of right wing as long as wide or slightly longer than wide, with all margins weakly convex. Posterior margin of tegmen straight or convex; apex of tegmen narrowly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally. Fore and mid femora unarmed dorsally but armed ventrally on anterior margins; genicular lobes of fore femora unarmed, lobes of mid and hind femora armed with short spines, but often only inner genicular lobes armed. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with shallow apical emargination, supraanal plate small, triangular. Male cercus stout, bent inwards, with short, blunt, ventral, subapical spine; female cercus simple, weakly incurved. Subgenital plate of male with small, triangular apical emargination; styli sometimes reduced to hardy visible pegs; female subgenital plate with conspicuous, triangular apical emargination.

Male concealed genitalia without well developed titillators but with part of phallic membrane partially sclerotized and covered by chitinous callosities. Ovipositor straight, somewhat longer than hind femur; both dorsal and ventral margins of ovipositor smooth, parallel; apex of upper valvula pointed or narrowly rounded.

Coloration. — Coloration light green; face often with yellow, irregular markings; clypeus, labrum and mandibles as well as abdominal sterna contrastingly black in one species (*L. coronatum*).

Remarks. — The genus *Lirometopum* includes 2 described species: *L. coronatum*, distributed from Nicaragua,

TABLE 5. Key for identification of known species of *Lirometopum*

Species	Head	Clypeus	Fastigium	Abdominal sterna
<i>coronatum</i>	face round, flat	black	5 times as wide as scapus	black
<i>concolor</i>	face oval, slightly convex	green	3 times as wide as scapus	green

through Costa Rica and Panama to Colombia, and *L. concolor* Karny, known only from a single male collected in the "Upper Amazon."

***Lirometopum coronatum* Scudder, 1875**

Common name: Pitbull katydid

Figs. 11A-F, 38B, 42A, 54A-C, Map 4

1875 Scudder, Proc. Boston Soc. Nat. Hist. 17: 60; type locality: "Greytown, New Granada" (Nicaragua); type depository: Academy of Natural Sciences, Philadelphia – holotype female

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description.— General characteristics as described above. Stridulatory file of male 3.2 mm long, with 160 lamelliform teeth, maximum width of file 0.27 mm; teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end (Fig. 42A). Mirror of stridulatory apparatus somewhat longer than wide, with all margins convex. Face nearly circular, flat; genal carinae strongly tuberculate (Fig. 11B); fastigium of vertex about 5 times as wide as scapus, continuous with fastigium of frons; apex of fastigium of vertex distinctly trituberculate (Fig. 11C). Male cercus stout, bent inwards, with short, blunt, ventral, subapical spine (Figs. 11E-F). Ovipositor longer than hind femur (ratio ovipositor/hind femur 1.42-1.60), straight, upper and lower margins parallel (Fig. 11A).

Coloration.— Body light green; face with more or less conspicuous yellow, irregular patches, clypeus, labrum and mandibles black; abdominal sterna black in adults (green in nymphs).

Measurements (mm). — (males, n=2; females, n=3; min-max, avrg±SD) body with wings: males 45.8-47.3, 46.55±1.1, females 47.6-51.5, 49.5±1.9; pronotum: males 13.6-13.9, 13.75±0.2, females 12.8-13.6, 13.2±0.4; tegmen: males 33.4-33.6, 33.5±0.1, females 33-36.2, 34.3±1.7; hind femur: males 16.6-17.1, 16.85±0.4, females 16.9-19, 17.7±1.16; ovipositor: 26.6-27.4, 27±0.4.

Biology, bioacoustics and distribution.— *L. coronatum* is probably the most easily recognizable cone-head katydid of Costa Rica. Its large, flat face, with characteristic

coloration, combined with the relatively large body size and strikingly black abdominal sterna makes the identification very easy. The only species with which it can be confused is *Erioloides macrocephalus*, but the latter has decidedly longer tegmina, different face markings, and unmistakable ovipositor. *L. coronatum* can be very common locally, but is rarely seen due to its nocturnal, secretive habits. This species has been recorded from Nicaragua, throughout Costa Rica and Panama to Colombia. In Costa Rica it seems to be absent only in the Pacific portion of the country (Map 4).

Both nymphs and adults feed on a variety of plant and animal material but do not seem capable of catching fast moving prey. I have seen adults of *L. coronatum* feeding at night on seeds of tall grasses as well as fruits and seeds of a variety of shrubs and trees. In captivity they readily accepted corn and sunflower seeds, fruits, vegetables and dead insects.

The preferred habitat of this species seems to be the primary lowland wet forest, where it can be found on understory vegetation as well as high in the canopy level. At La Selva Biological Station, *L. coronatum* can be seen and heard from tall stands of *Heliconia* at the edge of the forest as well as on low, shrubby vegetation on young succession plots within the primary forest.

Males start calling as soon as it gets dark and continue until after midnight. They call from medium thick branches or stems, located at the height of at least 3 m. The call of *L. coronatum* is readily perceivable by human listeners and consists of short, 5-15 second bouts of chirps, with each bout having 5-10 individual chirps (5 males were recorded) (Fig. 54A). Each chirp, lasting 95.7-121.1 ms (n=10 at 25°C), consist of 5-9 individual syllables (Fig. 54B). Each syllable, lasting 6.7-14.1 ms, displays a shift in the dominant frequency, beginning at about 15-16 kHz and ending at 8-9 kHz (keeping in mind the limitations of the recording technique, it is possible that a similar frequency shift occurs also in higher, not recorded harmonics of the call). The call is low duty, with bouts separated by several seconds to several minutes long periods of silence or substrate tremulation. The substrate transmitted signal consists of two parts. The body shaking, produced at frequency of only 4 Hz, lasts 1.8 seconds, and is followed by a brief, more rapid sequence of tapping of hind feet against the substratum. The tapping sequence lasts about 500 ms and is produced at the fre-

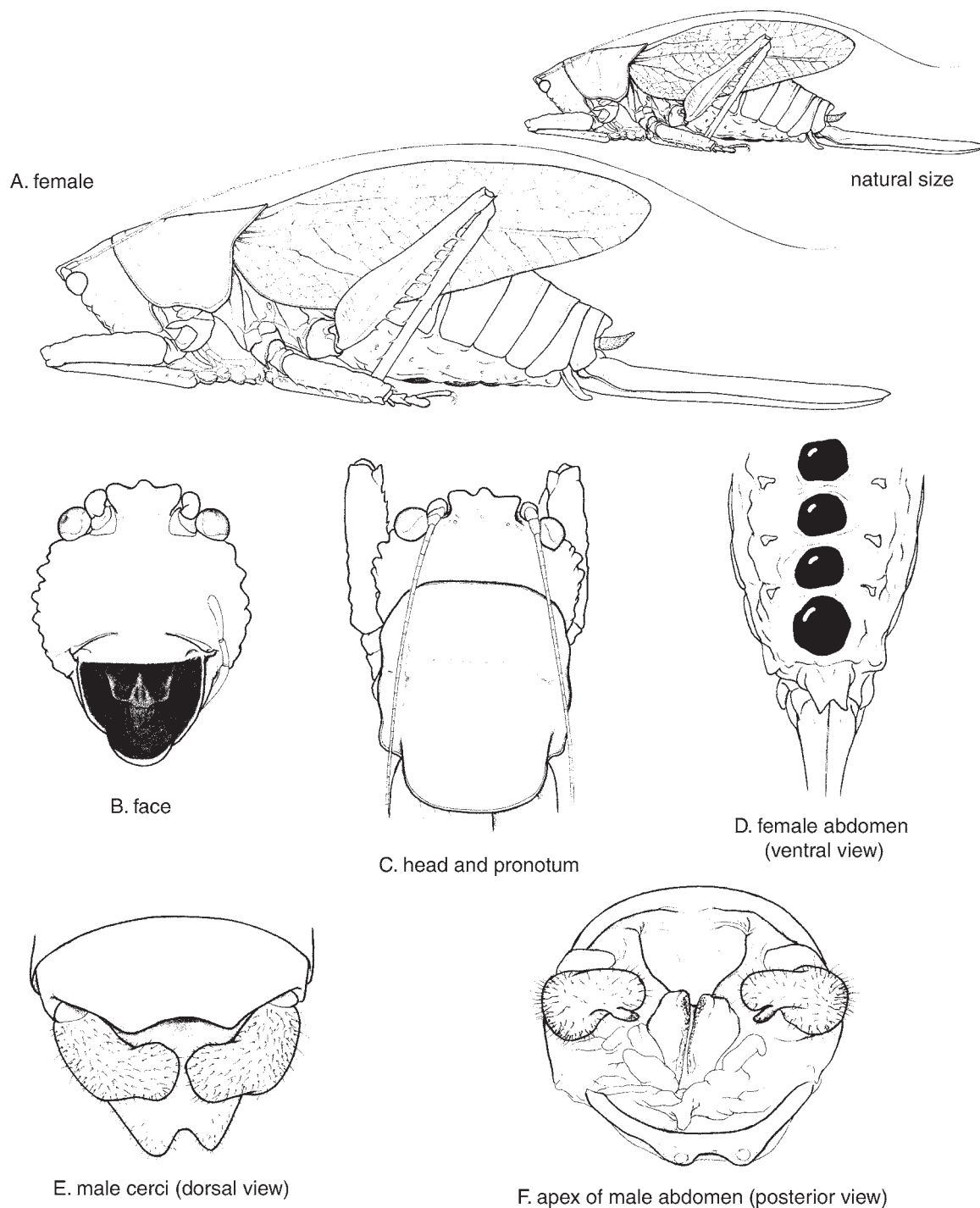


FIG. 11. *Lirometopum coronatum*. **A.** female - habitus, **B.** female face, **C.** female head and pronotum, dorsal view, **D.** female abdomen and subgenital plate, ventral view, **E.** male cerci, dorsal view, **F.** apex of male abdomen, posterior view.

quency of about 10 Hz, with the intensity of tapping gradually decreasing (Fig. 54C). The frequency of tremulation bouts increases in the presence of the female but females do not respond with tremulations as females of several species of *Copiphora* do.

The length of copulation has not been recorded. It ends in the male producing a spermatophore with a large, bulbous spermatophylax, which is subsequently eaten by the female. Eggs are deposited in soil, with the number of eggs laid by individual females varying between 9-317 (Saul-Gershenz 1993). Eggs are yellowish-white, slender, about 8.8 mm long (Fig. 38B). In captivity, nymphs hatched within 9-122 days after the deposition of eggs. Before the final molt, nymphs underwent 4 molts, and the entire life cycle of individual insects, from hatching until death, spanned 164-529 days (Saul-Gershenz 1993).

Material examined. — **COSTA RICA:** F. Waldeck b. Matina, 11 - 13 May 1930 (coll. Reimoser) - 3 males (NHMW); La Florida, (coll. Lankester) - 1 female (ANSP); La Lola, 21 April 1957 (coll. M.J. Stelzer) - 1 male (USNM); Tucunrique, (coll. Schild and Burgdorf) - 2 males (Philadelphia and USNM); **Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 24 April 1993 (coll. K. Flores) - 1 female (INBio); Estac. Laguna Pocosol, Res. Biol. Monteverde, elev. 850 m, 1 - 31 July 1991 (coll. E. Bello) - 1 female (INBio); Puesto Playuelas, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 2 August 1993 (coll. K. Martínez) - 1 female (INBio); San Cristobal, elev. 600 - 620 m, 16 June - 1 July 1997 (coll. F.A. Quesada) - 1 male (INBio); **Cartago Prov.**, 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 29 - 30 September 1961 (coll. Hubbell, Cantrall, Cohn) - 9 males, 2 females (UMMZ); same locality, 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 female (UMMZ); next big town seaward from Turrialba, 15 February 1976 (coll. E. Suriano) - 1 male (ANSP); Turrialba, (coll. Schild and Burgdorf) - 1 female (ANSP); **Guanacaste Prov.**, Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 1 - 31 May 1995 (coll. C. Moraga) - 1 female (INBio); Estac. Pitilla, 9 km S Sta. Cecilia, elev. 700 m, 15 May 1992 (coll. F. Araya) - 1 male (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 October 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 March 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 December 1992 (coll. P. Ríos) - 1 female (INBio); same locality, 15 October 1994 (coll. C. Moraga) - 2 females (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 February 1990 (coll. P. Rios, C. Moraga and R. Blanco) - 1 nymph (INBio); **Heredia Prov.**, Braulio Carillo N. P., Estac. El Ceibo, elev.

400 - 600 m, 15 November 1989 (coll. R. Aguilar and M. Zumbado) - 1 female (INBio); same locality, elev. 400 - 600 m, 15 April 1990 (coll. C. Chaves) - 1 male (INBio); Estac. Magsasay, P.N. Braulio Carillo, elev. 200 m, 15 June 1990 (coll. E. Alcazar) - 1 female (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 - 4 April 1994 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); same locality, 15 April 1996 (coll. D. Wagner) - 1 female (PN collection); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); **Limón Prov.**, 7 km W Guápiles at Río Toro Amarillo, 19 August 1964 (coll. S.P. Hubbell) - 1 female (UMMZ); Cuatro Esquinas, Tortuguero N. P., 15 October 1989 (coll. J. Solano) - 1 female (INBio); same locality, elev. 100 m, 15 January 1990 (coll. J. Solano) - 1 female (INBio); Estac. Cuatro Esquinas, Tortuguero N. P., 29 April 1992 (coll. D. García) - 1 female (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 100 m, 15 September 1991 (coll. G. Carballo) - 1 male, 2 nymphs (INBio); same locality, elev. 100 m, 20 December 1991 (coll. G. Carballo) - 1 female (INBio); same locality, elev. 100 m, 13 April 1992 (coll. G. Carballo) - 1 nymph (INBio); same locality, elev. 100 m, 20 June 1992 (coll. F.A. Quesada) - 1 female (INBio); same locality, elev. 100 m, 15 July 1992 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 100 m, 15 September 1992 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 100 m, 15 October 1992 (coll. G. Carballo) - 1 female (INBio); Río Sardinas, R.N.F.S. Barra del Colorado, elev. 50 m, 15 June 1994 (coll. F. Araya) - 1 female (INBio); **NICARAGUA:** Grey Town, New Grenada - 1 female (holotype) (ANSP).

NEOCONOCEPHALUS Karny, 1907

1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 22; type species: *Conocephalus subulatus* Bolivar, 1881 (type lost).

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>catalog of species

Diagnosis

Body slender; both sexes macropterous (Figs. 12A, 37E); tegumen smooth to moderately rugose. Fastigium of vertex broader than scapus, usually short and blunt; no traces of genal carinae present; frons flat or weakly convex; eyes small. All legs slender, armed on lower margins with minute spines. Male cercus armed apically with 2 incurved spines; ovipositor straight, with upper and lower margins parallel.

Description (male except where specified)

Head. — Fastigium of vertex 2 to 3 times as wide as scapus, blunt and 1.1 to 1.3 times as long as diameter of eye (Costa Rican species only; fastigium of vertex greatly enlarged in some North and South American species); fastigium of vertex separated from fastigium of frons by small gap, rarely fastigia touching (Figs. 13A-H). Eyes small relative to size of head, weakly protruding. Frons flat or weakly convex, smooth; tegumen of head smooth to weakly rugose, without traces of genal carinae; face slender. Mandibles and labrum weakly asymmetrical (right mandible smaller).

Thorax and wings. — Dorsal surface of pronotum smooth to weakly rugose, flat; anterior dorsal margin straight, posterior one convex; lateral lobes with posterior angle broadly rounded (Fig. 12D); humeral sinus well developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, widely separated spines (modified basisternum); meso- and metasternum with lateral lobes of basisterna triangular, their inner margins touching.

Wings in both sexes fully developed, extending well beyond apices of hind femora; tegmina slender. Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network of secondary veinlets; stridulatory file (vein AA₁) straight to weakly curved (Figs. 44A-H), in most species stridulatory teeth strongly narrowed towards proximal (inner) end of file, and wider and thicker towards distal (outer) end of file; mirror of right wing longer than high, with weak veinlet closely parallel to or divergent from AA₁ (Figs. 45A-D); caudal margin of mirror straight or rounded. Posterior margin of tegmen weakly concave; apex of tegmen narrowly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally. Fore and mid femora unarmed dorsally, but armed ventrally on anterior margins (sometimes both ventral margins of fore femur unarmed); genicular lobes of femora unarmed or armed with short spines; often only inner genicular lobes armed. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with shallow apical emar-

gination, supraanal plate small, triangular. Male cercus with 2 apical spines, both bent inwards under right angle; upper spine 1/3 to 1/2 as long as lower spine; both spines with apices curved downwards when seen from behind (Fig. 12E); female cercus, simple, slender and weakly incurved. Subgenital plate of male with a pair of styli, distinct median keel, and shallow, triangular apical emargination; female subgenital plate with shallow apical emargination.

Male concealed genitalia without well developed titillators but with part of phallic membrane partially sclerotized and covered by chitinous callosities. Ovipositor narrow, straight or weakly curved down; as long as or longer than hind femur; both dorsal and ventral margins of ovipositor smooth, parallel; apex of upper valvula sharp, slightly thickened.

Coloration. — Coloration in species of *Neoconocephalus* is extremely variable and, with the exception of the color markings on the fastigium of vertex, unreliable as a taxonomic character. Nearly all, or possibly all species have two, green and brown, color forms, both with numerous variations of shade and darkness. In several species mandibles are orange and some femoral spines are accompanied by black basal spots. Brown forms of several species have tegmina mottled with dark dots, and often veins R and M of tegmina are darker than the remainder of the wing (Fig. 37E). The resulting dark stripe is continuous with darker lateral lobes of the pronotum.

Remarks. — The genus *Neoconocephalus* belongs to some of the most problematic, from the taxonomic point of view, genera of Tettigoniidae. It currently includes over 100 named species, descriptions of most of which were based on single or very few specimens, often only females. The nearly complete uniformity of genitalic characters in the species of the genus, combined with the great intraspecific variation of coloration, and the recently recognized occurrence of cryptic and acoustically isolated sympatric species (Walker, Whitesell and Alexander 1973), makes identification of the forms described by older authors very difficult or downright impossible. Walker and Greenfield (1983) discussed problems with the identification of Caribbean species of *Neoconocephalus*, and concluded that of 36 names available to them, only 8 could be considered valid, with the rest being either junior synonyms or *nomina dubia*. In light of the above, most of the older literature records of *Neoconocephalus* should be treated with great caution as they may represent cases of misidentification.

The only non-molecular characters considered reliable for identification of species of *Neoconocephalus* are those of the sound produced by males, and associated morphological features of the stridulatory apparatus, such

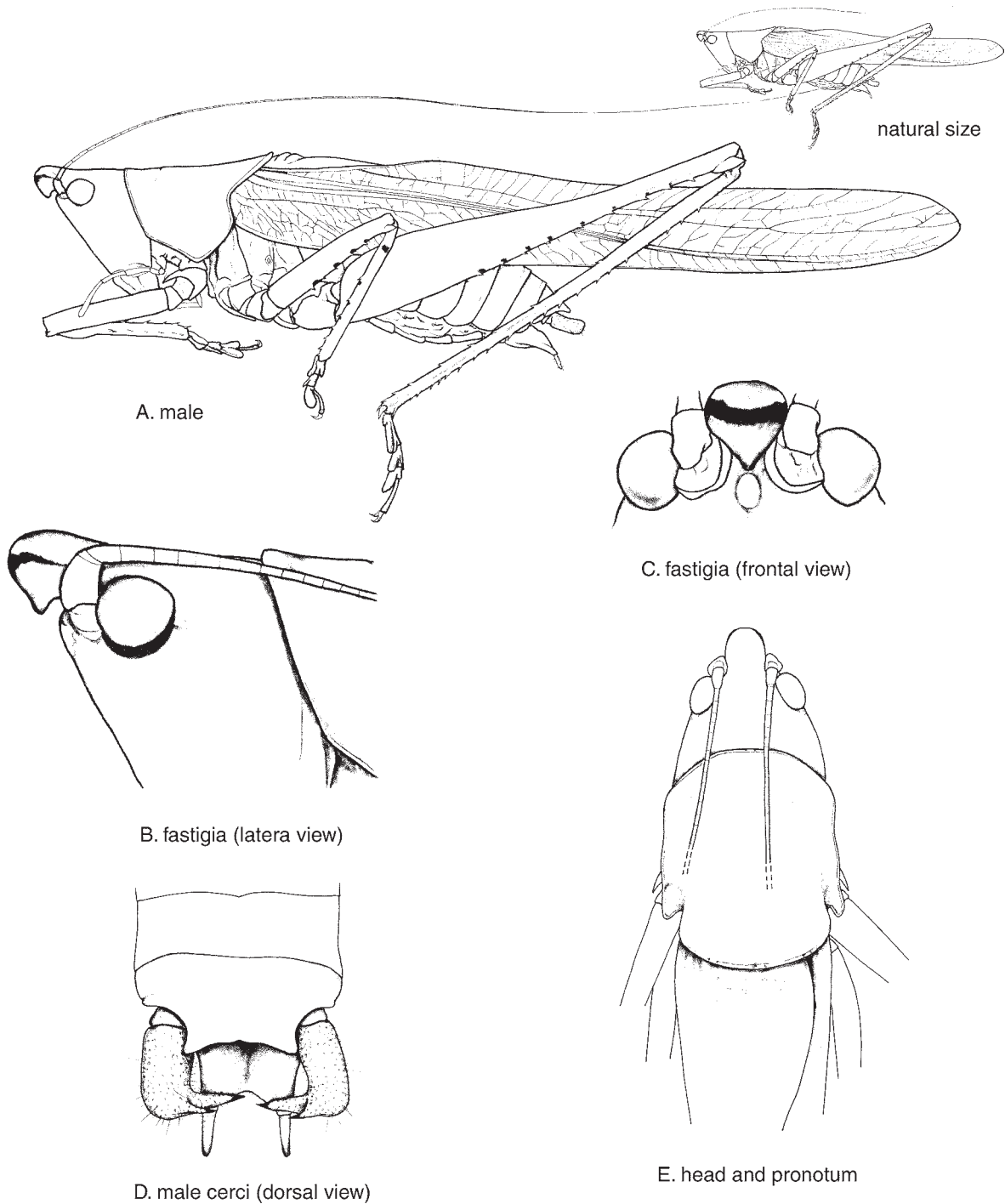


FIG. 12. *Neoconocephalus affinis*. **A.** male - habitus, **B.** head fastigia, lateral view, **C.** head fastigia, frontal view, **D.** male cerci, dorsal view, **E.** male head and pronotum, dorsal view.

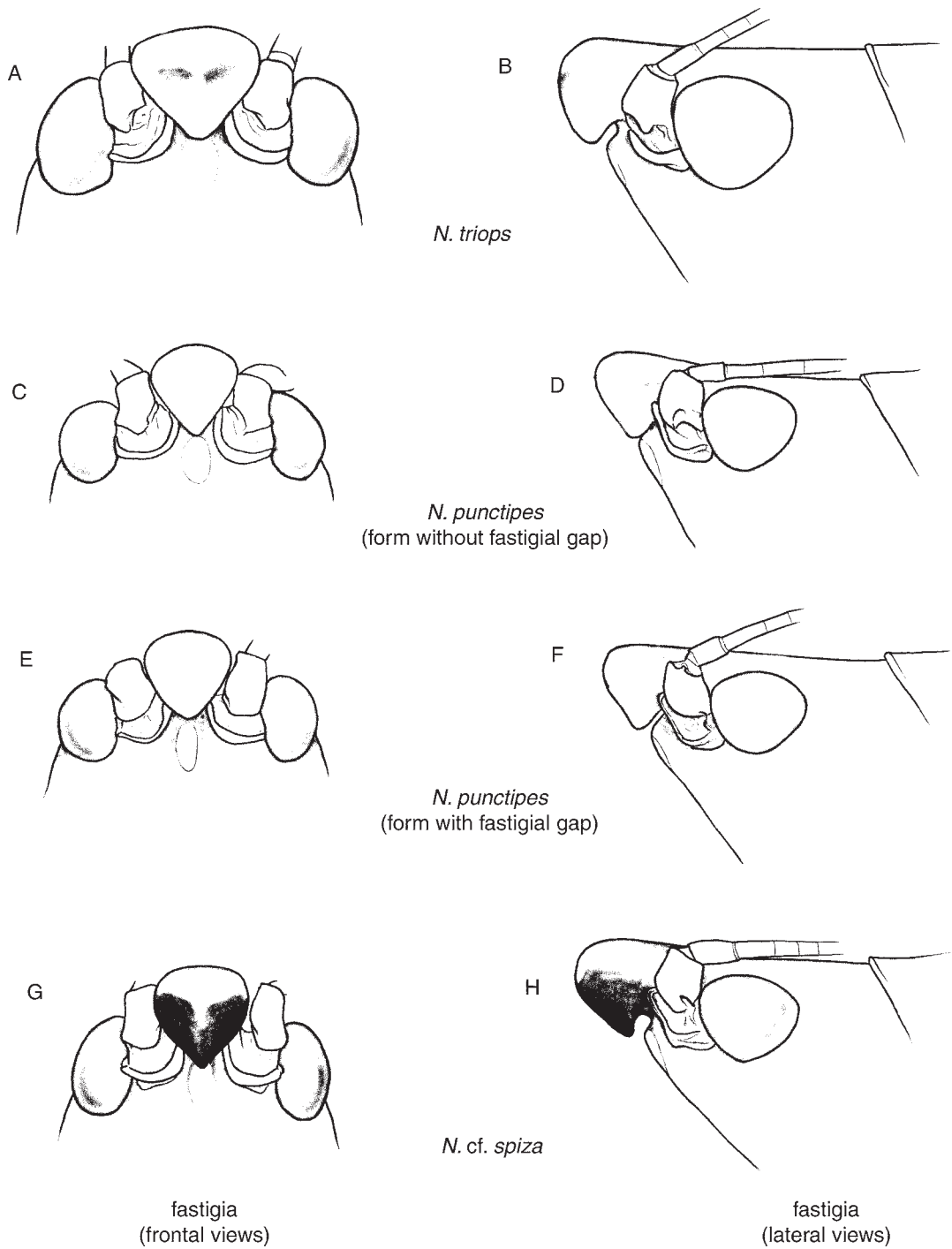


FIG. 13. Frontal and lateral view of fastigia of Costa Rican *Neoconocephalus* spp. A-B. *N. triops*, C-D. *N. punctipes* - form without a fastigial gap, E-F. *N. punctipes* - form with a fastigial gap, G-H. *N. cf. spiza*.

TABLE 6. Key for identification of Costa Rican species of *Neoconocephalus*

Species	Song	Mirror	Stridulatory file	Fastigium
<i>affinis</i>	continuous rattle (Figs. 53A-B)	distal margin straight, caudal and proximal margins rounded (Fig. 44A)	2.8-3.5 mm 129-151 teeth (Fig. 43A)	separated from fastigium of frons (Fig. 11C)
<i>triops</i>	interrupted coarse buzz (Figs. 54A-B)	oval (Fig. 44B)	1.8-2.4 mm 65-86 teeth (Fig. 43D)	separated from fastigium of frons (Fig. 12B)
<i>punctipes</i>	continuous buzz (Figs. 53C-D)	rectangular (Fig. 44C)	1.2-1.7 mm 56-84 teeth (Fig. 43E)	touching fastigium of frons (Fig. 12D) or separated by gap (Fig. 12F)
<i>spiza</i>	discontinuous chirps (Figs. 53E-F)	oval (Fig. 44D)	1.9-2.3 mm 78-96 teeth (Fig. 43H)	separated from fastigium of frons (Fig. 12H)

as the shape and length of the stridulatory file, the number and shape of stridulatory teeth, and features of the mirror. Less reliable, albeit considerably easier to examine, are the shape and color markings of the fastigium of vertex. The latter also allow one to identify females, which otherwise could only be identified by association with male individuals. This character, however, is also subject to a substantial degree of intraspecific variation and should not be used as the only and decisive character while identifying specimens of *Neoconocephalus*.

Distribution and biology.—The geographic distribution of species of *Neoconocephalus* covers temperate and tropical zones of the New World, from south-eastern Canada through Central America to Chile and Argentina. The closest relative of the genus *Neoconocephalus*, genus *Ruspolia* Schulthess is widely distributed in temperate and tropical areas of the entire Old World. As pointed out by Bailey (1975, 1979) and Walker and Greenfield (1983), these genera can only be separated based on their geographic distribution since neither displays consistent morphological characteristic warranting separate generic status. A similar problem applies to the chiefly Indo-Australasian genus *Euconocephalus* Karny, species of which, based on morphological criteria, could be assigned equally well to either *Neoconocephalus* or *Ruspolia*. Once undertaken, a critical phylogenetic revision of the three genera will probably reveal that they form a monophyletic unit, with species from all three genera occurring together on different branches of the clade.

In Costa Rica, species of the genus *Neoconocephalus* are

distributed over the entire country, at elevations ranging from sea level to 1700 m. It is quite possible that they will also be found at higher elevations in the Talamanca Range once a more extensive collecting effort is undertaken. The preferred habitats for most species of the genus are open or semi-open grasslands, pastures, clearings, and grassy hill slopes. At least one species, *N. affinis*, also occurs along paths in both primary and secondary forest. In the lowland Atlantic rainforest at La Selva Biological Station, it is not uncommon to find males of this species singing along with males of *Copiphora rhinoceros* from the same bush at the edge of the primary forest. The same species can also be found in open clearings and pastures with other species of *Neoconocephalus* and *Conocephalus*, as well as in swamps within the forest, alongside *Caulopsis microprora*.

There is no apparent seasonality in the development of Costa Rican species of *Neoconocephalus*, and both adults and nymph can be observed all year round. Greenfield (1990) reports that Panamanian populations of *N. triops*, a species that also occurs in the United States where it produces two generations per year and undergoes a diapause, show no signs of diapause. This is indicated by the presence in those populations of only one type of song, the “summer song,” while winter and summer generations (the winter generation undergoes a diapause) of the northern populations produce two distinctive types of song.

Little is known about the diet of Costa Rican species of *Neoconocephalus*, but it seems that most or all species feed

on a variety of grass species, eating both the leaves and seeds. In captivity they also accept fruits and dead insects.

Males of Costa Rican species start singing at dusk and continue through the night. *N. affinis* and *N. punctipes* may also sing during the day but usually only from shaded locations such as edges of trails within a forest. Males of *N. spiza* will switch from nocturnal to diurnal singing in places with high densities of congeneric species. In this species females stop responding phonotactically to the male's call if calls of other species of the genus interfere with it (Greenfield 1997). Singing males may either sit close to the ground, in tufts of grass, or, especially within the forest, on branches of low shrubs. In areas where grass is exceptionally tall, males sing more often from the tops of the grass rather than from their bases. The call of most species is a high duty, low Q call, with the principal frequencies between 9 and 16 kHz. The call usually consists of long (up to several minutes) bouts of continuous rattling or buzz, which from a close distance can have an ear-piercing effect on human listeners. Less frequently the song consists of series of short, buzzy chirps (*N. spiza*). In several species males form choruses and synchronize their songs (for an excellent review of this behavior see Greenfield 1990).

Copulation in some *Neoconocephalus* spp. is sometimes accompanied by bouts of substrate vibration (Gwynne 1977), although I have not seen this behavior in Costa Rican species. The spermatophore passed onto the female by the male during copulation is small and lacks a visible spermatophylax. Oviposition takes place in stems of grasses.

Neoconocephalus affinis (Palisot de Beauvois, 1805)
Figs. 12A-E, 44A-B, 45A, 56A-B, Map 7

- 1805 Palisot de Beauvois, Ins. rec. Afr. Amer., Orthopt.: 219, pl. 7, fig. 5 >>*Locusta*; type locality: Hispaniola, San Domingo; type lost?
1906 Kirby, Syn. Cat. Orth. 2: 251 >>*Conocephaloides*; syn. of *maxillosus*
1912 Karny, in Wytzman, Gen. Ins. 139: 60 >>*Neoconocephalus*; as syn. of *maxillosus*
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>illustrated
[syn.] *aztecus* = 1898 Saussure and Pictet, Biol. Centr. Amer. Orth. 1: 389, 391; Type locality: CA / Mexico: Tabasco, Teapa >>*Conocephalus*
1906 Kirby, Syn. Cat. Orth. 2: 243 >>*Conocephaloides*
1912 Karny, in Wytzman, Gen. Ins. 139: 31 >>*Neoconocephalus*
1983 Walker and Greenfield, Trans. Amer. Ent. Soc. 109:

- 365 >>Syn. of *Neoconocephalus affinis* (Beauvois 1805); from *Conocephalus*
[syn.] *crassus* = 1881 Bolivar, An. Soc. Espan. x: 49; type locality: Ecuador: Baeza >>*Conocephaloides*
1906 Kirby, Syn. Cat. Orth. 2: 242 >>*Conocephaloides*
1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 31 >>*Conocephalus* (*Neoconocephalus*)
1912 Karny, in Wytzman, Gen. Ins. 139: 30 >>*Neoconocephalus*
1924 Hebard, Proc. Acad. Nat. Sci. Philad. 76: 223
1926 Hebard, Trans. Amer. Ent. Soc. 52: 338 >>Syn. of *affinis*
[syn.] *guttatus* = 1839 Serville, Hist. nat. Ins., Orthopt.: 518; type locality: Cuba >>*Conocephalus*
1906 Kirby, Syn. Cat. Orth. 2: 242 >>*Conocephaloides*
1912 Karny, in Wytzman, Gen. Ins. 139: 30 >>*Neoconocephalus*
1914 Caudell, Proc. U.S. Nat. Mus. 47: 493 >>Attributes authorship to Walker; in Dominica
1926 Hebard, Trans. Amer. Ent. Soc. 52: 337 >>Syn. of *affinis*
[syn.] *nigropunctatus* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 380, 391; type locality: Guiana; Surinam etc. >>*Conocephalus*
1906 Kirby, Syn. Cat. Orth. 2: 242 >>*Conocephaloides*
1912 Karny, in Wytzman, Gen. Ins. 139: 30 >>*Neoconocephalus*
1924 Hebard, Proc. Acad. Nat. Sci. Philad. 76: 223 >>Syn. of *affinis*

Diagnostic description. — General characteristics as described above. Stridulatory file of male 2.8-3.5 mm long, with 129-151 lamelliform teeth, maximum width of file 0.21-0.22 mm; teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end (Figs. 44A-B). Mirror of stridulatory apparatus with distal margin straight, and caudal and proximal margins rounded (Fig. 45A). Fastigium of vertex separated from fastigium of frons by gap, usually with rounded but narrow and prominent tooth underneath (Fig. 12C); frontal portion of fastigium with narrow, contrasting white band, accompanied by black band below; sometimes entire ventral portion of fastigium black (Fig. 12B).

Mid femur with 3-4 small spines on anterior ventral margin, often accompanied by small, black spots at their bases. Hind tibia in green individuals usually contrastingly dark brown. Mandibles and labrum orange, clypeus green or yellowish, rest of face uniformly green or brown, depending on general coloration.

Ovipositor as long as hind femur (ratio ovipositor/hind femur 0.92-1.06), straight.

Measurements. — Table 7.

TABLE 7. Body measurements of species of *Neoconocephalus* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>affinis</i>					
male	42.6-62, 50.3±8	33.4-50.4, 40.2±6.9	7.2-9, 8±0.8	18.8-28.9, 23.5±3.8	na
female	54.8-67.1, 62.1±5.1	46.0-55.5, 51.4±4	7.5-8.6, 8.2±0.4	25.4-31.5, 29.0±2.4	26.9-31.5, 29±1.7
<i>triops</i>					
male	50.6-57.9, 54.4±2.7	41.7-48.1, 44.4±2.3	7.9-9.4, 8.7±0.5	23.1-25.8, 24.8±1.2	na
female	65.5-62.2, 65.9±0.5	54-54.3, 54.2±0.2	9.1-9.6, 9.4±0.4	29-29.2, 29.1±0.1	31.3-32.8, 32.1±1.1
<i>punctipes</i>					
male	42.5-48.5, 45.9±2.2	33.9-46.3, 37.6±3.8	6.9-8.1, 7.4±0.4	19.1-22, 20.5±1.1	na
female	49.3-63, 55.9±5.6	40-52.1, 45.5±5.2	7-8.8, 7.8±0.7	20.4-28, 24.1±3.1	22.1-28, 25±2.3
<i>spiza</i>					
male	48.2-52.1, 50.5±1.6	39.8-42.1, 40.6±1	8-8.4, 8.2±0.2	22.4-24.5, 23.4±0.8	na
female	63.4-67.3, 64.8±2.1	50.6-54, 51.9±1.9	8.1-9, 8.6±0.5	27.1-29.5, 27.9±1.4	30.6-34.2, 32.6±1.8

Bioacoustics. — The call of *N. affinis* constitutes lengthy (30 s to 20 minutes) bouts of continuous rattling (Figs. 56A-B). Walker and Greenfield (1983) calculated the wingstroke rate of singing males from Panamanian populations at 13.6±0.4 wingstrokes/s at 25°C. The length of individual chirps at the beginning of a bout (the first second of the call) is much shorter than during the remainder of the call: 14.6-27.8 ms (21.9±3.1) versus 32.6-46.8 ms (39.9±6.2) (n=30; specimens from La Selva, Costa Rica). Males form loosely synchronized choruses (Greenfield 1983). Most of the calling activity occurs 1-4 hours after sunset but individual males may sing during the day, especially in shaded habitats (e.g. part of Sendero Tres Rios at La Selva Biological Station). The bouts of males singing during the day are short, not exceeding 5-10 seconds.

Maximum energy of the call is located between 10 and 14 kHz. The call is loud and has an ear piercing quality, especially when listened to from a distance of 1 m or less. Greenfield (1983) measured its intensity at 98 dB at 10 cm from the singing insect.

Distribution. — This species has a wide distribution, from Nicaragua through Costa Rica and Panama to Venezuela, Colombia, Ecuador, Peru, and Brazil. It has also been recorded from Caribbean islands of Puerto Rico, Jamaica, Cuba, Hispaniola, Nevis, Grenada, and Trinidad, as well as Florida Keys. In Costa Rica it is the most common species of *Neoconocephalus* (and probably

the most common species of Tettigoniidae altogether), found in a variety of open, semi-open or even forest habitats all over the country (Map 7).

Material examined. — **COSTA RICA: Alajuela Prov.**, Estac. San Ramón Oeste, elev. 620 m, 19 April 1994 (coll. F. Quesada) - 1 male (INBio); Puesto Quebradón, elev. 300 m, 1 - 30 April 1997 (coll. G. Rodríguez) - 1 female (INBio); same locality, elev. 300 m, 1 - 31 August 1997 (coll. G. Rodríguez) - 1 female (INBio); Sect. San Ramón de Dos Rios, elev. 620 m, 18 March - 13 April 1995 (coll. F.A. Quesada) - 1 male (INBio); Sector Colonia Palmareña, 9 km SO de Bajo Rodríguez, elev. 700 m, 1 - 31 May 1997 (coll. G. Carballo) - 1 male (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 2 males, 3 females (PN collection); **Cartago Prov.**, 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 29 - 30 September 1961 (coll. Hubbell, Cantrall, Cohn) - 2 males (UMMZ); same locality, 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 male (UMMZ); Grano de Oro, Chirripó, Turrialba, elev. 1120 m, 15 October 1992 (coll. J.C. Saborio) - 1 female (INBio); Grano de Oro, Chirripó, Turrialba, A.C. Amistad, elev. 1120 m, 30 June 1993 (coll. P. Campos) - 1 female (INBio); Turrialba, 6 June 1951 (coll. O.L. Cartwright) - 1 male (USNM); same locality, 17 March 1965 (coll. S.S. and W.D. Duckworth) - 2 females (USNM); same locality, 19 July 1965 (coll. P.J. Spangler) - 1 male (USNM); **Guanacaste Prov.**, 2.7 mi. NE La Cruz on Pa. Amer. Hwy., 27 September 1961 (coll.

Hubbell, Cantrall, Cohn) - 1 male (UMMZ); 9 mi N Cañas on Río Tenorio, Finca La Pacifica, elev. 40 m, 3 - 10 February 1969 (coll. D.C. Rentz) - 1 female (ANIC); La Pacifica, 4 km NW Cañas, 2 March 1971 (coll. P.A. Opler) - 1 male (EMEC); **Heredia Prov.**, Braulio Carillo N. P., Estac. El Ceibo, elev. 400 - 600 m, 15 March 1990 (coll. C. Chaves) - 1 female (INBio); Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 4 - 31 January 1993 (coll. M. Ortiz) - 3 males, 1 female (INBio); Puerto Viejo, 6 April 1969 (coll. D.C.F. Rentz) - 1 male (ANIC); Puerto Viejo, Finca La Selva, 16 July 1973 (coll. D.C. Rentz and K.R. Brodey) - 4 males (ANIC); Puerto Viejo, Finca La Selva, on Río Puerto Viejo, 3 April 1969 (coll. D.C. Rentz) - 1 male (ANIC); same locality, 16 January 1975 (coll. D.C. Rentz) - 6 males (ANIC); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 17 - 22 February 1994 (coll. P. Naskrecki) - 1 female (, PN collection); same locality, 1 - 4 April 1994 (coll. P. Naskrecki) - 6 males, 7 females (PN collection); same locality, 30 November 1995 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); Sarapiquí, Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 8 March 1967 (coll. H.R. and E.H. Roberts et al.) - 6 males, 3 females (ANSP); **Limón Prov.**, Guápiles, 26 February 1903 - 1 male (UNSM); Amubri, Talamanca, elev. 70 m, 16 - 31 August 1992 (coll. G. Gallardo) - 1 female (INBio); same locality, elev. 70 m, 26 January 1993 (coll. G. Gallardo) - 1 male (INBio); same locality, elev. 70 m, 31 October 1993 (coll. G. Gallardo) - 1 female (INBio); Estac. Cuatro Esquinas, Tortuguero N. P., 15 June 1990 (coll. J. Solano) - 1 male, 1 female (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 200 m, 15 November 1990 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 100 m, 15 June 1991 (coll. A. Moreno) - 1 female (INBio); same locality, elev. 100 m, 20 December 1991 (coll. G. Carballo) - 1 female (INBio); same locality, elev. 100 m, 26 January 1992 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 100 m, 15 December 1992 (coll. G. Carballo) - 1 male (INBio); same locality, elev. 200 m, 16 September 1993 (coll. G. Carballo) - 1 female (INBio); same locality, elev. 200 m, 15 November 1993 (coll. G. Carballo) - 1 male (INBio); Manzanillo, RNFS Gandoca y Manzanillo, elev. 0 - 100 m, 27 January 1993 (coll. F.A. Quesada) - 1 female (INBio); R.B. Hitoy Cerere, Valle La Estrella, elev. 100 m, 27 February 1993 (coll. G. Carballo) - 1 female (INBio); Río Sardinas, R.N.F.S. Barra del Colorado, elev. 10 m, 25 August 1992 (coll. F. Araya) - 1 female (INBio); same locality, elev. 50 m, 24 April 1993 (coll. F. Araya) - 1 female (INBio); same locality, 12 November 1993 (coll. F. Araya) - 1 female (INBio); **Puntarenas Prov.**, 4 km NW of San Vito de Java (jct. of road and Río Java), elev. 914.4 m, 20

January 1967 (coll. I.J. Cantrall) - 1 male (UMMZ); Corcovado N. P., Península de Osa, 22 March 1979 (coll. D.H. Janzen) - 1 male (INBio); Estac. Aguias, Río Aguias, Sendero Purruja, elev. 300 m, 1 - 6 September 1997 (coll. A. Azofeifa) - 1 female (INBio); Estac. Aguias, Sendero Zamia, elev. 300 m, 11 - 27 July 1996 (coll. A. Azofeifa) - 1 female (INBio); Estac. Quebrada Bonita, Res. Biol. Carara, elev. 50 m, 15 February 1994 (coll. R. Guzmán) - 1 female (INBio); Estac. Quebrada Bonita, R.B. Carara, elev. 50 m, 15 February 1994 (coll. J. Saborio) - 1 female (INBio); Finca Las Cruces (OTS, 2 km S San Vito), elev. 1219.2 m, 15 March 1973 (coll. D.C. Rentz) - 1 male (ANIC); P. N. Manuel Antonio, Quepos, elev. 80 m, 15 July 1991 (coll. R. Zuniga) - 1 female (INBio); same locality, elev. 80 m, 15 October 1992 (coll. R. Zuniga) - 1 male (INBio); Península de Osa, 3.5 mi. S Rincón, 8° 42' N, 83° 29' W, 12 March 1969 (coll. D.C.F. Rentz) - 1 female (ANIC); Península de Osa, Corcovado N. P., elev. 10 - 100 m, 7 July 1977 (coll. D.H. Janzen) - 1 male, 1 female (INBio); same locality, elev. 10 - 100 m, 23 March 1978 (coll. D.H. Janzen) - 1 female (INBio); Península de Osa, Estac. Esquinas, elev. 200 m, 15 August 1993 (coll. M. Segura) - 1 male, 1 female (INBio); Peninsula de Osa, Rancho Quemado, elev. 200 m, 27 January 1992 (coll. A. Marín) - 1 male (INBio); same locality, elev. 200 m, 31 March 1992 (coll. A. Marín) - 1 male (INBio); same locality, elev. 200 m, 15 September 1992 (coll. A. Marín) - 1 male (INBio); same locality, elev. 200 m, 8 - 28 October 1993 (coll. A. Marín) - 1 male, 2 females (INBio); same locality, elev. 200 m, 20 December 1993 (coll. A. Marín) - 1 female (INBio); Rancho Quemado Península de Osa, elev. 200 m, 15 October 1990 (coll. F. Quesada) - 1 female (INBio); same locality, elev. 200 m, 15 December 1990 (coll. F. Quesada) - 1 female (INBio); Rancho Quemado, Península de Osa, elev. 200 m, 31 March 1993 (coll. A. Gutiérrez) - 1 female (INBio); Rincón de Osa, 7 March 1969 (coll. D.C. Rentz) - 1 male (ANIC); San Vito, 13 February 1970 (coll. M. Kosztarab) - 1 male (USNM); San Vito, 2 km S San Vito, Finca Las Cruces, elev. 1219.2 m, 8° 42' N, 83° 0' W, 14 March 1969 (coll. D.C. Rentz) - 1 female (ANIC); Sirena, Corcovado N.P., elev. 0 - 100 m, 10 - 25 August 1992 (coll. A. Gutiérrez) - 1 female (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); Vuelta Campana, R. Térraba, Rey Curré, elev. 100 - 500 m, 1 - 31 March 1993 (coll. S. Rojas) - 1 male (INBio).

- Neoconocephalus triops* (Linnaeus, 1758)
Figs. 13A-B, 37E, 44C-D, 45B, 57A-B, Map 7
- 1758 Linnaeus, Syst. Nat. (ed. x.) i: 430 >> *Gryllus* (*Tettigonia*); type locality: "Indiis" = ? West Indies; type depository: Collection of the Linnean Society, London, England
- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>illustrated, full references
[syn.] *bilineatus* = 1815 Thunberg, Mem. Acad. St. Petersb. 5: 275; type locality: Hispaniola, Santo Domingo, >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 246 >>*Conocephaloides*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 33 >>*Neoconocephalus*
- 1983 Walker and Greenfield, Trans. Amer. Ent. Soc. 109: 371 >>Syn. of *triops*
[syn.] *contingens* = 1869 Walker, Cat. Derm. Salt. Brit. Mus. 2: 304; type locality: Mexico >>*Conocephalus*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 31 >>*Neoconocephalus*; as syn. of *mexicanus*
[syn.] *dissimilis* = 1839 Serville, Hist. nat. Ins., Orthopt.: 518; type locality: North America, USA, South Carolina >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 246 >>Syn. of *triops*; *Conocephaloides*
[syn.] *exilis* = 1906 Kirby, Syn. Cat. Orth. 2: 246; type locality: Galápagos islands >>New name for *insularis* Scudder
- 1912 Karny, in Wytsman, Gen. Ins. 139: 32 >>*Conocephaloides*
- 1920 Hebard, Proc. Calif. Acad. Sci. (4) 2(2): 337 >>As *insularum*; syn. of *triops*
- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated
[syn.] *fuscostrigatus* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 380, 399; type locality: USA: southern states >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 244 >>*Conocephaloides*
- 1914 Rehn and Hebard, Trans. Amer. Ent. Soc. 40: 405 >>Syn. of *triops*; *Neoconocephalus*
[syn.] *hebes* = 1878 Scudder, Proc. Bost. Soc. Nat. Hist. 20: 90; type locality: Cuba >>*Conocephalus*
- 1888 Bolivar, Mem. Soc. Zool. France i: 150 >>*Conocephaloides*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 33 >>*Neoconocephalus*
- 1915 Rehn, J. A. G., Hebard, M., Trans. Amer. Entomol. Soc. 40: 405 >>syn. of *triops*
- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated
[syn.] *insularis* [Scudder] = 1893 Scudder, Bull. Mus. Harvard Coll. xxv.: 21; type locality: Galápagos: Chatham Is, Wreck Bay >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 246 >>Syn. of *exilis*; *Conocephaloides*
- 1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 38 >>Re-named *insularum*
- 1920 Hebard, Proc. Calif. Acad. Sci. (4) 2(2): 337 >>Syn. of *triops*
[syn.] *insularum* = 1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 38 >>New name for *insularis* Scudder
- 1920 Hebard, Proc. Calif. Acad. Sci. (4) 2(2): 337 >>As *insularum*; syn. of *triops*
[syn.] *macropterus* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 381, 402; type locality: Mexico; >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 245 >>*Conocephaloides*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 32 >>*Neoconocephalus*
- 1927 Hebard, Trans. Amer. Ent. Soc. 53: 371 >>Syn. of *triops*
[syn.] *mexicanus* = 1859 Saussure, Rev. et Mag. Zool. [2]11: 208; type locality: Mexico >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 243 >>*Conocephaloides*
- 1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 33 >>*Conocephalus* (*Neoconocephalus*)
- 1912 Karny, in Wytsman, Gen. Ins. 139: 31 >>*Neoconocephalus*
- 1937 Hebard, Unpubl. Syn. List >>Syn. of *triops*
[syn.] *nigrolimbatus* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 405, 406; type locality: Cuba >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 245 >>*Conocephaloides*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 32 >>*Neoconocephalus*
- 1927 Hebard, Trans. Amer. Ent. Soc. 53: 136 >>Syn. of *triops*
[syn.] *obscurellus* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 380, 397; type locality: Mexico: Cuernavaca >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 244 >>*Conocephaloides*
- 1912 Karny, in Wytsman, Gen. Ins. 139: 31 >>*Neoconocephalus*
- 1927 Hebard, Trans. Amer. Ent. Soc. 53: 136 >>Syn. of *triops*
[syn.] *obtusus* = 1838 Burmeister, Handb. Ent. 2: 705; Type locality: locality unknown >>*Conocephalus*
- 1906 Kirby, Syn. Cat. Orth. 2: 246 >>Syn. of *triops*; *Conocephaloides*
[syn.] *tibialis* = 1907 Karny, Abh. Zool.-bot. Ges. Wien 4: 33; type locality: USA: North Carolina >>*Neoconocephalus mexicanus* var. *tibialis*
- 1914 Rehn and Hebard, Trans. Amer. Ent. Soc. 40: 405 >>Syn. of *triops*

Diagnostic description. — General characteristics as described above. Stridulatory file of male 1.8-2.4 mm long, with 65-86 teeth, maximum width of file 0.27 mm (Figs. 44C-D); teeth thinner and spaced more densely in proximal third of file than thicker and less densely spaced teeth of distal end. Mirror of stridulatory apparatus oval (Fig. 45B). Fastigium of vertex separated from fastigium of frons by narrow gap, fastigium underneath blunt, without well developed tooth (Fig. 13B); frontal portion of fastigium with weakly defined white band, usually accompanied by thin, dark line below (Fig. 13A).

Mid femur with 2-3 small spines on anterior ventral margin, only rarely accompanied by black spots at their bases. Stridulatory area of left wing in most males with short, black longitudinal line parallel to veins M+CuA (Fig. 45A). Brown individuals often with dark speckles on tegmina (Fig. 36E).

Ovipositor approximately as long as hind femur (ratio ovipositor/hind femur 1.07-1.13), straight.

Measurements. — Table 7.

Bioacoustics. — The call of Panamanian populations of *N. triops* was described by Walker and Greenfield (1983) as a “coarse buzz momentarily interrupted at intervals of ca. 0.6 s” (Figs. 57A-B). The average calculated wingstroke rate of this species in Panama is 123±3 wingstrokes/s at 25°C. In populations from temperate areas, such as Gainesville, Florida, this species has two generations per year. Adults that mature in the fall (winter generation) undergo a reproductive diapause and start calling the following spring. Their song has a significantly lower wingstroke rate than that of the adults maturing without diapausing (summer generation). Populations in Central America display a call typical of the summer generation, which indicates a lack of the reproductive diapause (Greenfield 1990).

Distribution. — *Neoconocephalus triops* is the most widely distributed species of the genus, having been recorded from southeastern Ohio west to California in USA, through Central America to Peru and Guyana in South America, as well as throughout the Caribbean and Galápagos Island. In Costa Rica it has been collected all over the country (Map 7) although it does not seem to be as common as *N. affinis*.

Material examined. — **COSTA RICA:** no other locality data (coll. P. Biolley) - 1 male (ZMAN); 15 August 1935 - 1 female (USNM); Bataan (=Batan), 10° 5' N, 83° 20' W, 16 June 1951 (coll. O.L. Cartwright) - 1 female (USNM); C.M. Acc. 2745, (coll. P. Biolley) - 1 male (ANSP); **Alajuela**

Prov., Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 29 December 1994 - 24 January 1995 (coll. K. Flores) - 1 male (INBio); same locality, elev. 20 m, 3 - 23 April 1995 (coll. R. Villalobos) - 1 female (INBio); Finca San Gabriel, 2 km SW Dos Rios, elev. 600 m, 15 May 1989 (coll. GNP Biodiv. Survey) - 1 female (INBio); Playuelas, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 26 January 1992 (coll. K. Flores) - 1 female (INBio); Puesto Quebradón, elev. 300 m, 1 - 31 August 1997 (coll. G. Rodríguez) - 1 male (INBio); R.B. San Ramón, elev. 800 m, 1 - 31 March 1997 (coll. G. Carballo) - 1 female (INBio); same locality, elev. 800 m, 1 - 30 April 1997 (coll. K. Flores) - 1 male (INBio); Río San Lorencito, Res. For. Sn. Ramón, 5 km N Col. Palmarena, elev. 900 m, 15 March 1990 (coll. Curso Carabidae) - 1 female (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 2 males (PN collection); **Cartago Prov.,** 3 km SE Turrialba, CATIE, 13 May 1985 (coll. J. Powell, P. Opler and J.A. Chemsak) - 1 male (EMEC); Turrialba, 6 June 1951 (coll. O.L. Cartwright) - 1 male (USNM); same locality, 6 March 1965 (coll. S.S. and W.D. Duckworth) - 3 males, 3 females (USNM); **Guanacaste Prov.,** 5 mi N Cañas, PanAm Highway, 15 October 1969 (coll. E. Frankie) - 3 males (ANIC); 9 mi N Cañas on Río Tenorio, Finca La Pacifica, elev. 40 m, 3 - 10 February 1969 (coll. D.C. Rentz) - 2 males, 2 females (ANIC); Dos de Tilaran (San Ramón), elev. 1100 m, 1 - 31 May 1995 (coll. G. Rodríguez) - 2 females (INBio); Estac. Cacao, elev. 1100 m, 8 - 18 February 1995 (coll. M. Moraga) - 1 male, 1 female (INBio); Estac. Cacao, 2 km SW del Cerro Cacao, elev. 1100 - 1650 m, 7 - 18 February 1995 (coll. E. Nunez) - 3 males (INBio); same locality, elev. 1000 - 1400 m, 12 - 17 February 1995 (coll. S. Avila) - 1 female (INBio); Estac. Cacao, Lado suroeste del Volcán Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 15 June 1990 (coll. II curso Parataxon) - 2 females (INBio); Estac. Katalina, Parque Nacional Palo Verde, 13 April 1992 (coll. A. Gutiérrez) - 1 female (INBio); Estac. Maritza, lado O Vol. Orosí, elev. 600 m, 15 August 1990 (coll. II curso Parataxon) - 8 females (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 June 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, 15 July 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 September 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Estac. Cacao, SW side Volcán Cacao, elev. 1000 - 1400 m, 15 September 1989 (coll. R. Blanco and C. Chávez) - 1 male, 1 female (INBio); same locality, elev. 1000 - 1400 m, 1 December 1989 (coll. R. Blanco and C. Chávez) - 5 males, 10 females (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 March 1990 (coll. P. Rios, C. Moraga and R. Blanco) - 1 female (INBio); Estación Exper. Enrique

Jimenez Nuñez (20 km SW Cañas), 7 November 1991 (coll. A.S. Menke) - 3 males, 1 female (USNM); Finca Pasmompa Estación Pitilla, 5 km SW Santa Cecilia, elev. 400 m, 15 March 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); Finca Jenny, 31 km N Liberia, elev. 300 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, elev. 300 m, 15 October 1988 (coll. GNP Biodiversity Survey) - 2 males, 5 females (INBio); Hacienda "La Pacífica," 13 November 1965 (coll. T.H. Hubbell) - 1 male (UMMZ); Hda. Palo Verde on Río Tempisque, 17 January 1975 (coll. D.C. Rentz) - 2 males, 1 female (ANIC); Las Cañas, Río Corobicí, 26 July 1967 (coll. O.S. Flint, Jr.) - 3 males (USNM); Liberia, 27 August 1972 (coll. G.F. and S. Hevel) - 2 males, 4 females (USNM); Los Mesones, P.N. Barra Honda, elev. 100 m, 1 - 31 July 1995 (coll. M. Reves) - 1 male (INBio); Palo Verde N. P., Palo Verde Biological Station, 5 February 1994 (coll. P. Naskrecki) - 3 males, 1 female (PN collection); Río San Lorenzo, Tierras Morenas, Z.P. Tenorio, elev. 1050 m, 15 May 1991 (coll. C. Alvarado) - 1 male (INBio); Santa Rosa N. P., 12 August 1977 (coll. D.H. Janzen) - 1 male, 1 female (USNM); same locality, 10 January 1979 (coll. D.H. Janzen) - 1 female (USNM); same locality, 4 May 1980 (coll. D.H. Janzen and W. Hallwacha) - 1 male, 1 female (USNM); Santa Rosa N. P., Playa Naranjo, 15 September 1990 (coll. E. Alcazar) - 1 female (INBio); same locality, 15 October 1990 (coll. E. Alcazar) - 1 female (INBio); Sect. Palo Verde, elev. 10 m, 4 - 10 April 1995 (coll. E. Navarro) - 3 females (INBio); Taboga, 29 July 1967 (coll. Flint and Ortiz) - 1 male (USNM); Vicinity Estac. Murciélago, 8 km SW Cuajiniquíl, elev. 100 m, 15 June 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); **Heredia Prov.**, Est Magsasay, P. N. Braulio Carillo, elev. 200 m, 15 January 1991 (coll. M. Barellier) - 1 female (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 11 October 1995 (coll. P. Naskrecki) - 1 female (ALAS); **Limón Prov.**, Limón Plantation, Charges River G201, 24 August 1918 (coll. J. Zetek and H.F. Dietz) - 1 female (USNM); Pandora, 5 August 1961 (coll. C.F. Walker) - 1 male (UMMZ); **Puntarenas Prov.**, Albergue, Cerro de Oro, elev. 150 m, 29 September - 6 October 1995 (coll. E. Fletes) - 1 male (INBio); Buen Amigo, San Luís Monteverde, elev. 1000 - 1350 m, 1 - 31 March 1997 (coll. Z. Fuentes) - 2 males (INBio); Estac. Pittier, PILA-ACLA, elev. 1670 m, 23 January - 2 February 1995 (coll. A. Azofeifa) - 1 male (INBio); Estación Altamira, 1 km S del Cerro Biolley, elev. 1450 m, 2 - 29 June 1996 (coll. R. Vilalobos) - 1 female (INBio); Finca Las Cruces (OTS, 2 km S San Vito), elev. 1219.2 m, 15 March 1973 (coll. D.C. Rentz) - 1 female (ANIC); **Puntarenas Prov.**, Gulf of Nicoya, - 1 male (ANSP); Las Cruces, nr. San Vito, 20 March 1965 (coll. S.S. and W.D. Duckworth) - 2 females

(USNM); Monte Verde, Powell Property, elev. 1580 m, 23 March 1974 (coll. D.C. Rentz) - 1 male (ANIC); Mount Verde (Quaker Colony), elev. 1500 m, 22 March 1973 (coll. D.C. Rentz) - 1 male (ANIC); nr. San Vito de Java, 24 February 1970 (coll. M. Kosztarab) - 2 females (USNM); Río Seco, NW of Esparta (Esparza?), 23 July 1967 (coll. O.S. Flint, Jr.) - 1 male (USNM); San Vito, 13 February 1970 (coll. M. Kosztarab) - 3 females (USNM); San Vito, 2 km S San Vito, Finca Las Cruces, elev. 1219.2 m, 8° 42' N, 83° 0' W, 14 March 1969 (coll. D.C. Rentz) - 1 female (ANIC); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 December 1989 (coll. G. Fonseca) - 1 female (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, 22 March 1994 (coll. P. Naskrecki) - 1 male (PN collection); **San José Prov.**, San José, 15 February 1903 - 5 males, 3 female (UNSM); San José, 21 September 1905 (coll. F. Knab) - 1 female (USNM); same locality, 19 September 1912 (coll. A. Alfaro) - 1 male (USNM); same locality, 6 September 1915 (coll. A. Alfaro) - 2 males, 5 females (USNM); same locality, elev. 1135 m, 15 July 1928 (coll. M. Valerio) - 2 females (USNM); same locality, 7 March 1981 (coll. L. Hartshorn) - 1 male (USNM).

Neoconocephalus punctipes (Redtenbacher, 1891)

Figs. 13C-F, 44E, 45C, 56C-D, Map 8

1891 Redtenbacher, Monografie der Conocephaliden 1891: 422 >>*Conocephalus*; type locality: Caribbean: St. Vincent; type depository: The Natural History Museum, London - syntypes male and female

1906 Kirby, Syn. Cat. Orth. 2: 248 >>*Conocephaloides*
1983 Walker and Greenfield, Trans. Amer. Ent. Soc. 109: 378 >>*Neoconocephalus*

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

[syn.] *surinamensis* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 385, 422; type locality: Surinam >>*Conocephaloides*

1912 Karny, in Wytzman, Gen. Ins. 139: 37 >>*Homorocoryphus*

1983 Walker and Greenfield, Trans. Amer. Ent. Soc. 109: 378 >>Syn. of *Neoconocephalus punctipes*

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>syntype female illustrated

Diagnostic description. - General characteristics as described above. Stridulatory file of male 1.2-1.7 mm long, with 56-84 teeth, maximum width of file 0.17 mm (Figs. 44E); proximal third of file abruptly narrowing, with teeth only third as wide as in distal part of file. Mirror of stridu-

latory apparatus rectangular, with distal margin of mirror weakly convex (Fig. 45C). Fastigium of vertex touching fastigium of frons with no visible gap between them (Fig. 13D) or fastigia separated by narrow gap (Fig. 13F); frontal portion of fastigium with weakly defined white band but no dark markings beneath (Figs. 13C, 13E).

Mid femur with 2-3 small spines on anterior ventral margin, never accompanied by black spots at their bases; hind femora occasionally with dark spots at bases of ventral spines. Brown individuals often with dark speckles on tegmina; hind tibia in green individuals often brown but not nearly as dark as in *N. affinis*.

Ovipositor approximately as long as hind femur (ratio ovipositor/hind femur 0.99-1.08), straight.

Measurements.— Table 7.

Bioacoustics.— The call of *N. punctipes* is a long, high-pitched buzz (Figs. 56C-D). Costa Rican populations have the wingstroke rate of 230 wingstrokes/s, and similar rates were recorded by Walker and Greenfield (1983) for populations from Panama, Trinidad and Jamaica. The principal frequencies of the call are 9.5-15 kHz. Males sing mostly at dusk and at night although individual males may call briefly during the day.

Distribution.— *N. punctipes* has been recorded from St. Vincent, Trinidad, Jamaica, and Panama (Walker and Greenfield 1983). These are the first record of this species from Costa Rica. It occurs throughout the country in grassy habitats at low elevations.

Material examined.— **COSTA RICA: Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 8 - 24 August 1992 (coll. K. Flores) - 1 male, 1 female (INBio); same locality, elev. 20 m, 2 September 1993 (coll. K. Flores) - 1 male (INBio); La Marina, 18 August 1961 (coll. C.F. Walker) - 1 male (UMMZ); Playuelas, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 15 December 1992 (coll. K. Martínez) - 1 male (INBio); same locality, elev. 20 m, 31 December 1992 (coll. K. Martínez) - 1 female (INBio); Puesto Playuelas, Caño Negro, R.N.V.S. Caño Negro, elev. 20 m, 27 September 1993 (coll. K. Martínez) - 1 male (INBio); **Cartago Prov.**, Quebrada Segunda, P.N. Tapantí, elev. 1250 m, 15 March 1992 (coll. R. Vargas) - 1 male (INBio); **Guanacaste Prov.**, 9 mi N Cañas on Río Tenorio, Finca La Pacifica, elev. 40 m, 3 - 10 February 1969 (coll. D.C. Rentz) - 1 male (CSIRO); Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 22 August 1993 (coll. C. Moraga) - 1 male (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, elev. 700 m, 15 December

1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Finca Jenny, 30 km N Liberia, elev. 300 m, 15 January 1992 (coll. F. Araya) - 1 female (INBio); same locality, elev. 240 m, 15 January 1994 (coll. F. Araya) - 1 female (INBio); Finca Jenny, 31 km N Liberia, elev. 300 m, 15 December 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Los Almendros, P.N. Guanacaste, 24 April 1992 (coll. G. Gallardo) - 1 female (INBio); Palo Verde N. P., Palo Verde Biological Station, 5 February 1994 (coll. P. Naskrecki) - 2 males, 1 female (PN collection); **Heredia Prov.**, Finca La Selva, nr. Puerto Viejo, 6 April 1969 (coll. D.C. Rentz) - 1 male (CSIRO); Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 22 August 1992 (coll. M. Ortiz) - 2 males (INBio); same locality, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 3 males (INBio); same locality, elev. 90 m, 9 - 30 October 1992 (coll. M. Ortiz) - 1 male (INBio); same locality, elev. 90 m, 22 December 1992 (coll. M. Ortiz) - 2 males (INBio); same locality, elev. 90 m, 4 - 31 January 1993 (coll. M. Ortiz) - 3 males, 1 female (INBio); La Virgen de Sarapiquí, 24 April 1993 (coll. M. Ortiz) - 1 male (INBio); same locality, 30 May 1993 (coll. M. Ortiz) - 1 male (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 22 October 1995 (coll. P. Naskrecki) - 1 male (ALAS); **Limón Prov.**, Amubri, Talamanca, elev. 70 m, 29 August 1994 (coll. G. Gallardo) - 1 male (INBio); Cuatro Esquinas, Tortuguero N. P., 15 September 1989 (coll. J. Solano) - 1 male (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 100 m, 15 December 1992 (coll. G. Carballo) - 1 female (INBio); **Puntarenas Prov.**, Estac. Queb. Bonita, Res. Biol. Carara, elev. 50 m, 26 January 1993 (coll. R. Guzmán) - 1 male (INBio); P. N. Manuel Antonio, Quepos, 20 August 1993 (coll. G. Carballo) - 1 female (INBio); same locality, 15 December 1993 (coll. G. Carballo) - 1 male (INBio); Península de Osa, Corcovado N. P., Estac. Sirena, 22 March 1980 (coll. D.H. Janzen and W. Hallwachs) - 2 females (INBio); same locality, 12 August 1980 (coll. D.H. Janzen and W. Hallwachs) - 1 female (INBio); Península de Osa, Corcovado N. P., Sirena, 7 - 14 March 1994 (coll. P. Naskrecki) - 1 male (PN collection); Península de Osa, Rancho Quemado, elev. 200 m, 15 July 1992 (coll. M. Segura) - 1 male (INBio); same locality, elev. 200 m, 15 August 1992 (coll. M. Segura) - 1 female (INBio); same locality, elev. 200 m, 15 November 1992 (coll. R. Aguilar, M. Segura and F. Quesada) - 1 female (INBio); Peninsula de Osa, Rancho Quemado, elev. 200 m, 15 July 1992 (coll. A. Marín) - 1 female (INBio); same locality, elev. 200 m, 3 April 1994 (coll. A. Marín) - 1 male (INBio); Rancho Quemado, Pen. Osa, 1 November 1990 (coll. B. Apu) - 1 male (INBio); same locality, 15 February 1991 (coll. F. Quesada) - 1 female (INBio); Rancho

Quemado Península de Osa, elev. 200 m, 15 October 1990 (coll. F. Quesada) - 5 males (INBio); Rancho Quemado, Península de Osa, elev. 200 m, 15 May 1991 (coll. F. Quesada) - 1 female (INBio); same locality, elev. 200 m, 31 March 1993 (coll. A. Gutiérrez) - 1 female (INBio); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 January 1990 (coll. G. Fonseca) - 2 males (INBio); same locality, elev. 0 - 100 m, 15 February 1990 (coll. G. Fonseca) - 1 female (INBio); same locality, elev. 0 - 100 m, 10 - 25 August 1992 (coll. A. Gutiérrez) - 1 male (INBio); Vuelta Campana, R. Terraba, Rey Curré, elev. 100 - 500 m, 28 February 1993 (coll. S. Rojas) - 1 female (INBio); **PANAMA: Panama Prov.**, Tocumen Airport at Panama City, 22 January 1975 (coll. D.C. Rentz) - 1 female (CSIRO).

Neoconocephalus spiza Walker and Greenfield, 1983
Figs. 13G-H, 44F-G, 45D, 56E-G, Map 8

1983 Walker and Greenfield, Trans. Amer. Ent. Soc. 109: 385; type locality: Panama, Gamboa; type depository: Florida State Collection of Arthropods, Gainesville - holotype male

Note: Some Costa Rican specimens identified in this work as *N. spiza* may, in fact, represent a new, undescribed species. Although morphologically indistinguishable, and with the general song structure resembling that of individuals from Panamanian populations, the structure of individual chirps of the call differ significantly from "typical" *N. spiza*. All individuals of *N. spiza* from numerous localities in Panama and northern Costa Rica produce chirps with a distinctive pulse structure and chirps are seldom produced at a very regular rate for very long (usually no longer than several seconds, or 8-10 chirps; this applies to both chorusing and solo individuals) (Greenfield, pers. comm.). Contrastingly, individuals from southern Costa Rican populations (Osa Peninsula, Valle de Coto Brus) produce chirps without a recognizable pulse structure and chirps are produced at very regular rate for long periods of time.

On the other hand, Greenfield (pers. comm.) suggests that *N. spiza* may be a species exhibiting a considerable inter-population variation in the song structure, and the differences between southern Costa Rican and Panamanian populations are due to such local variations. A similar suggestion was made by Walker and Greenfield (1983) with regards to *N. saturatus* (Griffini) from Trinidad.

For the purpose of this work, I will treat the southern Costa Rican population as a possibly separate, unidentified species (it will be further referred to as *N. cf. spiza*), closely related to *N. spiza*, without officially describing it

as new, pending a more thorough analysis of a larger sample of specimens and recordings. The description below is based on Costa Rican specimens of *N. spiza* displaying acoustic behavior similar to that of Panamanian populations of this species.

Diagnostic description. - General characteristics as described above. Stridulatory file of male 1.8-2.3 mm long, with 68-96 teeth; file strongly but gradually narrows towards proximal end (Figs. 44F). Mirror of stridulatory apparatus oval (Fig. 45D). Fastigium of vertex separated from fastigium of frons by distinct gap; ventral fastigial tooth prominent (Fig. 13H); frontal portion of fastigium with light band, usually accompanied by black band below; often (especially in brown specimens) entire ventral portion of fastigium black (Fig. 13G).

Mid femur with 1-2 small spines on anterior ventral margin, never accompanied with black spots at their bases; fore femora occasionally unarmed ventrally. Brown individuals often with dark stripe on tegmina, continuous with darker lateral lobes of pronotum.

Ovipositor slightly longer than hind femur (ratio ovipositor/hind femur 1.16-1.22), straight. 1.08), straight.

Measurements. - Table 7.

Bioacoustics. - *N. spiza* and *N. cf. spiza* are the only Costa Rican species of the genus with a call consisting of individual, discontinuous chirps. Individuals from northern Costa Rica (Santa Rosa National Park) exhibit calling behavior identical to that of Panamanian populations of *N. spiza*. Their call consists of long sequences of chirps produced at the rate of about 3-5/s (at 27°C), each chirp (pulse train) lasting 30-32 ms (avrg. 45±72, n=50). The chirps have recognizable structure (Fig. 56G). Walker and Greenfield (1983) measured the wingstroke rate of individual chirps of *N. spiza* at ca. 150/s, with 6-8 wingstrokes per chirp. The peak of energy of the call is located between 10 and 11 kHz. Individuals from southern Costa Rica produce chirps at the rate of 3.2/s at 24°C (Fig. 56E) and unlike *N. spiza* from Panama (Fig. 56G), individual chirps have no recognizable structure (Fig. 56F). The stridulatory file in both forms is similar (Figs. 44F-G).

Costa Rican individuals of both *N. spiza* and *N. cf. spiza* call both at night and during the day. Greenfield (1988) demonstrated that males of *N. spiza* will cease their calling if other species of the genus call nearby, and females stop moving towards the singing male if congeneric males also sing. In places where populations of congeners are high, males of *N. spiza* will switch their calling periodicity from nocturnal to entirely diurnal. This be-

havior is presumably caused by the avoidance of energy wasted on calling while the females cannot be attracted. It is yet unknown if such behavior occurs also in the Costa Rican population.

Distribution. — *N. spiza* has been previously known only from Panama. These are the first records of this species from Costa Rica. Like other species of the genus, it occurs in a variety of open, grassy habitats.

Material examined (*N. spiza*). — **COSTA RICA: Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 8 - 24 August 1992 (coll. K. Flores) - 1 male (INBio); Puesto Playuelas, Caño Negro, R.N.V.S. Caño Negro, elev. 20 m, 26 February 1993 (coll. K. Martínez) - 1 female (INBio); **Cartago Prov.**, 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 male (UMMZ); **Guanacaste Prov.**, Estac. Murciélago, 8 km SO de Cuajinquil, 18 September 1993 (coll. F. Quesada) - 1 female (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 April 1994 (coll. C. Moraga) - 1 female (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 22 August 1993 (coll. C. Moraga) - 1 male (INBio); Finca Jenny, 30 km N Liberia, elev. 300 m, 27 March 1993 (coll. F. Araya) - 1 female (INBio); same locality, elev. 240 m, 15 January 1994 (coll. F. Araya) - 1 female (INBio); Finca Jenny, 30 km N Liberia, P.N. Guanacaste, elev. 300 m, 25 February 1993 (coll. F. Araya) - 1 female (INBio); Los Almendros, P.N. Guanacaste, 24 April 1992 (coll. G. Gallardo) - 1 female (INBio); same locality, 3 November 1993 (coll. K. Martínez) - 1 female (INBio); Río San Lorenzo, Tierras Morenas, Z.P. Tenorio, elev. 1050 m, 15 July 1991 (coll. C. Alvarado) - 1 female (INBio); same locality, elev. 1050 m, 21 April 1992 (coll. C. Alvarado) - 1 female (INBio); **Heredia Prov.**, Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 22 August 1992 (coll. M. Ortiz) - 2 males (INBio); **Puntarenas Prov.**, P. N. Manuel Antonio, Quepos, 20 August 1993 (coll. G. Carballo) - 1 female (INBio); **San José Prov.**, Estac. Zurquí, 500 m antes de Tunel, elev. 1600 m, 15 April 1991 (coll. G. Maass) - 1 female (INBio)

Material examined (*N. cf. spiza*). — **COSTA RICA: Puntarenas Prov.**, Península de Osa, Corcovado N. P., Estac. Sirena, 12 August 1980 (coll. D.H. Janzen and W. Hallwachs) - 1 female (INBio); Península de Osa, Rancho Quemado, elev. 200 m, 15 July 1992 (coll. M. Segura) - 1 male, 2 females (INBio); same locality, elev. 200 m, 15 August 1992 (coll. M. Segura) - 1 female (INBio); same locality, elev. 200 m, 15 November 1992 (coll. R. Aguilar, M. Segura and F. Quesada) - 1 female (INBio);

Corcovado N.P., elev. 0 - 100 m, 15 February 1990 (coll. G. Fonseca) - 1 female (INBio); same locality, elev. 0 - 100 m, 10 - 25 August 1992 (coll. A. Gutiérrez) - 1 male (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 2 males (PN collection).

BUCRATES Burmeister, 1838

1838 Burmeister, Handb. Ent. 2: 708; type species:

Locusta capitata De Geer, 1773

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>references; types illustrated

Diagnosis

Body robust, size medium to large; both sexes macropterous (Fig. 14A) or mesopterous; tegumen smooth to moderately rugose. Fastigium of vertex broader than scapus, short and blunt, continuous with fastigium of frons; no traces of genal carinae present; frons weakly convex. All femora armed on lower margins with minute spines, dorsal margins of hind tibia expanded laterally. Male cercus armed apically with 2 incurved spines; ovipositor weakly downcurved, with upper and lower margins parallel.

Description (male except where specified)

Head. — Fastigium of vertex 2 to 4 times as wide as scapus, blunt and as long as diameter of eye; fastigium of vertex touching fastigium of frons (Fig. 14H). Eyes small relative to size of head, weakly protruding. Frons weakly convex, smooth; tegumen of head smooth to weakly rugose, without traces of genal carinae; face slender to moderately broad. Mandibles and labrum weakly asymmetrical (right mandible smaller) (Fig. 14F).

Thorax and wings. — Dorsal surface of pronotum smooth to moderately punctate, flat; both anterior and posterior dorsal margins straight; lateral lobes with posterior angle broadly rounded; humeral sinus well developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, widely separated spines (modified basisternum); mesosternum with lateral lobes of basisterna triangular, their inner margins touching only at base; metasternal lobes touching along entire inner edge.

Wings in both sexes either fully developed, well surpassing apices of hind femora or shortened, not reaching end of abdomen; tegmina slender to moderately wide. Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network

TABLE 8. Key for identification of Costa Rican species of *Bucrates*

Species	Fastigium	Male cerci	Male styli	Stridulatory file
<i>capitatus</i>	4 times as wide as scapus (Fig. 13F)	teeth subapical (Fig. 13I)	flattened dorso-ventrally (Fig. 13I)	3.2 mm proximal end evenly narrowing (Fig. 42A)
<i>clausus</i>	twice as wide as scapus (Fig. 13B)	teeth apical (Fig. 13D)	cylindrical (Fig. 13D)	2.8 mm proximal fourth strongly narrowed (Fig. 42D)

of secondary veinlets; stridulatory file (vein AA₁) straight to weakly curved (Figs. 44A-D), in some species stridulatory teeth strongly narrowed towards proximal (inner) end of file, and wider and thicker towards distal (outer) end of file; mirror of right wing oval or nearly circular. Posterior margin of tegmen weakly concave; apex of tegmen narrowly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; mid coxa with small, hook-like spine on upper margin. Fore and mid femora unarmed dorsally but armed ventrally on anterior margins; genicular lobes of fore femora unarmed, lobes of mid and hind femora armed with short spines, often only inner genicular lobes armed on mid femora. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs; dorsal margins of hind tibia distinctly expanded laterally at apex. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with shallow apical emargination, supraanal plate small, triangular. Male cercus with 2 apical or subapical spines, both bent inwards under right angle; upper spine 1/3 to 1/2 as long as lower spine; both spines with apices curved downwards when seen from behind; female cercus, simple, slender and weakly incurved. Subgenital plate of male with a pair of styli and small, triangular apical emargination; styli often strongly flattened dorso-ventrally; female subgenital plate triangular, with shallow apical emargination.

Male concealed genitalia without well developed titillators, but with part of phallic membrane partially sclerotized and covered by chitinous callosities. Ovipositor narrow, weakly curved down; its length variable; both dorsal and ventral margins of ovipositor smooth, parallel; apex of upper valvula sharp, slightly thickened.

Coloration. — Coloration grass green, olive green, or

brown. Body dorsum usually with darker wide stripe, but often only lateral edges of pronotal dorsum with darker stripes. Tegmina frequently with numerous, dark speckles; stridulatory area of male tegmina often with darker edges.

Remarks. — The genus includes 4 described species, distributed from Florida, USA [*B. malivolans* (Scudder)] throughout Central America to Porto Alegre, Brazil (*B. lanista* Rehn). The closest relatives of the genus include *Neoconocephalus* and *Pyrgocorypha*. It differs in the shape of the fastigium of vertex and the presence of modified, laterally expanded dorsal edges of the hind tibia.

Bucrates capitatus (De Geer, 1773)

Figs. 14F-I, 46A-B, Map 9

1773 De Geer Mem. Ins. iii.: 455, pl. 40, fig. 1 >>*Locusta capitata*; type locality: unknown; type depository: Naturhistoriska Rijksmuseum, Stockholm – holotype female

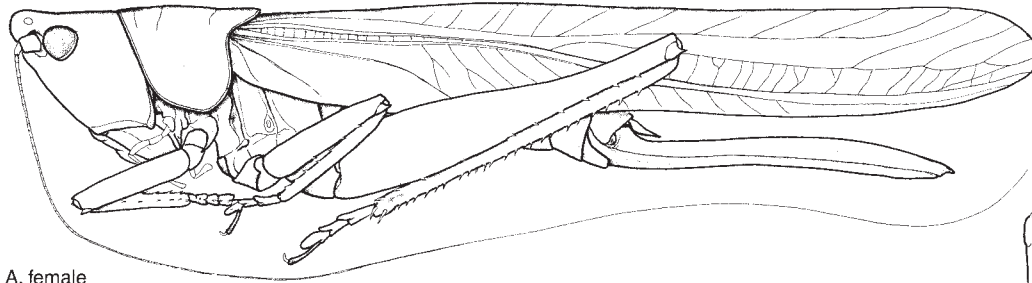
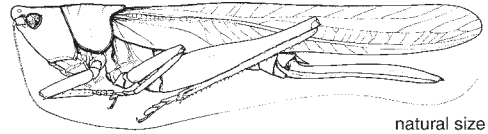
1838 Burmeister, Handb. Ent. 2: 709 >>*Bucrates*
1933 Sjöstedt, Y., Arkiv för Zoologi 25A: 7, pl. 15, fig. 5 >>photograph of the holotype

[syn.] *latifrons* = 1869 Walker, Cat. Derm. Salt. Brit.

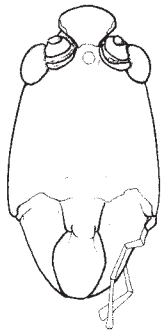
Mus. 2: 310; type locality: Venezuela, type depository: Museum of Natural History, London.

Diagnostic description. — General characteristics as described above. Wings fully developed, well surpassing apices of hind femora or shortened, not reaching apex of abdomen. Stridulatory file of male 3.2 mm long, with 113 lamelliform teeth, maximum width of file 0.27 mm (Figs. 46A-B); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Mirror of stridulatory apparatus somewhat longer than wide, with all margins convex. Fastigium of vertex about 4 times as wide as scapus, continuous with fastigium of frons; apex of fastigium of frons shallowly notched (Figs. 14F-H). Ovipositor somewhat longer than hind femur (ratio

Bucrates clausus



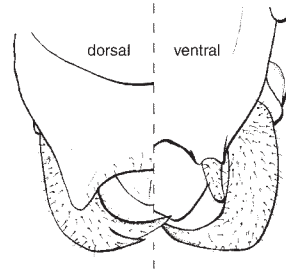
A. female



B. face



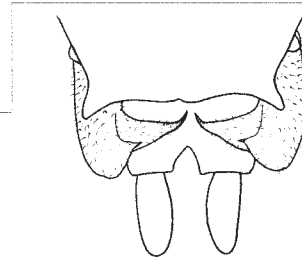
C. head and pronotum, dorsal view



D. male cerci

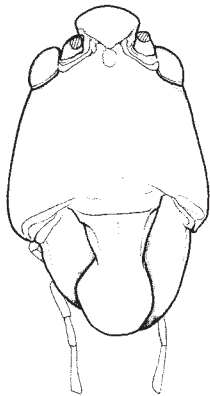


E. hind tibia

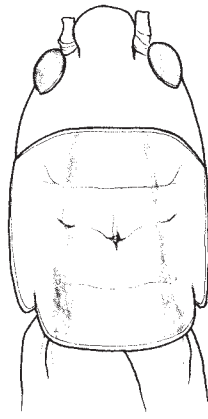


I. male cerci

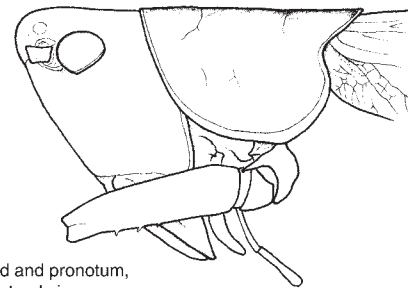
Bucrates capitatus



F. face



G. head and pronotum, dorsal view



H. head and pronotum, lateral view

FIG. 14. Costa Rican species of *Bucrates*. A-E. *B. clausus*: A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal and ventral views, E. right hind tibia, dorsal view; F-I. *B. capitatus*: F. female face, G. female head and pronotum, dorsal view, H. head and pronotum, lateral view, I. male cerci, dorsal view.

TABLE 9. Body measurements of species of *Bucrates*
(all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>capitatus</i>					
male	49.8-52, 50.9±1.6	38.4-38.8, 38.6±0.3	9.6-9.9, 9.8±0.2	21.6-24.3, 23±1.9	na
female	62.6-64.4, 63.6±0.9	45.6-50.1, 48.4±2.4	11-11.8, 11.3±0.4	27.2-28.6, 27.9±0.7	32.7-36.2, 34.4±1.8
<i>clausus</i>					
male	57.2-61.2, 59.2±2.8	44.5-44.8, 44.7±0.2	8.4-9.6, 9±0.8	21.8-22.8, 22.3±0.7	na
female	59.7-64.7, 61.8±2.0	47-50.5, 49.1±1.5	8.1-9.1, 8.6±0.4	22.5-24.1, 23.3±0.6	21.6-23.6, 22.6±0.7

ovipositor/hind femur 1.20-1.29), weakly downcurved.
Coloration.— Body coloration brown or olive green; dorsum of pronotum darker, with two dark brown stripes on edges; tegmina with numerous dark speckles.

Measurements.— Table 9.

Bioacoustics.— Belwood and Morris (1987) presented a spectrogram the call of *B. capitatus* (populations from Barro Colorado Island, Panama). The call is continuous, with an average call repetition rate of 450/min, and wide frequency range (approx. 7-40 kHz).

Distribution.— The geographic distribution of this species stretches from Guatemala through Costa Rica and Panama, to Venezuela and Bahia, Brazil. In Costa Rica this species is apparently uncommon, and is known only from one individual collected on the Osa Peninsula (Map 9).

Material examined.— **COSTA RICA: Puntarenas Prov.,** Bosque Esquinas, Peninsula de Osa, elev. 200 m, 1 - 30 May 1994 (coll. J. Quesada) - 1 female (INBio).

Other material.— Panama, French Guyana, and Venezuela.

Bucrates clausus (Scudder, 1878)
Figs. 14A-E, 46C-D, Map 9

- 1878 Scudder, Proc. Bost. Soc. Nat. Hist. 20: 94
>>*Conocephalus*; type locality: Mexico, Jalisco; type depository: Academy of Natural Sciences, Philadelphia - holotype female
1906 Kirby, Syn. Cat. Orth. 2: 248 >>*Conocephaloides*
1912 Karny, in Wytsman, Gen. Ins. 139: 38
>>*Homorocoryphus*
1920 Rehn, J. A. G., Proc. Acad. Nat. Sci., Philadelphia 1920: 281 >>*Bucrates*
1997 Otte, Orth. Spec. File 7: 58 >>*Neoconocephalus*

- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>*Bucrates*; holotype illustrated [syn.] *Conocephalus laticeps* = 1891 Redtenbacher, Monografie der Conocephaliden 1891: 385, 421 >>*Conocephalus*; type locality: South America: Colombia: Santa fe de Bogota; type depository: Naturhistorisches Museum, Vienna, Austria - lectotype female, here designated.
1898 Saussure and Pictet, Biol. Centr. Amer. Orth. 1: 389, 394
1906 Kirby, Syn. Cat. Orth. 2: 248 >>*Conocephaloides*
1907 Karny, Abh. Zool.-bot. Ges. Wien 4(3): 47 >>*Conocephalus (Homorocoryphus)*
1912 Karny, in Wytsman, Gen. Ins. 139: 37 >>*Homorocoryphus*
1997 Otte, Orth. Spec. File 7: 60 >>*Neoconocephalus*
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>syn. of *C. clausus*; lectotype illustrated

Diagnostic description.— General characteristics as described above. Both sexes always macropterous, with tegmina well surpassing hind femora (Fig. 14A). Stridulatory file of male 2.8 mm long, with 136 teeth, maximum width of file 0.26 mm (Figs. 46C-D); teeth of file much thinner and spaced more densely in proximal fourth of file (110 teeth/mm) than thicker and less densely spaced teeth of distal end (23 teeth/mm). Mirror of stridulatory apparatus almost circular. Fastigium of vertex about twice as wide as scapus, continuous with fastigium of frons (Figs. 14B-C). Ovipositor approximately as long as hind femur (ratio ovipositor/hind femur 0.92-1.01), straight (Fig. 14A).

Coloration.— Body coloration grass green or olive green, rarely brown; dorsum of pronotum and tegmina with darker, wide, longitudinal stripe; tegmina never speckled.

Measurements.— Table 9.

Bioacoustics.— Song unknown.

Taxonomic remarks. — A comparison of the type specimens of *Conocephalus clausus* Scudder and *Conocephalus laticeps* Redtenbacher clearly indicates their conspecific status. Therefore, Naskrecki and Otte (1999) regard *C. laticeps* as a junior synonym of *C. clausus*.

Distribution. — *B. clausus* has been recorded from Veracruz, Mexico, Costa Rica, and Colombia. In Costa Rica it seems to be restricted to the Pacific region of the country (Map 9).

Material examined. — **COSTA RICA: Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 12 October 1993 (coll. K. Flores) - 1 female (INBio); Puesto Playuelas, Caño Negro, R.N.V.S. Caño Negro, elev. 20 m, 2 September 1993 (coll. K. Martínez) - 1 female (INBio); **Guanacaste Prov.**, 3 km NO de Nacaome, P.N. Barra Honda, elev. 100 m, 5 October 1992 (coll. M. Reyes) - 1 male (INBio); same locality, elev. 100 m, 15 October 1993 (coll. M. Reyes) - 5 females (INBio); same locality, elev. 100 m, 15 November 1993 (coll. M. Reyes) - 4 males, 3 females (INBio); 5 mi N Cañas, PanAm Highway, 15 October 1969 (coll. E. Frankie) - 1 female (ANIC); Finca Jenny, 31 km N Liberia, elev. 300 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 3 females (INBio); same locality, elev. 300 m, 15 October 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, elev. 300 m, 12 September 1992 (coll. F. Araya) - 1 female (INBio); Santa Rosa N. P., Playa Naranjo, 15 September 1990 (coll. E. Alcazar) - 1 female (INBio); Vicinity Estac. Murciélago, 8 km SW Cuajiniquíl, elev. 100 m, 15 June 1989 (coll. GNP Biodiversity Survey) - 1 male (INBio); **COLOMBIA:** Santa Fe de Bogota, (coll. Staudinger) - 1 female (lectotype of *Conocephalus laticeps* Redtenbacher) (NHMW); **MEXICO:** Jalisco - 1 female (holotype) (ANSP); Veracruz, Córdoba, 26 March 1953 (coll. D.H. Janzen) - 1 male (EMEC); San Andrés, Tuxtla, 8 July 1961 (coll. D.H. Janzen) - 1 female (EMEC); Tlacotalpán, 23 - 31 July 1961 (coll. D.H. Janzen) - 2 females (EMEC); Surinam: (coll. Fruhstorfer) - 1 male, 1 female (NHMW).

PYRGOCORYPHA Stål, 1873

1873 Stål, Oefv. Vet.- Akad. Forh. xiii (4): 50; type species: *Conocephalus subulatus* Thunberg, 1815
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Note: The genus *Pyrgocorypha* Stål includes 16 described species, 2 of which are synonymized below. Of the remaining 14 species, 8 occur in the tropics and sub-

tropics of the south and south-east Asia, the remaining 6 species are known mostly from the tropics and sub-tropics of the New World. The generic description below is based on Nearctic and Neotropical representatives of the genus.

Diagnosis

Body medium size to large, robust; both sexes macropterous (Figs. 15A, 16A); tegumen moderately granulose. Fastigium of vertex strongly projecting, twice to four times as long as eye diameter, often with apical hook, with distinct gap between fastigium of frons; frons flat or weakly convex; eyes small. Male cercus with two strong apical teeth bent inwards.

Description (male except where specified)

Head. — Fastigium of vertex strongly projecting, triangular when seen from above, two to four times as long as eye diameter; apex of fastigium often with small hook; base of fastigium with distinct tooth, separated from fastigium of frons by deep gap (Figs. 15A-C, 16A-C). Eyes small relative to size of head, not particularly protruding. Frons flat or weakly convex, smooth; tegumen of head smooth to moderately granulose, without traces of genal carinae; face triangular, slender to moderately wide.

Thorax and wings. — Dorsal surface of pronotum moderately granulose, flat or weakly convex; anterior dorsal margin straight, posterior one straight to weakly convex; lateral lobes with posterior angle broadly rounded and with well developed humeral incision. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, widely separated spines (modified basisternum); meso- and metasternum with basisterna approximately narrowly.

Wings in both sexes fully developed, surpassing apices of hind femora. Stridulatory apparatus of male well developed; stridulatory file straight or weakly curved (Figs. 44E-H), evenly tapering on both ends, with broad and relatively thick, lamelliform teeth; stridulatory area of left wing with dense secondary venation (but not as dense as in *Neoconocephalus*); mirror of right wing almost circular, large. Posterior margin of front wing straight; apex of front wing rounded.

Legs. — Legs thick and robust. Fore coxa with an elongate, forward projecting spine dorsally; middle coxa with or without dorsal spine directed caudad. All femora unarmed dorsally, fore and mid femora armed ventrally on anterior margins, and posterior femora armed on both ventral margins; genicular lobes of fore femora unarmed, lobes on mid and hind femora unarmed or only inner

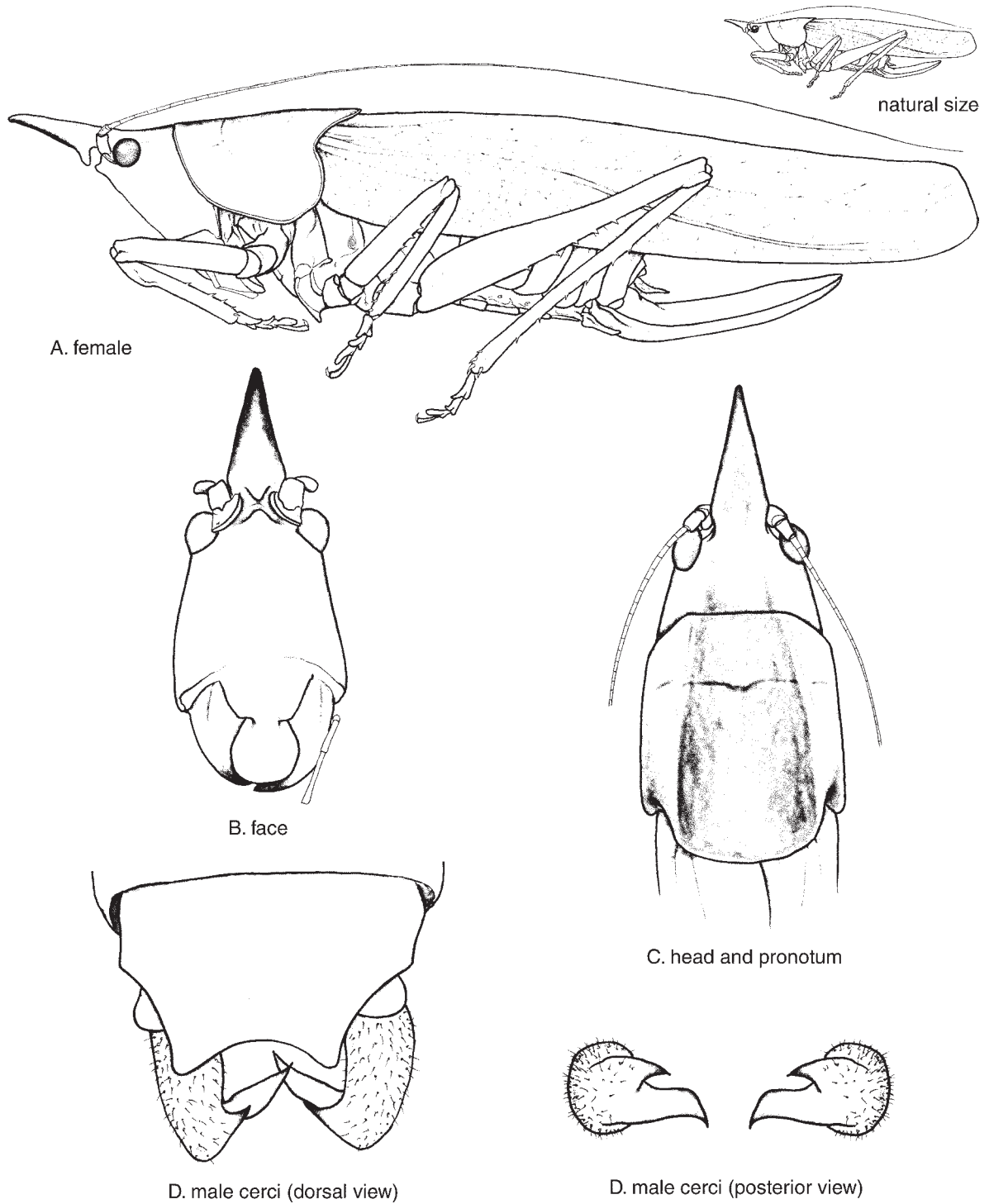


FIG. 15. *Pyrgocorypha rogersi*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal view, E. male cerci, posterior view.

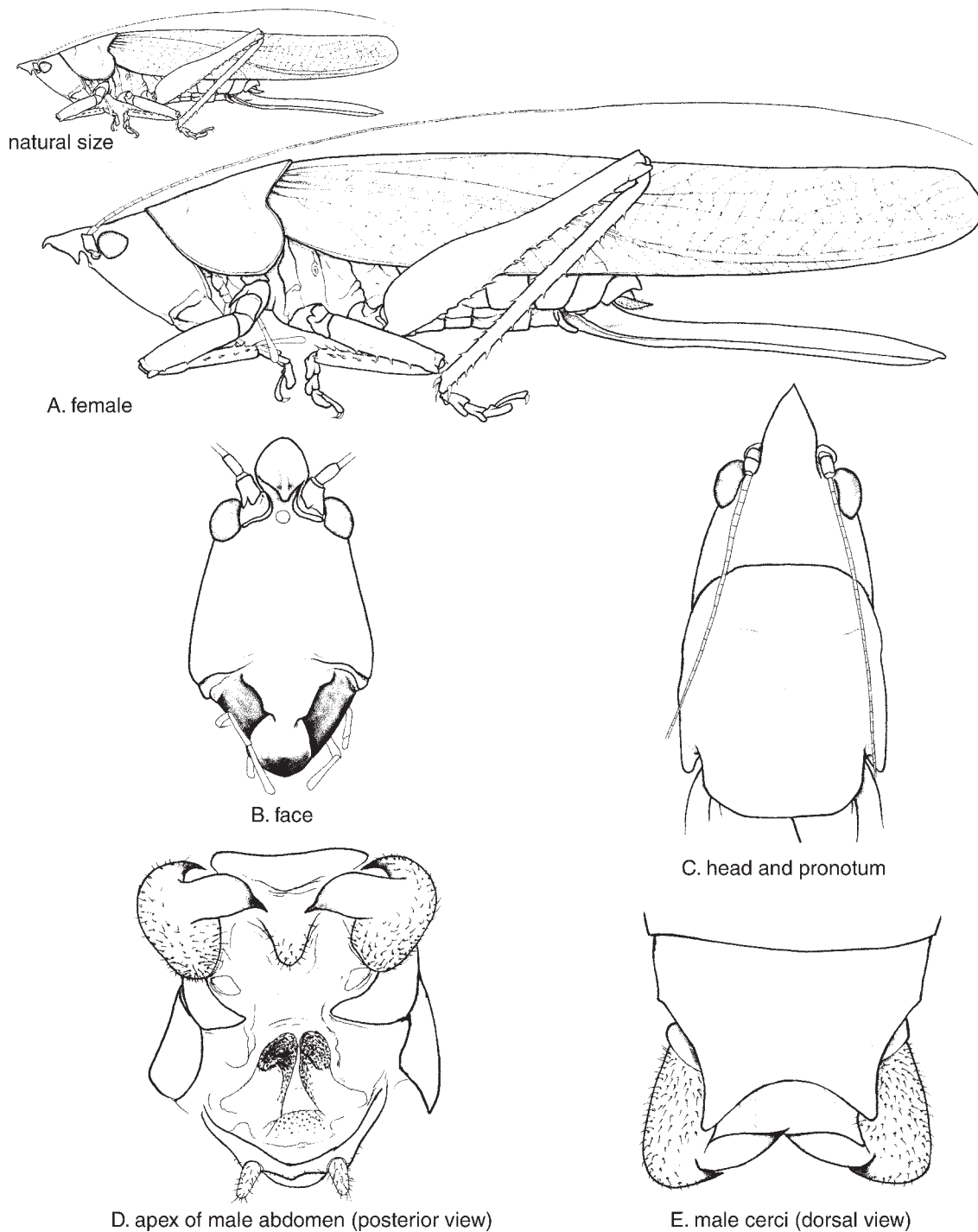


FIG. 16. *Pyrgocorypha hamata*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. apex of male abdomen, posterior view, E. male cerci, dorsal view.

TABLE 10. Key for identification of Costa Rican species of *Pyrgocorypha*

Species	Fastigium	Ovipositor	Stridulatory file	Coloration
<i>rogersi</i>	4 times as long as eye, black ventrally (Fig. 14B)	longer than hind femur, slightly downcurved	2.9 mm, 70 teeth	pronotum and head usually with dark, wide stripe dorsally
<i>hamata</i>	1.5 times as long as eye, light (Fig. 15B)	shorter than hind femur, bent upwards	3.8 mm, 95 teeth	pronotum and head at most slightly darker dorsally

(posterior) lobes with armed small spine. Front tibia unarmed dorsally, both ventral margins with immovable spines as long as 1/4 – 1/2 diameter of tibia. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area weakly swollen, with pair of small pits below tympanal slits; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs; dorsal surface of hind tibia sometimes densely pitted.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Posterior margin of male 10th tergite with shallow but distinct emargination. Female 10th tergite with deep furrow along midline and with deep triangular incision apically. Supraanal plate small, triangular; male cercus with two strong, apical teeth; lower tooth almost as long as basal part of cercus; upper, smaller tooth as long as 1/4 to 1/3 of lower tooth; both teeth strongly bent inwards (Figs 15D-E); female cercus, simple, narrowly conical, slightly incurved. Subgenital plate of male with a pair of styli, posterior margin of plate straight, weakly emarginated or with deep triangular incision; female subgenital plate with shallow, rounded or deeply triangular incision.

Epiphallus without well developed, strongly sclerotized titillators but with part of phallic membrane sclerotized (Fig. 16E). Ovipositor weakly curved downwards or distinctly bent upwards at base; both dorsal and ventral margins of ovipositor smooth; apex of upper valvula rounded; ovipositor shorter or longer than hind femur.

Coloration. — Most or all species of the genus have both green and brown color forms, usually with no conspicuous markings. Sometimes dorsal surface of the pronotum is darker than the lateral lobes, and bordered by light, thin stripes. In some species the face and the ventral part of the fastigium of vertex, and sometimes also mandibles have dark markings.

Remarks. — This genus in many ways resembles the closely related genus *Neoconocephalus*. It differs mostly in a more robust body form and the structure of the fastigium of vertex, which is always pointed and usually hooked

apically. The only species of *Neoconocephalus* with a similar fastigium of vertex is Cuban *N. aduncus* (Scudder).

The call of Costa Rican species is unknown. *Pyrgocorypha uncinata*, a species known from southern United States and Mexico has a call described as “loud buzzing” (Helfer 1987).

Pyrgocorypha rogersi Pictet et Saussure, 1898
Figs. 15A-E, 46E-F, Map 10

1898 Saussure and Pictet, Biol. Centr. Amer. Orth. 1: 387, pl. 19, figs.13-14; type locality: Costa Rica, Cache, type depository: The Natural History Museum, London – holotype female.

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description. — General characteristics as described above. Fastigium of vertex strongly developed, about 4 times as long as diameter of eye and, at its base, about twice as wide as eye diameter, slightly bent apically; ventral basal tooth of fastigium prominent; gap between fastigia of vertex and frons deep, about as wide as scapus (Figs. 15A-C).

Stridulatory file of male 2.87 mm long, with 70 lamelliform teeth (n=1), maximum width of file 0.23 mm (Figs. 46E-F). Male cercus as in Figs. 14D-E. Ovipositor distinctly bent upwards, shorter than hind femur (ratio ovipositor/hind femur 0.77), not reaching apex of tegmina (Fig. 15A).

Coloration. — Body coloration of most specimens from Costa Rica tan to sienna brown, dorsum of head and pronotum with dark brown (raw sepia), wide stripe; less frequently entire body pale green, with no dark stripe on dorsum.

Measurements. — Table 11.

Material examined. — **COSTA RICA:** Chitaría, elev. 500 m, 9 June 1929 (coll. M. Valerio) - 1 female (ANSP); Escasu, 15 January 1903 (coll. C.F. Underwood) - 1 female (ANSP);

TABLE 11. Body measurements of Costa Rican species of *Pyrgocorypha* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>rogersi</i>					
male	34.9-40.1, 37.6±2.6	24.1-28.8, 26.2±2.4	7.1-8, 7.5±0.5	11.8-13, 12.3±0.6	na
female	39.8	27	7.6	13.2	10.1
<i>hamata</i>					
male	56.9-59.9, 58.4±2.1	43.1-46.3, 44.7±2.3	10.8-11.5, 11.2±0.5	19.1-19.7, 19.4±0.4	na
female	57.4-65.3, 58.4±4.0	44.5-49.5, 47.1±2.5	9.4-11.2, 10.2±0.9	19.4-21.9, 20.9±1.3	23-25, 23.8±1.1

Santa Mario de Dota, 15 January 1909 (coll. J.F. Tristan) - 1 male, 1 female (ANSP); Verba Buena, 15 March 1926 (coll. P.C. Standley) - 1 male (USNM); **Cartago Prov.**, Cache - 1 female (holotype) (BMNH); **Puntarenas Prov.**, Buen Amigo, San Luís Monteverde, elev. 1000 - 1350 m, 1 - 31 March 1997 (coll. Z. Fuentes) - 1 male (INBio); **San José Prov.**, San José, (coll. C.F. Underwood) - 1 female (ANSP); same locality, elev. 1135 m, 15 July 1928 (coll. M. Valerio) - 2 females (ANSP).

Remarks. — This species is known only from Costa Rica (Map 10). Nothing is known about its biology or behavior.

Pyrgocorypha hamata (Scudder, 1876)

Figs. 16A-E, 46G-H, Map 10

- 1879 Scudder, Proc. Bost. Soc. Nat. Hist. 20: 87
 >>*Conocephalus hamatus*; type locality: Guatemala;
 type depository: Museum of Comparative
 Zoology, Harvard University, Cambridge
- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD
 ROM) >>holotype illustrated
- [**syn. n.**] *Pyrgocorypha inermis* = 1898 Saussure and
 Pictet, Biol. Centr. Amer. Orth. 1: 386, 387; type
 locality: Costa Rica, San José
- [**syn. n.**] *Pyrgocorypha affinis* = 1907 Karny, Abh. Zool.-
 bot. Ges. Wien 4(3): 20; type locality: Mexico
- 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD
 ROM) >>syntype illustrated

Diagnostic description. — General characteristics as described above. Fastigium of vertex wide and triangular, about twice as long as diameter of eye and, at its base, about twice as wide as eye diameter; apex with distinct tooth; basal tooth of fastigium prominent; gap between fastigia of vertex and frons deep, about as wide as scapus (Figs. 16A-C).

Stridulatory file of male 3.8 mm long, with 95 lamelli-

form teeth (n=1), teeth on distal (outer) end of file narrower and more densely arranged than on proximal (outer) end; maximum width of file 0.45 mm (Figs. 46G-H). Male cercus as in Figs. 16D-E. Ovipositor slightly bent downward, longer than hind femur (ratio ovipositor/hind femur 1.09-1.19), usually reaching or surpassing apex of tegmina (Fig. 16A).

Coloration. — Body coloration uniformly straw brown or light green, sometimes dorsum of pronotum darker than lateral lobes of pronotum.

Measurements. — Table 11.

Remarks. — A comparison of the type specimens of *Conocephalus hamatus* and *Pyrgocorypha affinis* reveals that they are conspecific. Hebard (1932) noted that *P. affinis* merely represents a smaller individual of *P. hamata* but did not officially synonymize the two species. Although I was unable to study the type specimen of *Pyrgocorypha inermis*, a detailed description and illustration leave no doubt that the specimen described by Saussure and Pictet from San José, Costa Rica, fits within the range of morphological variation of *P. hamata*. Therefore, I consider both *P. affinis* and *P. inermis* junior synonyms of *Conocephalus hamatus*.

The distribution of this species stretches from northern Mexico to Costa Rica. In Costa Rica it is restricted to the Pacific region of the country, occurring in open, grassy habitats (Map 10).

Little is known about the biology of this species. In Guanacaste it is frequently attracted to lights, which indicates a nocturnal activity. Preston-Mafham (1990) reports that *P. hamata* has been seen feeding on chafer beetles (*Phyllophaga* sp.) attracted to lights at night in tropical forest in Chiapas State, Mexico. The call of *P. hamata* is unknown.

Material examined. — **COSTA RICA: Guanacaste Prov.**, 3 k NW of Nacaome, P.N. Barra Honda, elev. 100 m, 13 - 30 November 1992 (coll. M. Reyes) - 1 female (INBio);

Cerro El Hacha, 12 km SE Las Cruz, elev. 300 m, 15 November 1986 - 1 female (INBio); Estac. Cacao, SW slope of Volcán Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 15 June 1990 (coll. II curso Parataxon) - 1 female (INBio); same locality, 1 December 1989 (coll. R. Blanco and C. Chávez) - 6 males, 12 females (INBio); same locality, 15 March 1990 (coll. GNP Biodiv. Survey) - 1 female (INBio); Estac. Mengo, SW side Volcán Cacao, elev. 1100 m, 15 February 1989 (coll. GNP Biodiversity Survey) - 2 females (INBio); Estac. Las Pailas, P.N. Rincón de la Vieja, elev. 800 m, 23 April 1993 (coll. K. Taylor) - 1 female (INBio); same locality, 26 May 1994 (coll. D. García) - 1 male (INBio); Estac. Maritza, W slope of Volcán Orosí, elev. 600 m, 15 May 1990 (coll. R. Blanco) - 1 female (INBio); Estac. Maritza, W side of Volcán Orosí, elev. 600 m, 15 June 1988 (coll. Janzen and Hallwachs) - 11 females (INBio); Estac. Murciélago, 8 km SO de Cuajiniquil, 18 September 1993 (coll. F. Quesada) - 1 male (INBio); Estac. Palo Verde, P.N. Palo Verde, elev. 10 m, 21 April 1992 (coll. A. Gutiérrez) - 1 female (INBio); same locality, 21 April 1992 (coll. M. Ortiz) - 1 male (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, P.N. Guanacaste, elev. 700 m, 3 June 1993 (coll. C. Moraga) - 2 males, 2 females (INBio); same locality, 15 May 1990 (coll. II curso Parataxon.) - 2 males, 3 females (INBio); same locality, 21 April 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 May 1988 (coll. GNP Biodiversity Survey) - 3 males, 2 females (INBio); same locality, 15 June 1988 (coll. GNP Biodiversity Survey) - 1 male, 1 female (INBio); same locality, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 male, 1 female (INBio); same locality, 15 December 1988 (coll. GNP Biodiversity Survey) - 2 males (INBio); same locality, 15 January 1989 (coll. GNP Biodiversity Survey) - 1 male, 4 females (INBio); same locality, 15 May 1989 (coll. GNP Biodiversity Survey) - 2 males, 3 females (INBio); same locality, 15 March 1990 (coll. P. Rios, C. Moraga and R. Blanco) - 1 male (INBio); Estación Santa Rosa, P.N. Santa Rosa, elev. 300 m, 15 February 1992 (coll. III Curso Parataxon.) - 1 female (INBio); Finca Jenny, 30 km N Liberia, P.N. Guanacaste, elev. 300 m, 15 December 1991 (coll. F. Araya) - 2 males, 4 females (INBio); same locality, 15 January 1992 (coll. F. Araya) - 1 female (INBio); same locality, 26 January 1993 (coll. F. Araya) - 1 male, 1 female (INBio); same locality, elev. 240 m, 15 January 1994 (coll. F. Araya) - 1 male, 1 female (INBio); same locality, 15 February 1993 (coll. F. Araya) - 1 female (INBio); same locality, 15 April 1993 (coll. F. Araya) - 1 female (INBio); same locality, 14 May 1993 (coll. F. Araya) - 1 male, 1 female (INBio); same locality, 15 October 1993 (coll. F. Araya) - 2 females (INBio); same locality, 15 November 1993 (coll. F. Araya) - 2 males, 3 females (INBio); same locality, 1 - 30 June 1997 (coll. F. Araya) - 4 males, 4 females (INBio); same locality, 1 - 31 July 1997 (coll. F. Araya) - 1 male (INBio); same locality, 15 October 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same

locality, 15 November 1988 (coll. GNP Biodiversity Survey) - 2 males, 2 females (INBio); same locality, 15 December 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, 11 July 1992 (coll. F. Araya) - 6 females (INBio); same locality, 15 February 1992 (coll. F. Araya) - 1 male, 1 female (INBio); same locality, 11 June 1992 (coll. F. Araya) - 1 male, 2 females (INBio); Los Almendros, P.N. Guanacaste, 3 November 1993 (coll. K. Martínez) - 1 male (INBio); P.N. Barra Honda, elev. 100 m, 15 February 1992 (coll. M. Reyes) - 2 males (INBio); Palo Verde N. P., Palo Verde Biological Station, 5 February 1994 (coll. P. Naskrecki) - 1 male, 2 females (PN collection); Playa Blanca, Sector Murciélago, Guanacaste N. P., 15 June 1990 (coll. R. Blanco) - 2 males (INBio); R. Gongora, P.N. Guanacaste, elev. 600 m, 15 June 1992 (coll. III Curso Parataxon.) - 1 female (INBio); Río San Lorenzo, Tierras Morenas, Z.P. Tenorio, elev. 1050 m, 15 May 1991 (coll. C. Alvarado) - 1 male (INBio); Tierras Morenas, Bajo Los Cartagos, R. Sn Lorenzo, Zona Prot. Tenorio, A.C. Arenal, elev. 1050 m, 15 January 1991 (coll. C. Alvarado) - 1 female (INBio); Vicinity Estac. Murciélago, 8 km SW Cuajiniquil, elev. 100 m, 15 June 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); **Puntarenas Prov.**, Estac. Quebrada Bonita, R.B. Carara, elev. 50 m, 15 May 1992 (coll. J. Saborio) - 1 female (INBio); same locality, 15 April 1993 (coll. J. Saborio) - 1 male (INBio); same locality, 15 January 1994 (coll. J. Saborio) - 1 male (INBio); Sector Altamira, 1 km SO de Cerro Biolley, A.C. Amistad, elev. 1150 - 1400 m, 1 - 31 December 1994 (coll. J.F. Quesada) - 1 male (INBio); **GUATEMALA:** (coll. Van Patte) - 1 female (holotype) (MCZC); **MEXICO:** no other data - 1 female (holotype of *Pyrgocorypha affinis* Karny) (NHMV).

METACAPUTUS Naskrecki, gen. n.

Type species: *Metacaputus brenesi* sp. n., here designated

Diagnosis

Body slender; both sexes macropterous (Fig. 17A); tegumen moderately rugose. Fastigium of vertex 3 times as broad as scapus, long, triangular; genal carinae weakly indicated; frons weakly concave; eyes small. All legs very long and slender. Male cercus armed apically with 2 strongly incurved spines; ovipositor short, distinctly bent upwards at base; rounded apically.

Description (male except where specified)

Head. — Fastigium of vertex 3 times as wide as scapus, triangular, strongly projecting in front of eyes, 3 times as long as eye diameter; fastigium of vertex separated from fastigium of frons by small gap (Fig. 17A). Eyes small relative to size of head, weakly protruding. Frons weakly

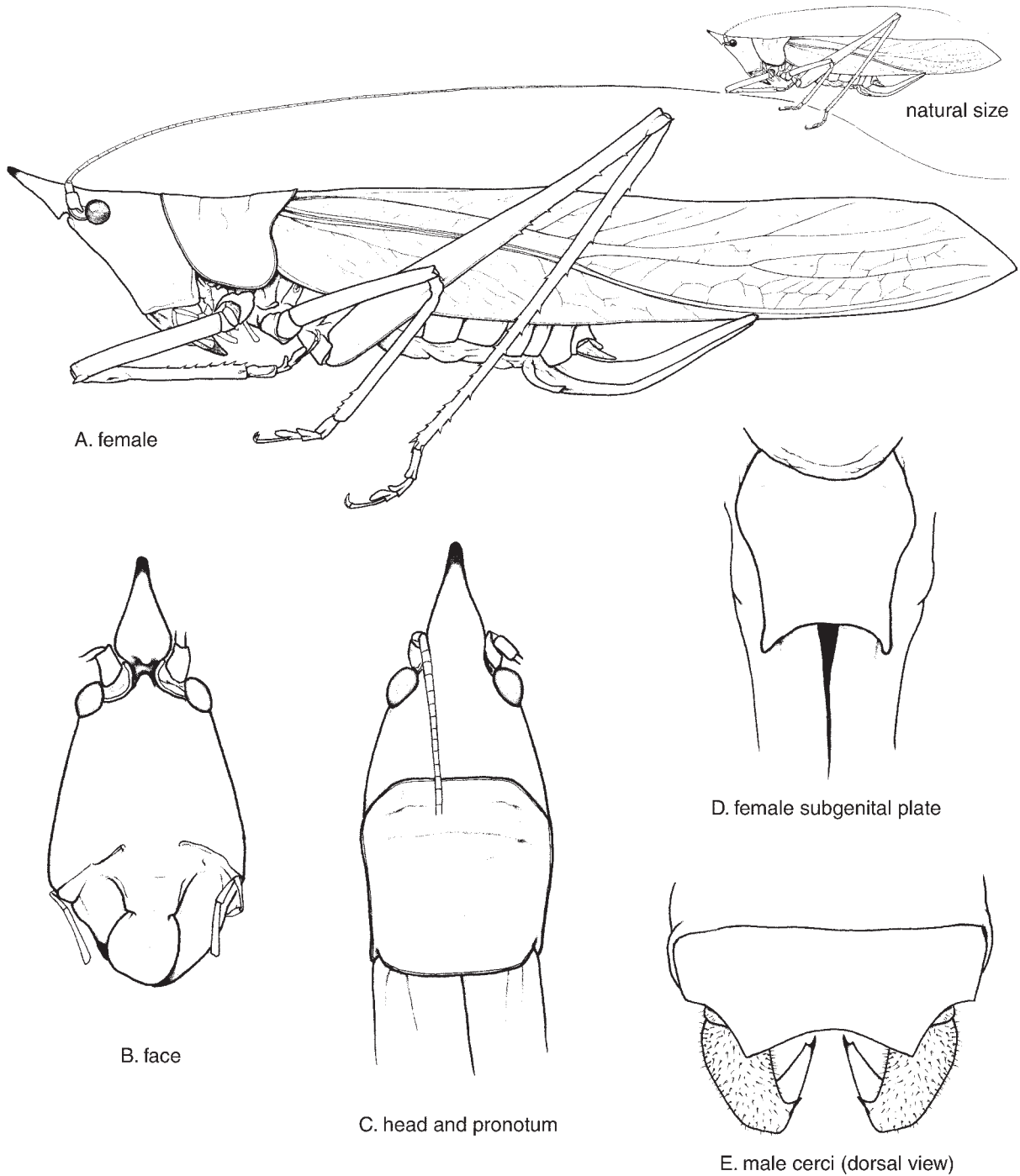


FIG. 17. *Metacaputus breneri*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. female subgenital plate, ventral view, E. male cerci, dorsal view.

concave; tegumen of head weakly rugose, with traces of genal carinae; face narrowly triangular; mandibles and clypeus weakly asymmetrical (right mandible smaller) (Fig. 17B).

Thorax and wings. — Dorsal surface of pronotum weakly rugose, flat; both anterior and posterior dorsal margins straight (Fig. 17C); lateral lobes with posterior angle broadly rounded; humeral sinus well developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum. Prosternum armed with two thin, widely separated spines (modified basisternum); meso- and metasternum with lateral lobes of basisterna triangular, their inner margins touching.

Wings in both sexes fully developed, well surpassing apices of hind femora. Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network of secondary veinlets; stridulatory file (vein AA₁) very short, consisting of only 17 (n=1) wide, thick teeth (Fig. 43F); mirror of right wing nearly circular. Posterior margin of tegmen weakly concave; apex of tegmen obliquely truncated.

Legs. — All legs exceptionally thin and long, fore coxa with elongate, forward projecting spine dorsally. Fore and mid femora completely unarmed; hind femora armed with minute spines on both ventral margins in apical half; all genicular lobes of femora armed with short spines. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with shallow apical emargination; supraanal plate small, triangular; female 10th tergite with narrow, triangular apical incision; female supraanal plate narrowly triangular. Male cercus with 2 apical spines, both strongly bent inwards under acute angle; upper spine 1/4 as long as lower spine; lower spine indented apically; female cercus, simple, slender, straight (Fig. 17D). Subgenital plate of male with pair of styli and shallow, triangular apical emargination; female subgenital plate longer than wide, with shallow apical emargination (Fig. 17E).

Male concealed genitalia with part of phallic membrane partially sclerotized and covered by large chitinous callosities. Ovipositor distinctly bent upwards at base, about as long as 1/2 of hind femur, gradually narrowing towards apex; apex rounded.

Coloration. — Coloration probably green, the only available specimens have yellowish-brown coloration, typical of specimens that had been stored in alcohol before

being dried. Apex of fastigium of vertex with dark edges.

Remarks. — *Metacaputus* seems to be closely related to the genera *Neoconocephalus* Karny and *Paroxyprora* Karny, sharing similar general body form, shape of male cerci, and weakly asymmetrical mouthparts. From *Neoconocephalus* it differs in having the ovipositor relatively very short and distinctly bent (long and straight or weakly downcurved in *Neoconocephalus*), male cerci with apical teeth bent under acute angle (right angle in *Neoconocephalus*), and very thin, unarmed fore and mid femora. From *Paroxyprora* this new genus differs in the shape of the ovipositor (weakly curved, dilated midlength in *Paroxyprora* and characteristics of the male stridulatory file (short, reduced in *Metacaputus*, long, multidentate in *Paroxyprora*).

Etymology. — The generic epithet is derived from Latin words “*Meta-* = pyramidal” and “*caput* = head,” indicating the strongly triangular shape of the head of the only species of the genus.

Metacaputus brenei Naskrecki, sp. n.

Figs. 16A-E, 43F, Map 9

Type locality: Costa Rica, Guanacaste Prov., Cerro El Hacha, 12 km SE Las Cruz, elev. 300 m; type depository: Academy of Natural Sciences, Philadelphia - holotype male

Diagnostic description. — General characteristics as described above. Stridulatory file of male 0.4 mm long, with 17 thick, wide teeth, maximum width of file 96 µm (Fig. 43F). Male cercus as in Fig. 16D. Ovipositor (Fig. 16A) shorter than hind femur (ratio ovipositor/hind femur 0.57).

Measurements (1 male, 1 female). — body with wings: male 43.5, female 45.8; pronotum: male 7.4, female 6.3; tegmen: male 34.1, female 35.4; hind femur: male 18.2, female 19.3; ovipositor: 11 mm.

Distribution. — This new species is known so far from a single site in northern Guanacaste Prov. (Map 9).

Material examined— **COSTA RICA: Guanacaste Prov.,** Cerro El Hacha, 12 km SE Las Cruz, elev. 300 m, 15 November 1986 - 1 male (holotype), 1 female (allotype) (ANSP).

Etymology. — Named after Mr. Danilo Brenes, a parataxonomist working with the project ALAS at La Selva Biological Station for his help with many aspects of this and other projects.

CAULOOPSIS Redtenbacher, 1891

1891 Redtenbacher, Monogr. Conoceph.: 376; type species: *Caulopsis gracilis* Redtenbacher, 1891
 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Diagnosis

Body very slender; both sexes macropterous (Figs. 18A, 36B); tegumen smooth to moderately rugose. Fastigium of vertex 2 to 3 times broader than scapus, 2 to 5 times longer than eye diameter; no traces of genal carinae present; mandibles and labrum strongly asymmetrical; eyes small. All legs slender, armed on lower margins with minute spines. Male cercus armed apically with 2 incurved spines; ovipositor straight, with upper and lower margins parallel.

Description (male except where specified)

Head. — Fastigium of vertex 2 to 3 times as wide as scapus, blunt or pointed apically, 2 to 5 times as long as diameter of eye; fastigium of vertex touching fastigium of frons, rarely fastigia separated (Figs. 18A, 18C-D). Eyes small relative to size of head, weakly protruding. Frons flat or weakly convex, smooth; tegumen of head smooth to weakly rugose, without traces of genal carinae; face very slender. Mandibles and labrum strongly asymmetrical (right mandible smaller) (Fig. 18C).

Thorax and wings. — Dorsal surface of pronotum smooth to weakly rugose, flat; anterior dorsal margin straight, posterior one straight or weakly convex; lateral lobes with posterior angle broadly rounded; humeral sinus well developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, long, widely separated spines (modified basisternum); meso- and metasternum with lateral lobes of basisterna small, triangular, their inner margins touching; posterior part of metasternum strongly compressed causing hind coxa to nearly touch one another.

Wings in both sexes fully developed, well surpassing apices of hind femora; tegmina slender. Stridulatory ap-

paratus of male well developed; stridulatory area of left wing membranous, without a network of secondary veinlets; stridulatory file (vein AA₁) weakly sinusoidal (Figs. 48F-I), teeth in proximal third of file much smaller and more densely arranged than in distal portion; mirror of right wing circular or somewhat longer than wide. Posterior margin of tegmen weakly concave; apex of tegmen broadly rounded.

Legs. — All legs long and slender; fore coxa with an elongate, forward projecting spine dorsally. All femora unarmed dorsally; fore and mid femora unarmed ventrally, rarely with minute spines on anterior margins; genicular lobes of femora unarmed or armed with short spines, often only inner genicular lobes armed. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with shallow apical emargination, supraanal plate small, triangular. Male cercus slender, with 2 apical spines, both bent inwards under acute angle; upper spine 1/3 to 1/2 as long as lower spine; both spines with apices curved downwards when seen from behind (Figs. 18E-F); female cercus, simple, slender and weakly incurved. Subgenital plate of male with pair of styli, distinct median keel, and shallow, triangular apical emargination; female subgenital plate with posterior margin straight or weakly emarginated.

Male concealed genitalia without well developed titillators but with part of phallic membrane partially sclerotized and covered by small chitinous callosities. Ovipositor narrow, weakly but noticeably curved down; as long as or longer than hind femur; both dorsal and ventral margins of ovipositor smooth, parallel; apex of upper valvula sharp, slightly thickened.

Coloration. — Coloration usually uniformly green, rarely brown; green individuals sometimes with dorsum

TABLE 12. Key for identification of Costa Rican species of *Caulopsis*

Species	Ovipositor	Mirror	Stridulatory file	Fastigium
<i>cuspidata</i>	at most as long as hind femur (Fig. 17B)	slightly longer than wide	proximal end strongly curved 1.75 mm long (Fig. 46F)	usually thick and blunt
<i>microprora</i>	distinctly longer than hind femur (Fig. 17A)	nearly circular	proximal end nearly straight 1.4 mm long (Fig. 46I)	usually pointed

TABLE 13. Body measurements of species of *Caulopsis* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>cuspidata</i>					
male	38.3-39.9, 39±0.6	29.3-31.3, 30.3±0.9	4.4-4.9, 4.7±0.2	13-15.4, 13.9±1.1	na
female	42.7-48.6, 45±2.8	33.2-37.9, 35.1±2.2	4.6-5.5, 5.1±0.4	14.1-16.4, 15.2±1.1	13-16.4, 14.9±1.6
<i>microprora</i>					
male	35.9-43.3, 37.7±2.4	28-33.9, 29.4±1.9	4.3-4.8, 4.4±0.2	11.7-14.4, 13.1±0.8	na
female	47.2-57.2, 53±3.3	37.1-44.2, 40.6±2.5	5.5-6.1, 5.8±0.2	16.1-19.1, 17.6±1	20.3-23.1, 21.6±0.9

of head, pronotum and posterior edges of tegmina ochre or tan; sometimes edges of pronotum with lighter stripes. Stridulatory area of male tegmina light brown.

Remarks.— The genus *Caulopsis* is represented by 12 described species, distributed from California through Mexico, the Caribbean and Central America to Paraguay, Bolivia and Argentina in South America. In Costa Rica it is represented by 2 species.

Caulopsis is closely related to the genus *Neoconocephalus* as well as the Old World genus *Pseudorhynchus* Serville. In fact, some species of the latter are morphologically indistinguishable from *Caulopsis*, and this may represent another case of solely geographic separation of the two “genera,” similar to that of genera *Neoconocephalus*, *Ruspolia* and *Euconocephalus*.

Caulopsis can be easily identified among other Central American Conocephalinae *s.l.* by its extremely slender body form and strongly asymmetrical mouthparts. From the somewhat similar, albeit always larger and more robust species of *Neoconocephalus* it differs in having much longer and more conical fastigium of vertex, which is always touching the fastigium of frons. Also, the metasternum is strongly compressed in its posterior part in all species of *Caulopsis*, resulting in the hind coxa being very close together, nearly touching in some species.

Little is known about the biology of Costa Rican species of the genus. *Caulopsis microprora* is locally common in swampy areas covered with long grasses. The species is nocturnal and seems to feed exclusively on both seeds and leaves of grasses (in captivity some individuals somewhat reluctantly ate carrots but refused to eat any fruit or insect food). *Caulopsis cuspidata* have been observed feeding on a variety of grass species as well as leaves of *Heliconia* sp. within lowland secondary forest. Zayas (1974) reports this species to be an economically important pest species of rice in Cuba. Nothing is known about the acoustic behavior of *Caulopsis* spp.

Caulopsis cuspidata (Scudder, 1878)

Figs. 18B, 36B, 48F-G, Map 11

1878 Scudder, Proc. Bost. Soc. Nat. Hist. 20: 88

>>*Conocephalus cuspidatus*; type locality: Cuba; type depository: Academy of Natural Sciences, Philadelphia - holotype female

1906 Kirby, Syn. Cat. Orth. 2: 240 >>*Caulopsis*

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

[syn.] = *prora* 1879 Scudder, Proc. Bost. Soc. Nat. Hist.

20: >>*Conocephalus*; type locality: Central America: Nicaragua: San Geronismo Palvon; type depository: Academy of Natural Sciences, Philadelphia - holotype female

1906 Kirby, Syn. Cat. Orth. 2: 240 >>*Caulopsis*

1925 Hebard, M., Trans. Amer. Entomol. Soc. 51: 300 >>synonym of *Caulopsis cuspidata*

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description.— General characteristics as described above. Stridulatory file of male 1.75 mm long, with 110 teeth, maximum width of file 79 µm; proximal end of file strongly curved, with teeth considerably smaller than on the remainder of file (Figs. 48F-G). Mirror of stridulatory apparatus approximately oval, somewhat longer than wide. Fastigium of vertex usually at least 3 times as long as eye diameter, somewhat dilated midlength when seen from above, and blunt apically.

Ovipositor at most as long as hind femur, sometimes shorter (ratio ovipositor/hind femur 0.92-1.04), distinctly downcurved (Fig. 18B).

Measurements.— Table 13.

Distribution.— This species, originally described from Cuba, has been recorded also from Mexico, Honduras, and Nicaragua. Reports of this species from South

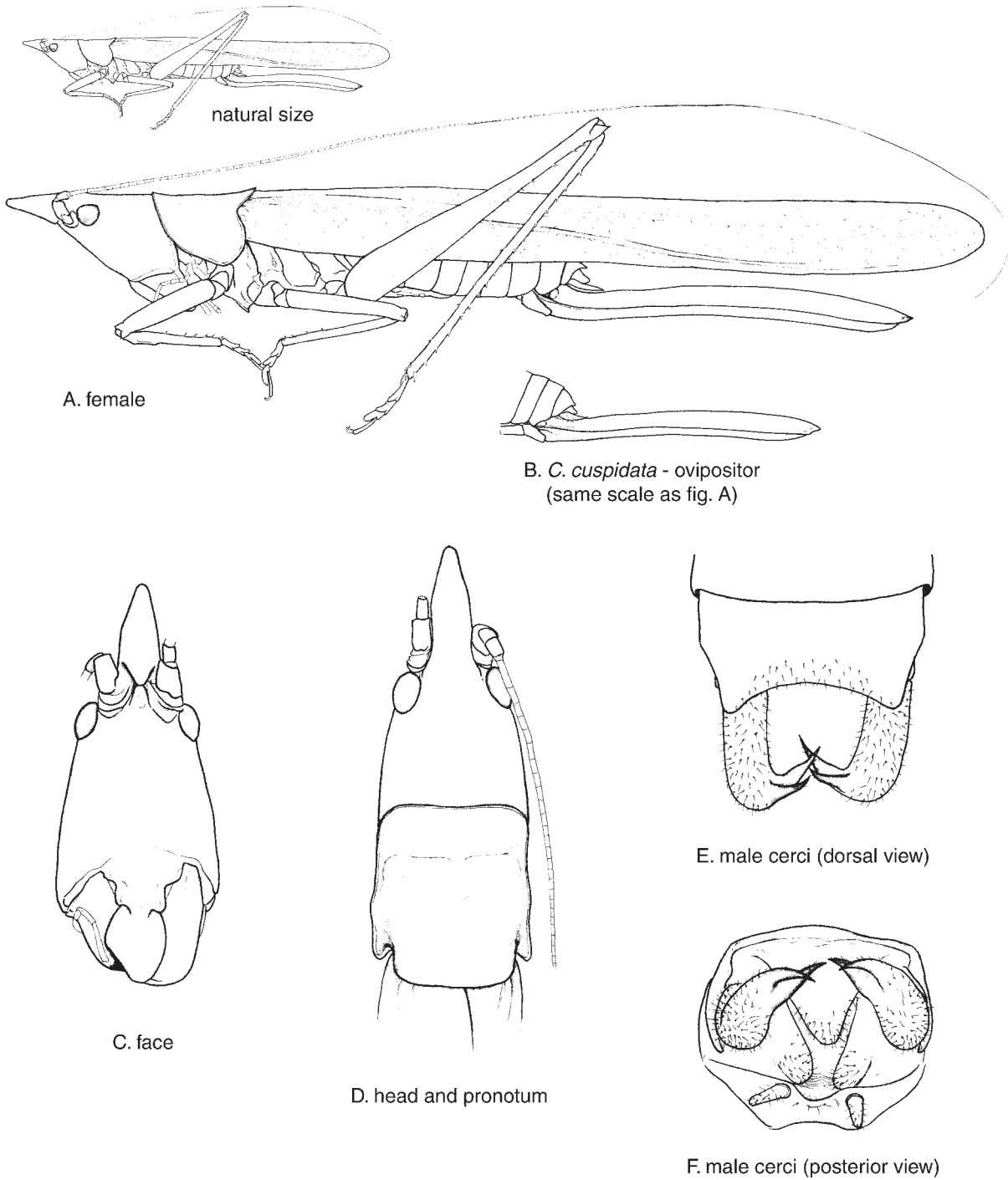


FIG. 18. Costa Rican species of *Caulopsis*. A, C-F. *C. microprora*: A. female - habitus, C. female face, D. female head and pronotum, dorsal view, E. male cerci, dorsal view, F. male cerci, posterior view; B. *C. cuspidata* - ovipositor.

America (Surinam, Brazil, Venezuela, Bolivia) (Redtenbacher 1891, Karny 1907) belong, according to Hebard (1925), to a closely related, but distinct species. In Costa Rica, *C. cuspidata* seems to be restricted in its distribution to the Pacific part of the country (Map 11).

Material examined.— **COSTA RICA: Alajuela Prov.**, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 8 - 24 August 1992 (coll. K. Flores) - 1 female (INBio); Playuelas, Caño Negro, R.N.V. S Caño Negro, elev. 20 m, 10 - 31 October 1992 (coll. K. Martínez) - 1 male (INBio); same locality, elev. 20 m, 31 December 1992 (coll. K. Martínez) - 1 male, 1 female (INBio); **Guanacaste Prov.**, 11 km S. Cañas Taboga, elev. 12 m, 10° 19' N, 85° 9' W, 10 March 1969 (coll. D.C. Rentz) - 1 female (ANIC); same locality, 10° 19' N, 85° 9' W, 19 July 1973 (coll. D.C. Rentz and K.R. Brodey) - 1 male (ANIC); 3 km NO de Nacaome, P.N. Barra Honda, elev. 100 m, 13 - 30 November 1992 (coll. M. Reyes) - 1 male, 1 female (INBio); same locality, elev. 100 m, 15 October 1993 (coll. M. Reyes) - 1 female (INBio); Finca Jenny, 31 km N Liberia, elev. 300 m, 15 September 1988 (coll. GNP Biodiversity Survey) - 1 male, 1 female (INBio); same locality, elev. 300 m, 15 October 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, elev. 300 m, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); Playas del Coco, 22 March 1965 (coll. J.B. Karren) - 1 male (ANSP); Santa Rosa N. P., 27 July 1979 (coll. D.H. Janzen) - 1 male (USNM); Santa Rosa N. P., Playa Naranjo, 26 January 1994 (coll. P. Naskrecki) - 1 female (PN collection); **Puntarenas Prov.**, Est Esquinas, Península de Osa, elev. 0 m, 15 January 1993 (coll. F. Quesada) - 1 male (INBio); Península de Osa, Estac. Esquinas, 15 January 1993 (coll. M. Segura) - 1 female (INBio); Rancho Quemado, Península de Osa, elev. 200 m, 12 - 24 May 1993 (coll. A. Gutiérrez) - 1 male (INBio); **CUBA**: 1 female (holotype) (ANSP).

Caulopsis microprora Hebard, 1926

Figs. 18A, 18C-F, 48H-I, Map 11

1926 Hebard, Trans. Amer. Ent. Soc. 52: 333; type locality: Colombia: Magdalena, Aracataca; type depositary: Academy of Natural Sciences, Philadelphia - holotype male
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description.— General characteristics as described above. Stridulatory file of male 1.4 mm long, with 110 teeth, maximum width of file 80 µm; proximal end of file nearly straight, with teeth considerably smaller than

on the remainder of file (Figs. 48H-I). Mirror of stridulatory apparatus nearly circular. Fastigium of vertex usually about 2 to 2.5 times as long as eye diameter, with sides evenly converging when seen from above, and pointed apically (Fig. 18D).

Ovipositor distinctly longer than hind femur (ratio ovipositor/hind femur 1.12-1.27), distinctly downcurved (Fig. 18A).

Measurements.— Table 13.

Distribution.— This species is distributed from Nicaragua and Costa Rica throughout Panama to Colombia (Map 11).

Material examined.— **COSTA RICA: Diria**, 14 March 1916 (coll. A. Alfaro) - 1 female (ANSP); **Cartago Prov.**, I.I.A.C., Turrialba, 27 July 1965 (coll. R.D. Sage and S.J. Arnold) - 1 female (EMEC); Turrialba, 4 - 13 August 1970 (coll. J. and M. Sedlacek) - 1 male, 1 female (BPBM); Turrialba, Agr. Sta., 10 February 1966 (coll. H.R. Roberts) - 1 female (ANSP); **Heredia Prov.**, Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 2 females (ALAS, INBio); Puerto Viejo, 6 April 1969 (coll. D.C.F. Rentz) - 1 male (ANIC); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 - 4 April 1994 (coll. P. Naskrecki) - 2 males, 3 females, 2 nymphs (PN collection); same locality, 14 October 1995 (coll. P. Naskrecki) - 3 males, 3 females, 6 nymphs (ALAS); same locality, 30 November 1995 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); **Puntarenas Prov.**, Estac. Esquinas, Península de Osa, elev. 200 m, 29 December 1992 (coll. A. Gutiérrez) - 1 male (INBio); Est Esquinas, Península de Osa, elev. 0 m, 15 January 1993 (coll. F. Quesada) - 1 male (INBio); Las Cruces, 1 July - 31 August 1991 (coll. J. Doubles) - 1 male (UMMZ); Rancho Quemado, Península de Osa, elev. 200 m, 12 - 24 May 1993 (coll. A. Gutiérrez) - 1 male (INBio); **PANAMA: Canal Zone**, Barro Colorado, 19 July 1924 (coll. N. Banks) - 1 male (MCZC); Pipeline rd., NW of Gamboa, 21 January 1975 (coll. D.C. Rentz) - 1 male (ANIC); **COLOMBIA: Magdalena**, Aracataca, 8 August 1920 - 3 males (holotype and paratypes), 1 female (allotype) (ANSP); Medellín, Verra Cruz, (coll. M. Hyde) - 1 female (ANSP).

ERIOLOIDES Hebard, 1927

(Scimitars)

- 1927 Hebard, Trans. Amer. Ent. Soc. 53: 141; type species: *Eriolus consobrinus* Pictet et Saussure, 1898, by original designation
 1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Diagnosis

Slender to quite robust; both sexes macropterous (Figs. 19A, 21A). Fastigium of vertex short, 1-1.5 times as long as diameter of eye; apex of fastigium blunt or acute. Head robust, frons flat or weakly convex; genae with weakly developed lateral carinae. Male cercus variable but nearly always biramose apically. Ovipositor unique, broad, with distinctly truncated apex (Fig. 19H).

Description (male except where specified)

Head. — Fastigium of vertex short, 1-1.5 times as long as eye diameter and 1-1.5 as wide as scapus; apex of fastigium blunt or acute; fastigium of vertex separated from fastigium of frons by small gap; occasionally fastigium of vertex with small ventral tooth at base; dorsal surface of fastigium smooth or somewhat rugose. Antennal sockets separated by distance equal to 0.3-0.5 diameter of eye. Eyes globose, weakly protruding. Frons flat or weakly convex; genae with moderately developed lateral carinae.

Thorax and wings. — Dorsal surface of pronotum smooth to moderately rugose, flat; anterior margin of pronotum straight, posterior margin straight or convex; lateral lobes with posterior angle rounded to almost acute. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobes of pronotum. Thoracic sternum unarmed.

Wings in both sexes fully developed, surpassing apices of hind femora by 1/6 to 1/2 their length. Stridulatory apparatus of male well developed; stridulatory file straight (Figs. 49A-F), with high number (160-230) of relatively very wide, lamelliform, closely spaced teeth; stridulatory area of left wing devoid of secondary venation; mirror of right wing rectangular or nearly square, with well developed veinlet next to AA₁. Posterior margin of front wing straight or weakly concave; apex of front wing narrowly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; middle and hind coxa without spine; all trochanters unarmed. Femora unarmed dorsally, but armed ventrally on both margins, sometimes posterior ventral margins of fore and/or mid femora unarmed; genicular lobes of all femora armed with sharp spines, occasionally lobes on fore and mid femora unarmed. Front tibia unarmed dorsally, both ventral margins with short, immovable spines; tympanum on fore tibia bilat-

erally closed, tympanal slits facing forward, tympanal area moderately swollen; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with surface smooth, its posterior margin weakly to distinctly incised, sometimes posterior margin of 10th tergite forming two pointed or rounded lobes; supraanal plate in both sexes small, broadly rounded apically; male cercus variable but nearly always biramose, rarely without subapical spine or lobe (Figs. 19D-E, 21D, 22B-J); titillators extremely variable, from flat, covered with cuticular scales and poorly differentiated from phallic membrane to well developed, needle-like; female cercus, simple, narrowly conical. Subgenital plate of male with well developed ventral keel and deep, triangular apical incision; styli short, 1.5-2.5 times as long as thick; female subgenital plate either triangular, with triangular apical incision, or much wider than long, with weakly emarginated apex. Ovipositor unique among Tettigoniidae, distinctly widened midlength, and with characteristic, obliquely truncated apex; apex thickened, heavily sclerotized; upper valvula usually with series of pegs or small teeth forming a file along its longitudinal axis, and with a similar series of pegs just below upper edge of valvula (Fig. 19H); ovipositor distinctly shorter than to as long as hind femur (ratio ovipositor/hind femur 0.6-1.1).

Coloration. — General coloration pale green; frons green, sometimes lower portion of frons brown or black; labrum sometimes black; mandibles black, brown, green to strikingly emerald green. Legs and abdomen green; tegmina often with contrastingly yellow venation.

Remarks. — The genus *Erioloides* is currently a subject of a taxonomic revision and phylogenetic analysis (Naskrecki and Cohn, in prep.). It includes over 20 species (both described and yet undescribed), distributed from Mexico, throughout the Caribbean and Central America, to the northern portion of South America. Below we redescribe 4 species known from Costa Rica and describe 4 new ones.

Little is known about the biology and behavior of the species of *Erioloides*. In Costa Rica, probably all species are exclusively arboreal and can be collected by canopy fogging or at lights. At La Selva Biological Station, nymphs of *E. consobrinus* have been collected from the tree *Trema micranta* (L.) Blume (Ulmaceae), and both nymphs and adults from the tree *Virola koschnyi* Warb. (Myristicaceae). *Erioloides consobrinus* and *E. longipennis* frequently come to lights. Nothing is known about the natural diet of *Erioloides* spp. but in captivity they thrived for several months on a diet of various fruits and vegetables.

TABLE 14. Key for identification of Costa Rican species of *Erioloides*









Species	Tegmina	Face	Male cerci D = dorsal L = lateral	Titillators	Stridulatory file
<i>longipennis</i>	surpassing apices of hind femora by 1/2 of their length	upper portion green; lower portion of face, upper portion of clypeus and mandibles brown; labrum yellow	long, incurved, with or without small subapical spine (D) 	long, needle-like (Figs. 18F-G)	1.2-1.3 mm long with about 160-180 teeth
<i>macrocephalus</i>	surpassing apices of hind femora by 1/2 of their length	upper portion of face green; lower portion of face, upper portion of clypeus and mandibles black; labrum yellow	apex constricted, subapical spine always present (D) 	strongly flattened, squamose, apices dilated (Fig. 19F)	1.8 mm long with about 190 teeth
<i>brevipennis</i>	surpassing apices of hind femora by only 1/6 of their length	light green, labrum yellow	with apical and subapical spines (D) 	strongly flattened, squamose, apices blunt (Fig. 20E)	2.3 mm long, with about 180 teeth
<i>longinoi</i>	surpassing apices of hind femora by 1/2 of their length	green, mandibles sometimes brightly emerald green, labrum black	thick, with blunt, hook-like spine (L) 	strongly flattened, squamose, apices dilated (Fig. 22A)	1.2 mm long with about 240 teeth
<i>consobrinus</i>	surpassing apices of hind femora by 1/2 of their length	green, mandibles sometimes brightly emerald green, labrum black	cylindrical, with blunt, hook-like spine (L) 	flattened, squamose, apices divergent (Fig. 22B)	1.2 mm long with about 230 teeth
<i>acutidentis</i>	surpassing apices of hind femora by 1/2 of their length	green, mandibles sometimes brightly emerald green, labrum black	cylindrical, with acute, spur-like spine (L) 	poorly defined, blunt, squamose (Fig. 22C)	1.0 mm long with about 180 teeth
<i>sikesi</i>	surpassing apices of hind femora by 1/2 of their length	green, mandibles sometimes brightly emerald green, labrum black	cylindrical, with blunt, spur-like spine (L) 	flattened, blunt, squamose (Fig. 22D)	1.4 mm long with about 200 teeth
<i>laticobinus</i>	surpassing apices of hind femora by 1/2 of their length	green, mandibles sometimes brightly emerald green, labrum black	cylindrical, with bluny, finger-like spine (L) 	flattened, blunt, squamose (Fig. 22E)	1.1 mm long with about 220 teeth

TABLE 15. Body measurements of species of *Erioloides*
(all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>longipennis</i>					
male	42.7-53.9, 48.1±4.3	34.4-43, 38.8±3.5	8.7-10.3, 9.2±0.6	13.6-17.4, 15.8±1.6	na
female	52.5-64.2, 57.1±4.3	42.2-51.8, 46.2±3.5	8.8-9.9, 9.3±0.6	17.2-19.3, 18.2±0.8	16.3-17.7, 17±0.5
<i>macrocephalus</i>					
male	51-56.7, 53.9±4	36.5-43.5, 40±4.9	11.5-11.7, 11.6±0.1	17.5-20, 18.8±1.8	na
female	61.7-65, 63.4±2.3	48.6-50.1, 49.4±1.1	11.9-12, 12±0.1	20.3-20.4, 20.4±0.1	21.2-21.7, 21.5±0.4
<i>brevipennis</i>					
male	24.9-30.9, 27.3±3.2	16.6-21.3, 18.6±2.4	6.3-7.1, 6.6±0.4	11.4-14, 12.4±1.4	na
female	29.8-31.2, 30.7±0.8	21.4-22.4, 21.9±0.5	5.9-6.4, 6.1±0.3	13.1-13.6, 13.3±0.3	9.9-10.3, 10.1±0.3
<i>consobrinus</i>					
male	31.1-37.9, 34.1±2.8	24.8-30.2, 27.3±2.2	4.7-6.1, 5.4±0.6	11-14, 12.3±1.5	na
female	34.7-37.5, 36.4±1.2	27.9-30.2, 29.3±1	4.8-5.4, 5.2±0.3	11.8-13.2, 12.4±0.6	7.2-8.3, 7.9±0.6
<i>longinoi</i>					
male	32.4-37.2, 36.1±1.6	25.8-29.7, 28.9±1.3	5.7-6.3, 6±0.2	11.9-12.9, 12.5±0.3	na
female	39.5-41.5, 40.2±1.1	31.1-34.1, 32.3±1.6	5.9-6.2, 6.1±0.2	12.8-14.1, 13.3±0.7	9.4-9.8, 9.7±0.2
<i>acutidentis</i>					
male	27.7	20.5	5.0	10.9	na
female	31.8	24.1	5.7	11.8	9.6
<i>sikesi</i>					
male	26.6	19.7	5.4	10.1	na
female	-	-	-	-	-
<i>laticobinus</i>					
male	32.7-35.3, 34.1±1.2	26.2-28.7, 27.5±1.1	5.3-5.8, 5.6±0.2	11.3-11.9, 11.6±0.2	na
female	42-45.4, 43.7±2.4	33.7-36.5, 35.1±2	5.9-6.5, 6.2±0.4	13.8-13.8, 13.8±0	10.2-10.7, 10.5±0.4

Little is known about the acoustic behavior of the species of the genus and only *E. brevipennis* has been recorded (see below). Females oviposit in plant tissues, using their highly modified ovipositor as a saw, making deep incisions in stems of various plants (Fig. 37A). Eggs are thin, spindle-shaped (Fig. 38C). In captivity, nymphs of *E. longipennis* hatched after about 3 weeks after oviposition.

Identification of species of *Erioloides* can be difficult, as many species differ only in details of the male concealed genitalia and the stridulatory apparatus. In many cases, females cannot be identified based on morphological criteria and can only be assigned to a species if collected with a male individual (the fact of occurrence at the same locality as a male is not evidence of conspecificity — frequently two or more species of *Erioloides* occur at the same location).

Erioloides longipennis (Redtenbacher, 1891) n. comb.
(Long-winged scimitar)
Figs. 19A-H, 37A, 38C, 49A-B, Map 14

1891 Redtenbacher, Monogr. Conoceph.: 350 >>*Eriolus*;
type locality: Costa Rica, San José; type deposi-
tory: Naturhistorisches Museum, Vienna —
holotype male.

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD
ROM) >>holotype illustrated

Diagnostic description. — General characteristics as described above. Body large, relatively slender; wings in both sexes surpassing apices of hind femora by about half their length (Fig. 19A, 37A). Fastigium of vertex blunt, about as long as eye diameter and as wide as 1.2 of scapus (Fig. 19B). Face slightly convex; genal carinae

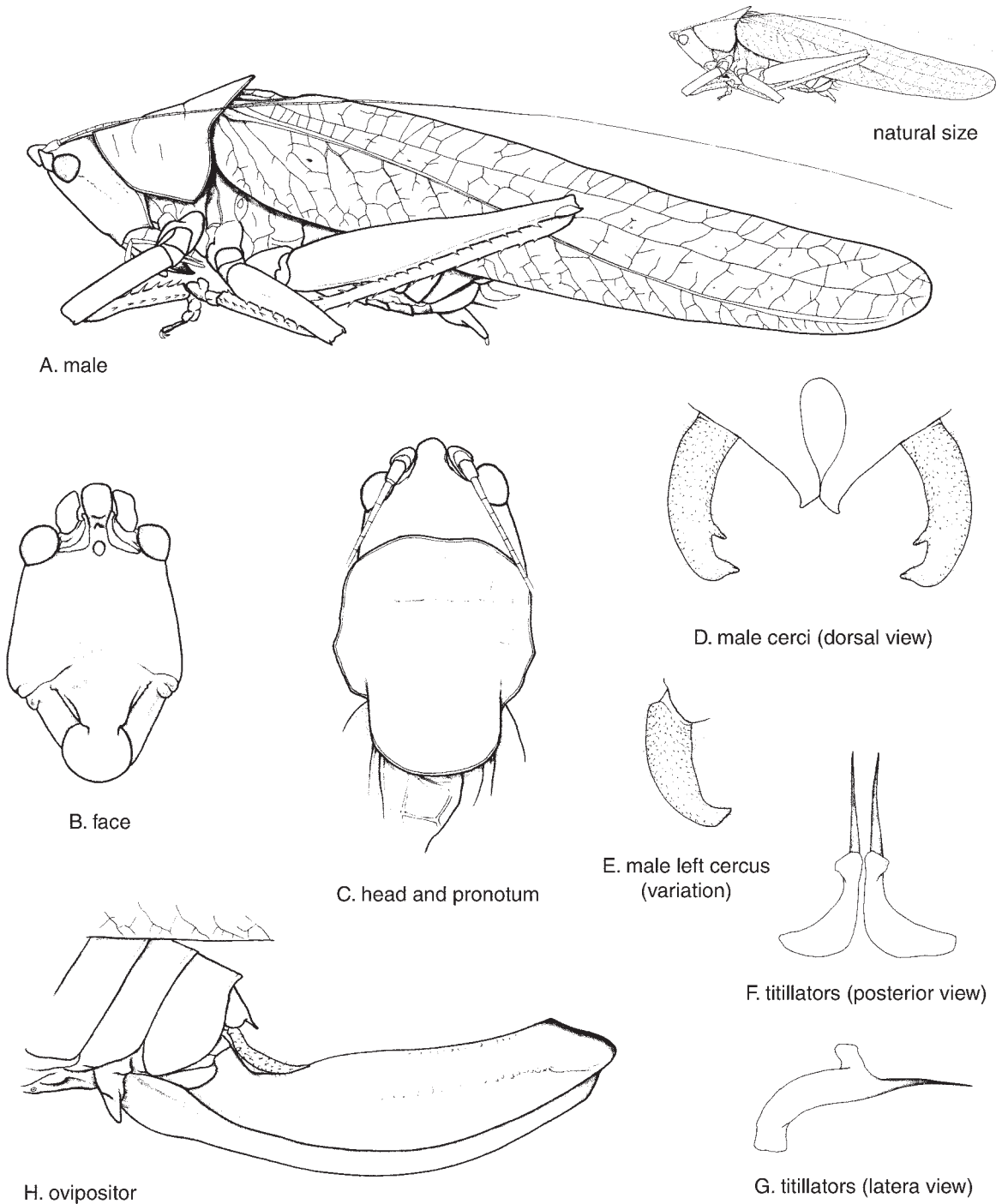


FIG. 19. *Erioloides longipennis*. A. male - habitus, B. male face, C. male head and pronotum, dorsal view, D. male cerci, dorsal view, E. male left cercus - variation, dorsal view, F. titillators, posterior view, G. titillators, lateral view.

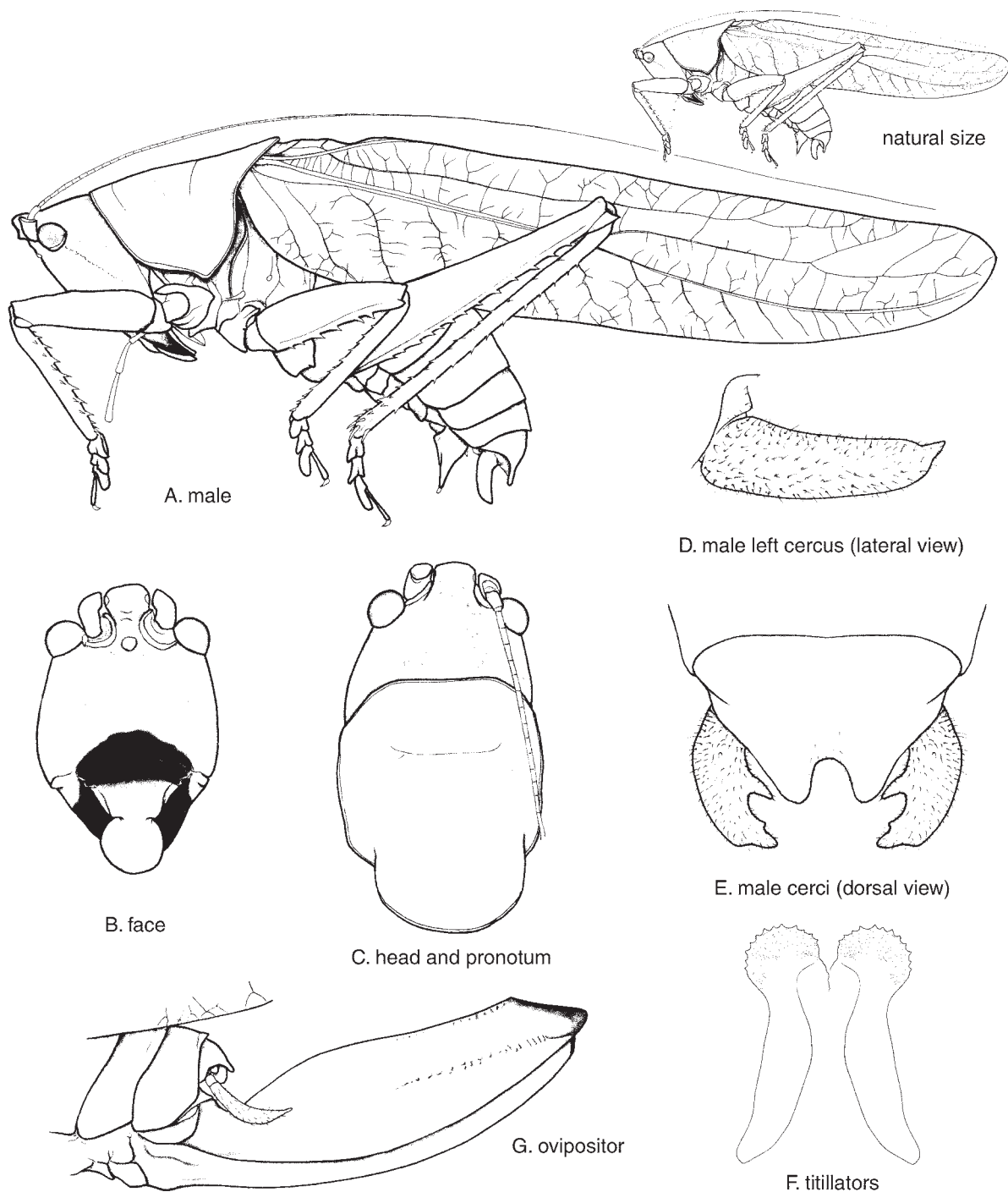


FIG. 20. *Erioloides macrocephalus*. A. male - habitus, B. male face, C. male head and pronotum, dorsal view, D. male left cercus, lateral view, E. male cerci, dorsal view, F. titillators, dorsal view.

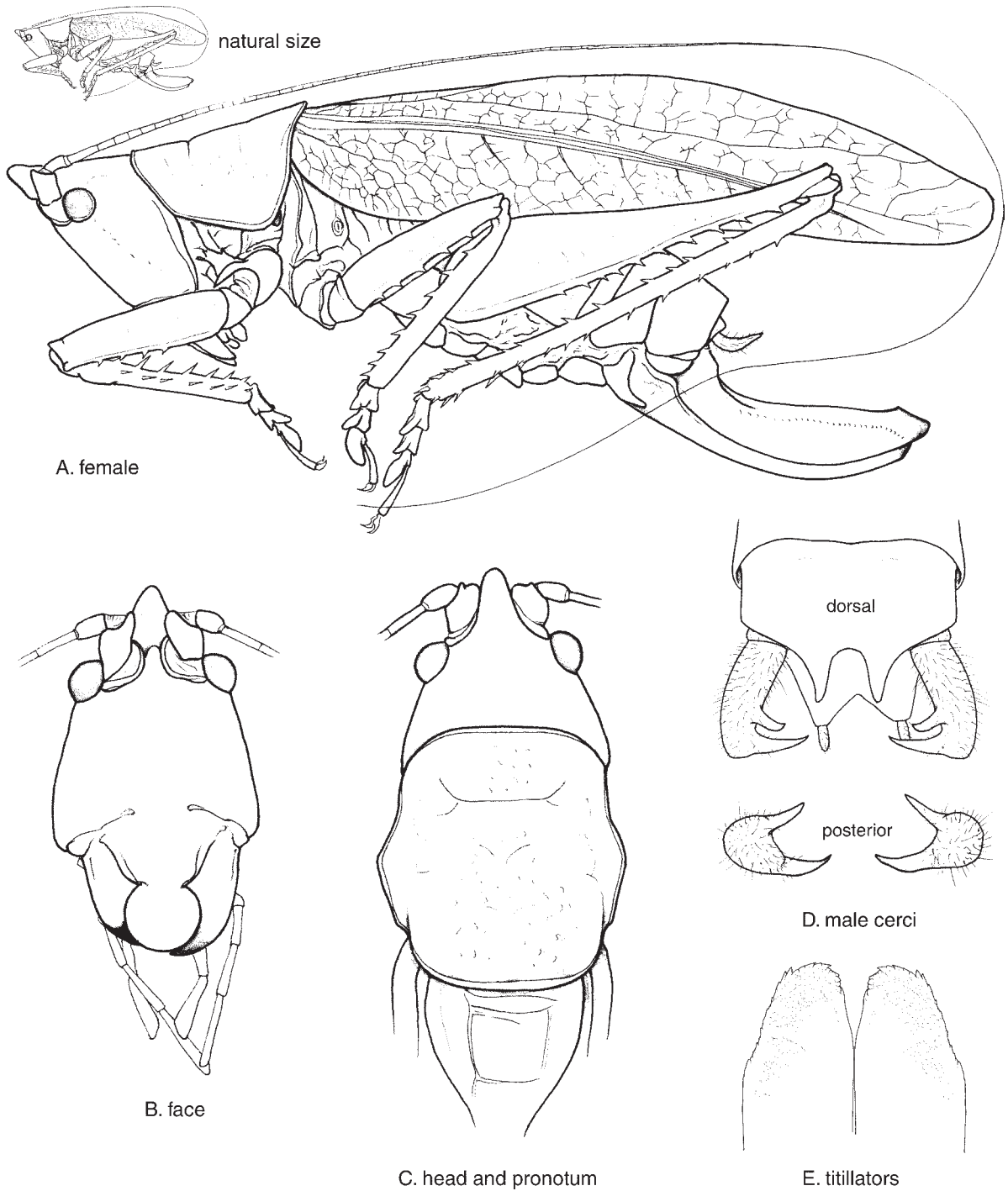


FIG. 21. *Erioloides brevipennis*. A. female - habitus, B. male face, C. male head and pronotum, dorsal view, D. male cerci, dorsal and posterior views, E. titillators, dorsal view.

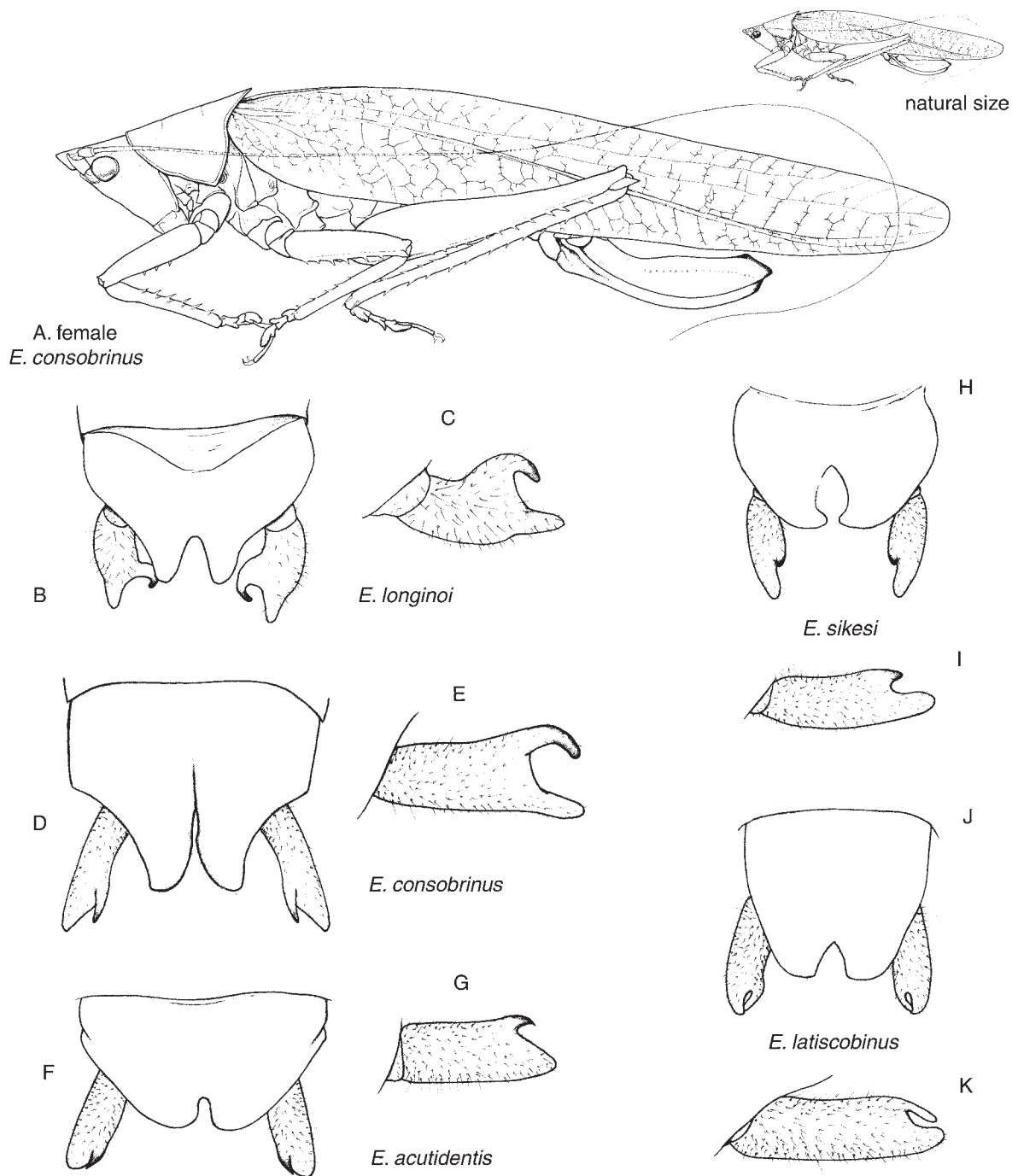


FIG. 22. Costa Rican species of *Erioloides*. A. *E. consobrinus* - female, habitus, B. *E. longinoi* - male cerci, dorsal view, C. *E. longinoi* - male left cercus, lateral view, D. *E. consobrinus* - male cerci, dorsal view, E. *E. consobrinus* - male left cercus, lateral view, F. *E. acutidentis* - male cerci, dorsal view, G. *E. acutidentis* - male left cercus, lateral view, H. *E. sikesi* - male cerci, dorsal view, I. *E. sikesi* - male left cercus, lateral view, J. *E. laticobinus* - male cerci, dorsal view, K. *E. laticobinus* - male left cercus, lateral view.

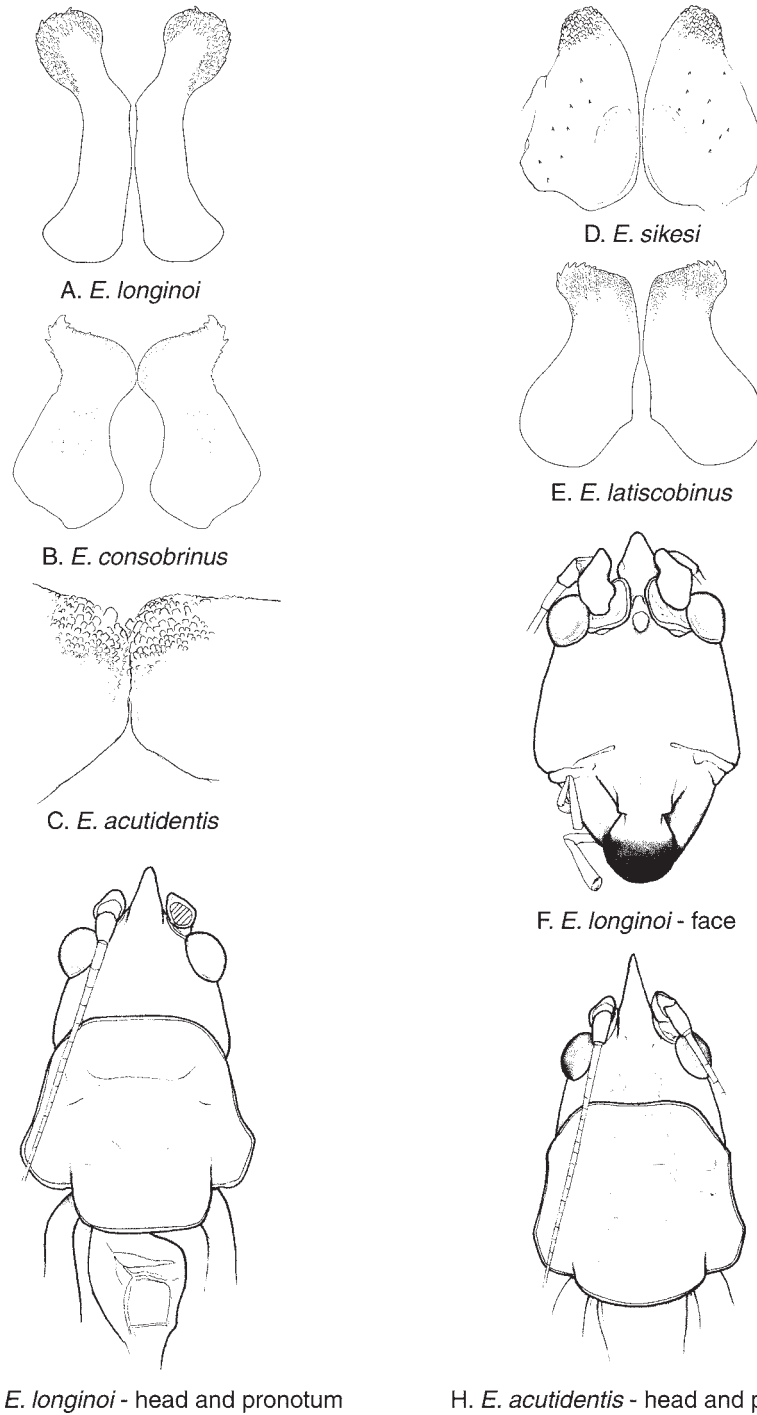


FIG. 23. Costa Rican species of *Erioloides*. **A-E.** titillators, dorsal views: **A.** *E. longinoi*, **B.** *E. consobrinus*, **C.** *E. acutidentis*, **D.** *E. sikesi*, **E.** *E. laticobinus*, **F.** *E. longinoi* - male face, **G.** *E. longinoi* - male head and pronotum, dorsal view, **H.** *E. acutidentis* - male head and pronotum, dorsal view.

of head poorly developed but usually discernible. Dorsal surface of pronotum smooth, shiny; flat; anterior margin of pronotum straight, posterior one convex (more so in males than in females) (Fig. 19C); lateral lobes of pronotum about 1.8 times longer than high, their surface distinctly rougher than that of pronotal dorsum. Male stridulatory file straight, 1.2-1.3 mm long, 157-158 μm wide, with 163-178 very closely spaced and relatively very wide, lamelliform teeth; teeth in proximal half of file much thinner and more closely arranged than in distal part; sometimes teeth at proximal end of file peg-like, irregularly scattered (Figs. 49A-B); mirror approximately rectangular, only slightly longer than wide; secondary veinlet next to AA_1 present, well developed; stridulatory area of left wing devoid of secondary venation, secondary veinlet next to AA_1 present, divergent from AA_1 .

Male 10th tergite with two slender, divergent lobes (Fig. 19D); female 10th tergite with deep, narrowly triangular incision. Male cercus relatively long and slender for the genus, distinctly incurved; its apex attenuated but blunt; subapical inner spine small, occasionally absent, blunt (Figs. 19D-E). Female cercus simple, elongately conical, distinctly curved. Titillators in shape of paired needles, their bases weakly sclerotized, L-shaped when seen from above, and downcurved if seen from side (Figs. 19F-G). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate widely triangular, with small, triangular apical incision. Ovipositor robust, with distinct file of pegs along midline of upper valvula, and small, oblique lamella below apex (Fig. 19H); ratio ovipositor/hind femur 0.90-0.95.

Coloration. — General coloration bright green (Fig. 37A). Upper portion of face green, lower portion of face, upper half of clypeus, and mandibles light brown; lower half of clypeus and labrum yellow (Fig. 19B). Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green; ovipositor brown, with dark, nearly black apex.

Measurements. — Table 15.

Bioacoustics. — Call unknown.

Remarks. — This species is known from Belize, Costa Rica, and Panama. A similar, still undescribed species, different in the details of the stridulatory apparatus and male genitalia occurs in Guatemala. In Costa Rica *E. longipennis* is distributed over the entire country (although I have no records of this species from Puntarenas Prov., undoubtedly it occurs there as well). Rehn's (1905) record of *Eriolus spiniger* from Tarbaca (San José Prov.) is in fact a record of a female of *E. longipennis*.

Little is known about its biology. Adults sometimes

come to light and females have been seen depositing eggs in the stem of various understory plants (Fig. 37A), using the ovipositor in a saw-like manner. Eggs are elongate, about 5.8 mm long and 0.9 mm wide. In captivity, nymphs hatched from eggs laid in stem of *Heliconia* sp. after about 3 weeks but none survived beyond the second nymphal instar. Both the adults and nymphs ate carrots, apple, corn, and lettuce.

Material examined. — **COSTA RICA:** locality unknown (coll. P. Biolley) - 1 male (UMMZ); Boucard, - 1 male (NHMW); **Alajuela Prov.**, Finca San Gabriel, 2 km SW Dos Rios, elev. 600 m, 15 May 1989 (coll. GNP Biodiv. Survey) - 1 female (INBio); **Guanacaste Prov.**, Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 18 - 23 July 1993 (coll. C. Moraga) - 4 males (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 December 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 May 1989 (coll. GNP Biodiversity Survey) - 2 females (INBio); Estac. Cacao, SW side Volcán Cacao, elev. 1000 - 1400 m, 1 December 1989 (coll. R. Blanco and C. Chávez) - 2 females (INBio); same locality, elev. 1000 - 1400 m, 15 March 1990 (coll. GNP Biodiv. Survey) - 1 male (INBio); Vicinity Estac. Murciélago, 8 km SW Cuajiniquíl, elev. 100 m, 15 February 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); **Heredia Prov.**, Est. Magsasay, P. N. Braulio Carillo, elev. 200 m, 15 January 1991 (coll. M. Bareller) - 3 males (INBio); Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 1 female (INBio); same locality, elev. 90 m, 9 - 30 October 1992 (coll. M. Ortiz) - 1 female (INBio); same locality, elev. 90 m, 9 - 30 November 1992 (coll. M. Ortiz) - 1 female (INBio); same locality, elev. 90 m, 22 December 1992 (coll. M. Ortiz) - 1 female (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 10 - 15 November 1995 (coll. P. Naskrecki) - 1 female (PN collection); **Limón Prov.**, Amubri, Talamanca, elev. 70 m, 22 July 1992 (coll. G. Gallardo) - 1 female (INBio); Cerro Tortuguero, Tortuguero N. P., elev. 0 - 120 m, 15 June 1990 (coll. E. Quesada) - 1 female (INBio); Cuatro Esquinas, Tortuguero N. P., 15 September 1989 (coll. J. Solano) - 1 female (INBio); same locality, elev. 100 m, 15 January 1990 (coll. J. Solano) - 1 female (INBio); **San José Prov.**, San José - 1 male (holotype) (NHMV); Tarbaca, 15 November 1902 (coll. C.F. Underwood) - 1 female (ANSP); **BELIZE:** Dangriga distr., Twin Cays, 5 June 1985 (coll. T.L. Erwin, L.L. Sims, W.N. Mathis) - 1 male (USNM); **PANAMA:** Canal Zone, Barro Colorado Isl., 12 February 1956 (coll. C. Rettenmeyer) - 1 female.

Erioloides macrocephalus (Carl, 1908) n. comb.
(Big-headed scimitar)
Figs. 20A-G, 49C, Map 14

1908 Carl, Rev. Suisse Zool. 16: 132. >>*Eriolus*; type locality: Costa Rica, Monte Aquacate, 600 m; type depository: Museum d'Histoire Naturelle, Geneva – holotype female

Diagnostic description. — General characteristics as described above. The largest species of the genus, body robust; wings in both sexes surpassing apices of hind femora by about half their length (Fig. 20A). Fastigium of vertex blunt, about as long as eye diameter and twice as wide as scapus (Fig. 20B). Face convex, distinctly punctate; genal carinae of head poorly developed but usually discernible. Dorsal surface of pronotum relatively rugose; flat; anterior margin of pronotum straight, posterior one convex (Fig. 20C); lateral lobes of pronotum about 1.7 times longer than high. Male stridulatory file straight, 1.8 mm long, 229 μ m wide, with 187 closely spaced and relatively very wide, lamelliform teeth; teeth in proximal half of file much thinner and more closely arranged than in distal part; teeth on proximal end of file peg-like, irregularly clustered (Fig. 49C); mirror approximately rectangular, slightly longer than wide; secondary veinlet next to AA₁ present, well developed; stridulatory area of left wing devoid of secondary venation, secondary veinlet next to AA₁ present, somewhat divergent from AA₁.

Male 10th tergite with two short, rounded lobes (Fig. 20E); female 10th tergite with deep, narrowly triangular incision. Male cercus relatively robust, distinctly incurved; its apex constricted; subapical inner spine small, blunt (Figs. 20D-E). Female cercus simple, elongately conical, distinctly curved. Titillators flattened, squamose, distinctly dilated apically, apices multidentate (Fig. 20F). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate widely triangular, with wide, semicircular incision at apex. Ovipositor robust, with distinct file of pegs along midline of upper valvula (Fig. 20G); ratio ovipositor/hind femur 1.04-1.07.

Coloration. — General coloration light green. Upper portion of face green, lower portion of face, upper half of clypeus, and mandibles black; lower half of clypeus and labrum yellow (Fig. 20B). Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green; ovipositor brown, with dark, nearly black apex.

Measurements. — Table 15.

Bioacoustics. — Call unknown.

Remarks. — This species is known only from a few individuals collected in Costa Rica (southern Puntarenas Prov.) (Map 14) and Panama. Nothing is known about its biology except that individuals of *E. macrocephalus* sometimes come to light, suggesting nocturnal activity.

Material examined. — **COSTA RICA: Puntarenas Prov.**, Aquas Buenas, Centro Juvenil Tropical, elev. 100 m, 3 - 13 July 1997 (coll. A. Azofeifa) - 1 female (INBio); Bosque Esquinas, Península de Osa, elev. 200 m, 1 - 30 May 1994 (coll. J. Quesada) - 1 female (INBio); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 February 1994 (coll. G. Fonseca) - 1 male (INBio); **PANAMA: Chiriquí Prov.**, 16 February 1960 (coll. D.F. Veirs) - 1 male (ANIC).

Erioloides brevipennis (Redtenbacher, 1891) n. comb.
(Short-winged scimitar)
Figs. 21A-E, 49D, 51G-H, Map 14

1891 Redtenbacher, Monogr. Conoceph.: 351 >>*Eriolus*; type locality: Guatemala; type depository: Naturhistorisches Museum, Vienna – holotype male

1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description. — General characteristics as described above. Body small, robust; wings in both sexes surpassing apices of hind femora by only 1/6 of their length (Fig. 21A). Fastigium of vertex blunt, about 1.5 times as long as eye diameter and about as wide as scapus (Fig. 21B). Face slightly convex, smooth; genal carinae of head poorly developed and sometimes hardly discernible. Dorsal surface of pronotum relatively rugose, flat in females, metazona slightly raised in males; anterior margin of pronotum straight, posterior one straight to weakly convex (Fig. 21C); lateral lobes of pronotum about 1.8 times longer than high. Male stridulatory file straight, 2.3 mm long, 192 μ m wide, with 178 closely spaced and relatively wide, lamelliform teeth; teeth arranged evenly along entire length of file (Fig. 49E); mirror approximately square, only slightly longer than wide; secondary veinlet next to AA₁ present, well developed; stridulatory area of left wing devoid of secondary venation, secondary veinlet next to AA₁ present, somewhat divergent from AA₁.

Male 10th tergite with two narrow, pointed lobes (Fig. 21D); female 10th tergite with deep, narrowly triangular incision. Male cercus relatively slender, straight; its apex armed with large spine bent under right angle, and similar but somewhat smaller spine located dorsally, subapically (Fig. 21D). Female cercus simple, elongately conical, distinctly curved. Titillators flattened, broad, squa-

mose, somewhat narrowed towards apices (Fig. 21E). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate triangular, with deep, triangular incision at apex. Ovipositor relatively slender, with distinct file of pegs along midline of upper valvula (Fig. 21A); ratio ovipositor/hind femur 0.73-0.77.

Coloration.— General coloration light green; face green, labrum yellow; pronotum sometimes with two thin, light bands along lateral, dorsal edges; posterior edge of metazona in male with reddish-brown markings (Fig. 21C). Tegmina green, with yellow venation; posterior margins of tegmina behind stridulatory apparatus in male reddish. Legs green; abdomen light green; ovipositor green, with brown apex.

Measurements.— Table 15.

Bioacoustics.— The call of *E. brevipennis* consists of series of short buzzes produced every 1.6-4.1 s (avrg. 2.38±0.8, n=12 at 28°C) (Fig. 51-G-H). Each buzz lasts 0.28-0.51 s (avrg. 0.35±0.06, n=13) and consists of 19-34 individual pulse trains (chirps). Most of the energy of the call seems to be allocated in the acoustic range, between 11 and 17 kHz.

Males start singing after dusk from tall shrubs and low trees, about 3-4 m above the ground.

Remarks.— This species is distributed from El Salvador, through Nicaragua to northern Costa Rica (Map 14). A closely related, still undescribed species occurs in Mexico (Oaxaca).

In Guanacaste Prov. *E. brevipennis* is a common species, found frequently on low trees as well as tall grasses on the edge of the forest. I have seen numerous individuals feeding on grass seeds.

Material examined.— **COSTA RICA: Guanacaste Prov.**, Area de Conservacion Guanacaste, Santa Rosa National Park, Estación Santa Rosa, elev. 300 m, 15 January 1989 (coll. GNP Biodiversity Survey) - 1 male, 1 female (INBio); same locality, 20 July 1978 (coll. D.H. Janzen) - 1 male (USNM); same locality, 31 December 1980 (coll. D.H. Janzen and W. Hallwacha) - 1 female (USNM); same locality, elev. 300 m, 1 - 30 June 1995 (coll. D.H. Janzen and W. Hallwacha) - 1 female (INBio); same locality, 21 - 24 August 1999 (coll. P. Naskrecki, D. Otte, G. Morris) - 4 males, 2 females (PN collection); **EL SALVADOR:** La Libertad, 25 February 1974 (coll. Chemnick et al.) - 1 male (UMMZ); San Salvador, Parque Balboa, 6.2 mi. S. San Salvador, 7 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 male (UMMZ); Guatemala: (coll. Dr. Candéze) - 1 male (NHMW); **NICARAGUA:** Madriz, 7.8 mi. SE Somoto on Pan. Amer. Hwy., 26 September 1961 (coll. Hubbell, Cantrall, Cohn) - 1 female (UMMZ).

Frater species group

The following, informal assemblage of species of the genus *Erioloidea* includes a number of cryptic taxa, virtually indistinguishable based on their overall appearance. Besides clearly defined differences in the male genital and stridulatory structures, their size, coloration, and external morphology are nearly identical. Females of these species can only be identified with a fair degree of certainty by comparing their coloration and features of the fastigium of vertex with those of males collected at the same site. Often conspecific males exhibit minor variations in coloration and fastigium morphology among sites, and several species can be found at one location. Therefore, males and females collected from the same locality should not be automatically considered conspecific. The structure of the file (or lamella) on the upper valvula of the ovipositor can help identify some species of the *Frater* species group, but this character is subject to intraspecific variation and should not be used as a definitive key character in identifying females.

Virtually nothing is known about the biology of the species of the *Frater* species group. Occasionally, individuals of these species come to light, and are frequently collected by canopy fogging, indicating a nocturnal, arboreal life. In captivity they ate numerous fruits and vegetables, refusing any insect material. Nothing is known about their bioacoustic behavior.

Erioloidea consobrinus (Pictet and Saussure, 1898)
Figs. 22A, 22D-E, 23B, 48B, 49E, Map 15

- 1898 Pictet and Saussure, Biol. Centr.-Amer.: 382 >> *Eriolus*; type locality: Panama, Volcán de Chiriquí, 25-4000 ft; type depository: The Natural History Museum, London - lectotype male
1912 Karny, in Wytzman, Gen. Ins. 139: 16 >>Syn. of *Eriolus frater* Redtenbacher
1927 Hebard, Trans. Amer. Ent. Soc. 53: 141 >>Designated type species of *Erioloidea*
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>lectotype designated and illustrated

Diagnostic description.— General characteristics as described above. Male stridulatory file straight, 1.2 mm long, 153 µm wide, with 229 closely spaced and very wide, lamelliform teeth; teeth in proximal half of file thinner and more closely arranged than in distal part (Fig. 49E); mirror approximately rectangular, slightly longer than wide; secondary veinlet next to AA₁ well developed, strongly divergent from AA₁; stridulatory area of left wing devoid of secondary venation, distal margin of left mirror concave; secondary veinlet next to AA₁ present, strongly divergent from AA₁.

Male 10th tergite with two long, rounded, clearly divergent lobes (Fig. 22D). Male cercus relatively slender, cylindrical, with large, blunt, hook-like dorsal spine; apex of cercus finger-like (Fig. 22D-E). Female cercus simple, elongately conical, distinctly curved. Tiltators flattened, squamose, distinctly dilated subapically, apices multidentate, narrowed, strongly divergent (Fig. 23B). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate broadly triangular, with small, semicircular incision at apex. Ovipositor relatively slender, with file of pegs along midline of upper valvula (Fig. 22A); ratio ovipositor/hind femur 0.70-0.77.

Coloration.— General coloration light green. Face pale green, mandibles brightly emerald green, labrum dark brown. Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green dorsally; purple ventrally; ovipositor light brown, with darker apex.

Measurements.— Table 15.

Distribution.— This species seems to be distributed throughout Costa Rica (Map 15), Panama, and Colombia.

Material examined.— **COSTA RICA: Alajuela Prov.,** Puesto Quebradón, elev. 300 m, 1 - 30 September 1997 (coll. G. Rodríguez) - 3 males (INBio); **Guanacaste Prov.,** Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 July 1994 (coll. C. Moraga) - 1 male, 1 female (INBio); Estac. Pitilla, 9 km S Sta. Cecilia, elev. 700 m, 15 May 1992 (coll. F. Araya) - 1 male (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 July 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 September 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 January 1989 (coll. GNP Biodiversity Survey) - 2 females (INBio); **Heredia Prov.,** Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 2 males (INBio); same locality, elev. 90 m, 4 - 31 January 1993 (coll. M. Ortiz) - 1 male (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 15 September 1993 (coll. ALAS) - 1 male (ALAS); same locality, 22 September 1995 (coll. P. Naskrecki) - 1 female (ALAS); same locality, 11 October 1995 (coll. P. Naskrecki) - 1 male (ALAS); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 male, 1 female (ALAS); **Limón Prov.,** 16 km W Guápiles, elev. 400 m, 15 February 1989 (coll. P. Hanson) - 1 female (INBio); Río Sardinias, R.N.F.S. Barra del Colorado, elev. 50 m, 20 August 1994 (coll. F. Araya) - 1 male (INBio); **Puntarenas Prov.,** Rancho Quemado Península de Osa, elev. 200 m, 15 December 1991 (coll. F. Quesada) - 1 female (INBio); **PANAMA:**

Volcán de Chiriquí, 25-4000 ft, Champion - 1 male (lectotype) (BMNH); Canal Zone, Barro Colorado Island, 24 - 25 June 1968 (coll. O.J. Sexton) - 1 male (UMMZ); **COLOMBIA:** Dept. Magdalena, Minca, elev. 610 m, - 1 male (ANSP).

Erioloides longinoi Naskrecki and Cohn, n. sp.
Figs. 22B-C, 23A, 23F-G, 36B, 50A, Map 14

Type locality: Costa Rica, Guanacaste Prov., Estac. Pitilla; type depository: Academy of Natural Sciences, Philadelphia - holotype male

Diagnostic description.— Very similar to the previous species. Body slender, small for the genus; wings in both sexes surpassing apices of hind femora by about half their length (Fig. 37B). Fastigium of vertex evenly tapered, its apex narrowly rounded, about as long as eye diameter and as wide as scapus (Fig. 23F). Face flat, smooth; genal carinae of head poorly developed, hardly discernible. Dorsal surface of pronotum relatively rugose, flat; anterior margin of pronotum straight, posterior one weakly convex (Fig. 23G); lateral lobes of pronotum about 1.7 times longer than high, their posterior angles right. Male stridulatory file straight, 1.2 mm long, 130 µm wide, with 239 closely spaced and relatively very wide, lamelliform teeth; teeth in proximal half of file thinner and more closely arranged than in distal part (Fig. 50A); mirror approximately rectangular, slightly longer than wide; secondary veinlet next to AA₁ well developed and forming actual margin of mirror; stridulatory area of left wing devoid of secondary venation, distal margin of left mirror convex; secondary veinlet next to AA₁ present, somewhat divergent from AA₁.

Male 10th tergite with two short, rounded, usually more or less parallel lobes (Fig. 22B); female 10th tergite with deep, narrowly triangular incision. Male cercus robust, somewhat inflated, with large, blunt, hook-like dorsal spine; apex of cercus constricted (Figs. 22B-C). Female cercus simple, elongately conical, distinctly curved. Tiltators flattened, squamose, distinctly dilated apically, apices multidentate, divergent (Fig. 23A). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate broadly triangular, with small, semicircular incision at apex. Ovipositor relatively slender, with distinct lamella along midline of upper valvula; ratio ovipositor/hind femur 0.61-0.67.

Coloration.— General coloration light green (Fig. 37B). Face pale green, mandibles brightly emerald green, labrum dark brown. Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green; ovipositor light brown, with darker apex.

Measurements.— Table 15.

Distribution.— This species seems to have a wide distribution, ranging from Mexico, through Costa Rica (Map 14), to Panama.

Material examined.— **COSTA RICA: Guanacaste Prov.**, Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 3 May 1993 (coll. C. Moraga) - 1 female (paratype) (INBio); same locality, 15 June 1994 (coll. C. Moraga) - 1 male (paratype) (INBio); same locality, 15 July 1994 (coll. C. Moraga) - 1 male (holotype) (ANSP); Estac. Pitilla, 9 km S. Santa Cecilia, P.N. Guanacaste, elev. 700 m, 3 June 1993 (coll. C. Moraga) - 1 female (allotype) (ANSP); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 January 1989 (coll. GNP Biodiversity Survey) - 1 female (paratype) (INBio); **Heredia Prov.**, Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 22 August 1992 (coll. M. Ortiz) - 1 male (paratype) (INBio); same locality, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 1 female (paratype) (INBio); **PANAMA:** Canal Zone, Barro Colorado Is., 22 May 1977 (coll. Silberglied/Aiello) - 1 male (paratype) (UMMZ); **MEXICO:** 20 mi W Tamazunchale, 19 September 1974 (coll. G. Bohart and W. Hanson) - 1 male (paratype) (EMUS).

Etymology.— This species is named in honor of John (Jack) Longino, one of the founders of the project ALAS, the first large scale inventory of the Arthropoda of the tropical rain forest.

Erioloides acutidentis Naskrecki and Cohn, n. sp.
Figs. 22F-G, 23C, 23H, 50C, Map15

Type locality: Costa Rica, Puntarenas Prov., Estac. Pittier; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— Very similar to the previous species; fastigium of vertex more pointed than in other species of the genus (Fig. 23H). Male stridulatory file straight, 1.0 mm long, 103 μ m wide, with 179 closely spaced and very wide, lamelliform teeth; teeth in proximal half of file thinner and more closely arranged than in distal part (Fig. 50C); mirror elongately rectangular, distinctly longer than wide; secondary veinlet next to AA₁ well developed, strongly divergent from AA₁; stridulatory area of left wing devoid of secondary venation.

Male 10th tergite with small, narrow incision on posterior margin (Fig. 22F). Male cercus relatively slender, cylindrical, with small, spur-like dorsal spine; apex of cercus blunt (Fig. 22F-G). Female cercus simple, elongately conical, distinctly curved. Titillators not clearly

differentiated from phallic membrane, squamose (Fig. 23C). Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate broadly triangular, with small, triangular incision at apex. Ovipositor relatively slender, with irregular lamella along midline of upper valvula; ratio ovipositor/hind femur 0.81.

Coloration.— General coloration light green. Face pale green, mandibles brightly emerald green, labrum dark brown. Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green dorsally; purple ventrally; ovipositor light brown, with darker apex.

Measurements.— Table 15.

Distribution.— So far, this species is known from only a one locality in southern Puntarenas Prov. (Map 15).

Material examined.— **COSTA RICA: Puntarenas Prov.**, Estac. Pittier, elev. 1670 m, 23 August - 13 September 1995 (coll. E. Navarro) - 1 female (allotype) (ANSP); same locality, 26 September - 5 October 1995 (coll. E. Navarro) - 1 male (holotype) (ANSP).

Etymology.— The specific epithet refers to the sharp, spur-like spine on the male cercus.

Erioloides sikesi Naskrecki and Cohn, n. sp.
Figs. 22I-H, 23D, 50B, Map 15

Type locality: Costa Rica, Puntarenas Prov., Res. Biol. Monteverde, Estac. La Casona; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description (male, female unknown).— Very similar to the previous species; fastigium of vertex more pointed than in other species of the genus. Male stridulatory file straight, 1.4 mm long, 146 μ m wide, with 198 closely spaced and very wide, lamelliform teeth; teeth in proximal half of file thinner and more closely arranged than in distal part (Fig. 50B); mirror nearly perfectly square; secondary veinlet next to AA₁ present, parallel to AA₁; stridulatory area of left wing devoid of secondary venation.

Male 10th tergite with deep incision on posterior margin, resulting in two large, pointed lobes (note: Fig. 22H shows the lobes from above, when the pointed ends of the lobes cannot be seen). Male cercus relatively slender, cylindrical, with small, blunt dorsal spine; apex of cercus blunt (Fig. 22I). Titillators flat, squamose, somewhat narrowed towards their apices (Fig. 23D). Male subgenital plate with distinct ventral keel and deep tri-

angular incision apically; female subgenital plate broadly triangular, with small, triangular incision at apex.

Coloration.— General coloration light green. Face pale green, mandibles brightly emerald green, labrum yellow. Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green dorsally; purple ventrally.

Measurements.— Table 15.

Distribution.— This species is known only from its type locality (Map 15).

Material examined.— **COSTA RICA: Puntarenas Prov.**, Estac. La Casona, Res. Biol. Monteverde, 1 - 30 April 1992 (coll. K. Flores) - 1 male (holotype) (ANSP).

Etymology.— This species was named in honor of Derek S. Sikes, a fine coleopterist and good friend.

Erioloides latiscobinus Naskrecki and Cohn, n. sp.
Figs. 22J-K, 23E, 49E, Map 15

Type locality: Costa Rica, Alajuela Prov., Sector Colonia Palmareña; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— Very similar to previous species. Male stridulatory file straight, 1.1 mm long, 145 µm wide, with 220 closely spaced and extremely wide, lamelliform teeth; teeth in proximal half of file thinner and more closely arranged than in distal part (Fig. 49E); mirror approximately rectangular, distinctly longer than wide; secondary veinlet next to AA₁ well developed, slightly divergent from AA₁; stridulatory area of left wing devoid of secondary venation, distal margin of left mirror concave; secondary veinlet next to AA₁ present, strongly divergent from AA₁.

Male 10th tergite with small, triangular apical incision (Fig. 22J). Male cercus relatively slender, cylindrical, with thin, finger-like dorsal spine; apex of cercus somewhat constricted (Fig. 22K). Female cercus simple, elongately conical, distinctly curved. Titillators flattened, squamose, apices multidentate, strongly divergent. Male subgenital plate with distinct ventral keel and deep triangular incision apically; female subgenital plate broadly triangular, with small, semicircular incision at apex. Ovipositor relatively slender, with file of pegs along midline of upper valvula; ratio ovipositor/hind femur 0.74-0.78.

Coloration.— General coloration light green. Face pale

green, mandibles brightly emerald green, labrum dark brown. Tegmina green, with contrastingly yellow venation. Legs green; abdomen light green dorsally; purple ventrally; ovipositor light brown, with darker apex.

Measurements.— Table 15.

Distribution.— This new species seems to be widely distributed in Costa Rica, with most records from low or mid elevation forest habitats (Map 15).

Material examined.— **COSTA RICA: Alajuela Prov.**, Estac. San Ramón Oeste, elev. 620 m, 19 April 1994 (coll. F. Quesada) - 1 male (paratype) (INBio); Sect. San Ramón de Dos Rios, elev. 620 m, 18 March - 13 April 1995 (coll. F.A. Quesada) - 1 female (paratype) (INBio); Sector Colonia Palmareña, 9 km SO de Bajo Rodríguez, elev. 700 m, 1 - 30 April 1995 (coll. G. Carballo) - 1 female (allotype) (ANSP); same locality, 1 - 31 May 1997 (coll. G. Carballo) - 1 male (holotype) (ANSP); **Guanacaste Prov.**, Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 18 - 23 July 1993 (coll. C. Moraga) - 3 males (paratypes) (INBio); same locality, 15 June 1994 (coll. C. Moraga) - 1 male (paratype) (INBio); same locality, 15 July 1994 (coll. C. Moraga) - 1 male (paratype) (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1988 (coll. GNP Biodiversity Survey) - 3 males (paratypes) (INBio); same locality, 15 January 1989 (coll. GNP Biodiversity Survey) - 2 males, 2 females (paratypes) (INBio); Estac. Mengo, SW side Volcán Cacao, elev. 1100 m, 15 February 1989 (coll. GNP Biodiversity Survey) - 1 female (paratype) (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 March 1990 (coll. P. Rios, C. Moraga and R. Blanco) - 1 female (paratype) (INBio); **Heredia Prov.**, Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 1 female (paratype) (INBio); **Puntarenas Prov.**, Las Cruces, 1 July - 31 August 1991 (coll. J. Doubles) - 1 male (paratype) (UMMZ); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 April 1989 (coll. R. Blanco and G. Fonseca) - 1 female (paratype) (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, 22 March 1994 (coll. P. Naskrecki) - 1 male (paratype) (PN collection).

Etymology.— Named in reference to the extremely wide teeth of the stridulatory file of the male.

EPPIA Stål, 1876

1876 Stål, *Observ. Orth.*, *Bihang Vet.-akad.* 3:42.; type species: *Eppia truncatipennis* Stål, 1876

Diagnosis

Body moderately robust, size medium to large; both sexes macropterous; tegmina characteristically truncated at apex (Fig. 24A); tegumen moderately rugose. Fastigium of vertex 1.5-2 times as wide as scapus, short and blunt, touching fastigium of frons; dorsum of pronotum rugose, with deep, transverse suture in prozona, and low longitudinal keel in metazona. All femora armed on lower margins with spines, mid tibia armed dorsally. Male cercus armed apically with 2 incurved spines; lower spine movable; ovipositor short, upcurved, somewhat dilated midlength. Coloration grayish-brown, face with large black patch.

Description (male except where specified)

Head. — Fastigium of vertex 1.5-2 times as wide as scapus, blunt and as long as diameter of eye (Fig. 24B); fastigium of vertex touching fastigium of frons. Eyes small relative to size of head, weakly protruding. Frons flat, smooth; tegumen of genae rugose, but with no traces of genal carinae; face moderately broad. Mandibles and clypeus symmetrical.

Thorax and wings. — Dorsal surface of pronotum rugose, metazona slightly raised; prozona with deep transverse suture, metazona with more or less developed longitudinal keel; both anterior and posterior dorsal margins convex (Fig. 24C); lateral lobes with posterior angle narrowly rounded; humeral sinus well developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, widely separated spines (modified basisternum); mesosternum with lateral lobes of basisterna triangular, their inner margins touching only at base; metasternal lobes touching along 2/3 of their inner edge.

Wings in both sexes either fully developed, well surpassing apices of hind femora; apices of tegmina characteristically truncated and emarginated (Fig. 24A). Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network of secondary veinlets; stridulatory file (vein AA₁) weakly curved; teeth of file wide, lamelliform, becoming thicker and narrower towards proximal end of file (Fig. 48E); mirror of right wing somewhat longer than wide, its distal margin convex, other margins straight. Posterior margin of tegmen weakly concave.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; mid coxa with small, hook-like spine on upper margin. Fore and mid femora unarmed dorsally but armed ventrally on anterior margins; genicular lobes of fore femora unarmed, lobes of mid and hind femora armed with short spines, often only inner genicular lobes armed on mid femora. Fore tibia unarmed dorsally but mid tibia with 1-2 prominent dorsal spines, ventral margins of both fore and mid tibiae with immovable spines as long as 1/4 to 1/2 diameter of tibia; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits; outer (posterior) flap of tympanum often with lower edge free.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with nearly rectangular apical emargination, supraanal plate small, triangular. Male cercus with 2 apical spines, both bent inwards; upper spine about half as long as lower spine; lower spine movable, articulated (Fig. 24D); female cercus, simple, slender and weakly incurved. Subgenital plate of male with a pair of styli and small, triangular apical emargination; female subgenital plate wider than long, with deep, semicircular apical emargination.

Male concealed genitalia with part of phallic membrane strongly sclerotized and covered by chitinous callosities but without separate titillators (Fig. 24E). Ovipositor about as long as half of hind femur, distinctly upcurved; upper valvula about 4 times as wide as lower one, somewhat expanded midlength; apex of ovipositor pointed.

Coloration. — General coloration grayish-brown, with numerous, irregular lighter and darker patches. Sometimes head, pronotum, and legs with small green patches. Frons, upper portion of clypeus, and mandibles black; frons often with tiny, white, widely scattered dots; lower part of clypeus and labrum reddish-brown to orange. Ventral side of abdomen black.

Remarks. — This monotypic genus is widely distributed from Chiapas Province in Mexico, through Guatemala, Costa Rica (Map 13), and Panama, to Colombia and Guayas Province in Ecuador. Nothing is known about its biology.

Although *Eppia* has traditionally been assigned to *Agraeciini*, there is hardly any indication of its relatedness to *Agraecia* and related genera. The structure of the male cercus, the auditory spiracle, and the fastigium of vertex indicate affinity to such genera as *Bucrates* or *Pyrrocorypha*.

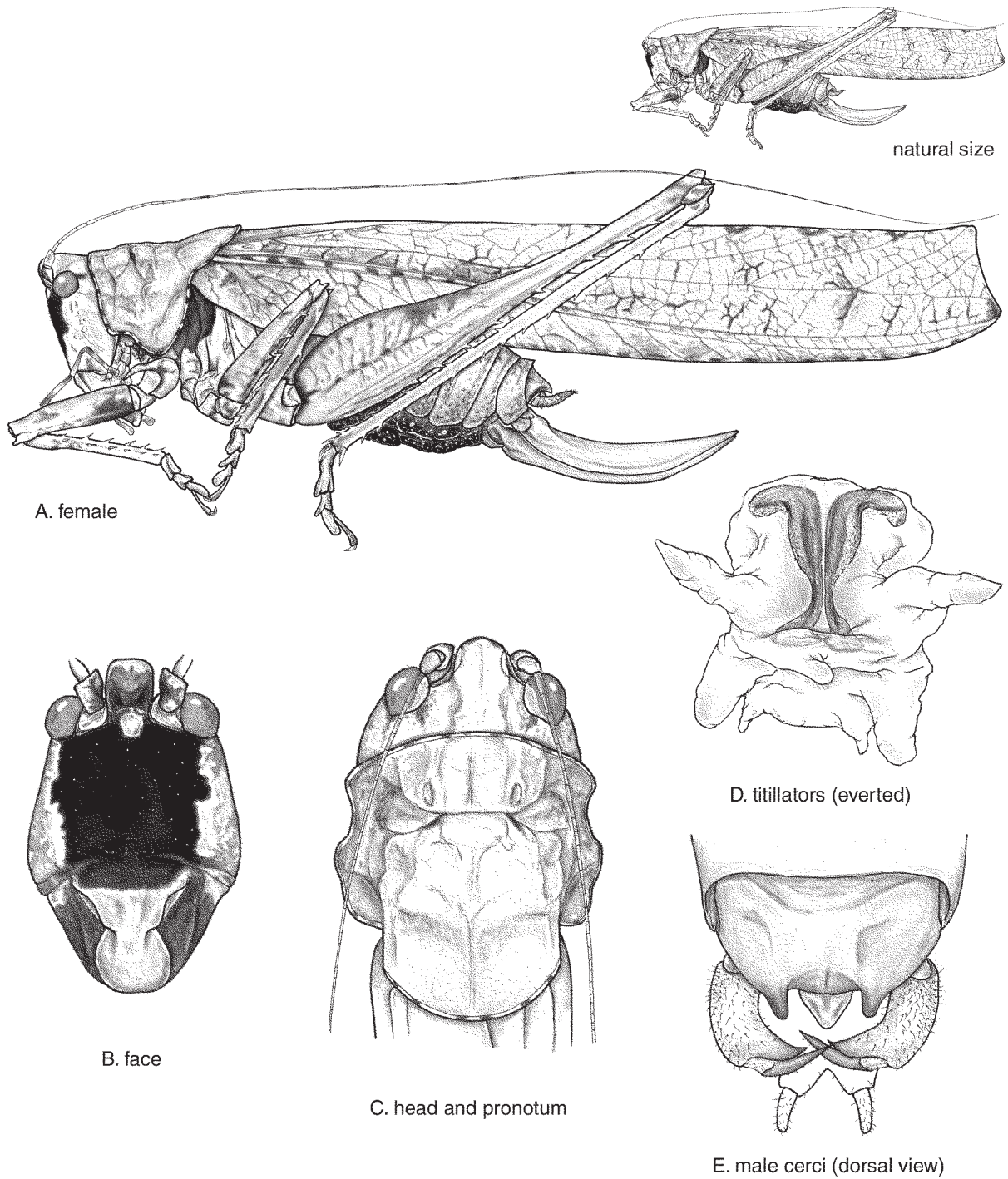


FIG. 24. *Eppia truncatipennis*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. titillators, everted, E. male cerci, dorsal view.

Eppia truncatipennis Stål, 1876
Figs. 24A-E, 48E, 57C-D, Map 13

1876 Stål, *Observ. Orth.*, *Bihang Vet.-akad.* 3:42; type locality: Panama, Chiriquí; type depository: Naturihistoriska Rijksmuseum, Stockholm – holotype female

Diagnostic description. – General characteristics as described above. Male stridulatory file (n=1) 2 mm long, with 112 teeth, maximum width of teeth 140 µm (Fig. 48E).

Measurements (in mm). – (6 males, 7 females; range, avg±SD) body with wings: male 50.3-57.8, 53.1±2.7, female 53.9-59.9, 56.5±2.1; pronotum: male 8.5-10.2, 9.1±0.6, female 8.9-9.7, 9.3±0.3; tegmen: male 41.8-47.3, 44.1±2, female 45.4-49.8, 47.3±1.6; hind femur: male 24.6-28.2, 26.1±1.2, female 26-29.5, 27.4±1.3; ovipositor: 12.5-15.1, 14±0.9.

Bioacoustics. – The call of *E. truncatipennis* (based on a specimen from Gamboa, Panama, courtesy of M. Greenfield) consist of a series of rapid chirps, produced at the rate of about 3/s (temperature unknown). Each chirp, lasting 105.3-139.5 ms (n=15), consists of 6-7 pulses (Figs. 57C-D). Most energy of the call is allocated between 8 and 9.5 kHz, and in the first harmonic between 16 and 19 kHz. The energy distribution above 22 kHz is unknown.

Material examined. – **COSTA RICA: Puntarenas Prov.**, 4 km NW of San Vito de Java (jct. of road and Río Java), elev. 914.4 m, 20 January 1967 (coll. I.J. Cantrall) - 4 females (UMMZ); **Península de Osa, Rancho Quemado**, elev. 200 m, 15 November 1992 (coll. R. Aguilar, M. Segura and F. Quesada) - 1 male (INBio); **Rancho Quemado, Pen. Osa**, 15 February 1991 (coll. F. Quesada) - 1 female (INBio); **Rancho Quemado Península de Osa**, elev. 200 m, 15 October 1992 (coll. F. Quesada) - 1 female (INBio); **Rancho Quemado, Península de Osa**, elev. 200 m, 19 - 27 August 1993 (coll. A. Gutiérrez) - 1 female (INBio); **Sirena, Corcovado N.P.**, elev. 0 - 100 m, 15 October 1990 (coll. J.C. Saborio) - 1 male (INBio); **COLOMBIA: Dept. Magdalena, Río Frío**, 22 March 1925 (coll. F.W. Walker) - 24 males, 32 females (UMMZ); **ECUADOR: Guayas Prov., Río Frío**, 20 km E of Hda. Balao Chico, 26 - 27 April 1963 (coll. Hubbell and Peña) - 3 females (UMMZ); **MEXICO: Chiapas Prov., Dist. Soconusco, Finca Esperanza**, 14 - 17 July 1937 (coll. Hartweg-Brodcorp) - 1 female (UMMZ); **PANAMA: Bocas del Toro, Changuinola**, 14 January 1922 (coll. F. Cobb) - 1 male (UMMZ); **Canal Zone, Barro Colo-**

rado Island, 16 - 18 March 1926 (coll. F.M. Gaige) - 2 males (UMMZ); same locality, 2 January 1967 (coll. I.J. Cantrall) - 1 male (UMMZ); same locality, 27 January 1968 (coll. O.J. Sexton) - 1 female (UMMZ); **S-9 Road (ca. 6 km SW Gatun)**, 30 December 1972 (coll. E.A. Strauch) - 1 female (UMMZ); **Panama, top of Cerro Azul (10 mi. E and 9 mi. N Panama City)**, 14 January 1967 (coll. I.J. Cantrall) - 1 female (UMMZ).

SPHYROMETOPA Carl, 1908

1908 Carl, *Revue Suisse de Zool.* 16: 135; type species: *Sphyrometopa femorata* Carl, 1908

Diagnosis

Body robust, size medium for the subfamily; both sexes mesopterous, with tegmina not reaching apex of abdomen (Figs. 25A, 37F); tegumen moderately rugose. Fastigium of vertex nearly 4 times broader than scapus, short and blunt, continuous with fastigium of frons; no traces of genal carinae present; frons weakly convex. Fore femora unarmed ventrally, mid and hind femora armed on lower anterior margins with minute spines. Male cercus unique (Figs. 25E-F); ovipositor shorter than half of femur, distinctly upcurved, acute apically.

Description (male except where specified)

Head. – Fastigium of vertex about 4 times as wide as scapus, blunt and as long as diameter of eye; fastigium of vertex continuous with fastigium of frons (Fig. 25B). Eyes small relative to size of head, weakly protruding. Frons weakly convex, smooth; tegumen of head weakly rugose, without traces of genal carinae; face broad. Mandibles and labrum weakly asymmetrical.

Thorax and wings. – Dorsal surface of pronotum moderately rugose, flat; anterior dorsal margin straight, posterior one straight to weakly convex (Fig. 25C); lateral lobes with posterior angle narrowly rounded; humeral sinus weakly developed. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum. Prosternum armed with two thin, widely separated spines (modified basisternum); mesosternum with lateral lobes of basisterna triangular, oblique; metasternal lobes also triangular and oblique but with their bases wider than those of mesobasisterna.

Tegmina in both sexes shortened, not reaching end of abdomen; tegmina oval to narrowly triangular with rounded apex (Figs. 25A-B); hind wings reduced, as long as 1/3 to 3/4 of tegmina. Stridulatory apparatus of male well developed; stridulatory area of left wing thickened, with dense network of secondary veinlets; stridulatory

TABLE 16. Key for identification of Costa Rican species of *Sphyrometopa*

Species	Tegmina	Male cerci	Stridulatory file
<i>femorata</i>	broadly oval, reaching 6th or 7th tergite (Fig. 25A)	dorsal lobe of cercus always pointed, same color as remainder of cercus (Fig. 24E)	with about 200 teeth (Fig. 46B)
<i>atlantica</i>	narrowly triangular, reaching 8th or 9th tergite (Fig. 25B)	dorsal lobe of cercus usually rounded, darker than remainder of cercus (Fig. 24F)	with about 170 teeth (Fig. 46B)

file (vein AA₁) weakly curved (Figs. 48A-C), with narrow, regularly spaced teeth.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally. All femora unarmed dorsally; fore femora unarmed ventrally, mid and hind femora armed ventrally on anterior ventral margins with few minute spines; only posterior genicular lobes of mid and hind femora armed with short spines, remaining lobes obtuse. Fore and mid tibiae unarmed dorsally, both ventral margins with immovable, short spines; hind tibia armed on both dorsal margins but with only 2 small spines on anterior ventral margin; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area only weakly swollen, with pair of small, elongated pits below tympanal slits.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with deep apical emargination, supraanal plate small, triangular; female 10th tergite with deep, narrowly triangular incision. Male cercus unique (Figs. 25E-F), its base stout, with two dorsal lobes and long apical projection, curved backwards, overhanging basal part of cercus, its tip serrated ventrally; female cercus, simple, conical, but with apex distinctly attenuated. Subgenital plate of male with pair of styli, its posterior margin straight or with small, triangular emargination; female subgenital plate widely trapezoidal, its apex

straight or weakly emarginated.

Male concealed genitalia with inner phallic lobes strongly sclerotized, forming a pair of divergent titillators (titillators not separated from membrane); outer phallic lobes with small, sclerotized patches (Fig. 26C). Ovipositor short, sickle-shaped (Fig. 25A), very thick at base (when seen from below).

Coloration. — General coloration mottled grayish-brown to dark brown (Fig. 37F); face with large, black patch, bordered with thin, diffused, whitish margins (Fig. 25B); legs mottled brown, lower half of outer pagina of hind femur black, bordered by diffused, whitish stripe; dorsal portion of abdomen usually lighter; cerci yellowish-brown with dark apical portions.

Remarks. — The genus *Sphyrometopa* includes two species, both of them originally described from Costa Rica, and both apparently endemic to this country [although an unidentified species of *Sphyrometopa* was reported from Panama by Nickle (1992)]. The closest relatives of the genus seem to be genera *Dectinomima* Caudell, *Eppia* Stål, and *Uchuca* Caudell. The unique appearance of the members of the genus, with shortened wings, characteristic coloration, and the shape of male cerci, makes them some of the easiest to identify species of Costa Rican Tettigoniidae. They are also the only species of the family that can be found almost exclusively on the forest floor,

TABLE 17. Body measurements of species of *Sphyrometopa* (all measurements are lengths in mm: range, mean±SD)

Species	Body	Tegmen	Pronotum	Hind femur	Ovipositor
<i>femorata</i>					
male	19.9-27.6, 23.8±5.4	11.8-12.2, 12±0.3	8.4-9.3, 8.9±0.6	18.7-22.2, 20.5±2.5	na
female	26-30.9, 27.4±2.4	9.4-10.8, 10±0.6	8.6-9.5, 8.9±0.4	21.4-23.8, 22.4±1	10.2-10.7, 10.5±0.3
<i>atlantica</i>					
male	24.1-28.3, 26.1±1.7	14.4-15.6, 14.9±0.4	8.6-9.3, 8.9±0.3	21.4-23.5, 22.5±0.9	na
female	21.9-27.7, 24.5±2.5	12.3-14.8, 13.9±1.15	8.4-9.2, 8.7±0.4	22.9-23.8, 23.3±0.5	9.3-10.2, 9.8±0.4

among fallen leaves or on low, herbaceous vegetation. Rentz (1976), who reviewed the genus, noted that they inhabit primary growth forests and only secondarily move to clearings and forest openings of early secondary growth. At La Selva Biological Station, *S. atlantica* can be found along primary forest trails among low vegetation, especially if the habitat is vegetated by *Selaginella eurynota* A. Braun, *Diffenbachia seguine* (L.) Schott, and *Costus malorteanus* H.A. Wendl. I also observed this species deep within the primary forest, in places with sparse vegetation at the ground level and the canopy permitting at least a small amount of light to reach the ground.

Unlike adult individuals, nymphs of *Sphyrmetopa atlantica* are light green, with small, dark, irregular patches (Fig. 36F). They undergo at least 5 nymphal instars before reaching maturity. The 5th nymphal instar loses its green coloration and turns dark brown. Nymphs of *S. femorata* turn brown much earlier or are never green. Nymphs of both species are diurnal. They occur in green vegetation and rarely descend to the ground. Adults are strictly nocturnal and spend most of their time on the ground, with the exception of singing males that have been observed singing from underneath large leaves at least 1 m above the ground. Little is known about the diet of *Sphyrmetopa* spp. Rentz (1976) reported that adults of *S. atlantica* had been seen feeding on flowers of ginger (*C. malorteanus*). In captivity individuals of this species thrived for several months on the diet of corn, carrots, lettuce, and apple.

Sphyrmetopa femorata Carl, 1908

Figs. 25A-E, 26A, 26C, 48A, 57G, Map 13

1908 Carl, Revue Suisse de Zool. 16: 135; type locality: Costa Rica; type depository: Museum d'Histoire Naturelle, Geneva – holotype female

[syn.] *Conocephalus diversus* = 1905 Rehn, J. A. G., Proce. Acad. Nat. Sci. Philadelphia: 825; type locality: Guatel, Costa Rica; type depository: Acad. Nat. Sci., Philadelphia

[syn.] *Sphyrmetopa rehni* = 1912 Karny, in Wytzman, Gen. Ins. 139: 37; new name for *Conocephalus diversus*

Diagnostic description. — General characteristics as described above. Tegmina shortened, reaching 6th or 7th abdominal tergite, approximately oval in shape (Fig. 26A); hind wings greatly reduced about as long as 1/3 of tegmina. Stridulatory file of male 1.3 mm long, with 202 lamelliform teeth, maximum width of file 130 µm (Fig. 48A); teeth of file uniform in thickness, evenly spaced

and smoothly narrowing towards proximal end. Mirror of stridulatory apparatus approximately square, with distal margin of mirror convex. Male cercus with dorsal lobe pointed apically and of the same color or only slightly darker than remainder of cercus (Figs. 25D-E).

Measurements. — Table 17.

Bioacoustics. — Morris and Beier (1982) describe the call of *S. femorata* (a population from Monteverde) as a steady sequence of paired lisps, with the lisps repeated every 10 seconds at 16°C. Each lisp consists of a faint minor pulse train followed by a much longer and more intense major pulse train (the minor pulse train could not be detected in the recordings made by M. Greenfield in Monteverde, see Fig. 57G). Both lisps in a pair have the same structure. Most of the energy of the call is allocated near 11 kHz, and in a broader higher frequency peak centered on 27 kHz.

Distribution. — *S. femorata* is restricted in its distribution to the Pacific portion of Costa Rica (Map 13). Most specimens of this species have been collected from middle elevation sites between 500 and 1580 m Rentz (1976)

Material examined. — **COSTA RICA: Alajuela Prov.,** Finca San Gabriel, 2 km SW Dos Rios, elev. 600 m, 15 May 1990 (coll. II curso parataxon.) - 1 female (INBio); R.B. San Ramón, elev. 800 m, 1 - 31 March 1997 (coll. G. Carballo) - 1 female (INBio); Zona Protectora de Arenal, Pocosol, 10 - 16 February 1994 (coll. P. Naskrecki) - 2 nymphs (PN collection); **Cartago Prov.,** P.N. Tapantí, Río Dos Amigos, A.C. Amistad, elev. 1480 m, 1 - 31 March 1994 (coll. G. Mora) - 1 female (INBio); **Guanacaste Prov.,** Estac. Cacao, 2 km SW del Cerro Cacao, elev. 1000 - 1400 m, 8 - 17 February 1995 (coll. M.A. Zumbado) - 1 female (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 July 1988 (coll. GNP Biodiversity Survey) - 2 females (INBio); same locality, 15 August 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 November 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 January 1989 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 6 - 7 December 1993 - 1 female (INBio); same locality, 15 August 1994 (coll. C. Moraga) - 1 male, 1 female (INBio); Estac. Cacao, SW side Volcán Cacao, elev. 1000 - 1400 m, 15 March 1988 (coll. GNP Biodiv. Survey) - 1 female (INBio); same locality, elev. 1000 - 1400 m, 1 December 1989 (coll. R. Blanco and C. Chávez) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 September 1989 (coll. C. Moraga and P. Rios) -

1 female (INBio); **San José Prov.**, Estac. Zurquí, 500 m antes de Tunel, elev. 1600 m, 15 April 1991 (coll. G. Maass) - 1 male (INBio).

Sphyrometopa atlantica Rentz, 1976
Figs. 25F, 26B, 37E, 48B-C, 57E-F, Map 13

Rentz, Ent. News 87: 197; type locality: Costa Rica: Heredia Province, Puerto Viejo, Finca La Selva; type depository: Academy of Natural Sciences, Philadelphia - holotype male
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>paratypes illustrated

Diagnostic description. - General characteristics as described above. Tegmina shortened, reaching 8th or 9th abdominal tergite, narrowly triangular in shape (Fig. 26B); hind wings greatly reduced, about as long as 3/4 of tegmina. Stridulatory file of male 1.4 mm long, with 166 lamelliform teeth, maximum width of file 144 µm (Figs. 48B-C); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Mirror of stridulatory apparatus approximately rectangular, with distal margin of mirror convex. Male cercus with dorsal lobe rounded apically and much darker than remainder of cercus (Fig. 25F).

Measurements. - Table 17.

Bioacoustics. - The call of *S. atlantica* is very similar to that of *S. femora*, and also consists of a sequence of paired lips, repeated every 2.2 s at 25°C (Figs. 57E-F). Individual lips last 28.4-36.3 ms, but unlike those of *S. femorata* they do not contain minor pulse trains. Most of the energy of the call is allocated between 9 and 14 kHz, with the peak near 12.3 kHz. The presence of higher frequency peaks could not be detected due to the constraints imposed by technical limitations of the recording equipment.

Distribution. - *S. atlantica* is widely distributed in the Atlantic portion of Costa Rica and does not seem to overlap in its distribution with the second species of the genus (Map 13).

Material examined. - **COSTA RICA: Cartago Prov.**, 13 km by road NW Turrialba (0.7 km NW Santa Cruz), 1 October 1961 (coll. Hubbell, Cantrall, Cohn) - 4 males, 3 females (UMMZ); 2 mi SE Turrialba (grounds of Inst. Interamer. de Sci. Agrícolas), 1 - 3 October 1961 (coll. Hubbell, Cantrall, Cohn) - 2 males (UMMZ); **Heredia Prov.**, La Selva (estate of L. Holdridge), 13 November 1964 (coll. T.H. Hubbell) - 1 female (UMMZ); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1'

W, 15 March 1994 (coll. P. Naskrecki) - 1 female (PN collection); same locality, 12 October 1995 (coll. P. Naskrecki) - 1 male (ALAS); same locality, 30 November 1995 (coll. P. Naskrecki) - 2 males, 2 females (PN collection); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 2 males (PN collection); **Limón Prov.**, 7 km W Guápiles at Río Toro Amarillo, 19 August 1964 (coll. S.P. Hubbell) - 1 male (UMMZ); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 200 m, 15 November 1993 (coll. G. Carballo) - 1 female (INBio); La Emilia, near Guápiles, elev. 305 m, 22 August 1923 - 1 female (ANSP); La Lola (0.5 mi. W Madre de Dios), 2 October 1961 (coll. Hubbell, Cantrall, Cohn) - 9 males, 5 females (Philadelphia, UMMZ); Río Sardinias, R.N.F.S. Barra del Colorado, elev. 10 m, 2 July 1992 (coll. F. Araya) - 1 male (INBio); Vesta Farm, Estrella Valley, elev. 60 m, 13 September 1923 - 1 male (UMMZ); **San José Prov.**, La Palma (on saddle between V. Irazu and V. Barva, 13 August 1964 (coll. S.P. Hubbell) - 3 males (UMMZ).

MONCHECA Walker, 1869

1869 Walker, Cat. Derm. Salt. Brit. Mus. 2: 289; type species: *Monchecca pretiosa* Walker, 1869
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Diagnosis

Body relatively robust; both sexes macropterous (Fig. 27A) tegumen smooth and shiny. Fastigium of vertex small, only slightly projecting in front of eyes, gap between fastigia of vertex and frons shallow; frons flat; eyes small. Male cercus cylindrical or strongly flattened laterally, with apical part expanded ventrally; ovipositor straight. Coloration striking, tegmina turquoise with crimson red costal field in life, dark olive to black in preserved specimens.

Description (male except where specified)

Head. - Fastigium of vertex small, only slightly projecting in front of eyes; lateral ocelli prominent when seen from above (Fig. 26E); base of fastigium of vertex between eyes sometimes with several tubercles dorsally; fastigium of vertex separated from fastigium of frons by small gap. Eyes small relative to size of head, not particularly protruding. Frons flat, smooth; tegumen of head smooth, shiny, without traces of genal carinae; face with sides slightly convex, narrower below eyes than at mandibular joints but not triangular (Fig. 27B).

Thorax and wings. - Dorsal surface of pronotum smooth, shiny, cut by two deep, transverse sulci; metazona slightly raised; anterior dorsal margin straight, posterior one straight to weakly convex (Figs. 26E, 27C);

TABLE 18. Key for identification of Costa Rican species of *Monchecha*

Species	Male cerci	Male 10th tergite	Coloration of pronotum
<i>elegans</i>	foot-shaped, laterally flattened (Fig. 26E)	posterior margin expanded (Fig. 26D)	one light band in metazona (Fig. 26C)
<i>pretiosa</i>	cylindrical, with apical hook-like spine (Fig. 25G)	posterior margin incised (Fig. 25F)	two light bands – one in prozona, one in metazona (Fig. 25E)

lateral lobes with posterior angle rounded and with well developed humeral incision. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, rounded flap. Prosternum unarmed; mesosternum with basisterna approximately triangular, almost vertical, with short apical spines; metasternum unarmed.

Wings in both sexes fully developed, surpassing apices of hind femora (Fig. 27A). Stridulatory apparatus of male small but well developed; stridulatory file straight to weakly curved (Figs. 47D-E), evenly tapering on both ends, with relatively thick and narrow teeth; stridulatory area of both wings with no secondary venation; mirror of right wing slightly longer than high, vein AA₁ sometimes strongly oblique. Posterior margin of front wing weakly concave; apex of front wing broadly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; mid and hind coxa unarmed. All femora unarmed dorsally; anterior femora armed ventrally on both margins, sometimes posterior margin unarmed; mid femora armed on anterior ventral margin only; hind femora armed on both ventral margins; genicular lobes of all femora unarmed or armed only on hind femora; hind femora very short relative to body length. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, sometimes posterior (outer) slit weakly sinusoidal and part of tympanal membrane visible; tympanal area weakly swollen, with pair of small pits below tympanal slits; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite strongly sclerotized, smooth but sometimes with dense hair along posterior margin; posterior margin sometimes expanded caudad, with subapical concavity; supraanal plate simple, triangular; female 10th tergite simple, unmodified. Male cercus with small apical tooth, sometimes apex of cercus expanded dorso-ventrally (Figs. 26F-G, 27D-E); female cercus, simple, narrowly conical. Subgenital plate of male wider than long, with a pair of short styli and small, triangular incision on hind margin; female subgenital plate

much wider than long, with shallow, triangular incision and two, small, spine-like lobes apically.

C concealed genitalia of male membranous, without sclerotized titillators. Ovipositor longer than hind femur, perfectly straight; both dorsal and ventral margins of ovipositor smooth, parallel, weakly narrowing towards apex; apex of ovipositor sharp (Fig. 27A).

Coloration. — Coloration striking, especially in live individuals (coloration deteriorates strongly in preserved specimens). Face shiny black, mouthparts crimson red or orange; antennae black, with sparsely distributed narrow light bands; pronotum black or brown, with one or two transverse white or yellow bands. Costal area of tegmina yellow, bordered by a diffused crimson band, often with distinct, green venation; costal area of tegmina crimson red underneath; remaining portions of tegmina green to brown, often turning nearly black in preserved specimens; hind wings with strikingly green venation, sometimes slightly infumated. Coloration of legs variable, sometimes hind tarsi crimson red. Abdomen turquoise, dorsal portions of abdominal terga sometimes blue (abdomen often turns yellow in preserved specimens). Male 10th tergite partially or entirely black; ovipositor dark brown, sometimes lower valvula yellow.

Monchecha elegans (Giglio-Tos, 1898)

Figs. 27A-E, 47D, Map 12

- 1898 Giglio-Tos, Boll. Mus. Torino 13: 86 >> *Exocephala*; type locality: Ecuador, San José; type depository: Museo de Instituto di Zoologia Sistemática dell'Università di Torino, Italy – holotype male
- 1912 Karny, in Wytzman, Gen. Ins. 139: 16 >> *Monchecha*
- 1926 Hebard, Trans. Amer. Ent. Soc. 52: 342 >> as *Monchecha pretiosa* (partim)
- 1927 Hebard, Trans. Amer. Ent. Soc. 53: 83 >> as *Monchecha pretiosa*
- 1982 Morris and Beier, Trans. Amer. Ent. Soc. 108: 302 >> as *Monchecha pretiosa*

Diagnostic description. — General characteristics as described above. Stridulatory file of male weakly curved,

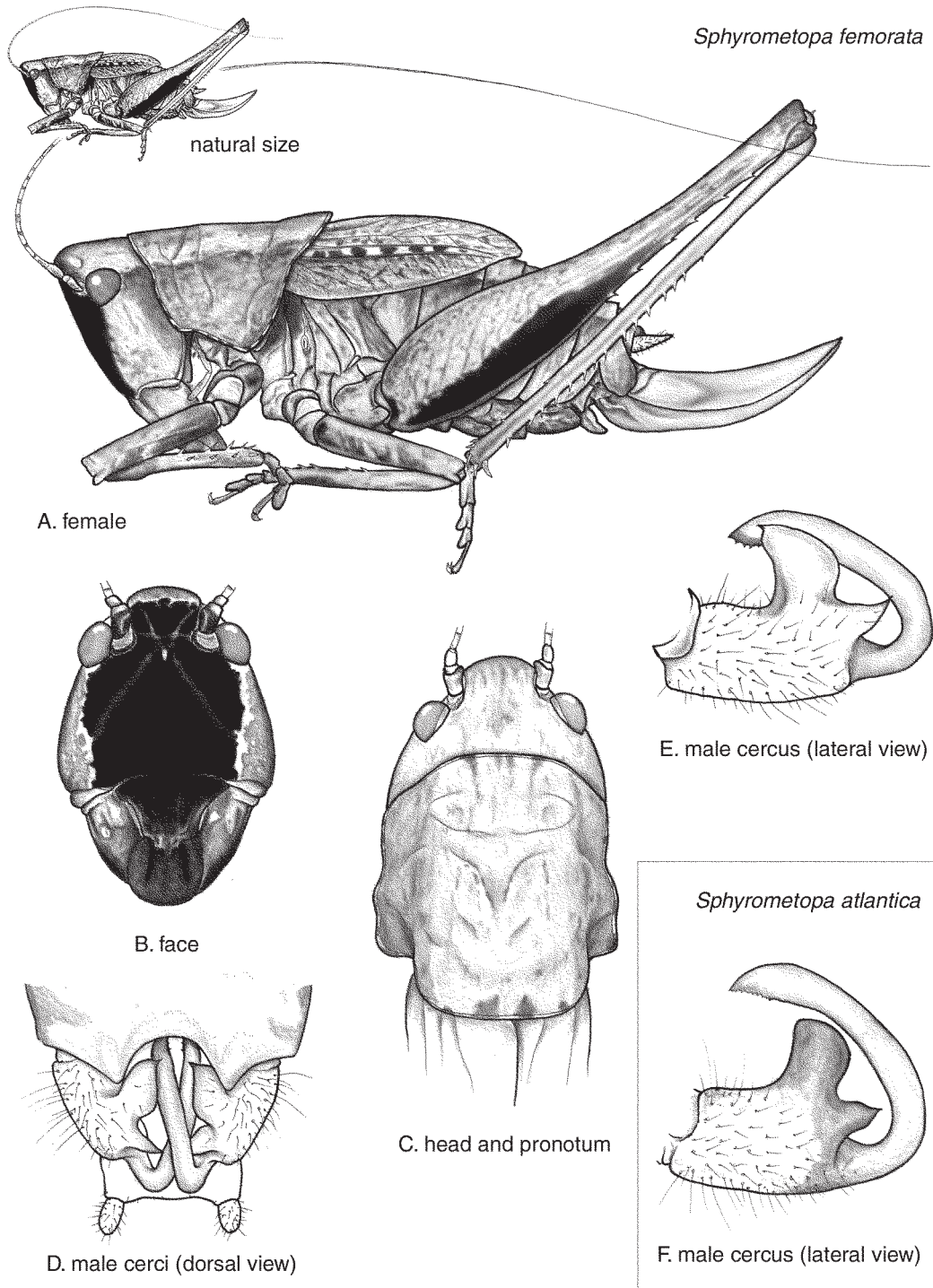


FIG. 25. Costa Rican species of *Sphyrometopa*. **A-E.** *S. femorata*: **A.** female - habitus, **B.** female face, **C.** female head and pronotum, dorsal view, **D.** male cerci, dorsal view, **E.** male left cercus, lateral view, **F.** *S. atlantica* - male left cercus, lateral view.

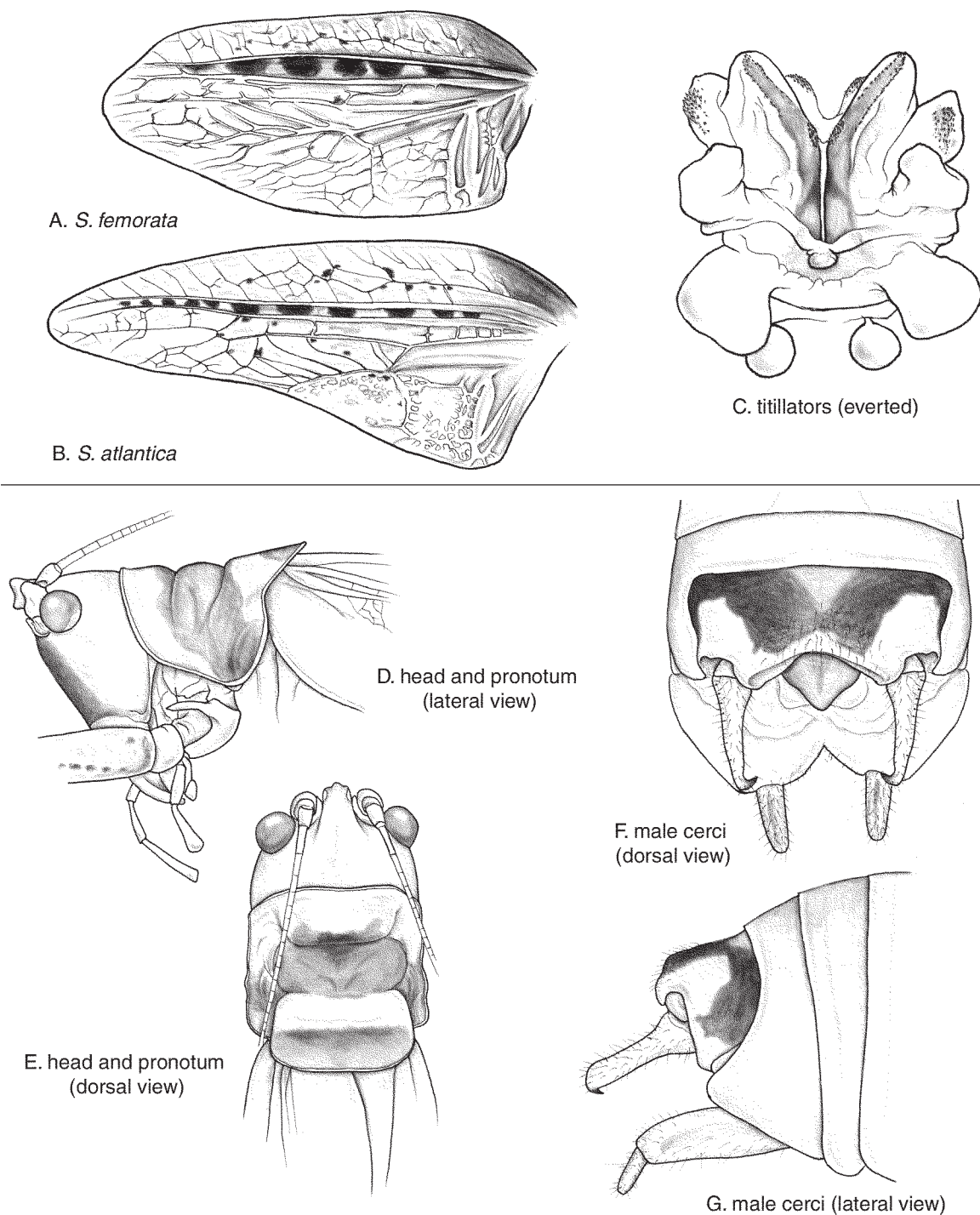


FIG. 26. Costa Rican species of *Sphymetopa* and *Monchecha*. A. *S. femorata* - male left tegmen, B. *S. atlantica*- male left tegmen, C. *S. femorata* - titillators, everted, D-F. *M. pretiosa*: D. female head and pronotum, lateral view, E. female head and pronotum, dorsal view, F. male cerci, dorsal view, G. male cerci, lateral view.

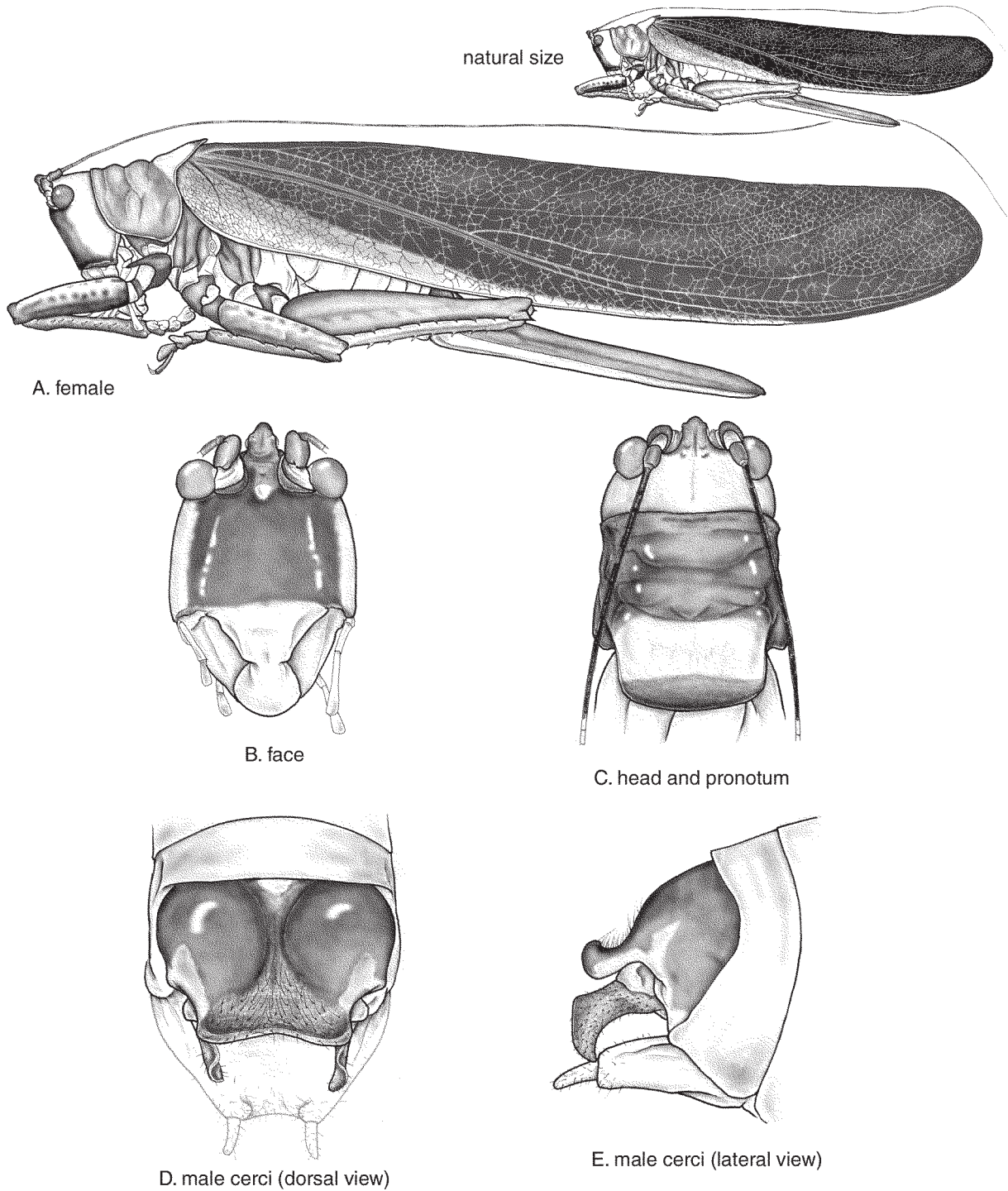


FIG. 27. *Moncheca elegans*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal view, E. male cerci, lateral view.

TABLE 19. Body measurements of Costa Rican species of *Moncheca* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>elegans</i>					
male	50-54.7, 52.4±2.2	42.7-46.8, 44.9±2.2	6.2-6.7, 6.4±0.2	14.4-14.9, 14.6±0.2	na
female	64.9-71.6, 68.4±3	55.9-62.2, 59.1±3	8.1-8.7, 8.4±0.3	17.4-19.3, 18.6±0.8	23.2-24.9, 24±0.8
<i>pretiosa</i>					
male	44.4-53.6, 47.8±3.6	36.8-45.7, 40.2±3.4	5.4-6.3, 5.9±0.4	14.3-17, 15.6±1.1	na
female	57.6-66.7, 61.2±3.1	48.5-58.2, 52±3.3	6.7-7.5, 7.2±0.3	16.5-19.5, 18.3±1.1	21.6-25, 23.1±1.2

2.18 mm long, with 114 narrow and relatively thick teeth, maximum width of file 79 μm (Fig. 47D); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Mirror of stridulatory apparatus with vein AA₁ strongly oblique. Male cercus flattened laterally and strongly expanded dorso-ventrally at apex, resulting in foot-like shape of cercus (Fig. 27E); male 10th tergite almost completely black, strongly sclerotized, convex and shiny, its posterior margin expanded, forming concave, lobe-like projection, covered with dense hair (Fig. 27D). Ovipositor longer than hind femur (ratio ovipositor/hind femur 1.24-1.36), perfectly straight (Fig. 27A).

Coloration.— Body coloration of preserved specimens mostly dark olive green. Face (Fig. 27B), larger part of pronotum (Fig. 27C) and legs shiny black. Clypeus and labrum crimson red and pronotum with wide, ivory band in metazona. Costal field of tegmina yellow to pink (crimson underneath), the remainder of tegmina dark olive green with yellow venation. Abdomen yellow or yellowish green. Sometimes lower valvula of ovipositor yellow.

Measurements.— Table 19.

Bioacoustics.— Morris and Beier (1982) describe a calling sound of what they identified as a male of *Moncheca pretiosa*. The description of its coloration, combined with the origin of specimens (Monteverde — *M. pretiosa* does not seem to occur in that part of Costa Rica), suggest that it was in fact *M. elegans* (this conclusion was confirmed by G. K. Morris upon reexamination of the specimen described in their paper, pers. comm.). The call is described as sibilant and quavering, low Q buzz. Pulse train groups consist of two train types of similar duration but differing in amplitude envelopes (Morris and Beier 1982: 313, Fig. 13). Energy of the call occurs in a wide band, 20-70 kHz, with the strongest peak near 30-34 kHz.

Remarks.— Although frequently collected, it seems that this species has long remained unrecognized. I did not

have a chance to examine the holotype personally, but I compared my specimens to color photographic slides of the type made by T.H. Hubbell, now deposited in the slide collection of the Museum of Zoology at the University of Michigan. Hebard (1927, 1933) considered it a junior synonym of *Moncheca pretiosa*, but a comparison of his specimens with the holotypes of *M. elegans* and *M. pretiosa* reveals the presence of two distinct species (see Table 18 for a list of differences). Surprisingly, he failed to notice well defined differences in the male genital characters of the two species, as well as less prominent but nonetheless consistently present differences in the pattern of coloration. Specimens from Peru mentioned by Hebard (1927) as having much darker coloration are also distinct from the two species known from Costa Rica, and possibly represent another undescribed species. The taxonomic problems with the genus *Moncheca* stem from the fact that most authors have paid a lot attention to the coloration, which can be quite variable, while almost entirely neglecting morphological characters of male genitalia and the stridulatory apparatus.

Guanacaste Province in Costa Rica seems to be the northern boundary of distribution of *M. elegans*. It occurs throughout Costa Rica (Map 12) and part of Colombia. Records of *M. pretiosa* from Panama (Hebard 1927) most likely also represent this species.

Material examined.— **COSTA RICA:** Navarro, elev. 1158.24 - 1112.52 m, 24 July 1927 (coll. Lankester and Rehn) - 1 female (ANSP); **Alajuela Prov.**, 2 km N Colonia Blanca, P. N. Rincón de la Vieja, elev. 800 m, 28 June 1992 (coll. III curso Parataxon.) - 6 males, 2 females (INBio); Dos Rios de Upala, elev. 600 m, 9 July 1990 (coll. A. Fernández) - 1 male (INBio); Finca San Gabriel, 2 km SW Dos Rios, elev. 600 m, 15 June 1989 (coll. GNP Biodiv. Survey) - 2 males, 1 female (INBio); N slope Volcán Poas, 8 km N Vara Blanca, elev. 1300 m, 25 - 26 July 1990 (coll. Meredith and Powell) - 1 male (EMEC); **Cartago Prov.**, Grano de Oro, Chirripó, Turrialba, elev. 1120 m, 30 July 1992 (coll. P. Campos) - 1 male (INBio); **Guanacaste Prov.**,

Estac. Cacao, elev. 1000 - 1400 m, 3 November 1994 (coll. J.F. Corrales) - 1 male (INBio); Estac. Cacao, lado SO, elev. 1000 - 1400 m, 15 July 1993 (coll. J.F. Quesada) - 2 males, 1 female (INBio); same locality, elev. 800 - 1600 m, 15 July 1993 (coll. G. Mora et al.) - 1 male (INBio); Estac. Cacao, Lado SO Vol. Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 29 May 1992 (coll. K. Taylor) - 1 female (INBio); Estac. Cacao, Lado suroeste del Volcán Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 15 June 1990 (coll. II curso Parataxon) - 3 males (INBio); same locality, elev. 1000 - 1400 m, 15 June 1991 (coll. C. Chávez) - 1 female (INBio); Estac. Las Pailas, P.N. Rincón de la Vieja, elev. 800 m, 15 August 1992 (coll. C. Caño) - 2 males (INBio); same locality, elev. 800 m, 11 July 1993 (coll. K. Taylor) - 1 male (INBio); same locality, elev. 800 m, 16 - 24 August 1993 (coll. D. García) - 1 female (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 June 1992 (coll. C. Moraga) - 1 male, 1 female (INBio); same locality, 15 June 1993 (coll. C. Moraga) - 5 males, 1 female (INBio); same locality, 18 - 23 July 1993 (coll. C. Moraga) - 1 male (INBio); same locality, 15 June 1994 (coll. C. Moraga) - 1 female (INBio); Estac. Pitilla, 9 km S Sta Cecilia, elev. 700 m, 15 May 1990 (coll. II curso Parataxon.) - 2 males, 2 females (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1988 (coll. GNP Biodiversity Survey) - 2 males, 1 female (INBio); same locality, 15 June 1988 (coll. GNP Biodiversity Survey) - 1 female (INBio); same locality, 15 July 1988 (coll. GNP Biodiversity Survey) - 2 males, 2 females (INBio); same locality, 15 May 1989 (coll. GNP Biodiversity Survey) - 3 males, 5 females (INBio); same locality, 15 June 1994 (coll. P. Rios) - 1 female (INBio); Estac. Cacao, SW side Volcán Cacao, elev. 1000 - 1400 m, 15 September 1989 (coll. R. Blanco and C. Chávez) - 7 males (INBio); Estac. Mengo, SW side Volcán Cacao, elev. 1100 m, 15 September 1989 (coll. R. Blanco and C. Chávez) - 2 males, 2 females (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 June 1991 (coll. P. Rios) - 1 female (INBio); Hda. Santa Maria, elev. 750 m, 1 - 30 September 1996 (coll. D. Briceño) - 1 female (INBio); **Puntarenas Prov.**, Monteverde, 13-15 June 1986 (coll. B.C. Ratcliffe and party) - 1 male (UNSM); Buen Amigo, San Luís Monteverde, elev. 1000 - 1350 m, 15 September 1994 (coll. Z. Fuentes) - 1 male (INBio); Estac. Pittier, 4.2 km SO del Cerro Gemelo, elev. 1670 m, 11 - 25 May 1997 (coll. M.M. Moraga) - 1 female (INBio); Finca Cafrosa, Estac. Las Mellizas, P.N. Amistad, elev. 1300 m, 15 April 1989 (coll. M. Ramirez and G. Mora) - 3 females (INBio); same locality, elev. 1300 m, 20 August - 4 September 1989 (coll. M. Ramirez and G. Mora) - 3 females (INBio); same locality, elev. 1300 m, 15 October 1989 (coll. M. Ramirez and G. Mora) - 2 females (INBio); San Luís, Monteverde, A.C. Arenal, elev. 1040 - 1350 m, 15 July 1993 (coll. Z.

Fuentes) - 1 male, 2 females (INBio); San Luís, R.B. Monteverde, elev. 1040 m, 15 August 1992 (coll. Z. Fuentes) - 1 female (INBio); same locality, elev. 1040 m, 15 September 1992 (coll. F.A. Quesada) - 2 males (INBio); **San José Prov.**, Estac. Santa Elena, Las Nubes, elev. 1210 m, 6 - 10 April 1997 (coll. E. Alfaro) - 1 male, 1 female (INBio); same locality, elev. 1210 m, 4 - 9 July 1997 (coll. E. Alfaro) - 1 male (INBio); COLOMBIA: Sn. Fortuna to Bonis, - 1 female (ANSP).

Moncheca pretiosa (Walker, 1869)

Figs. 26D-G, 47E, Map 12

1869 Walker, Cat. Derm. Salt. Brit. Mus. 2: 289; type locality: Honduras; type depository: The Natural History Museum, London >>holotype female
1906 Kirby, Syn. Cat. Orth. 2: 233 >>*Exocephala*, as syn. of *E. bisulca*
1912 Karny, in Wytsman, Gen. Ins. 139: 16 >>*Moncheca*, as syn. of *M. bisulca*
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description. — General characteristics as described above. Stridulatory file of male almost perfectly straight, 1.8 mm long, with 86 narrow and relatively thick teeth, maximum width of file 84 μ m (Fig. 47E); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Mirror of stridulatory apparatus with vein AA₁ only slightly oblique. Male cercus straight, cylindrical, with small, apical, hook-like tooth (Fig. 26G); male 10th tergite with large, dark patch but its posterior margin always lightly colored; posterior margin of tergite with wide incision (Fig. 26F). Ovipositor longer than hind femur (ratio ovipositor/hind femur 1.21-1.37), perfectly straight.

Coloration. — Body coloration of live individuals dark turquoise green, turning light green in preserved specimens. Face shiny black; clypeus and labrum crimson red; pronotum olive green, with narrow, white band in prozona and wide one in metazona (Figs. 26D-E). Costal field of tegmina yellow to pink (crimson underneath), remainder of tegmina dark olive green with yellow venation. Abdomen turquoise; sometimes lower valvula of ovipositor yellow.

Measurements. — Table 19.

Bioacoustics. — Song unknown; see discussion under *M. elegans*.

Distribution. — This species occurs from southern Mexico, through Guatemala, Honduras, Belize to southern Costa Rica (Osa Peninsula) (Map 12). It is possible that this species also occurs in Panama but all specimens collected south of Costa Rica (ANSP collection), and identified by M. Hebard as *M. pretiosa*, belong to *M. elegans*.

Material examined. — **COSTA RICA:** **Limón Prov.**, Suerre, Atlantic Side, 20 July 1923 (coll. A. Alfaro) - 1 female (ANSP); **Puntarenas Prov.**, Albergue, Cerro de Oro, ACOSA, elev. 270 m, 14 - 18 March 1995 (coll. A. Picado) - 1 male, 1 female (INBio); Estac. Agujas, elev. 300 m, 15 - 22 April 1996 (coll. A. Azofeifa) - 1 female (INBio); Estac. Agujas, Sendero Zamia, Río Agujas, elev. 300 m, 9 - 28 March 1996 (coll. A. Azofeifa) - 2 females (INBio); Estac. Carara, R.B. Carara, elev. 200 m, 15 March 1990 (coll. R. Zuniga) - 1 male (INBio); Fila Cerro de Oro, elev. 260 m, 14 - 19 March 1995 (coll. F. Alvarado) - 1 female (INBio); Fila Guerra, Península de Osa, elev. 1 - 100 m, 15 March 1991 (coll. J. Quesada) - 1 female (INBio); Peninsula de Osa, Rancho Quemado, elev. 200 m, 15 April 1992 (coll. D. Brenes) - 1 male (INBio); **HONDURAS:** 1 female (lectotype) (BMNH); **GUATEMALA:** Piedras Negras, 1 April - 30 June 1937 (coll. T. Proskouriakoff) - 1 male (ANSP); Piedras Negras, Petén, 1 April - 30 June 1936 (coll. L. Satterthwaite Jr.) - 1 male (ANSP); **MEXICO:** South Mexico, - 1 female (ANSP).

VESTRIA Stål, 1874

1874 Stål, Recens. Orth. 2: 97, 105; type species: *Locusta repanda* Walker, 1869
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Note: The genus *Vestria* is in need of a critical taxonomic revision, which unfortunately is beyond the scope of this work. Currently with four described (including *Eriolus nigrifrons* Karny, transferred to *Vestria* in this work) and three yet unnamed species (Nickle et al. 1996), it may in fact represent more than just one monophyletic lineage. *Vestria punctata*, the only Central American member of the genus, bears little resemblance to its South American counterparts and seems to be more closely related to species traditionally placed in the genus *Moncheca*. Therefore, instead of providing a description of the entire genus, I will limit it to the description of *V. punctata*, hoping that a future revision will help clarify its phylogenetic position.

Vestria punctata (Redtenbacher, 1891)
Figs. 28A-E, 36D, 47A-B, 58A-B, Map 12

1891 Redtenbacher, Monogr. Conoceph.: 348
>>*Exocephala*; type locality: Panama: Chiriquí;
type depository: Instytut Zoologii PAN, Warsaw
- holotype male
1912 Karny, in Wytzman, Gen. Ins. 139: 16 >>*Moncheca*
1927 Hebard, M., Trans. Amer. Ent. Soc. 52: 345
>>*Vestria*

Diagnosis

Body relatively slender; both sexes macropterous (Fig. 28, 36D), tegumen smooth. Fastigium of vertex about as long as eye diameter, gap between fastigia of vertex and frons shallow; frons flat; eyes small but strongly protruding. Front femora with spines on both ventral margins. Male cercus strongly flattened laterally, with small inner tooth; ovipositor straight. Facial markings striking.

Description (male except where specified)

Head. — Fastigium of vertex about as long as eye diameter, approximately triangular when seen from above, with small tubercles at base dorsally (Fig. 28C); gap between fastigium of vertex and fastigium of frons small. Eyes small relative to size of head, but strongly protruding (Fig. 28B). Frons flat, smooth; tegumen of head smooth, with weak traces of genal carinae; face with sides slightly convex.

Thorax and wings. — Dorsal surface of pronotum smooth, shiny, cut by three transverse sulci; metazona slightly raised; anterior dorsal margin straight, posterior one weakly convex (Fig. 28C); lateral lobes with posterior angle rounded and with well developed humeral incision. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, rounded flap. Prosternum unarmed; mesosternum with basisterna approximately triangular, almost vertical, with short apical spines; metasternum unarmed, without well developed lobes.

Wings in both sexes fully developed, surpassing apices of hind femora (Fig. 28A). Stridulatory apparatus of male small but well developed, membranous, without secondary veinlets; stridulatory file curved at its distal end (Figs. 47A-B), with 175 teeth, evenly tapering on both ends; stridulatory teeth relatively thin and wide. Mirror on right wing small, nearly circular. Posterior margin of front wing straight; apex of front wing broadly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; mid and hind coxa unarmed. All femora unarmed dorsally; anterior femora armed ventrally on both margins with short but prominent spines (5 spines

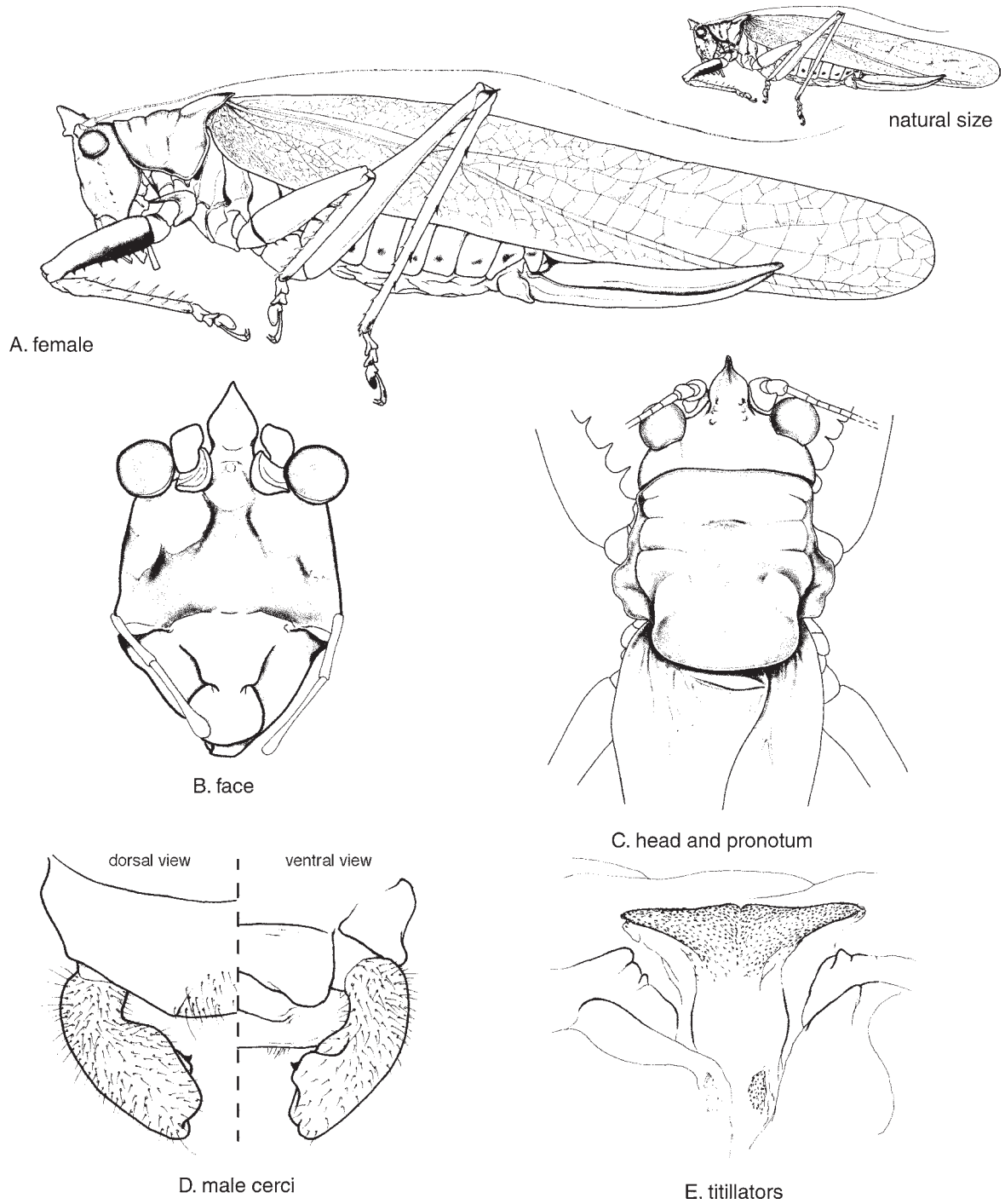


FIG. 28. *Vestria punctata*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal and ventral views, E. titillators, posterior view.

on anterior and 6 spines on posterior margin; spines on anterior margin distinctly larger); mid femora armed on anterior ventral margin with 5-6 spines and 1-3 spines at base of posterior ventral margin; hind femora armed only with 3 small spines on anterior ventral margin below knee; only anterior genicular lobes of fore and mid femora armed, lobes of hind femora armed on both sides. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward; tympanal area distinctly swollen, with pair of small pits below tympanal slits; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of hind tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite unmodified; supraanal plate simple, triangular; female 10th tergite simple, unmodified. Male cercus strongly compressed laterally, with small tooth situated on small, inner lobe (Fig. 28D). Subgenital plate of male longer than wide, with a pair of long styli and deep, narrow, triangular incision on hind margin; female subgenital plate about as wide as long, truncated apically.

Concealed genitalia of male with phallic membrane forming poorly sclerotized titillators (Fig. 28E). Ovipositor about as long as hind femur (ratio ovipositor/hind femur 0.98-1.09), nearly straight; both dorsal and ventral margins of ovipositor smooth, parallel, narrowing towards apex; apex of ovipositor acute.

Coloration. — General coloration pale green, with pronotum and dorsum of head brown to dark olive green, and legs yellowish brown (Fig. 36D). Facial markings striking: frontal part of fastigium of vertex, scapi, and most of upper portion of frons white, lower portion of face dark green, and clypeus, labrum and mandibles yellow (Fig. 28B). Dorsal part of pronotum with two prominent, white spots in metazona. Fore femora black ventrally; mid and hind femora light brown but with black ventral spines; sometimes mid and hind femora with elongate black spots on their inner surfaces; hind tibia with all dorsal spines black. Tegmina light green, sometimes with small, dark dots and patches in apical half; hind wings clear. Abdomen green dorsally, yellow on sides, and with black spot at margin of each tergite. Ovipositor yellowish-brown, with lower edge of upper valvula dark brown to black.

Measurements (4 males, 3 females) (in mm). — body with wings: male 41.2-45.8, 44±2.1, female 47.9-48.9, 48.5±0.5; pronotum: male 5.5-6.4, 6±0.4, female 6.3-6.8, 6.5±0.3; tegmen: male 33.7-36.3, 35.4±1.2, female 39.9-41, 40.4±0.6; hind femur: male 11.8-13.1, 12.5±0.5, female 14-14.5, 14.2±0.3; ovipositor: female 13.8-15.2, 14.5±0.7.

Bioacoustics. — The call of this species consists of irregularly produced bouts of individual, discontinuous chirps, produced at the rate of 4 to 5 per second at 25°C (Figs. 58A-B). Each chirp lasts 84.1 to 99.9 ms, and is probably produced by opening, closing, and again opening of the wings. Most of the energy of the call is allocated between 7 and 13 kHz, although the presence of the energy at the higher end of the spectrum cannot be ruled out.

Distribution. — *V. punctata* occurs throughout Costa Rica and Panama. A specimen of this species from the Naturhistorisches Museum in Vienna, labeled "Alto-Amazonas" has probably been mislabeled.

Material examined. — **COSTA RICA: Alajuela Prov.,** Puesto Quebradón, elev. 300 m, 1 - 31 August 1997 (coll. G. Rodríguez) - 1 female (INBio); **Guanacaste Prov.,** Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 June 1994 (coll. C. Moraga) - 1 female (INBio); same locality, 1 - 30 June 1996 (coll. C. Moraga) - 1 male (INBio); Estac. Pitilla, 9 km St. Cecilia, elev. 700 m, 15 May 1994 (coll. P. Rios) - 1 male (INBio); **Heredia Prov.,** Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 17 - 22 February 1994 (coll. P. Naskrecki) - 1 female (PN collection); same locality, 20 September 1995 (coll. P. Naskrecki) - 1 male (ALAS); **Limón Prov.,** Cuatro Esquinas, Tortuguero N. P., elev. 100 m, 15 January 1990 (coll. J. Solano) - 1 female (INBio); **Puntarenas Prov.,** AC. Osa, Bosque Esquinas, elev. 200 m, 15 May 1994 (coll. M. Segura) - 1 male (INBio); Estac. Sirena (ACOSA), elev. 100 m, 6 - 12 April 1995 (coll. A. Picado) - 2 males (INBio); Península de Osa, Corcovado N. P., Estac. Sirena, 27 March 1981 (coll. D.H. Janzen and W. Hallwachs) - 7 males, 2 females (INBio, PN collection); Rincón, Osa Peninsula, 7 - 20 February 1967 (coll. H.R. Roberts) - 2 males (ANSP); Rincón, Osa Peninsula, insecticide in forest btw. Rincón and air strip, 26 February 1966 (coll. H.R. Roberts) - 1 female (ANSP).

PLUVIASILVA Naskrecki, gen. n.

Type species: *Pluviasilva levis* sp. n., here designated

Diagnosis

Body slender; both sexes macropterous (Figs. 29A-B); tegumen smooth, glossy. Fastigium of vertex almost lamelliform, narrower than scapus; tegumen of head smooth, no traces of genal carinae present; frons flat or weakly convex; eyes small. All legs slender, armed on lower margins with minute spines. Male cercus unarmed, flattened laterally and dorso-ven-

trally expanded apically; ovipositor straight, slightly expanded midlength, apex blunt.

Description (male except where specified)

Head. — Fastigium of vertex almost lamelliform, at its base as broad as 2/3 of scapus; fastigium with distinct longitudinal furrow dorsally (Figs. 29I-J). Eyes small relative to size of head, not particularly protruding. Frons flat or weakly convex, smooth; tegmen of head smooth, without traces of genal carinae; face slender.

Thorax and wings. — Dorsal surface of pronotum smooth and glossy, flat; both anterior and posterior dorsal margins straight (Fig. 29I); lateral lobes with posterior angle broadly rounded. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum armed with two thin, widely separated spines (modified basisternum); meso- and metasternum with basisterna approximately triangular, almost vertical.

Wings in both sexes fully developed, surpassing apices of hind femora (Figs. 29A-B). Stridulatory apparatus of male well developed; stridulatory file (vein AA₁) weakly sinusoid (Figs. 51E-F), broad, lamelliform teeth; stridulatory area of both wings with no secondary venation; mirror of right wing slightly longer than high, with weak veinlet closely parallel to AA₁. Posterior margin of front wing straight or weakly concave; apex of front wing narrowly rounded.

Legs. — Fore coxa with an elongate, forward projecting spine dorsally; middle and hind coxa with ventral spine-like lobes on posterior margins; all trochanters unarmed. All femora unarmed dorsally but armed ventrally on both margins (sometimes posterior ventral margin of fore femur unarmed); genicular lobes of all femora armed with short spines, outer (anterior) spine usually slightly longer than inner (posterior) one; spines on fore femur usually less developed. Front tibia unarmed dorsally, both ventral margins with immovable spines as long as diameter of tibia. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area moderately swollen, with pair of small pits below tympanal slits; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite strongly sclerotized, convex and smooth, devoid of hairs except for its apical portion between and on shallow, horizontal lobes formed by hind margin of tergite (Figs. 29D-G). Female 10th tergite with deep furrow along midline, narrowly incised apically. Supraanal plate small, rounded, completely hid-

den under 10th tergite; male cercus unarmed, cylindrical except for apical portion laterally flattened and somewhat dorso-ventrally expanded; female cercus, simple, narrowly conical. Subgenital plate of male with a pair of styli and shallow apical emargination; female subgenital plate small, with hind margin straight or with shallow emargination.

Epiphallus with a pair of sclerotized, blunt convexities, covered by the phallic membrane but without well developed, strongly sclerotized titillators (Fig. 29H). Ovipositor long and narrow, straight or weakly curved in apical third, narrowed in basal part; both dorsal and ventral margins of ovipositor smooth; apex of upper valvula rounded; ovipositor shorter or considerably longer than hind femur.

Coloration. — General coloration green; frons green, clypeus and labrum purple (yellow in poorly preserved specimens) antennal articles yellow with posterior edges black resulting in "annulated" appearance of antennae. Thorax uniformly green; legs green but often tympanal area of fore tibia or entire dorsal surface of fore tibia black. Tegmina green with numerous, small, dark brown or black spots; stridulatory area on male wings brown; hind wings transparent but with brightly emerald-green venation (often fades in poorly preserved specimens). Abdominal terga pale emerald-green, sometimes with brown midline on first 4-5 terga, 10th tergite of male brownish-orange; abdominal sterna and pleural membranes purple in well preserved specimens. Dried specimens in entomological collections usually turn yellowish-green in time.

Etymology. — The generic epithet is derived from a combination of Latin words *Pluvia* (rain) and *Silva* (forest) to indicate the preferred habitat of at least one species of the new genus.

Remarks. — The two species described below are very similar and males can only be distinguished by the characteristics of the stridulatory file. However, the combination of strong differences between the size of the ovipositor in females of the two species, combined with the differences in the structure of the stridulatory file and minor differences in male genitalia, indicates the presence of two distinct species. Unfortunately, no sound recordings are available for the new species, as it is likely that their availability would confirm the separate status of the two populations.

Only one of the two species, *P. levis*, is known from Costa Rica. It seems appropriate, however, to provide descriptions of both known species of the new genus within one publication.

Virtually nothing is known about the biology of the new taxa. All specimens of *P. levis* sp. n. were collected in lowland tropical rainforest of Costa Rica and all of them

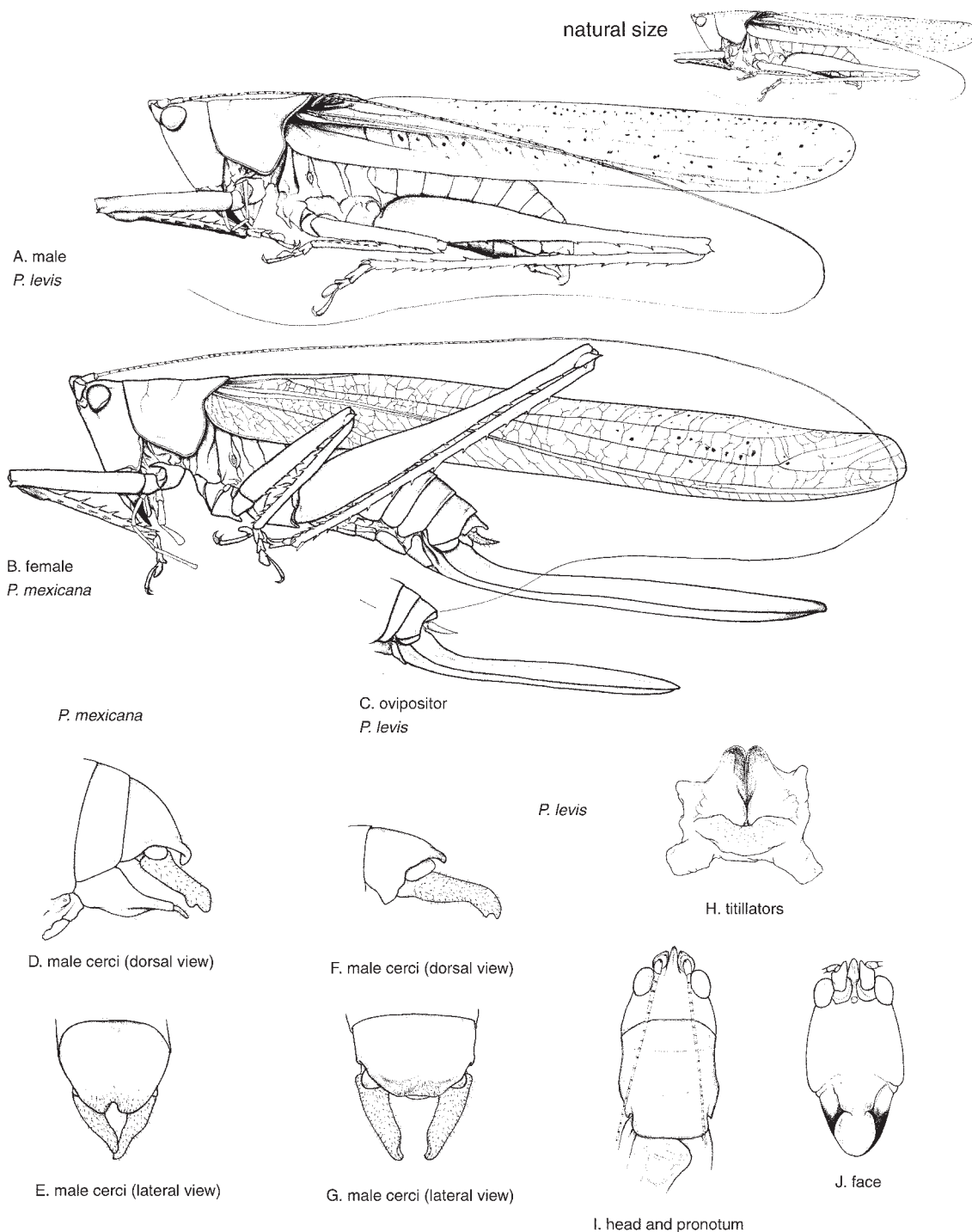


FIG. 29. Species of *Pluviasilva*. A, C, F-J. *P. levis*: A. male - habitus, C. ovipositor, E. male cerci, lateral view, G. male cerci, dorsal view, H. titillators, I. male head and pronotum, dorsal view, J. male face; B, D-E. *P. mexicana*: B. male - habitus, D. male cerci, lateral view, E. male cerci, dorsal view.

TABLE 20. Key for identification of known species of *Pluviasilva*

Species	Ovipositor	Stridulatory file	Distribution
<i>levis</i>	slightly shorter than hind femur (Fig. 28C)	1.8-1.9 mm 147-149 teeth (Fig. 49E)	Costa Rica
<i>mexicana</i>	distinctly longer than hind femur (Fig. 28B)	1.4 mm 112 teeth (Fig. 49F)	Mexico

were collected by either canopy fogging or from freshly felled trees. The rarity of these insects in entomological collection further suggests their exclusively arboreal lifestyle.

The two new species of *Pluviasilva* bear several similarities to species of the genus *Moncheca* Walker. The shared characters include a highly sclerotized and strongly convex 10th tergite in male, which is devoid of hairs, except for their small concentration on the posterior edge of the tergite (Fig. 28D). The male cercus in both genera lacks inner armature and displays generally similar shape, with laterally flattened and dorso-ventrally expanded apex. In addition, both genera share a rather unique for the family glossy appearance of the cuticle.

The differences between the two genera include the shape of fastigium of vertex (narrow, almost lamelliform in *Pluviasilva*, wider than scapus in *Moncheca*), the structure of prosternum (armed with two spines in *Pluviasilva*, unarmed in *Moncheca*), and the structure of stridulatory apparatus (both left and right mirrors membranous, without secondary veinlets in *Pluviasilva*, left mirror with secondary veinlets in *Moncheca*). The fact that *Pluviasilva* spp. have a narrow fastigium may also indicate their relatedness to taxa traditionally placed in the subfamily Agraeciini. However, as I mentioned earlier, the status of this subfamily is uncertain, since there is not enough evidence to support its monophyly, nor is the subfamily diagnosable (Nickle and Naskrecki 1997). For these reasons *Pluviasilva* is placed tentatively in Conocephalinae s.l.

Unique, apomorphic character states of the new genus are as follows: (1) epiphallus with a pair of sclerotized, blunt convexities, covered by the phallic membrane; (2) male cercus unarmed, with the apex laterally flattened, downcurved, with two small, apical lobes; (3) male 10th tergite strongly sclerotized and convex, with its posterior portion expanded into shallow, horizontal lobes; (4) cuticle (including tegmina) very smooth, glossy; (5) venation of the hind wings emerald-green.

Pluviasilva levis Naskrecki, sp. n.
Figs. 29A, 29C, 29F-J, 51E, Map 9

Type locality: Costa Rica, Puntarenas Prov., Península de Osa, Rancho Quemado, elev. 200 m; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description. – General characteristics as described above. Stridulatory file of male 1.75-1.9 mm long, with 147-149 lamelliform teeth, maximum width of file 0.12-0.13 mm (Fig. 51E). Male cercus as in Fig. 4. Ovipositor (Fig. 29C) shorter than hind femur (ratio ovipositor/hind femur 0.95-0.96), not reaching apex of tegmina.

Measurements. – Table 21.

TABLE 21. Body measurements of known species of *Pluviasilva* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>levis</i>					
male	39.5-44.3, 41.9±3.4	31.9-35.1, 33.5±2.3	5.4-5.9, 5.7±0.4	16.5-19.9, 18.2±2.4	na
female	47-48.6, 47.8±1.1	37.6-40.4, 39±2	6-6.5, 6.3±0.4	18.8	17.9-18, 18±0.1
<i>mexicana</i>					
male	38.9	31.8	6.4	16.2	na
female	44.7-49.8, 47.4±1.7	37.2-41.4, 40±1.5	5.6-6.5, 6±0.3	17.8-21, 18.9±1.3	23.6-26.2, 25.1±1

Material examined.— **COSTA RICA: Heredia Prov.**, Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m (10° 26' N, 84° 1' W) 20 October 1995 (coll. P. Naskrecki) - 1 nymph (INBio); **Puntarenas Prov.**, Finca Las Cruces (5 km S of San Vito de Java), elev. 1158.24 m, 10 August 1967 (coll. C.F. Walker) - 1 female (paratype) (UMMZ); Las Cruces, 1 July - 31 August 1991 (coll. J. Doubles) - 1 male (paratype), 1 female (allotype) (ANSP); Península de Osa, Rancho Quemado, elev. 200 m, 15 July 1992 (coll. M. Segura) - 1 male (holotype) (ANSP).

Pluviasilva mexicana Naskrecki, sp. n.
Figs. 29B, 29D-E, 51F

Type locality: Mexico, Veracruz, 5 mi E Córdoba, elev. 670.56 m; type depository: Academy of Natural Sciences, Philadelphia - holotype male

Diagnostic description.— General characteristics as described above. Stridulatory file of male 1.4 mm long, with 112 lamelliform teeth, maximum width of file 0.09 mm (Fig. 51F). Male cercus as in Figs. 29D-E. Ovipositor distinctly longer than hind femur - ratio ovipositor/hind femur 1.21-1.44, usually exceeding or at least reaching apex of tegmina (not reaching apex of tegmina only in specimens with poorly preserved, shrunk abdomen).

Measurements.— Table 21.

Material examined.— **MEXICO:** Chiapas Prov., 12 mi. W Teapa on Pichucalco Rd., elev. 60.96 m, 9 September 1959 (coll. I.J. Cantrall and T.J. Cohn) - 1 female (paratype) (UMMZ); Veracruz, 2.6 rd. mi. SW Fortín de las Flores, 7 - 10 November 1961 (coll. T.J. Cohn and S.P. Hubbell) - 2 females (paratypes) (UMMZ); 5 mi E Córdoba, elev. 670.56 m, 29 August 1936 (coll. H.R. Roberts) - 1 male (holotype), 3 females (allotype and paratypes) (ANSP).

ERIOLUS Bolivar, 1888

1888 Bolivar, Mem. Soc. Zool. France 1: 150; type species: *Eriolus caribeus* Bolivar, 1888
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Diagnosis

Body small as for the subfamily, slender; both sexes macropterous (Figs. 30A, 31A, 37C). Head with fastigium of vertex 0.8-1.5 times as long as diameter of eye, sharply conical or blunt. Head narrow, frons flat or weakly convex; genae without lateral carinae. Prosternum unarmed

or armed with two spines. Male cerci and concealed genitalia extremely variable, titillators always well developed; male paraprocts modified into long, finger-like processes; 10th tergite in both sexes often with long, narrow lobes on posterior margin; ovipositor moderately to strongly curved upwards, pointed apically.

Description (male except where specified)





Head.— Fastigium of vertex small as for the subfamily, 0.8-1.5 times as long as diameter of eye (Figs. 30C, 31C); fastigium sharply conical, with lamelliform, ventral keel, or blunt apically and rounded underneath; dorsal surface of fastigium smooth or with weak longitudinal furrow; lateral ocelli well developed; fastigium of vertex continuous with fastigium of frons. Antennal sockets separated by distance equal to about 0.4 diameter of eye. Eyes globose, moderately projecting; frons flat or weakly convex; genae with lateral carinae. Labrum and mandibles symmetrical to weakly asymmetrical (right mandible smaller) (Fig. 30B).

Thorax and wings.— Dorsal surface of pronotum smooth, flat; anterior margin of pronotum straight, posterior margin straight or weakly convex; lateral lobes with posterior angle narrowly rounded, with well developed humeral sinus. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobes of pronotum; posterior margin of spiracle with finger-like projection. Prosternum unarmed or armed with two, thin, widely separated spines, meso- and metasternum unarmed, without well developed basisternal lobes.

Wings in both sexes fully developed, surpassing apices of hind femora. Stridulatory apparatus of male well developed; stridulatory file straight or weakly sinusoidal (Figs. 50D-F), teeth relatively thick and narrow to very thin and wide; stridulatory area of left wing without secondary venation, rectangular or nearly triangular; mirror of right wing rectangular to nearly triangular, with very well developed veinlet next to AA₁. Posterior margin of front wing straight or weakly convex; apex of front wing narrowly rounded.

Legs.— Fore coxa with an elongate, sometimes laterally flattened, forward projecting spine dorsally; middle and hind coxa without spine; all trochanters unarmed. All femora unarmed dorsally but with small spines on anterior ventral margins, posterior ventral margins unarmed; genicular lobes of all femora armed with long spines, sometimes posterior lobes of fore and/or mid femora unarmed. Front and mid tibia unarmed dorsally, their ventral margins with short, immovable spines; tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area moderately swollen; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

TABLE 22. Key for identification of Costa Rican species of *Eriolus*

Species	Male cercus	10th tergite (both sexes)	Ovipositor	Male subgenital plate
<i>acutipennis</i>	straight, with small sub-basal tooth internally 	with two small, triangular lobes (Fig. 31E)	sickle-shaped, as long as half of hind femur (Fig. 31F)	with styli located on widely separated, narrow lobes
<i>aculeus</i>	with large, oblique, apical arm 	with two long, thin, parallel lobes (Fig. 29D)	saber-shaped, as long as 0.7 of hind femur (Fig. 29A)	with small apical incision and long styli
<i>penicillus</i>	with thin, finger-like subapical spine 	with two long, thin, convergent lobes (Fig. 31A)	saber-shaped, as long as 0.8-0.9 of hind femur (Fig. 31B)	with small apical incision and long styli
<i>duplidentis</i>	conical, with small, thick basal spine and large protuberance midlength 	with shallow, widely triangular incision (Fig. 30D)	sickle-shaped, as long as half of hind femur (Fig. 30A)	without styli and with small, triangular apical incision

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite often with hind margin bearing two, widely separated, narrow lobes (Fig. 30D); female 10th tergite similar to that of conspecific males, often with a pair of long, narrow, lobes; supraanal plate in both sexes small, broadly rounded apically; male cercus variable but always with one or two inner, blunt spines; spines basal, subapical or apical; paraprocts modified into long, finger-like processes (Figs. 30D, 31D, 32A, 32E); female cercus, simple, narrowly conical. Subgenital plate of male with a very shallow apical emargination; with or without styli; female subgenital plate approximately triangular, with shallow apical incision and sometimes with small lobe in the middle of apical incision. Male internal genitalia extremely variable but always with well developed titillators (Figs. 30E-F, 31E, 32D, 32G). Ovipositor narrow, moderately to strongly upcurved, its margins usually parallel; both dorsal and ventral margins of ovipositor smooth, its apex pointed; ovipositor always shorter than hind femur (Figs. 30A, 31A, 32B, 32F).

Coloration. — General coloration pale green (Fig. 37C); face green, sometimes clypeus and labrum brown; pronotum sometimes with two thin, light stripes along dorsal edges, and darker, brown or reddish markings in metazona; tegmina sometimes with irregularly distributed small, black dots.

Remarks. — The genus *Eriolus* was originally described to include only one species, *Erioloides caribeus* Bolivar from Cuba. Subsequent authors included in this genus numerous additional, often unrelated species. Hebard (1927) moved 4 of these species (*E. consobrinus* Pictet et Saussure, *E. frater* Redtenbacher, *E. mexicanum* Saussure, *E. spiniger* Redtenbacher) to a new genus, *Erioloides*. He also indicated the possibility that some other species (*E. jamaicensis* Bruner, *E. longipennis* Redtenbacher), unknown to him, may also belong to his new genus. *Erioloides longipennis* is formally transferred to *Erioloides* in this work, while *E. jamaicensis* will be treated in an upcoming revision of the genus *Erioloides* and related genera (Naskrecki and Cohn, in prep.). Having exam-

TABLE 23. Body measurements of species of *Eriolus*
(all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>acutipennis</i>					
male	22.6	15.5	5.0	12.1	na
female	27.9	21.5	4.8	12.1	6.4
<i>aculeus</i>					
male	27.4-31.4, 30±1.4	21.2-24.3, 23.2±1.1	4.5-4.9, 4.7±0.2	11.4-13.5, 12.5±0.7	na
female	31.8-36.2, 34±1.9	25-28.2, 26.6±1.3	4.8-5.3, 5±0.2	13.1-13.6, 13.4±0.2	8.4-10.1, 9.3±0.7
<i>penicillus</i>					
male	29.6-31.9, 30.8±1.6	24.5-26.4, 25.5±1.3	4.6-4.7, 4.7±0.1	11.7-12.8, 12.3±0.8	na
female	32.8-36.4, 34.9±1.3	26.1-30, 28.2±1.3	4.7-5.1, 4.9±0.1	12.5-13.9, 13.3±0.5	10.5-12.1, 11.1±0.6
<i>duplidentis</i>					
male	32-34.3, 32.7±0.9	25-27.8, 26.5±1.1	5-5.7, 5.2±0.3	12.7-13.6, 13.2±0.4	na
female	33-36.3, 34.4±1.2	26-29.4, 27.7±1.2	4.8-5.4, 5.1±0.2	13.1-14.9, 13.8±0.7	6.4-7.3, 6.9±0.3

ined the holotype of *Eriolus nigrifrons* Karny, I came to the conclusion that it is more closely related to the genus *Vestria* than *Eriolus*, and is here formally transferred to the former.

In Costa Rica, the genus *Eriolus* is represented by 4 species. Both males and females can be easily identified to species based on their unique genitalic characters. Nothing is known about the biology and acoustic behavior these species. They sometimes come to light and most of them were collected by canopy fogging in primary, lowland wet forests.

Eriolus acutipennis Saussure et Pictet, 1898
Figs. 32E-G, Map 16

1898 Saussure and Pictet, Biol. Centr. Amer. Orth. 1: 384; type locality: Panama, Bugaba, 800-1500 ft.; type depository: The Natural History Museum, London – holotype female.
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>holotype illustrated

Diagnostic description. — Body small, with wings in both sexes extending beyond apices of hind femora by less than 1/3 of their length. Fastigium of vertex small, blunt, about as long as eye diameter. Prosternum unarmed. Male stridulatory file and left stridulatory area damaged in the only available male specimen; mirror approximately rectangular, with rounded corners. Tenth tergite in both sexes with two small, roughly triangular lobes; male cercus straight, slightly thickened subapically, with

small sub-basal tooth internally (Fig. 32E); female cercus simple, elongately conical, somewhat curved. Male titillators elongate, flattened, with subapical, round dilatations, apices truncated (Fig. 32G). Male subgenital plate with deep, rectangular incision, resulting in styli being situated on long, widely separated lobes; styli long and thin; female subgenital plate wider than long, with minute, triangular lobe on its hind margin. Ovipositor short, sickle-shaped, about as long as half of hind femur (ratio ovipositor/hind femur 0.53) (Fig. 32F).

Coloration. — General coloration light green; clypeus and mandibles green; pronotum in both sexes with two thin, yellow stripes on dorsal edges of pronotum; posterior edge of metazona in male with two small, brown, rectangular markings.

Measurements. — Table 23.

Distribution. — This species is known only from the southernmost portion of Puntarenas Prov. (Map 16) and adjacent areas of Panama (Bugaba).

Material examined. — **COSTA RICA: Puntarenas Prov.**, Las Alturas, 15 July - 15 August 1991 (coll. J. Doubles) - 1 female (UMMZ); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 1 male (ANSP); **PANAMA:** Bugaba, 800-1500 ft., Champion - 1 female (holotype) (BMNH).

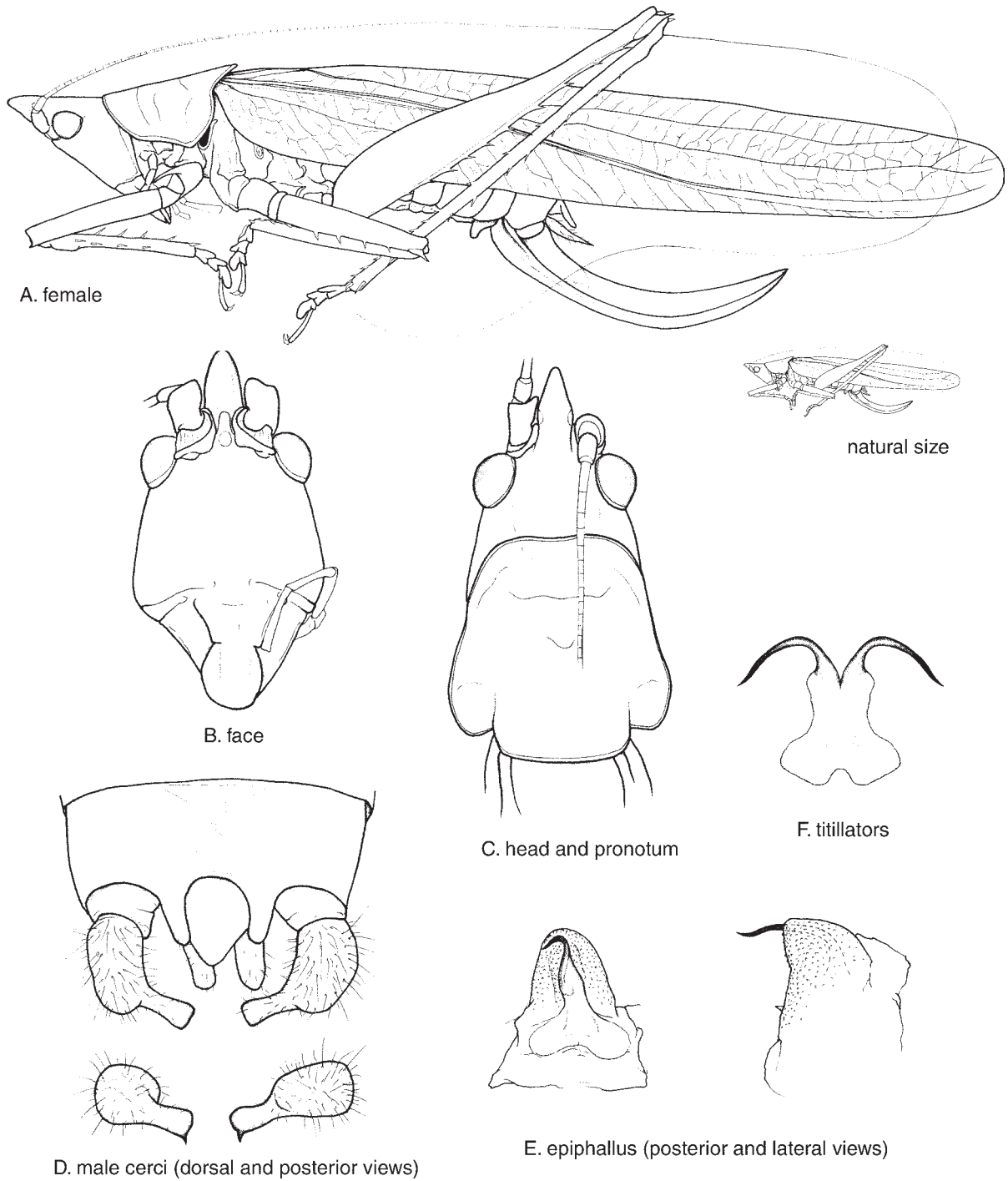


FIG. 30. *Eriolus aculeus*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal and posterior views, E. epiphallus, posterior and lateral views, F. titillators.

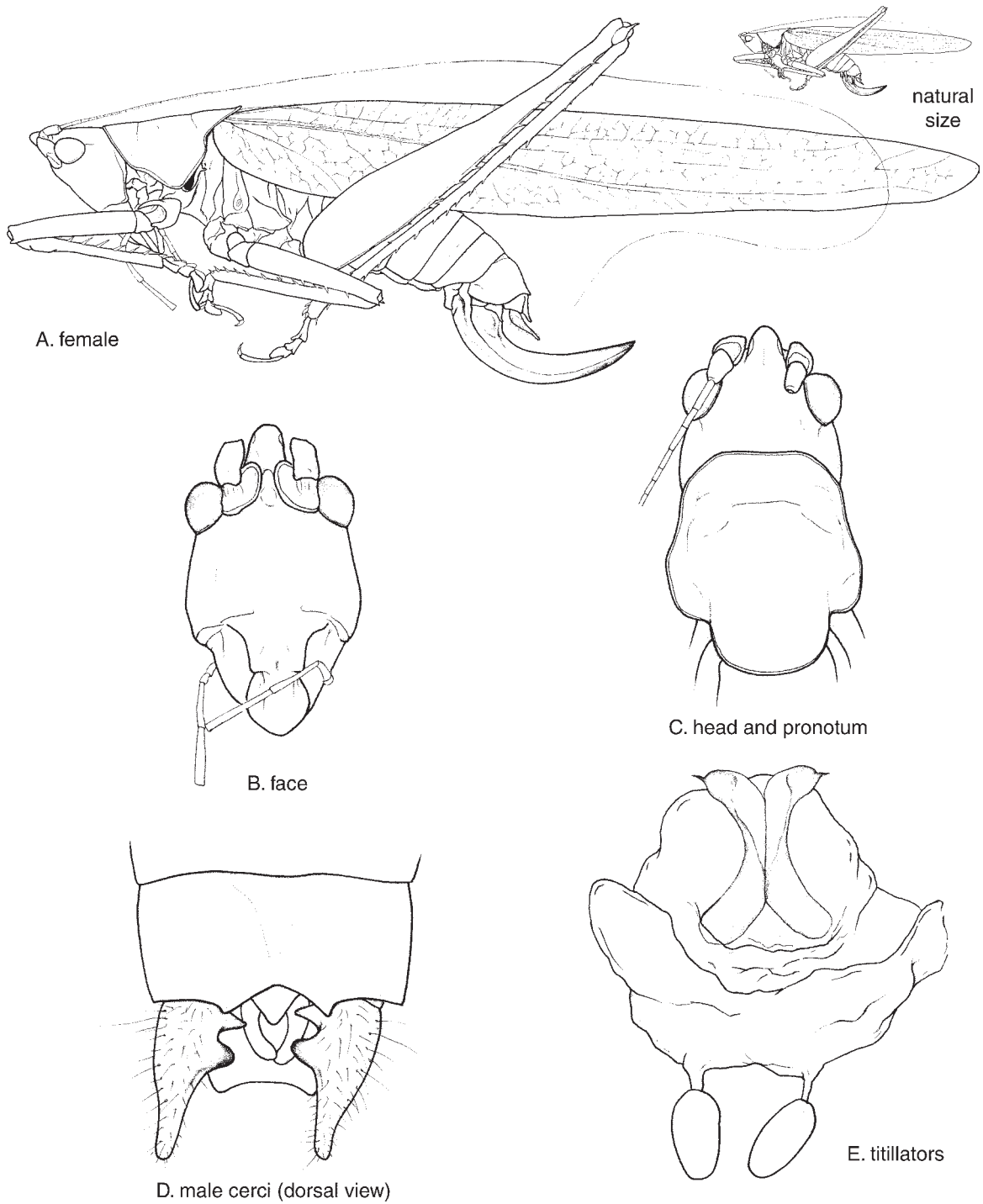
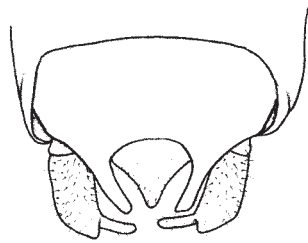


FIG. 31. *Eriolus duplidentis*. A. female - habitus, B. female face, C. female head and pronotum, dorsal view, D. male cerci, dorsal and posterior views, E. titillators.

E. penicillus



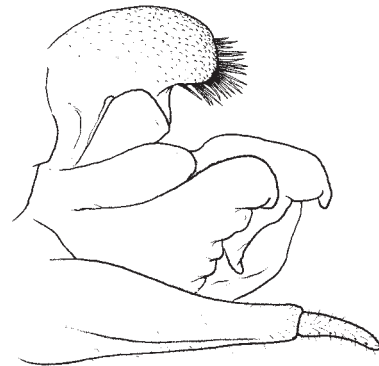
A. male cerci (dorsal view)



B. ovipositor

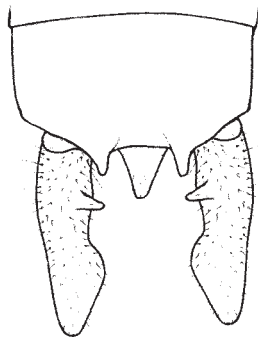


C. epiphallus (posterior view)

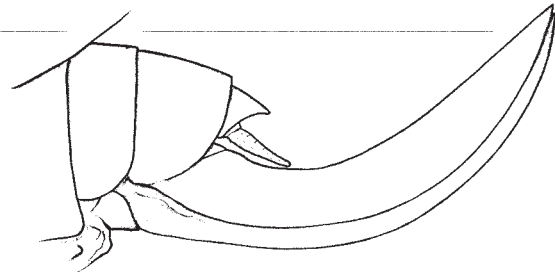


D. epiphallus (lateral view)

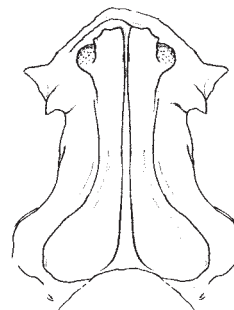
E. acutipennis



E. male cerci (dorsal view)



F. ovipositor



G. titillators

FIG. 32. Costa Rican species of *Eriolus*. **A-D.** *E. penicillus*: **A.** male cerci, dorsal view, **B.** ovipositor, **C.** epiphallus, posterior view, **D.** epiphallus, lateral view, **E-G.** *E. acutipennis*: **E.** male cerci, dorsal view, **F.** ovipositor, **G.** titillators.

Eriolus aculeus Naskrecki, sp. n.

Figs. 30A-F, 50E, Map 16

Type locality: Costa Rica: Puntarenas Prov., Osa Peninsula, Rincón; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— Body small, with wings in both sexes extending beyond apices of hind femora by less than half of their length (Fig. 30A). Fastigium of vertex conical, with well developed ventral keel, as long as 1.5 eye diameter (Fig. 30B-C). Prosternum armed with two thin, widely separated processes. Male stridulatory file weakly sinusoidal, 1.3 mm long, 100 μ m wide, with 179 closely spaced and relatively narrow teeth (Fig. 50E); stridulatory area on male wings strongly projecting, approximately triangular in shape; mirror triangular; secondary veinlet next to AA₁ present, parallel; stridulatory area of left wing devoid of secondary venation.

Tenth tergite in both sexes with two parallel, long and narrow, apically rounded lobes; male cercus about twice as long as thick, with large, oblique, apical arm bent inwards; apex of arm with small ventral tooth (Fig. 30D); female cercus simple, elongately conical, somewhat curved. Male titillators shaped as long, thin, curved needles, their basal parts in a sheath of phallic membrane (Figs. 30E-F). Male subgenital plate with small apical incision and long styli; female subgenital plate approximately triangular, with small incision on its hind margin. Ovipositor long, saber-shaped, distinctly longer than half of hind femur (ratio ovipositor/hind femur 0.62-0.74) (Fig. 30A).

Coloration.— General coloration light green; clypeus and mandibles green; pronotum in both sexes with two thin, yellow stripes on dorsal edges of pronotum; posterior edge of metazona in male without additional markings.

Measurements.— Table 23.

Distribution.— This species has been collected only from Osa Peninsula in Costa Rica (Map 16).

Material examined.— **COSTA RICA: Puntarenas Prov.**, Corcovado N. P., Península de Osa, 5 - 11 August 1979 (coll. D.H. Janzen) - 1 female (paratype) (INBio); Osa Peninsula, 3-20 mi S Rincón, 7 - 20 February 1967 (coll. H.R. Roberts et al.) - 1 male (paratype); Osa Peninsula, 3-10 mi. S Rincón, 7 - 20 February 1967 (coll. H.R. and E.H. Roberts, M.S. Harrison, W.W. Moss, D.A. Nickle) - 1 male, 1 female (paratypes) (ANSP); Península de Osa, 3.5 mi. S Rincón, 8° 42' N, 83° 29' W, 12 March 1969 (coll. D.C.F. Rentz) - 1 female (paratype) (ANIC); Rincón, Osa Peninsula, at night near air strip, 25 February 1966 (coll. H.R.

Roberts) - 1 female (allotype) (ANSP); Rincón, Osa Peninsula, insecticide in forest, 6 mi. S, 27 February 1966 (coll. H.R. Roberts) - 3 males (holotype, paratypes) (ANSP); **PANAMA:** 22 July 1976 - 1 male (paratype) (USNM).

Eriolus penicillus Naskrecki, sp. n.

Figs. 32A-D, 37C, 50F, Map 16

Type locality: Costa Rica: Heredia Prov., La Selva Biological Station; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— Body small, slender, with wings in both sexes extending beyond apices of hind femora by about half of their length (Fig. 37C). Fastigium of vertex conical, with well developed ventral keel, as long as 1.5 eye diameter. Prosternum unarmed. Male stridulatory file weakly sinusoidal, 1.2 mm long, 76 μ m wide, with 146 closely spaced and relatively narrow teeth (Fig. 50F); stridulatory area on male wings strongly projecting, approximately triangular in shape; mirror triangular; secondary veinlet next to AA₁ present, parallel; stridulatory area of left wing devoid of secondary venation.

Tenth tergite in both sexes with two, somewhat converging, long and narrow, apically rounded lobes; male cercus about twice as long as thick, with thin, finger-like, subapical spine (Fig. 32A); female cercus simple, elongately conical, somewhat curved. Male titillators in the form of a tuft of thin, cuticular threads, their basal parts hidden in sheath of phallic membrane (Figs. 32C-D). Male subgenital plate with small apical incision and long styli; female subgenital plate approximately triangular, with minute, triangular lobe on its hind margin. Ovipositor long, saber-shaped, distinctly longer than half of hind femur (ratio ovipositor/hind femur 0.77-0.93) (Fig. 32B).

Coloration.— General coloration pale green (Fig. 37C); clypeus and mandibles purple; pronotum in both sexes with two thin, yellow stripes on dorsal edges of pronotum; posterior edge of metazona in male without additional markings; tegmina with irregularly distributed, numerous small, black dots.

Measurements.— Table 23.

Distribution.— *E. penicillus* is known only from the northeastern Atlantic portion of Costa Rica (Map 16).

Material examined.— **COSTA RICA: Heredia Prov.**, Finca Naranjo Valenciana, 2 km S Pueblo Nuevo, Sarapiquí, elev. 90 m, 9 - 30 September 1992 (coll. M. Ortiz) - 1 female (paratype) (INBio); same locality, elev. 90 m,

22 December 1992 (coll. M. Ortiz) - 1 female (paratype) (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 5 May 1993 (coll. ALAS) - 1 male, 1 female (paratypes) (ALAS); same locality, 1 - 30 November 1993 (coll. ALAS) - 2 males (paratypes) (ALAS); same locality, 1 - 4 April 1994 (coll. P. Naskrecki) - 1 female (paratype) (PN collection); same locality, 7 October 1995 (coll. P. Naskrecki) - 1 female (allotype) (ANSP); same locality, 10 - 15 November 1995 (coll. P. Naskrecki) - 1 female (paratype) (PN collection); same locality, 10-25 January 1999 (coll. D.L. Wagner) - 1 male (holotype) (ANSP); **Limón Prov.**, Río Sardinias, R.N.F.S. Barra del Colorado, 12 November 1993 (coll. F. Araya) - 1 female (paratype) (INBio).

Eriolus duplidentis Naskrecki, sp. n.
Figs. 32A-E, 50D, Map 16

Type locality: Costa Rica: Puntarenas Prov., Parque Nacional Manuel Antonio, Quepos; type depositary: Academy of Natural Sciences, Philadelphia - holotype male

Diagnostic description.— Body small, slender, with wings in both sexes extending beyond apices of hind femora by about half of their length (Fig. 31A). Fastigium of vertex short, rounded apically, without ventral keel, as long as eye diameter (Figs. 31B-C). Prosternum unarmed. Male stridulatory file nearly straight, 0.87 mm long, 96 µm wide, with 242 closely spaced and relatively very wide teeth (Fig. 50D); mirror of stridulatory apparatus approximately rectangular; secondary veinlet next to AA₁ present, parallel; stridulatory area of left wing devoid of secondary venation.

Tenth tergite in both sexes with shallow, widely triangular incision; male cercus conical, with small, thick basal spine, and large, heavily sclerotized protuberance midlength, above spine (Fig. 31D); female cercus simple, elongately conical, somewhat curved. Male titillators flattened, with apices rounded and each armed with simple, small spine (Fig. 31E). Male subgenital plate with shallow, rounded emargination on its hind margin, and no traces of styli; female subgenital plate approximately trapezoidal in shape. Ovipositor short, sickle-shaped, about as long as half of hind femur (ratio ovipositor/hind femur 0.44-0.55) (Fig. 31A).

Coloration.— General coloration light green; clypeus and mandibles green; pronotum in both sexes with two thin, yellow stripes on dorsal edges of pronotum; posterior edge of metazona in male sometimes with two small, brown, rectangular markings.

Measurements.— Table 23.

Distribution.— This new species occurs in wet, lowland rainforests of the Pacific coast of Costa Rica (Map 16).

Material examined.— **COSTA RICA: Puntarenas Prov.**, Estac. Queb. Bonita, Res. Biol. Carara, elev. 50 m (coll. P. Campos) - 1 male (holotype) (ANSP); Estac. Quebrada Bonita, R.B. Carara, elev. 50 m, 15 March 1994 (coll. J. Saborio) - 2 females (allotype, paratype) (ANSP); same locality, elev. 50 m, 15 April 1994 (coll. J. Saborio) - 2 females (paratypes) (INBio); Estac. Sirena (ACOSA), elev. 100 m, 6 - 12 April 1995 (coll. A. Picado) - 1 male (paratype) (INBio); Osa Peninsula, Rincón, 5.5 mi. S, 1 March 1966 (coll. H.R. Roberts) - 1 male (paratype) (ANSP); Osa Peninsula, 3-10 mi. S Rincón, 7 - 20 February 1967 (coll. H.R. and E.H. Roberts, M.S. Harrison, W.W. Moss, D.A. Nickle) - 1 male, 1 female (paratypes) (ANSP); P. N. Manuel Antonio, Quepos, 20 August 1993 (coll. G. Carballo) - 1 male, 2 females (paratypes) (INBio); Rincón, Osa Peninsula, 5.5 mi. S, 24 February 1966 (coll. H.R. Roberts) - 1 male (paratypes) (ANSP); Rincón, Osa Peninsula, insecticide in forest, 6 mi. S, 27 February 1966 (coll. H.R. Roberts) - 1 female (paratype) (ANSP); Rincón, Osa Peninsula, insecticide in forest btw. Rincón and air strip, 26 February 1966 (coll. H.R. Roberts) - 1 male (paratype) (ANSP); **San José Prov.**, Estac. Bijagual, 600 m N de Bijagualito, elev. 500 m, 1 - 31 March 1995 (coll. J.C. Saborio) - 1 female (paratype) (INBio).

SUBRIA Stål, 1874

1874 Stål, Rec. Orth. 2: 114; type species: *Subria nitida* Stål, 1874
1999 Naskrecki and Otte, Illustr. Cat. Orthop. I (CD ROM) >>full references

Note: The genus *Subria* currently includes 9 described species (plus 3 additional species from Costa Rica and Panama described below), 6 of which (including the type species of the genus) are known from the neotropics. The remaining 3 species are known from the Australasian and Indo-Malaysian regions, and most likely should be placed in a separate genus, as were several other species originally described in the genus *Subria* (see Ingrisch 1998). All Neotropical members of the genus are currently subjects of a taxonomic review, focusing on the acoustic behavior of several species (Naskrecki and Morris, in prep.). The generic description below is based on the neotropical representatives of the genus.

TABLE 24. Key for identification of Costa Rican species of *Subria*

Species	Coloration	Male pronotum	Male cerci	Stridulatory file
<i>sylvestris</i>	light green, olive green, or light brown	short, covers at most half of stridulatory apparatus (Fig. 32B)	apex of cercus incised, with large, ventral, subapical lobe (Fig. 37D)	with about 180 teeth (Fig. 49A)
<i>scutellaris</i>	light to dark brown, never green	metazona expanded, covers entire stridulatory apparatus (Fig. 32C)	cercus about twice as long as thick, with large apical spine (Fig. 37E)	with about 140 teeth (Fig. 48G)
<i>crassicerca</i>	light to dark brown, never green	metazona expanded, covers entire stridulatory apparatus (Fig. 32D)	cercus nearly as thick as long, with large apical spine (Fig. 37F)	with about 200 teeth (Fig. 48H)

Diagnosis

Body moderately robust; both sexes macropterous (Figs. 33A, 36H); tegumen smooth. Fastigium of vertex rounded, about as wide as scapus; tegumen of head smooth, no traces of genal carinae present; frons flat or weakly convex; eyes small. Legs moderately robust, armed on lower margins with small spines. Male cercus armed apically with 1 or 2 spines; ovipositor upcurved, slightly expanded midlength, apex pointed.

Description (male except where specified)

Head.— Fastigium of vertex rounded apically, weakly protruding in front of eyes, about as wide as scapus; fastigium of vertex continuous with fastigium of frons. Eyes small relative to size of head, not particularly protruding. Frons flat or weakly convex, smooth; tegmen of head smooth, without traces of genal carinae. Mouthparts symmetrical.

Thorax and wings.— Dorsal surface of pronotum smooth and glossy, flat or weakly convex; anterior dorsal margin straight, posterior one moderately to strongly convex; metazona often expanded, entirely covering stridulatory apparatus (Figs. 33B-D); lateral lobes 2-2.2 times as long as high, humeral sinus weakly indicated. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobe of pronotum; posterior edge of spiracle with small, finger-like projection. Prosternum unarmed; mesosternum with basisterna approximately triangular, oblique; metasternum unmodified or metasternal presternum with two, spine-like projections.

Wings in both sexes fully developed, surpassing apices of hind femora (Figs. 33A, 36H). Stridulatory apparatus of male well developed; stridulatory file weakly curved (Figs. 50G-H, 51A), with evenly distributed, lamelliform teeth; stridulatory area of both wings with no secondary venation; mirror of right wing nearly square, with weak veinlet closely parallel to

AA1. Posterior margin of front wing straight; apex of front wing narrowly rounded.

Legs.— Fore coxa with an elongate, forward projecting spine dorsally; middle and hind coxa with ventral spine-like lobes on posterior margins; all trochanters unarmed. All femora unarmed dorsally; fore and mid femora armed only on anterior ventral margins, hind femora armed on both ventral margins with small spines; genicular lobes of all femora armed with short spines, sometimes anterior lobes of fore and mid femora unarmed. Front tibia unarmed dorsally, both ventral margins with immovable spines as long as diameter of tibia. Tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area moderately swollen, with pair of small pits below tympanal slits; middle tibia unarmed dorsally, ventrally armed on both margins; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen.— Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite moderately to strongly incised apically; female 10th tergite with deep furrow along midline, narrowly incised apically; supraanal plate small, triangular. Male cercus stout, weakly incurved, with 1 or 2 apical spines, sometimes apex of cercus incised; female cercus, simple, narrowly conical. Subgenital plate of male with a pair of styli and shallow apical emargination; female subgenital plate much wider than long, with posterior angles forming small, pointed, widely separated lobes.

Epiphallus with a pair of sclerotized, blunt convexities, covered by the phallic membrane but without well developed, strongly sclerotized titillators (Figs. 33G-I). Ovipositor long and narrow, straight or weakly curved in apical third, narrowed in basal part (Fig. 33J); both dorsal and ventral margins of ovipositor smooth; apex of upper valvula rounded; ovipositor shorter or considerably longer than hind femur.

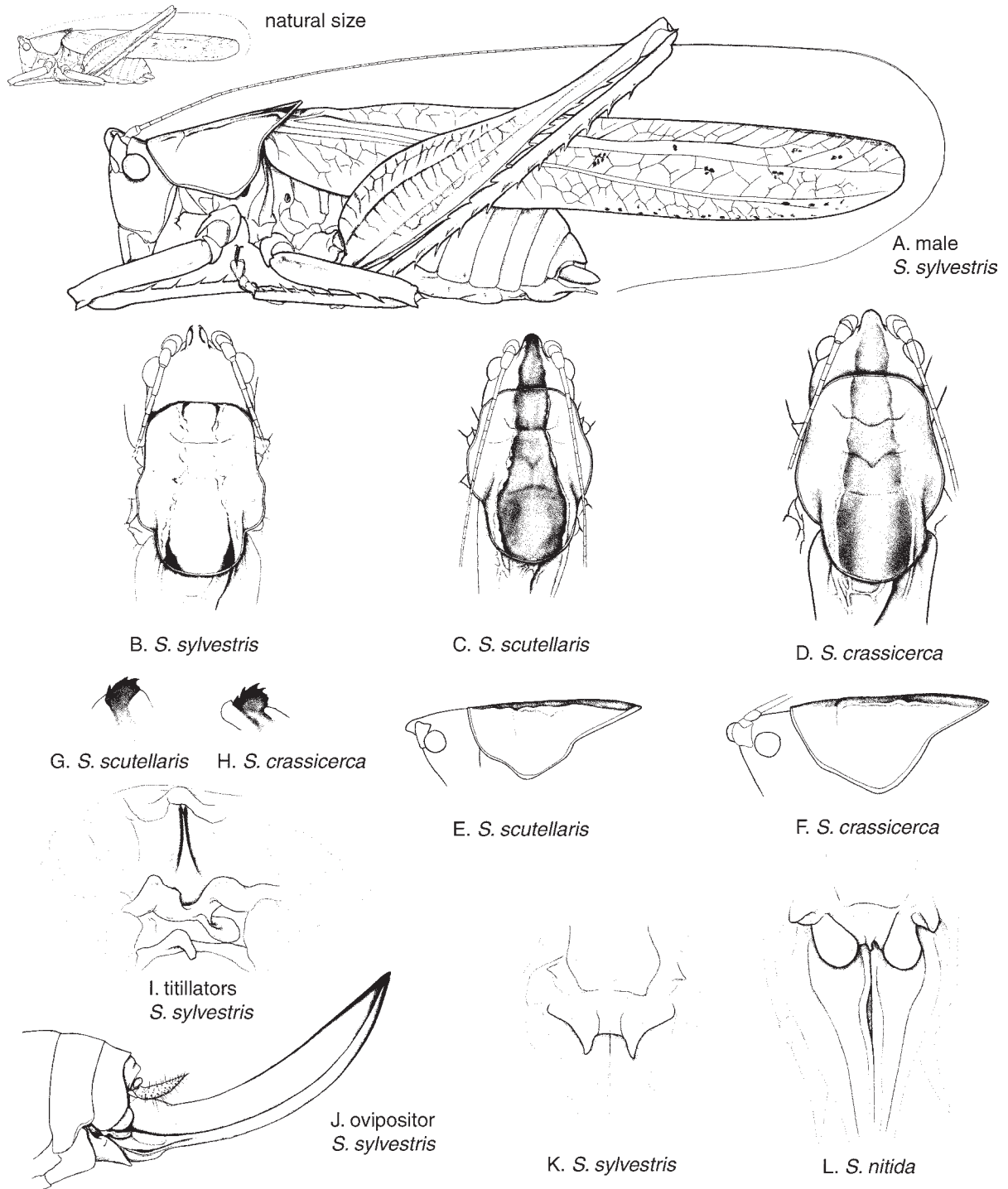


FIG. 33. *Subria* spp. A. *S. sylvestris* - male, habitus, B. *S. sylvestris* - male head and pronotum, dorsal view, C. *S. scutellaris* - ditto, D. *S. crassicerca* - ditto, E. *S. scutellaris* - male head and pronotum, lateral view, F. *S. crassicerca* - ditto, G. *S. scutellaris* - apex of right titillator, H. *S. crassicerca* - ditto, I. *S. sylvestris* - titillators, J. *S. sylvestris* - ovipositor, K. *S. sylvestris* - female subgenital plate, L. *S. nitida* - ditto.

TABLE 25. Body measurements of Costa Rican species of *Subria* (all measurements are lengths in mm: range, mean±SD)

Species	Body	Tegmen	Pronotum	Hind femur	Ovipositor
<i>sylvestris</i>					
male	35.5-37.2, 36.1±0.6	26.9-30.1, 28.1±1.1	7.1-18.2, 9.1±4.5	17.4-19.5, 18.4±0.9	na
female	39.5-52.1, 42.1±4.3	31-43, 33.3±4.1	6.8-8, 7.3±0.4	19.6-22.5, 20.5±0.9	13.2-15, 14.1±0.7
<i>scutellaris</i>					
male	28-28.2, 28.1±0.1	19.7-19.9, 19.8±0.1	7.9-8.1, 8±0.11	4.7-15.7, 15.2±0.7	na
female	33.4-37.4, 35.4±2.8	25.2-27.7, 26.5±1.8	8.1-8.6, 8.4±0.4	17-18.6, 17.8±1.1	12.3-14.5, 13.4±1.6
<i>crassicerca</i>					
male	34.8-37.6, 36.5±1.3	26.2-28.9, 27.4±1.2	8.4-9.5, 9±0.5	18.9-22, 20.4±1.3	na
female	41.6-43.9, 42.7±0.9	31.5-34, 32.6±1	8.9-9.5, 9.2±0.2	21.2-22.9, 22.1±0.6	14.2-16, 15.2±0.7

Coloration. — General coloration variable, green, olive green, brown (Fig. 36H) or pinkish; often several different color morphs can be encountered within a single population of one species. In most species dorsum of pronotum with a dark, wide band, bordered with narrow, yellow or white stripes; tegmina often with numerous, small dark speckles; outer pagina of hind femur often with distinct, reticulate pattern.

Remarks. — Costa Rican representatives of the genus can be found on vegetation from the canopy to low understory levels of both the primary and secondary forests. Canopy fogging in the Atlantic lowland forest of La Selva Biological Station often results in collecting a high number of immature individuals of *S. sylvestris*, although adult individuals of this species are very common on broad-leaved plants in the low understory. At Las Cruces Biological Station, individuals of *S. scutellaris* can often be found along trails on vegetation at the level of about 2 m and more.

Species of *Subria* are omnivorous and have been seen feeding on a variety of animal and plant material, including caterpillars and pupae of Lepidoptera, fruits and flowers of a variety of plants, and the bark of the tree *Pentaclethra macroloba* (Mimosaceae).

Males of *Subria* spp. produce quiet, low Q calls, consisting of either paired lisps or short bouts of rattle-like chirps. Males of *S. scutellaris* alternate their chirps if more than one individual is singing, while *S. sylvestris* does not show any kind of synchrony among singing males. Courtship behavior also includes substrate tremulation, where males produce short bouts of vigorous body shaking, but unlike the genus *Copiphora* females do not respond with similar tremulations. Copulation results in production of a spermatophore with a large, gelatinous spermatophylax. Females deposit eggs in plant tissues.

Subria sylvestris Naskrecki and Morris, sp. n.

Common name: Forest subria

Figs. 33A-B, 33I-K, 36H, 38D, 58C-D, Map 17

Type locality: Costa Rica: Heredia Prov., La Selva Biological Station; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description. — General characteristics as described above. Male pronotum short, barely covering basal half of stridulatory apparatus (Fig. 33B). Tegmina surpassing apices of hind femora by about 1/3 of their length (Fig. 33A, 36H) (in one female from La Selva Biological Station tegmina are abnormally long, surpassing the apices of the hind femora by more than half the length of the tegmen). Stridulatory file of male weakly curved, 2.1 mm long, with 170-179 (n=3) wide and thin teeth, maximum width of file 142 µm (Fig. 51A); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Male cercus weakly incurved, with incised apex, and large, blunt, ventral tooth subapically (Fig. 38D). Ovipositor distinctly curved upwards and slightly widened midlength, slightly longer than half of hind femur (ratio ovipositor/hind femur 0.65-0.74) (Fig. 33J).

Coloration — Unlike other species of the genus, *S. sylvestris* exhibits a remarkable color dimorphism, having both green and brown (Fig. 36H) color morphs occurring within the same population. The material examined included 35% of brown individuals and 65% of green ones (including olive green ones). There seem to be no correlation between the color and season or geographical distribution. Most individuals of the species lack a wide, dark band on the pronotum, typical of the remain-

ing two species of the genus. Instead, the sides of pronotum have two, thin, white or light brown stripes. Occasionally the brown band, or intermediate stages are present. Tegmina often have several irregularly distributed, diffused dark spots. The outer pagina of the hind femur may or may not have a distinct reticulate pattern (the pattern is present in most brown individuals but is only rarely distinct in green ones).

Measurements. — Table 25.

Bioacoustics. — The call of *S. sylvestris* is low duty, with sound production accounting for only about 14% of the calling cycle. It consists of short (147-175 ms) phrases produced at intervals of 0.85 - 4.0 S, each phrase consists of two short (38 - 78 ms) pulses (Figs. 58C-D) (all data apply to songs recorded at temperature 26½C). Typical of most Tettigoniidae, it is a low Q call, with most energy allocated between 6 and 12 kHz in the audible range, and above 20 kHz (the upper frequency range of the call is unknown because call components above 22 kHz were not recorded due to technical constraints of the equipment used). Males start calling at dusk and continue probably all night. Calls are undetectable in field conditions, even on relatively quiet nights. In laboratory conditions the calls are audible from a distance of about 1-1.5 m.

Remarks — *Subria sylvestris* is one of the most common species of Copiphorinae in the lowland rain forests of Costa Rica, occurring in both primary and secondary forests at elevations ranging from sea level to about 700 m (Map 17). It can be found on broad leafed understory vegetation as well as in the canopy. In the field individuals of this species have been seen eating generative parts of plants (e.g. flowers of *Costus* sp., fallen fruits), decaying leaves, tree bark (*Pentaclethra macroloba* (Mimosaceae)), and occasionally insects. In laboratory conditions they can thrive for months on a diet consisting of lettuce, carrot, and apples.

This new species is very closely related to *S. nitida*, from which it differs in the shape of male cerci and female subgenital plate (Fig. 33L).

Etymology. — The specific epithet simply reflects the preferred habitat of the new species.

Material examined (holotype and paratypes). — **COSTA RICA:** Las Ánimas, 18 April 1930 (coll. C.H. Lankester) - 1 female (ANSP); **Alajuela Prov.**, Sector San Ramón, P.N. Guanacaste, elev. 620 m, 15 August - 2 September 1994 (coll. H. García) - 2 females (INBio); **Guanacaste Prov.**, Estac. Pitilla, 9 km S. Santa Cecilia, elev. 700 m, 15 June 1993 (coll. C. Moraga) - 9 females (INBio); Estac. Pitilla, 9 km S. Santa Cecilia, P.N. Guanacaste, elev. 700 m, 3 June 1993 (coll. C. Moraga) - 1 female (INBio); Estac. Pitilla, 9

km St. Cecilia, elev. 700 m, 15 July 1988 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, 15 May 1989 (coll. GNP Biodiversity Survey) - 1 male (INBio); same locality, 15 August 1994 (coll. C. Moraga) - 1 male (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 September 1989 (coll. C. Moraga and P. Rios) - 1 female (INBio); Estac. Pitilla, 9 km S Santa Cecilia, elev. 700 m, 15 May 1991 (coll. P. Rios, C. Moraga and R. Blanco) - 1 female (INBio); **Heredia Prov.**, Estac. Magsasay, P.N. Braulio Carillo, elev. 200 m, 15 June 1990 (coll. E. Alcazar) - 4 females (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 17 - 22 February 1994 (coll. P. Naskrecki) - 1 male (PN collection); same locality, 15 March 1994 (coll. P. Naskrecki) - 2 males, 3 females (PN collection); same locality, 1 - 4 April 1994 (coll. P. Naskrecki) - 6 males, 1 female, 1 nymph (incl. holotype, allotype) (ANSP); same locality, 7 - 10 December 1995 (coll. P. Naskrecki) - 2 males (PN collection); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 male, 1 female (PN collection); **Limón Prov.**, Cuatro Esquinas, Tortuguero N. P., 15 September 1989 (coll. J. Solano) - 1 female (INBio); same locality, elev. 100 m, 15 January 1990 (coll. J. Solano) - 1 female (INBio); Estac. Hitoy-Cerere Res. Biol. Hitoy Cerere, Río Cerere, elev. 100 m, 15 May 1991 (coll. A. Moreno) - 1 male (INBio); same locality, elev. 100 m, 20 June 1992 (coll. F.A. Quesada) - 1 female (INBio); La Emilia, near Guápiles, elev. 304.8 m, 24 August 1923 - 1 female (ANSP); La Lola (0.5 mi. W Madre de Dios), 2 October 1961 (coll. Hubbell, Cantrall, Cohn) - 4 females (UMMZ); **Puntarenas Prov.**, Las Cruces, 1 July - 31 August 1991 (coll. J. Doubles) - 1 male, 1 female (UMMZ); **PANAMA:** Barro Colorado Island, 28 June 1933 (coll. H.H. Hood) - 1 female (ANSP); Canal Zone, Barro Colorado, 18 July 1924 (coll. N. Banks) - 1 female (ANSP).

Subria scutellaris Naskrecki and Morris, sp. n.

Common name: Lesser subria

Figs. 33C, 33E, 33G, 38E, 50G, 58E-F, Map 17

Type locality: Costa Rica: Puntarenas Prov., Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens; type depository: Academy of Natural Sciences, Philadelphia - holotype male

Diagnostic description. — General characteristics as described above. Tegmina surpassing apices of hind femora by only about 1/6 of their length. Male pronotum with metazona expanded, entirely covering stridulatory apparatus (Fig. 38C, 38E). Stridulatory file of male weakly curved, 1.8 mm long, with 137 (n=1) wide and thin teeth, maximum width of file 102 µm (Fig. 50G); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Male cercus weakly incurved, about twice as long as thick, with large apical

spine (Fig. 38E); apices of titillators expanded and flattened, with several large teeth (Fig. 33G). Ovipositor distinctly curved upwards and widened midlength, slightly longer than half of hind femur (ratio ovipositor/hind femur 0.72-0.78).

Coloration.— General coloration chestnut brown, with wide, dark band extending across the top of the head, pronotum, and posterior edges of tegmina; tegmina with irregularly distributed, small, diffused darker spots; outer pagina of hind femur with distinct reticulate pattern. No green form is known for this species.

Measurements.— Table 25.

Bioacoustics.— Males of *S. scutellaris* produce relatively high duty calls, consisting of paired chirps separated by about 1 second of silence (at 26°C) (Figs. 58E-F). Each chirp in a pair is produced by 6-7 wing strokes, and lasts 176-181 ms. Chirps in the pair are separated by 514-654 ms of silence (based on 5 recordings of 2 males). Males of this species alternate their calls if they can hear each other.

Distribution — *Subria scutellaris* is known only from southern portion of Puntarenas Province, near the border with Panama (Map 17). All specimens were collected at elevations of 700-1300 m.

Etymology.— The specific epithet reflects the somewhat enlarged, shield-like pronotum of the males of the new species.

Material examined (holotype and paratypes).— **COSTA RICA: Puntarenas Prov.**, Finca Cafrosa, Estac. Las Mellizas, P.N. Amistad, elev. 1300 m, 15 April 1989 (coll. M. Ramirez and G. Mora) - 1 male (INBio); Valle de Coto Brus, Las Cruces, Wilson Botanical Gardens, 22 March 1994 (coll. P. Naskrecki) - 2 males, 2 females (incl. holotype, allotype) (ANSP); same locality, elev. 700 - 1000 m, 1 - 6 December 1995 (coll. P. Naskrecki) - 2 males, 1 female (PN collection).

Subria crassicerca Naskrecki and Morris, sp. n.

Common name: Greater subria

Figs. 33D, 33F, 33H, 38F, 50H, Map 17

Type locality: Costa Rica: Puntarenas Prov., Albergue, Cerro de Oro; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— General characteristics as described above; very similar to *S. scutellaris* but distinctly larger. Tegmina surpassing apices of hind femora by about 1/5 of their length. Male pronotum with metazona expanded, entirely or almost entirely covering stridulatory apparatus (Figs. 33D, 33F). Stridulatory file of male

weakly curved, 2.14 mm long, with 202 (n=1) wide and thin teeth, maximum width of file 141 μ m (Fig. 50H); teeth of file uniform in thickness, evenly spaced and smoothly narrowing towards proximal end. Male cercus weakly incurved, nearly as thick as long, with large apical spine (Fig. 38F); apices of titillators expanded and flattened, with several large teeth (Fig. 33G). Ovipositor distinctly curved upwards and clearly widened midlength, slightly longer than half of hind femur (ratio ovipositor/hind femur 0.64-0.75).

Coloration.— General coloration straw brown to chestnut brown, with wide, dark band extending across the top of the head, pronotum, and posterior edges of tegmina; tegmina with irregularly distributed, small, diffused darker spots; outer pagina of hind femur with distinct reticulate pattern. No green form is known for this species.

Measurements.— Table 25.

Bioacoustics.— Song unknown.

Distribution — *S. crassicerca* most likely occurs only in the Pacific portion of Costa Rica (Map 17).

Etymology.— The specific epithet reflects the shape of the male cercus, which is thicker and stouter than in other members of the genus.

Material examined (holotype and paratypes).— **COSTA RICA: Alajuela Prov.**, Río Surubres, near San Mateo, elev. 250 m, (coll. P. Biolley) - 1 female (ANSP); **Puntarenas Prov.**, Albergue, Cerro de Oro, elev. 270 m, 14 - 19 March 1995 (coll. R. Villalobos) - 1 male (holotype) (ANSP); Estac. Agujas, Río Agujas, Sendero Ajo, elev. 300 m, 1 - 3 June 1997 (coll. M. Lobo) - 1 male (INBio); Estac. Quebrada Bonita, R.B. Carara, elev. 50 m, 15 April 1989 (coll. R. Zuniga) - 2 females (INBio); Fila Guerra, Península de Osa, elev. 1 - 100 m, 15 March 1991 (coll. J. Quesada) - 1 female (INBio); nr. Rincón, Osa Peninsula, 23 February 1966 (coll. H.R. Roberts) - 1 male (ANSP); Península de Osa, Corcovado N. P., elev. 10 - 100 m, 25 March 1977 (coll. D.H. Janzen) - 2 females (INBio); same locality, elev. 10 - 100 m, 27 March 1982 (coll. D.H. Janzen and W. Hallwachs) - 2 males, 4 females (INBio, PN collection); Rincón, Osa Peninsula, forest trail, 19 February 1965 (coll. H.R. Roberts) - 1 female (ANSP); Rincón, Osa Peninsula, stream trail, S ride air strip II, 22 - 23 February 1966 (coll. H.R. Roberts) - 1 male (INBio); Sirena, Corcovado N.P., elev. 0 - 100 m, 15 April 1989 (coll. R. Blanco and G. Fonseca) - 1 female (INBio).

PODACANTHOPHORUS Naskrecki, gen. n.

Type species: *Podacanthophorus alas* sp. n., here designated

Diagnosis

Body small as for the subfamily, relatively robust; both sexes macropterous (Figs. 34A, 36F). Head with fastigium of vertex 2-3 times as long as diameter of eye, conical, with distinct ventral keel. Head narrow, frons flat or weakly convex; genae without lateral carinae. Pronotum wide, with lateral lobes oblique; metazona in males entirely covers stridulatory apparatus. Thoracic sterna unarmed. Male cerci with long basal spine; titillators needle-like; ovipositor strongly curved upwards, pointed apically.

Description (male except where specified)

Head. — Fastigium of vertex conical, 2-3 times as long as diameter of eye (Figs. 35A-I), with well developed, lamelliform, ventral keel; dorsal surface of fastigium smooth or with longitudinal furrow; ocelli reduced, hardly discernible; fastigium of vertex continuous with fastigium of frons. Antennal sockets separated by distance equal to width of scapus. Eyes globose, moderately protruding, small relative to size of head; frons flat or weakly convex; genae without lateral carinae. Labrum and mandibles symmetrical.

Thorax and wings. — Pronotum widely semi-circular in cross-section, with lateral lobes oblique; dorsal surface of pronotum smooth, flat; anterior margin of pronotum concave, posterior margin convex (Figs. 35B-F); lateral lobes not well differentiated from dorsum of pronotum, lacking humeral sinuses (Figs. 35G-I); shape of pronotum sexually dimorphic: metazona in male much longer, narrowed towards apex, entirely covering stridulatory apparatus. Thoracic auditory spiracle large, elliptical, completely hidden under lateral lobes of pronotum. Thoracic sterna unarmed, without well developed basisternal lobes.

Wings in both sexes fully developed or somewhat reduced; tegmina reaching or surpassing apices of hind femora (Fig. 34A, 36F); hind wings reaching apices of tegmina or somewhat shortened. Stridulatory apparatus of male well developed; stridulatory file straight or weakly curved (Figs. 51B-D), teeth thin and very wide; stridulatory area of left wing without secondary venation, nearly square; mirror of right wing nearly square, with very well developed veinlet next to AA₁. Posterior margin of front wing straight or weakly convex; apex of front wing narrowly rounded.

Legs. — Legs robust, their tegumen strongly rugose. Fore coxa with an elongate, forward projecting spine dorsally; middle and hind coxa without spine; all tro-

chanters unarmed. All femora unarmed dorsally but armed with long to very long spines on both ventral margins; all femora robust, strongly flattened laterally (Figs. 35K-N); anterior ventral spines on hind tibia often very long, flattened; genicular lobes of hind femora armed with long spines, lobes on fore and mid femora unarmed in most species. Front and mid tibia unarmed dorsally, their ventral margins with immovable spines about as long as tibia diameter; tympanum on fore tibia bilaterally closed, tympanal slits facing forward, tympanal area weakly swollen, cuticular flaps above tympanum nearly transparent; hind tibia armed on all four dorsal and ventral margins; apex of tibia with two pairs of ventral and one pair of dorsal movable spurs.

Abdomen. — Dorsal surface of abdominal terga smooth, unmodified. Male 10th tergite with deep, narrow incision, resulting in two wide lobes; tergal lobes of female 10th tergite similar to that of conspecific males but narrower and pointed apically; supraanal plate in both sexes small, broadly rounded apically; male cercus narrowly cylindrical, with long, basal internal spine; cercal spine completely hidden under 10th tergite, invisible from above (Figs. 34B, 34D, 34F); female cercus, simple, narrowly conical. Subgenital plate of male triangular, with small, narrow apical incision; styli well developed; female subgenital plate approximately triangular, with or without shallow apical emargination. Titillators of male well developed, shaped like a pair of cuticular needles, straight or sinusoidal (Figs. 34C, 34E, 34G). Ovipositor sickle-shaped, strongly upcurved, its margins parallel or ovipositor somewhat dilated midlength; both dorsal and ventral margins of ovipositor smooth, its apex pointed; ovipositor always shorter than hind femur (Fig. 34A, 35J).

Coloration. — General coloration light green (Fig. 36F); face light green to creamy white, sometimes labrum and mandibles dark purple; fastigium of vertex yellow or reddish; pronotum of male with species-specific color markings in metazona; tegmina with contrastingly yellow venation; legs with densely distributed small black and larger emerald dots; ventral spines of femora white with black tips.

Remarks. — This new genus is closely related to the genus *Eriolus* but can be easily separated by the unique shape of the pronotum; the presence of long, flattened spines on hind femora; stout, robust legs; the structure of male cerci; and general, somewhat dorso-ventrally flattened appearance of live individuals. The two genera share similar features of the fastigium of vertex, the stridulatory apparatus, thoracic sterna, and the ovipositor.

All species of the genus are exclusively arboreal and nocturnal, and being unable to fly actively, are never attracted to light. This makes collecting them difficult, and specimens of the genus are rare in entomological collec-

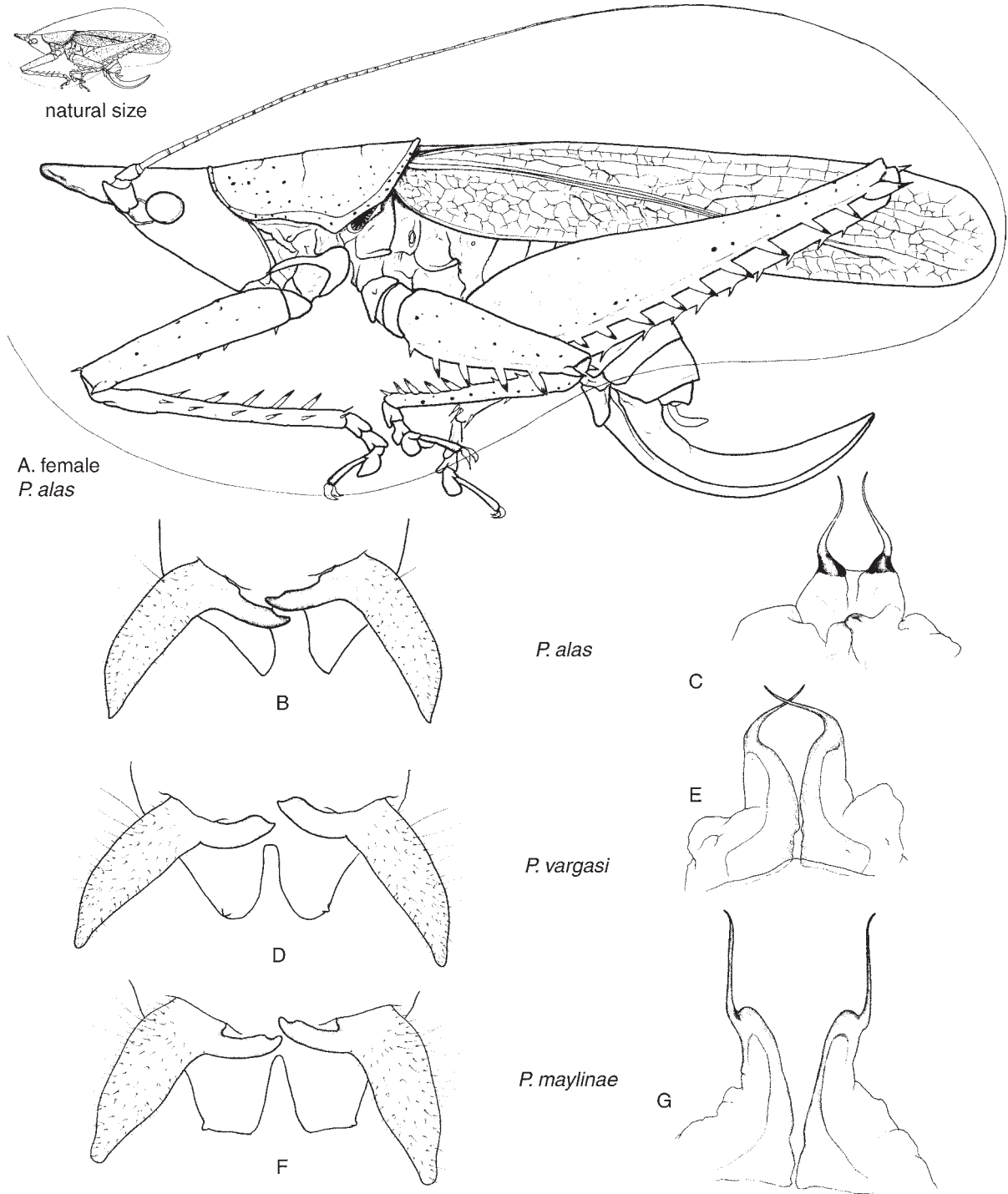


FIG. 34 Costa Rican species of *Podacanthophorus*. A-C. *P. alas*: A. female, habitus, B. male cerci, ventral view, C. titillators, D-E. *P. vargasi*., D. male cerci, ventral view, E. titillators, F-G. *P. maylinae*: F. male cerci, ventral view, G. titillators.

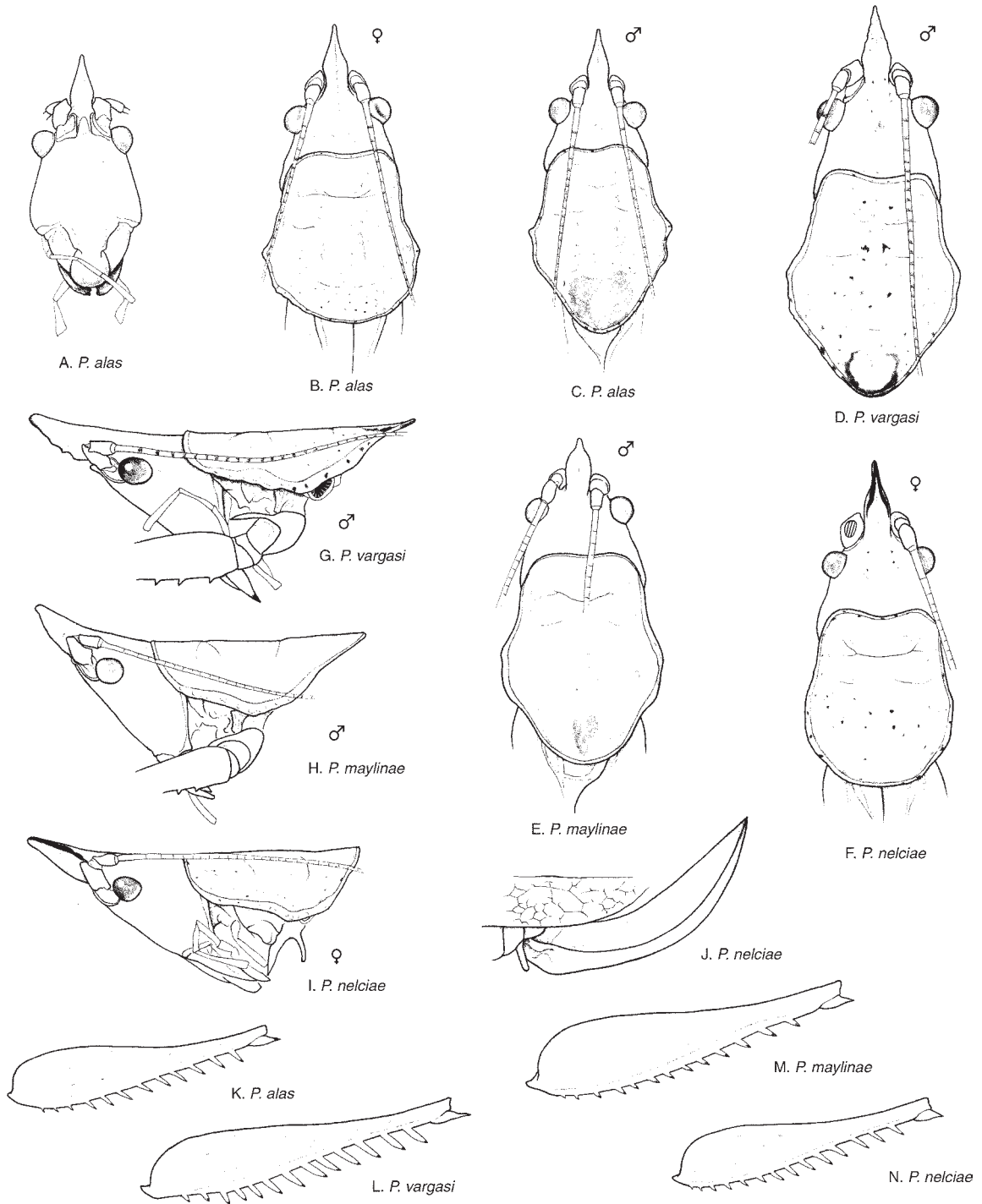


FIG. 35. Costa Rican species of *Podacanthophorus*. A. *P. alas* - male face, B-F. head and pronotum, dorsal views: B. *P. alas* - female, C. *P. alas* - male, D. *P. vargasi* - male, E. *P. maylinae* - male, F. *P. nelciae* - female; G-I. head and pronotum, lateral views: G. *P. vargasi* - male, H. *P. maylinae* - male, I. *P. nelciae* - female; J. *P. nelciae* - ovipositor; K-N. left hind femora, outer views: K. *P. alas*, L. *P. vargasi*, M. *P. maylinae*, N. *P. nelciae*.

TABLE 26. Key for identification of Costa Rican species of *Podacanthophorus*

Species	Ventral spines on hind femur	Markings on male pronotum	Fastigium of vertex
<i>alas</i>	the longest spine as long as the smallest width of femur (below knee) (Fig. 34K)	large, brown, usually heart-shaped spot in metazona (Fig. 34C)	without dorsal markings (Fig. 34B-C)
<i>vargasi</i>	the longest spine nearly twice as long as the smallest width of femur (below knee) (Fig. 34L)	white spot surrounded by brown margin in metazona (Fig. 34D)	without dorsal markings (Fig. 34D)
<i>maylinae</i>	the longest spine as long as half the smallest width of femur (below knee) (Fig. 34M)	small, dark red, V-shaped spot surrounded by thick white margin in metazona (Fig. 34E)	without dorsal markings (Fig. 34E)
<i>nelciae</i>	the longest spine as long as the smallest width of femur (below knee) (Fig. 34N)	male unknown	with black, longitudinal dorsal markings (Fig. 34F)

tions. Most of the specimens of the four new species described below were collected by either collecting directly in the canopy level of the forest or by canopy fogging.

Little is known about the biology of *Podacanthophorus* spp. In captivity, *P. alas* and *P. vargasi* thrived for several months on the diet consisting of various fruits and vegetables, as well as dead insects. The call is known for only *P. alas* (see description below). Females lay eggs in stems of plants. Eggs are long and thin, somewhat resembling thin grains of rice.

Etymology.— The generic epithet relates to the large femoral spines typical of all species of the genus.

Podacanthophorus alas Naskrecki, sp. n.
Figs. 34A-C, 35A-C, 35K, 51C, 58G, Map 18

Type locality: Costa Rica, Heredia Prov., La Selva Biological Station; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— The smallest species of the genus; general characteristics as described above; wings in both sexes hardly reaching apices of hind femora or slightly surpassing them (Fig. 34A). Fastigium of vertex 2.5-3 times as long as eye diameter, narrowly rounded apically, with distinct dorsal furrow dorsally; ventral keel of fastigium somewhat undulant (Figs. 35A-C). Male stridulatory file weakly curved, 0.9 mm long, 89 μ m wide, with 284 closely spaced and relatively very wide teeth (Fig. 51C); stridulatory area on male without secondary venation; mirror square; secondary veinlet next to AA₁ present, divergent from AA₁. Ventral anterior spines of

hind femora as long as width of hind femur below knee (Fig. 35K).

Tenth tergite of male with two somewhat divergent, wide lobes; female 10th tergite with lobes much narrower, pointed; male cercus straight, basal internal spine nearly straight, distinctly constricted apically (Fig. 34B); female cercus simple, elongately conical, somewhat curved. Male titillators needle-like, sinusoidal (Fig. 34C). Ovipositor short, sickle-shaped, about as long as half of hind femur (ratio ovipositor/hind femur 0.50-0.60) (Fig. 34A).

Coloration.— General coloration light green; face creamy white; fastigium reddish-brown; clypeus and mandibles dark purple; metazona of pronotum in male with large, brown, usually heart-shaped spot; venation of tegmina and posterior edge of tegmina contrastingly yellow.

Measurements.— Table 27.

Bioacoustics.— The call of *P. alas* is low Q and low duty. Most of the energy is probably allocated in the ultrasonic frequencies, which unfortunately I was unable to record. The audible portion of the call consists of irregularly produced, paired lisps, with each lisp lasting 8.2- 14.5 ms (n=20) at 28°C (Fig. 58G). The interval between the lisps ranged from 168 to 763 ms. The audible portion of the call does not have a clearly defined frequency peak, although frequencies between 9-12 kHz seem to have more energy.

Distribution.— This new species been collected so far only at La Selva Biological Station, Heredia Prov. (Map 18).

TABLE 27. Body measurements of species of *Podacanthophorus* (all measurements are lengths in mm: range, mean±SD)

Species	Body with wings	Tegmen	Pronotum	Hind femur	Ovipositor
<i>alas</i>					
male	18.5-21.8, 20.2±2.3	12-12.8, 12.4±0.6	6.2-6.8, 6.5±0.4	10.8-12, 11.4±0.8	na
female	24.3-25.1, 24.7±0.4	15.8-16.6, 16.1±0.4	5.8-5.8, 5.8±0	12.5-12.7, 12.6±0.1	6.3-7.5, 6.9±0.6
<i>vargasi</i>					
male	22.3-26.3, 24.2±2	13.2-15.6, 14.5±1.2	11.5-14.2, 12.7±1.4	11.4-13.5, 12.5±0.7	na
female	27.7-29.5, 28.7±0.8	18.3-19.7, 18.9±0.6	13.7-15.3, 14.4±0.7	13.1-13.6, 13.4±0.2	7.6-8.6, 8.2±0.4
<i>maylinae</i>					
male	25.9-27.1, 26.5±0.8	17.3-17.5, 17.4±0.1	7-7.7, 7.4±0.5	12.3-12.9, 12.6±0.4	na
female	32.3-34.6, 33.3±1	22-23, 22.5±0.4	6.7-7.2, 7±0.2	14.1-15.1, 14.7±0.5	9.4-10.3, 10±0.4
<i>nelciae</i>					
male	?	?	?	?	na
female	24.2-29.8, 26.5±2.5	15-19.3, 16.7±1.8	5.3-6.2, 5.7±0.4	11.2-12.7, 12.1±0.6	7.7-10.1, 8.7±1

Material examined.— **COSTA RICA: Heredia Prov.**, Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 1 October 1995 (coll. P. Naskrecki) - 1 nymph (ALAS); same locality, 4 October 1995 (coll. P. Naskrecki) - 1 female (allotype) (ANSP); same locality, 10 - 15 November 1995 (coll. P. Naskrecki) - 1 male (holotype) (ANSP); same locality, 7 - 10 December 1995 (coll. P. Naskrecki) - 1 male, 1 female (paratypes) (PN collection); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 female (paratype) (PN collection).

Etymology.— This species is named after the project ALAS (Arthropoda of La Selva) – the first large scale inventory of the Arthropoda of the tropical rainforest.

Podacanthophorus vargasi Naskrecki, sp. n.
Figs. 34D-E, 35D, 35G, 35L, 36F, 51D, Map 18

Type locality: Costa Rica; Limón Prov., La Lola (0.5 mi. W Madre de Dios); type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description.— General characteristics as described above; wings in both sexes barely reaching apices of hind femora (Fig. 36F). Fastigium of vertex 2.5 times as long as eye diameter, narrowly rounded apically, with distinct dorsal furrow dorsally; ventral keel of fastigium distinctly undulant (Figs. 35D, 35G). Male stridulatory file nearly straight, 0.95 mm long, 111 µm wide, with 209 closely spaced and relatively very wide teeth (Fig. 51D);

stridulatory area on male without secondary venation; mirror square; secondary veinlet next to AA₁ present, thick, divergent from AA₁. Ventral anterior spines of hind femora nearly twice as long as width of hind femur below knee, distinctly flattened (Fig. 35L).

Tenth tergite of male with two somewhat divergent, wide lobes; female 10th tergite with lobes somewhat narrower, pointed; male cercus straight, basal internal spine curved towards base, slightly inflated subapically and distinctly constricted apically (Fig. 34D); female cercus simple, elongately conical, somewhat curved. Male titillators needle-like, strongly bent (Fig. 34E). Ovipositor short, sickle-shaped, about as long as half of hind femur (ratio ovipositor/hind femur 0.53-0.61).

Coloration.— General coloration light green (Fig. 36F); face creamy white; fastigium reddish-brown; clypeus and mandibles dark purple; metazona of pronotum in male with large, white, round spot; surrounded with dark brown margin; venation of tegmina and posterior edge of tegmina contrastingly yellow.

Measurements.— Table 27.

Distribution.— This species is known from only a few records in northeastern Atlantic portion of the country (Map 18).

Material examined.— **COSTA RICA: Cartago Prov.**, Monumento Nacional Guayabo, A.C.A.C. Amistad, 1 - 31 October 1994 (coll. G. Fonseca) - 1 male (paratype) (INBio); **Heredia Prov.**, Estac. Magsasay, P.N. Braulio

Carillo, elev. 200 m, 15 June 1990 (coll. E. Alcazar) - 1 male (paratype) (INBio); Estac. Magsasay, P. N. Braulio Carillo, elev. 200 m, 15 March 1991 (coll. A. Fernández) - 1 female (paratype) (INBio); Puerto Viejo, La Selva Biological Station, elev. 50 - 150 m, 10° 26' N, 84° 1' W, 7 - 10 December 1995 (coll. P. Naskrecki) - 2 females (paratypes) (PN collection); same locality, 13 April - 10 May 1998 (coll. P. Naskrecki) - 1 female (allotype) (ANSP); **Limón Prov.**, La Lola (0.5 mi. W Madre de Dios), 2 October 1961 (coll. Hubbell, Cantrall, Cohn) - 1 male (holotype) (ANSP).

Etymology. — This species is named in honor of Ronald Vargas, a parataxonomist working with the project ALAS (Arthropoda of La Selva).

Podacanthophorus maylinae Naskrecki, sp. n.
Figs. 34F-G, 35E, 35H, 35M, 51B, Map 18

Type locality: Costa Rica., Guanacaste Prov., 3 km SE R. Naranjo; type depository: Academy of Natural Sciences, Philadelphia – holotype male

Diagnostic description. — The largest species of the genus; general characteristics as described above; wings in both sexes surpassing apices of hind femora by about fifth of their length. Fastigium of vertex twice as long as eye diameter, narrowly rounded apically, with distinct dorsal furrow dorsally; ventral keel of fastigium smooth (Figs. 35E, 35H). Male stridulatory file weakly curved, 1.4 mm long, 115 µm wide, with 310 closely spaced and relatively very wide teeth (Fig. 51B); stridulatory area on male without secondary venation; mirror square; secondary veinlet next to AA₁ present, divergent from AA₁. Ventral anterior spines of hind femora relatively short, as long as half of width of hind femur below knee (Fig. 35M).

Tenth tergite of male with two somewhat divergent, wide lobes; female 10th tergite with lobes somewhat narrower, pointed; male cercus straight, basal internal spine curved towards base, distinctly constricted apically (Fig. 34F); female cercus simple, elongately conical, somewhat curved. Male titillators needle-like, straight but slightly bent outwards apically (Fig. 34G). Ovipositor short, sickle-shaped, slightly longer than half of hind femur (ratio ovipositor/hind femur 0.66-0.70).

Coloration. — General coloration light green; face creamy white; fastigium reddish-brown; lower half of clypeus dark purple; metazona of pronotum in male with small, V-shaped, dark red spot, surrounded by thick, white margin; venation of tegmina and posterior edge

of tegmina contrastingly yellow.

Measurements. — Table 27.

Distribution. — This species is known only from a few widely scattered records in Cartago, Alajuela, and Guanacaste provinces (Map 18).

Material examined. — **COSTA RICA: Alajuela Prov.**, San Cristobal, elev. 600 - 620 m, 1 October - 30 November 1997 (coll. F.A. Quesada) - 1 male (paratype) (INBio); **Cartago Prov.**, Cachí, 6 February 1916 (coll. C.F. Lankester) - 1 female (paratype) (ANSP); **Guanacaste Prov.**, 3 km SE R. Naranjo, 1 November 1991 (coll. F.D. Parker) - 1 female (allotype) (ANSP); same locality, 1 - 15 March 1992 (coll. F.D. Parker) - 1 male (holotype) (ANSP); Estac. Las Pailas, P.N. Rincón de la Vieja, elev. 800 m, 6 - 7 June 1994 (coll. D. García) - 1 female (paratype) (INBio); Estac. Pitilla, 9 km S Sta Cecilia, elev. 700 m, 15 May 1990 (coll. II curso Parataxon.) - 1 female (paratype) (INBio).

Etymology. — This species is named in honor of Maylin Paniagua, a parataxonomist working with the project ALAS (Arthropoda of La Selva).

Podacanthophorus nelciae Naskrecki, sp. n.
Figs. 35F, 35I-J, 35N

Type locality: Costa Rica., Guanacaste Prov., Estac. Cacao, Lado SO Vol. Cacao, P.N. Guanacaste, elev. 1000 - 1400 m; type depository: Academy of Natural Sciences, Philadelphia – holotype female

Diagnostic description (female; male unknown). — General characteristics as described above; wings in female barely reaching apices of hind femora. Fastigium of vertex 3 times as long as eye diameter, pointed apically, with distinct dorsal furrow dorsally; ventral keel of fastigium smooth (Figs. 35F, 35I). Ventral anterior spines of hind femora as long as half of width of hind femur below knee (Fig. 35N).

Tenth tergite of female with two somewhat divergent, pointed lobes; female cercus simple, elongately conical, somewhat curved. Ovipositor short, sickle-shaped, upper valvula distinctly wider than lower one, resulting in ovipositor somewhat dilated midlength; ovipositor longer than half of hind femur (ratio ovipositor/hind femur 0.67-0.82) (Fig. 35J).

Coloration. — General coloration light green; face

creamy white; fastigium with two black stripes on sides; clypeus without dark markings; venation of tegmina and posterior edge of tegmina contrastingly yellow.

Measurements.— Table 27.

Distribution.— Known only from a few widely scattered records in Costa Rica (Map 18).

Material examined.— **COSTA RICA: Alajuela Prov.**, R. Jesús, C. La Lana, San Ramón, elev. 1200 m, 15 January 1992 (coll. G. Carballo) - 1 female (paratype) (INBio);

Cartago Prov., Cachí, elev. 1524 m, 17 September 1916 (coll. C.F. Lankester) - 1 female (paratype) (ANSP); **Guanacaste Prov.**, Estac. Cacao, Lado SO Vol. Cacao, P.N. Guanacaste, elev. 1000 - 1400 m, 29 May 1992 (coll. K. Taylor) - 1 female (holotype) (ANSP); **Puntarenas Prov.**, Estac. La Casona, Res. Biol. Monteverde, elev. 1520 m, 15 October 1990 (coll. E. Bello) - 1 female (paratype) (INBio).

Etymology.— This species is named in honor of Nelci Oconotrillo, a parataxonomist working with the project ALAS (Arthropoda of La Selva).

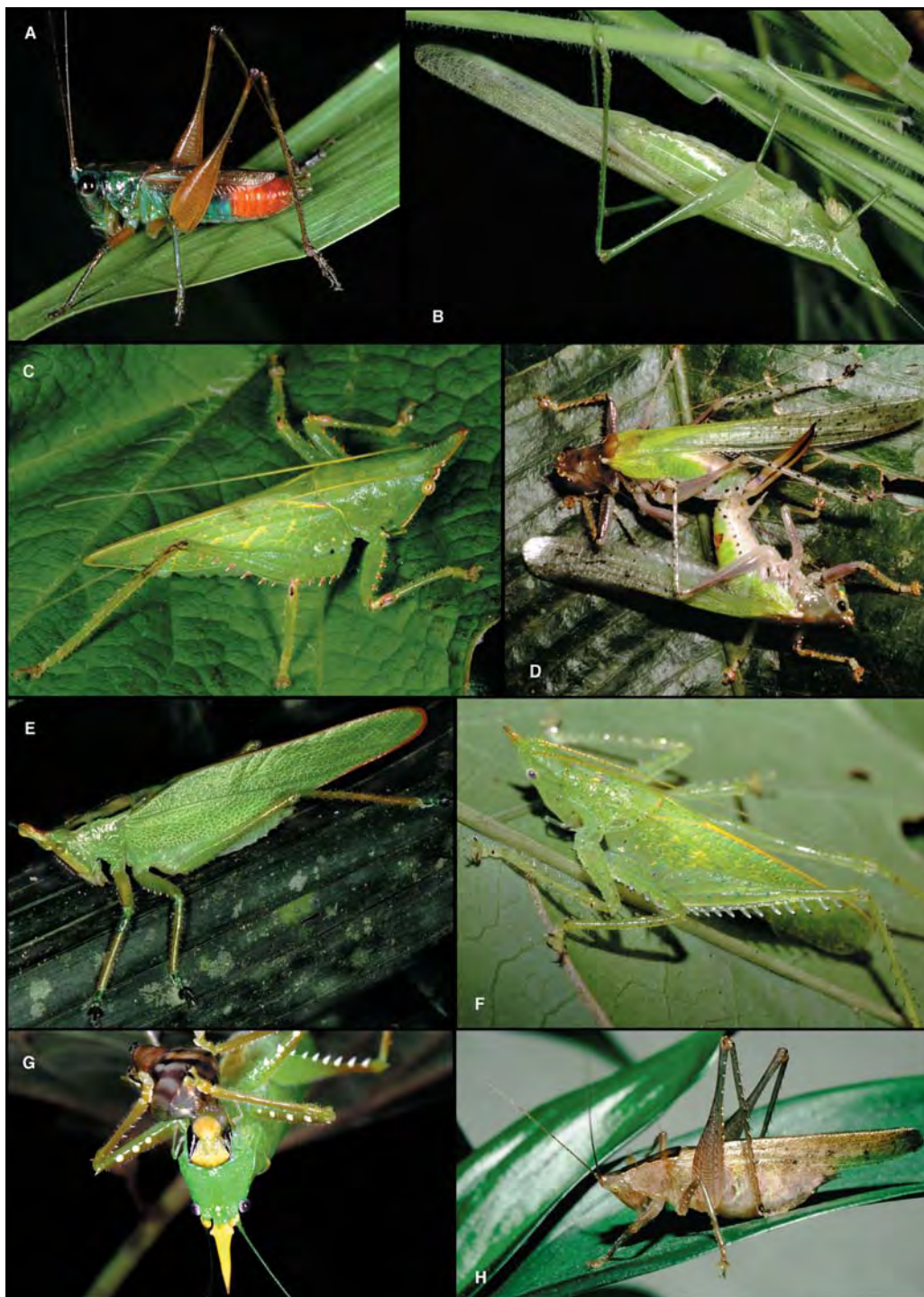


FIG. 36. Costa Rican species of Conocephalinae s. l. **A.** *Conocephalus angustifrons* - male, **B.** *Caulopsis cuspidata* - female, **C.** *Acantheremus colwelli* - male, **D.** *Vestria punctata* - male and female, in copula, **E.** *Copiphora hastata* - male, **F.** *Podacanthophorus vargasi* - female, **G.** *Copiphora rhinoceros* - male eating a snail, **H.** *Subria sylvestris* - male, brown form.



FIG. 37. Costa Rican species of Conocephalinae s. l. **A.** *Erioloides longipennis* - female ovipositing, **B.** *Erioloides longinoi* - male, **C.** *Eriolus penicillus* - female, **D.** *Conocephalus cinereus* - male, macropterous form, **E.** *Neoconocephalus triops* - male, brown form, **F.** *Sphyrometopa atlantica* - male, inset - nymph.

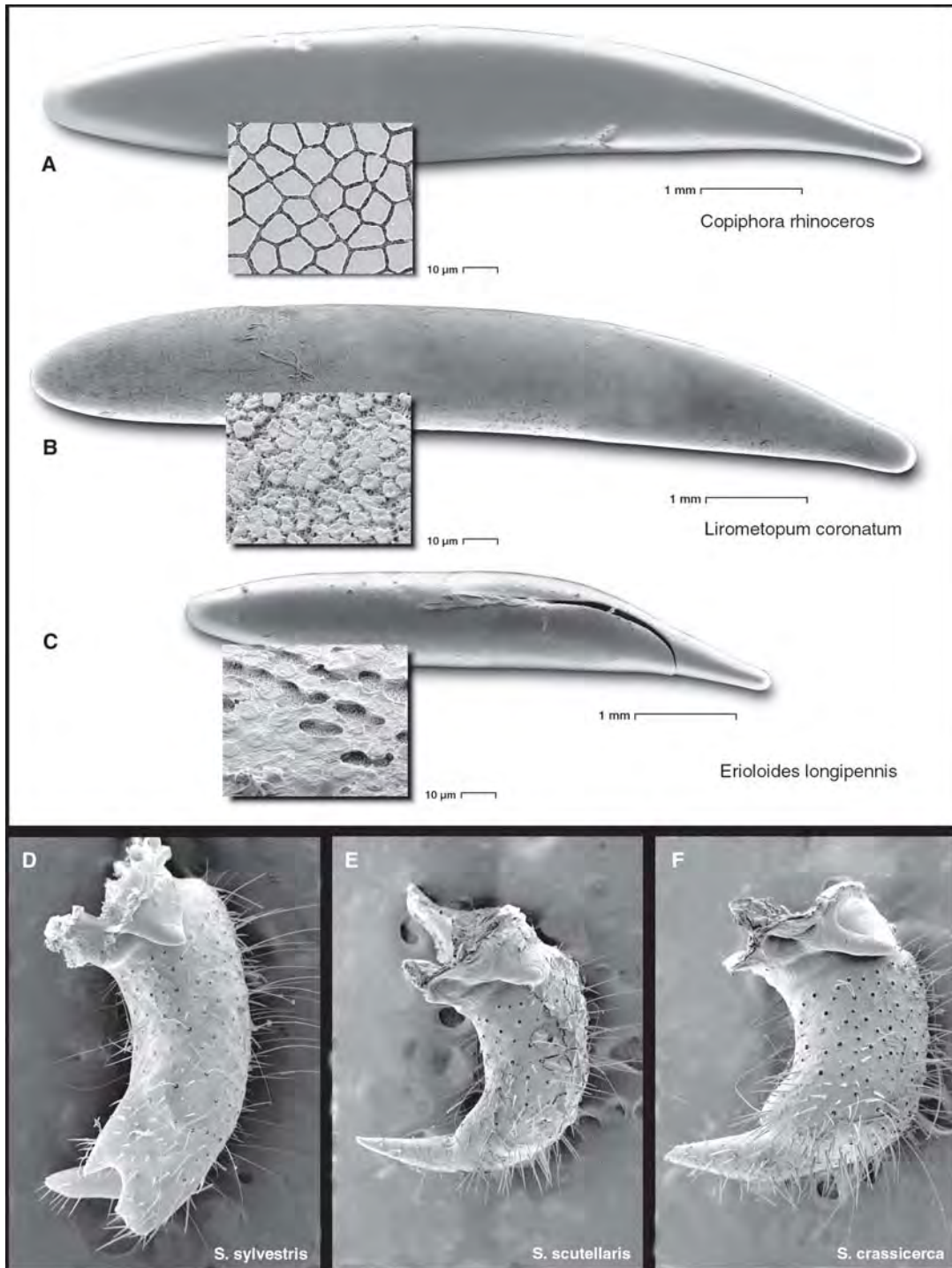


FIG. 38. Eggs and cerci of Costa Rican species of Conocephalinae s. l. A-C. eggs, with enlarged fragments of the chorion: A. *Copiphora rhinoceros*, B. *Lirometopum coronatum*, C. *Erioloides longipennis*, hatched egg, D-F. male right cerci of *Subria* spp., dorsal views: D. *S. sylvestris*, E. *S. scutellaris*, F. *S. crassicerca*.

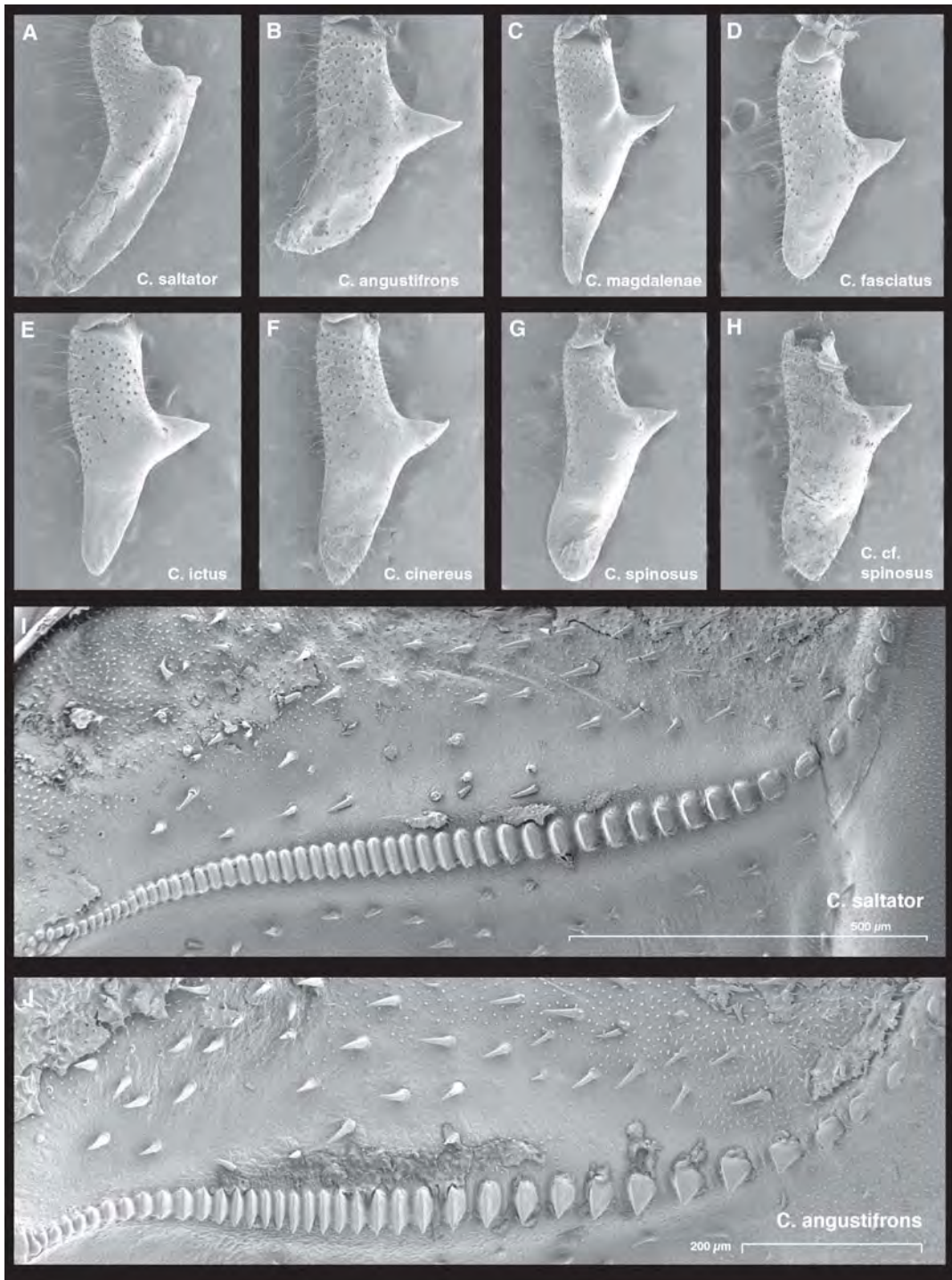


FIG. 39. Cerci and stridulatory files of species of *Conocephalus*. A-H. male left cerci, dorsal views: A. *C. saltator*, B. *C. angustifrons*, C. *C. magdalenae*, D. *C. fasciatus*, E. *C. ictus*, F. *C. cinereus*, G. *C. spinosus*, H. *C. cf. spinosus*; I-J. male stridulatory files: I. *C. saltator*, J. *C. angustifrons*.

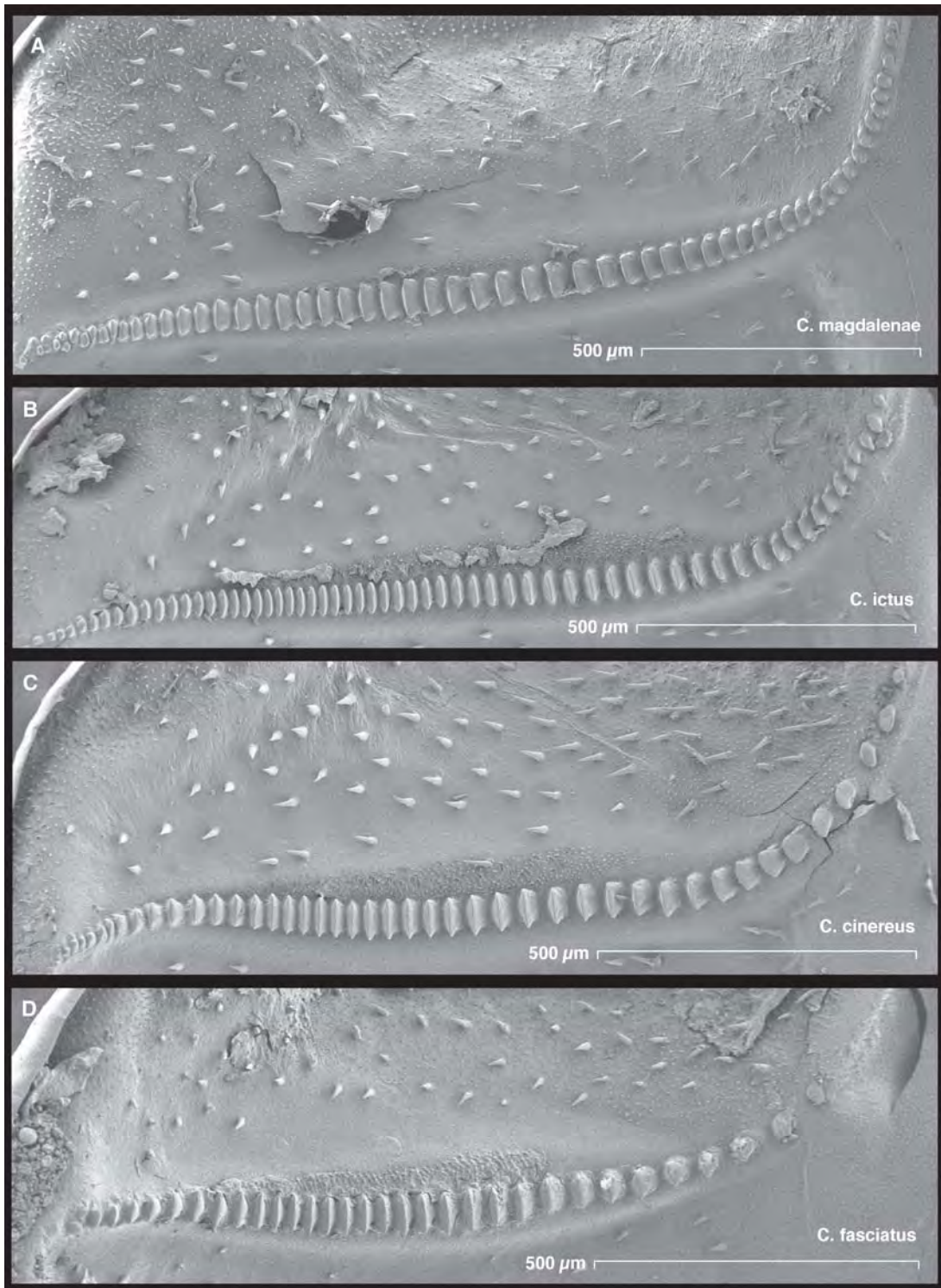


FIG. 40. Stridulatory files of species of *Conocephalus*. A. *C. magdalenae*, B. *C. ictus*, C. *C. cinereus*, D. *C. fasciatus*.

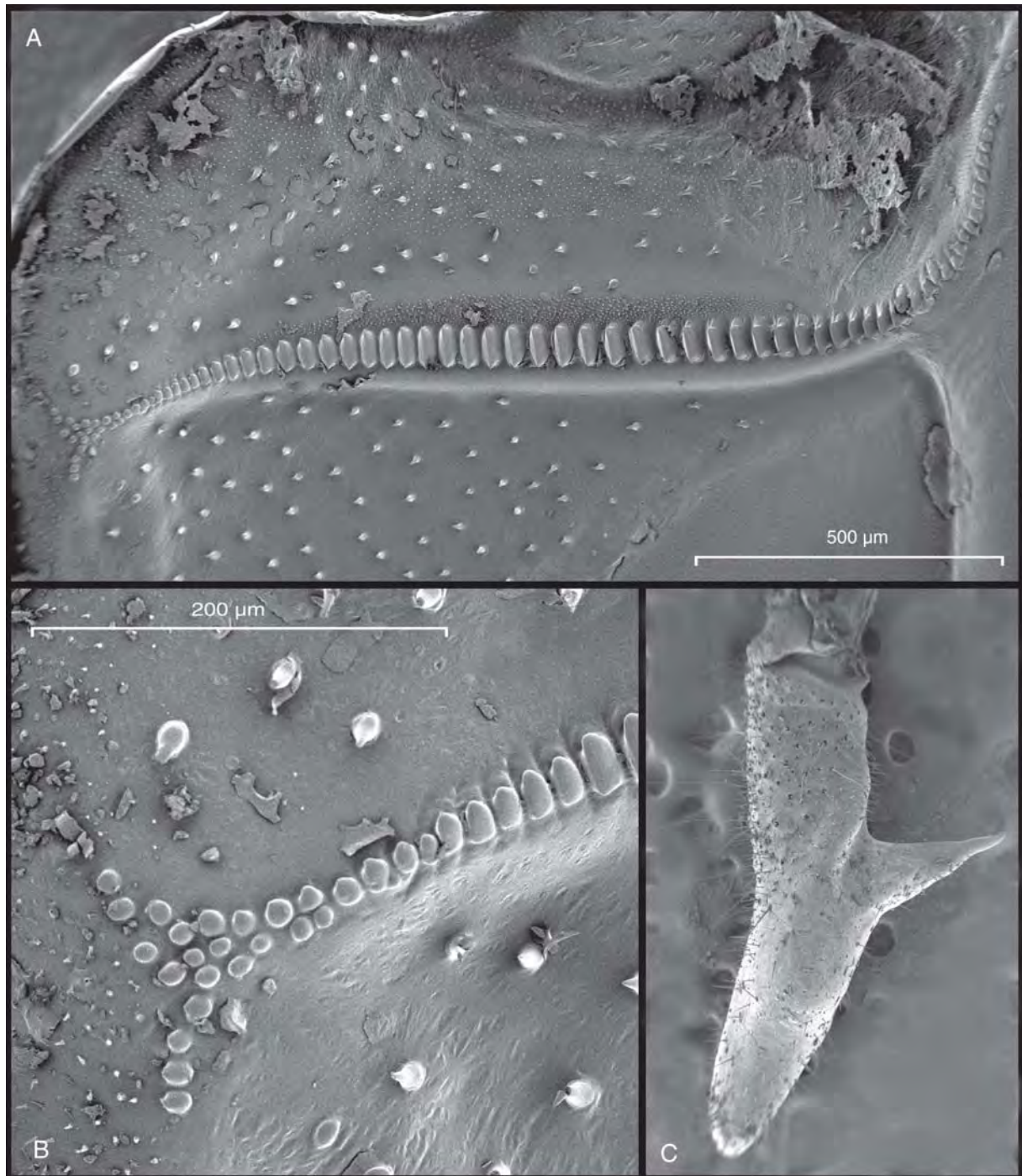


FIG. 41. Stridulatory file and cercus of *Orchelimum fraternum*. A. stridulatory file, B. proximal end of the stridulatory file, C. male left cercus, dorsal view.



FIG. 42. Stridulatory files of species of *Lirometopum* and *Copiphora*. A. *L. coronatum*, B. *C. cultricornis*, C. *C. hastata*, D. *C. brevicauda brevicauda*, E. *C. brevicauda costaricensis*, F. *C. ottei*.

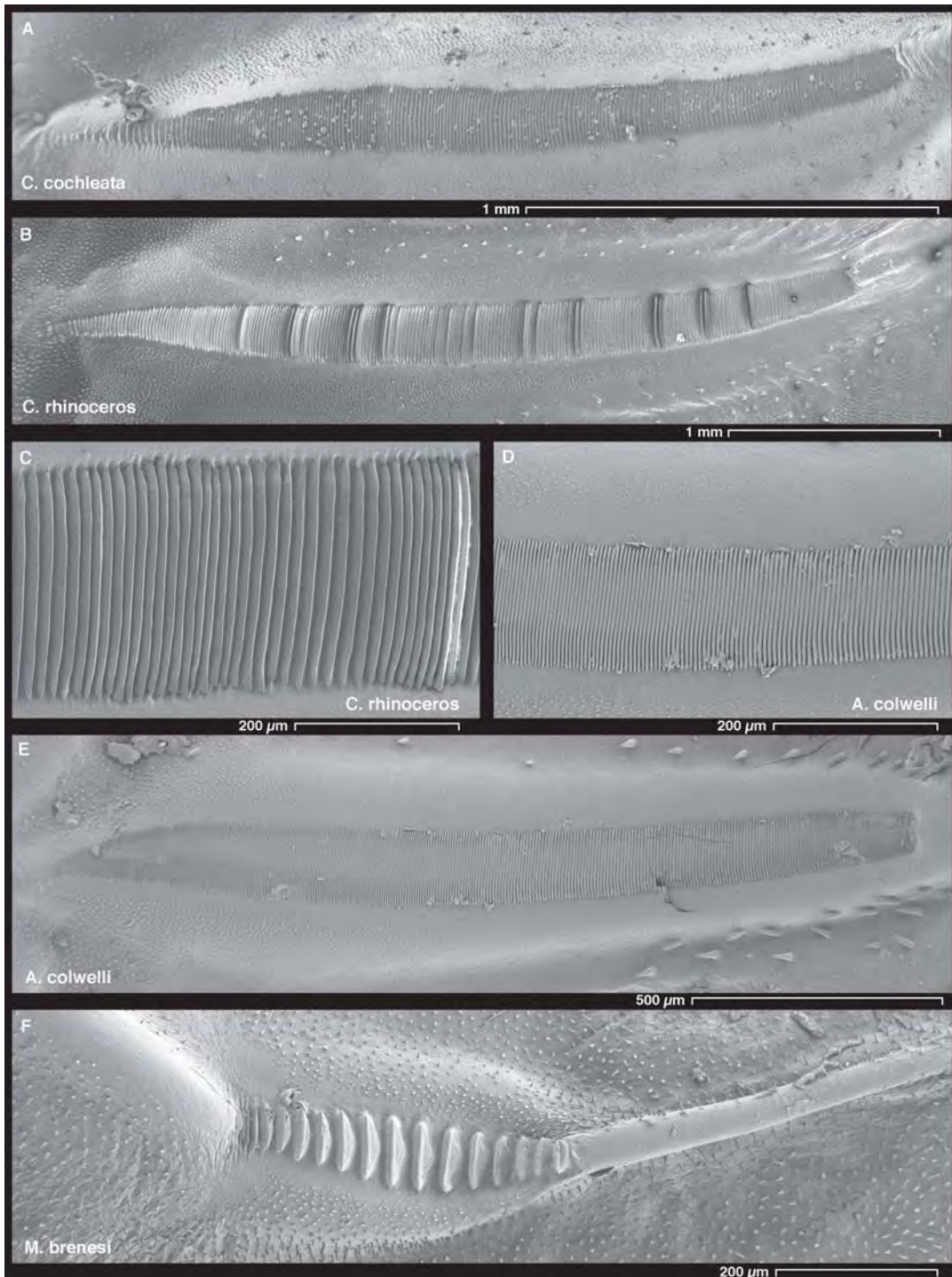


FIG. 43. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Copiphora cochleata*, B. *Copiphora rhinoceros*, C. ditto, enlarged fragment, D. *Acantheremus colwelli*, enlarged fragment, E. ditto, entire file, F. *Metacaputus brenesi*.

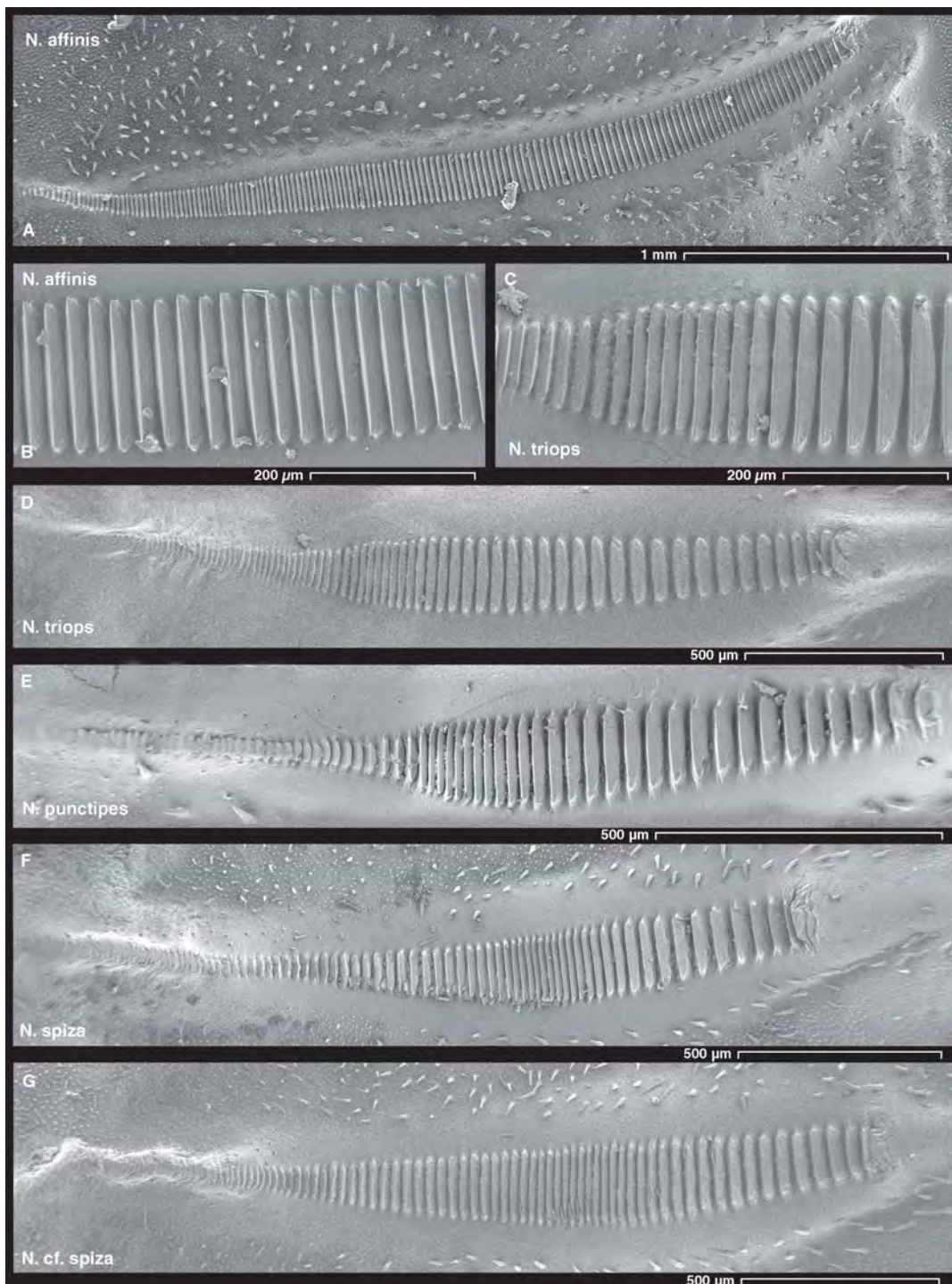


FIG. 44. Stridulatory files of Costa Rican species of *Neoconocephalus*. A. *N. affinis*, B. ditto, enlarged fragment, C. *N. triops*, enlarged fragment, D. ditto, entire file, E. *N. punctipes*, entire file, F. ditto, enlarged fragment, G. *N. cf. spiza*, enlarged fragment, H. ditto, entire file.

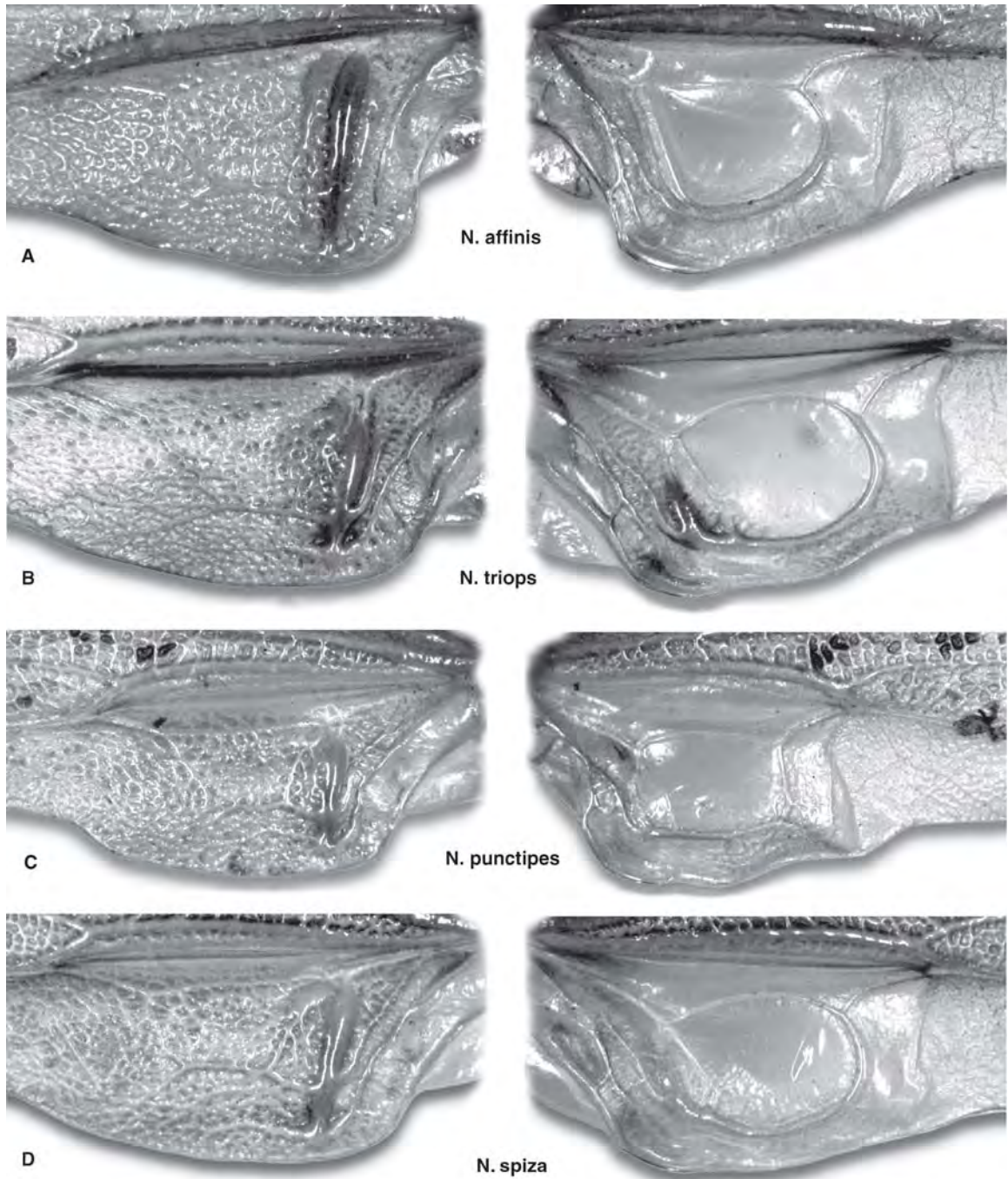


FIG. 45. Stridulatory areas of Costa Rican species of *Neoconocephalus*, dorsal views, left and right sides. **A.** *N. affinis*, **B.** *N. triops*, **C.** *N. punctipes*, **D.** *N. spiza*.

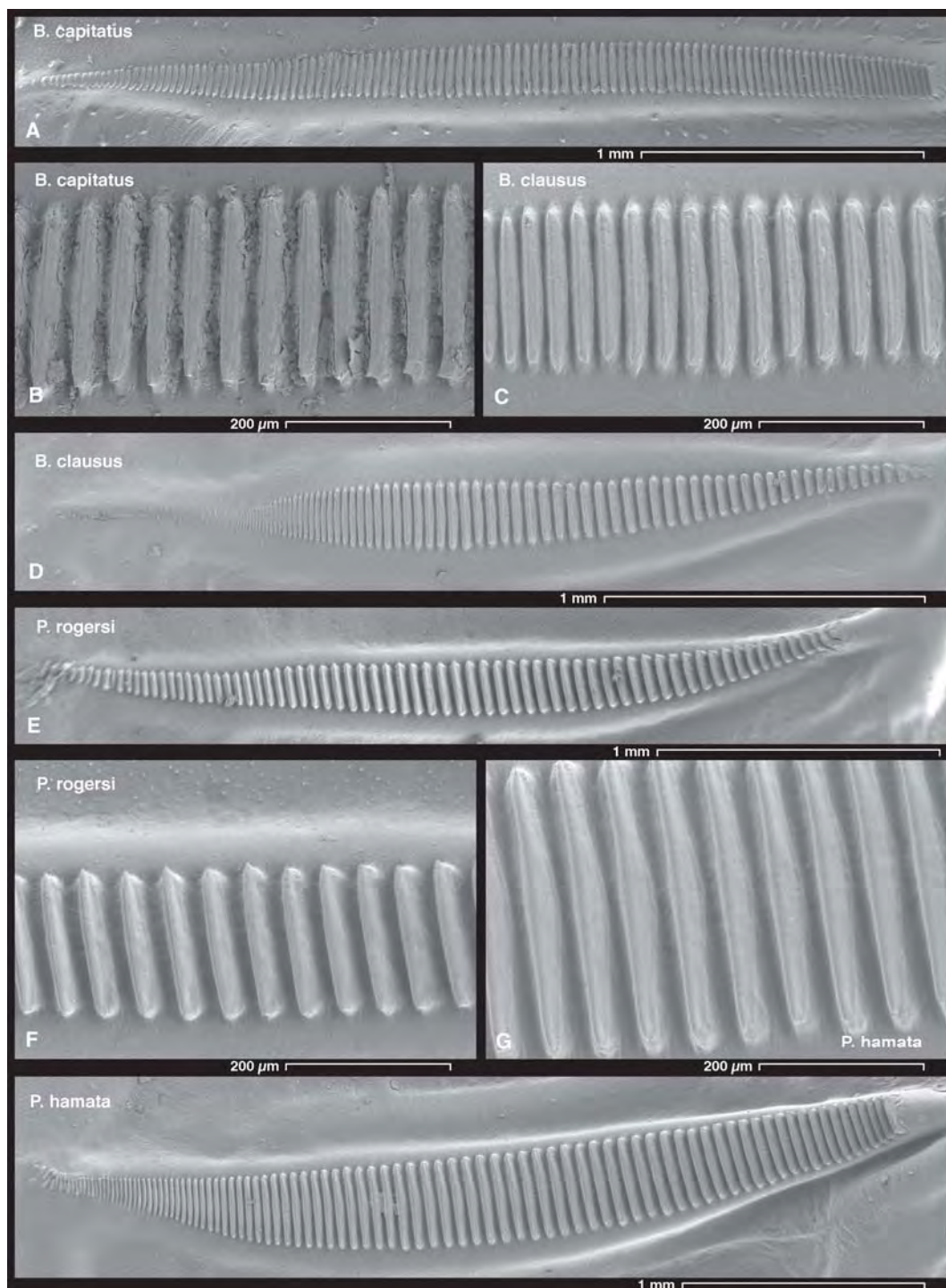


FIG. 46. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Bucrates capitatus*, B. ditto, enlarged fragment, C. *Bucrates clausus*, enlarged fragment, D. ditto, entire file, E. *Pyrgocorypha rogersi*, entire file, F. ditto, enlarged fragment, G. *Pyrgocorypha hamata*, enlarged fragment, H. ditto, entire file.

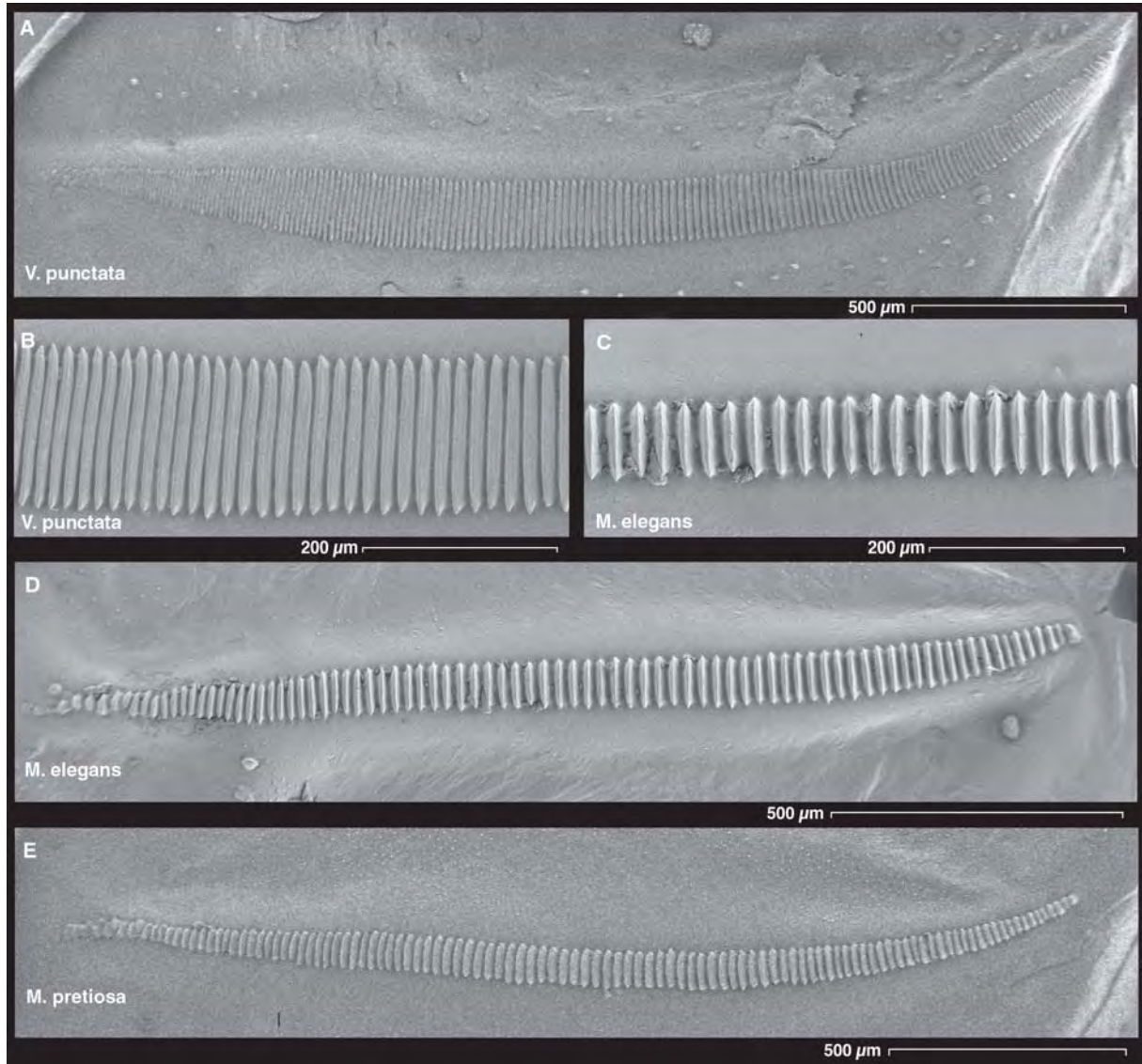


FIG. 47. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Vestria punctata*, B. ditto, enlarged fragment, C. *Moncheca elegans*, enlarged fragment, D. ditto, entire file, E. *Moncheca pretiosa*.

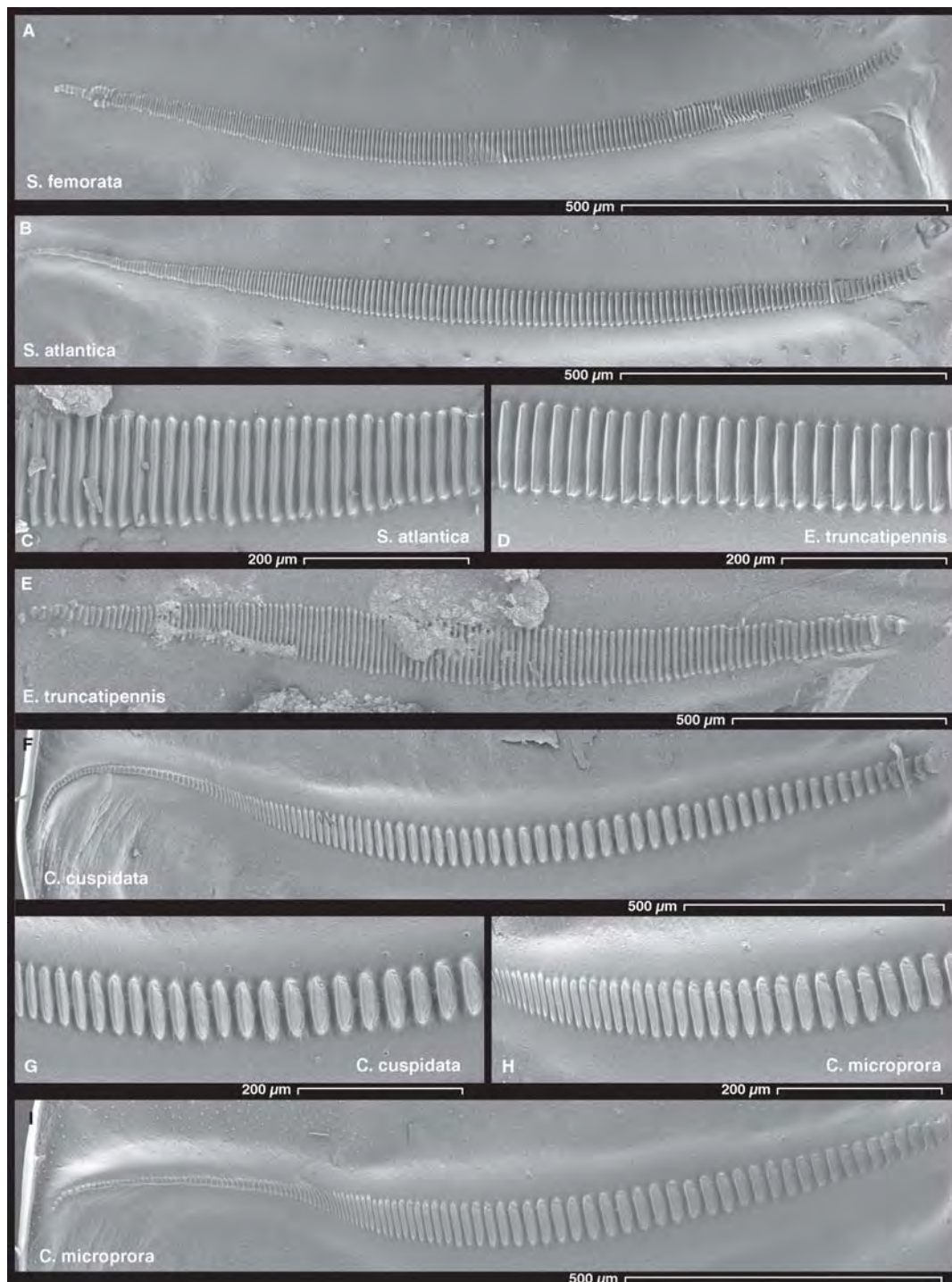


FIG. 48. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Sphyrmetopa femorata*, C. *Sphyrmetopa atlantica*, C. ditto, enlarged fragment, D. *Eppia truncatipennis*, enlarged fragment, E. ditto, entire file, F. *Caulopsis cuspidata*, entire file, G. ditto, enlarged fragment, H. *Caulopsis microprora*, enlarged fragment, I. ditto, entire file.

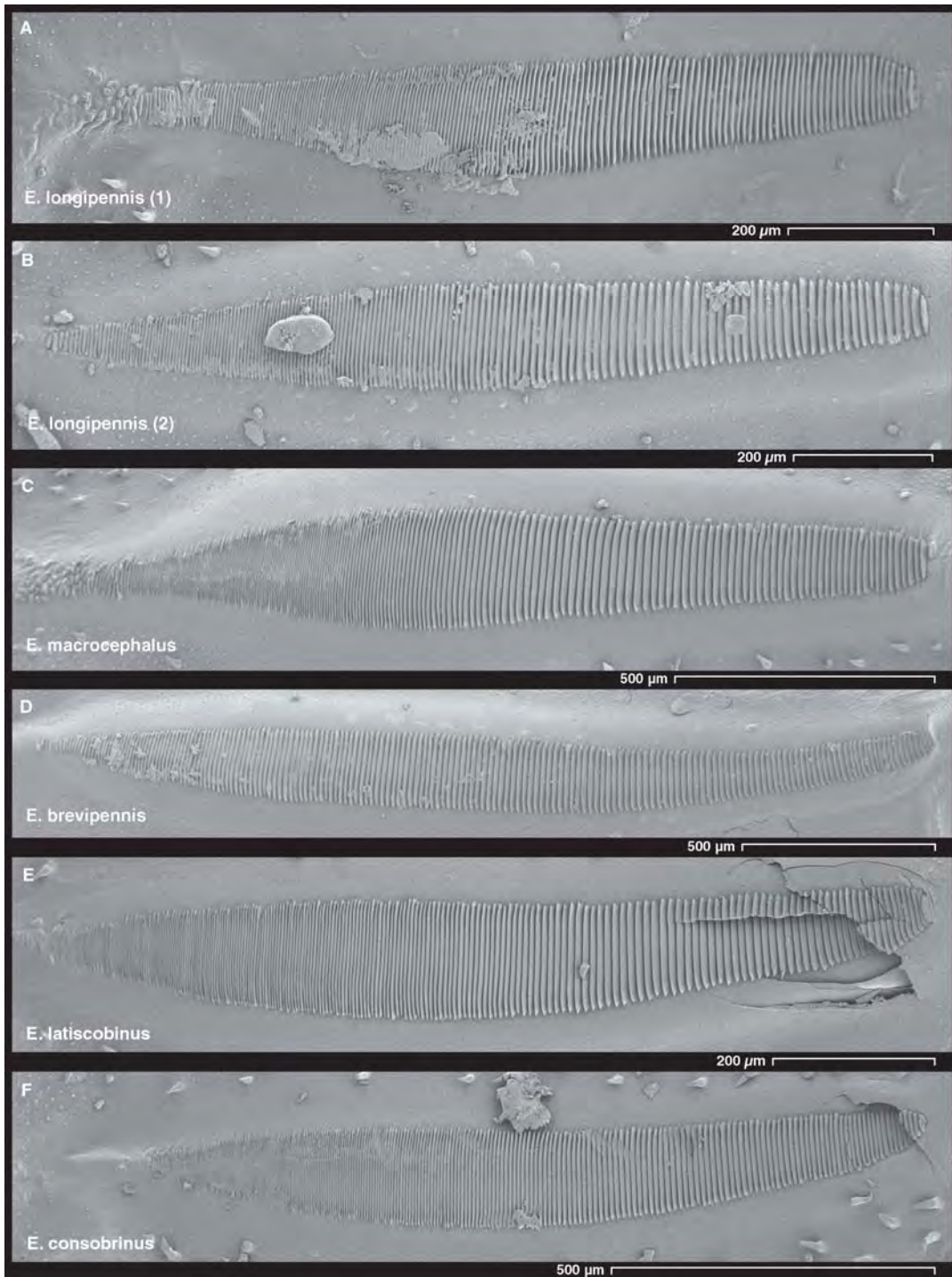


FIG. 49. Stridulatory files of species of *Erioloides*. A. *E. longipennis*, B. ditto, variation, C. *E. macrocephalus*, D. *E. brevipennis*, E. *E. laticobinus*, F. *E. consobrinus*.

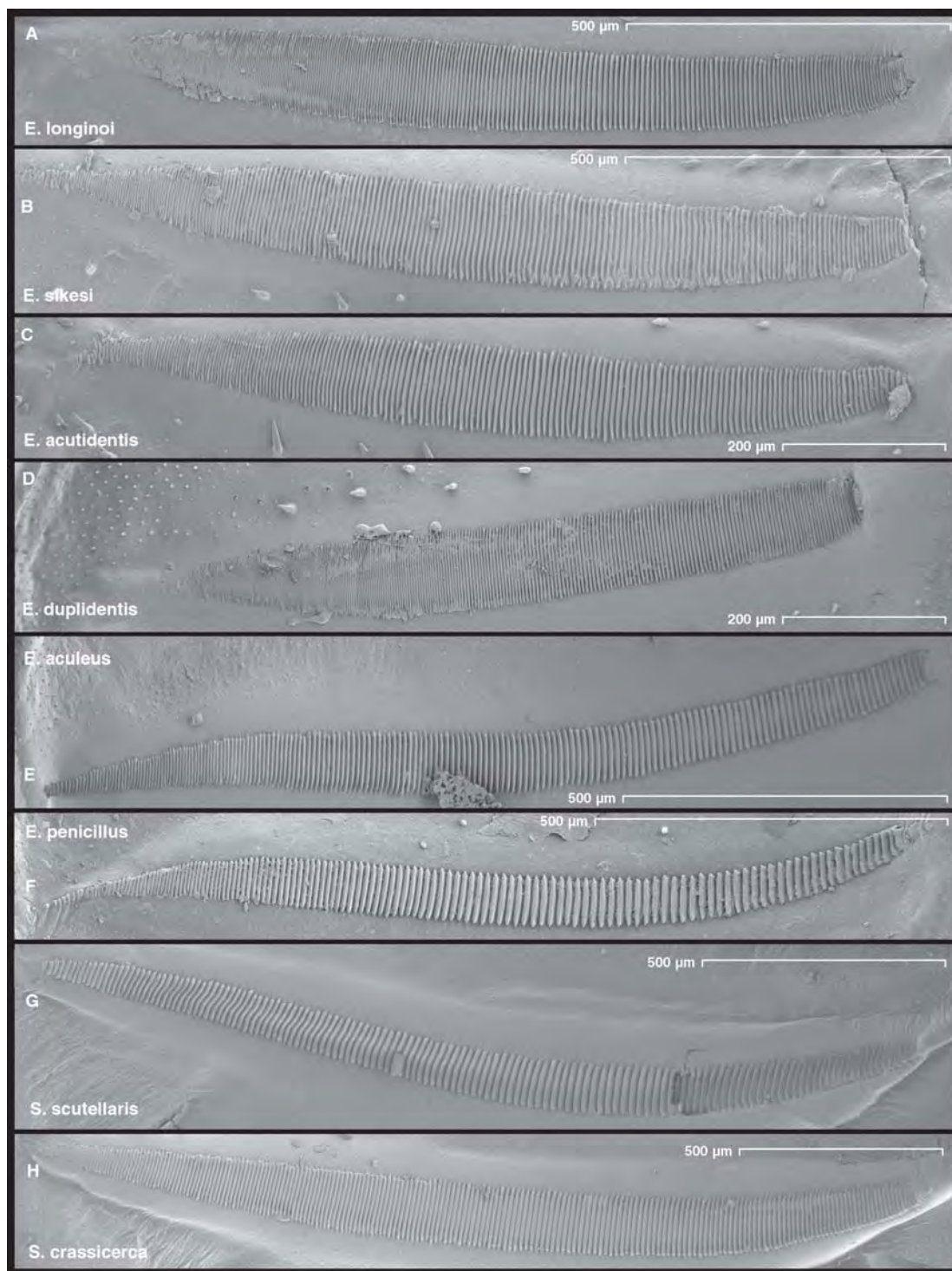


FIG. 50. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Erioloides longinoi*, C. *Erioloides sikesi*, C. *Erioloides acutidentis*, D. *Eriolus duplidentis*, E. *Eriolus aculeus*, F. *Eriolus penicillus*, G. *Subria scutellaris*, H. *Subria crassicerca*.

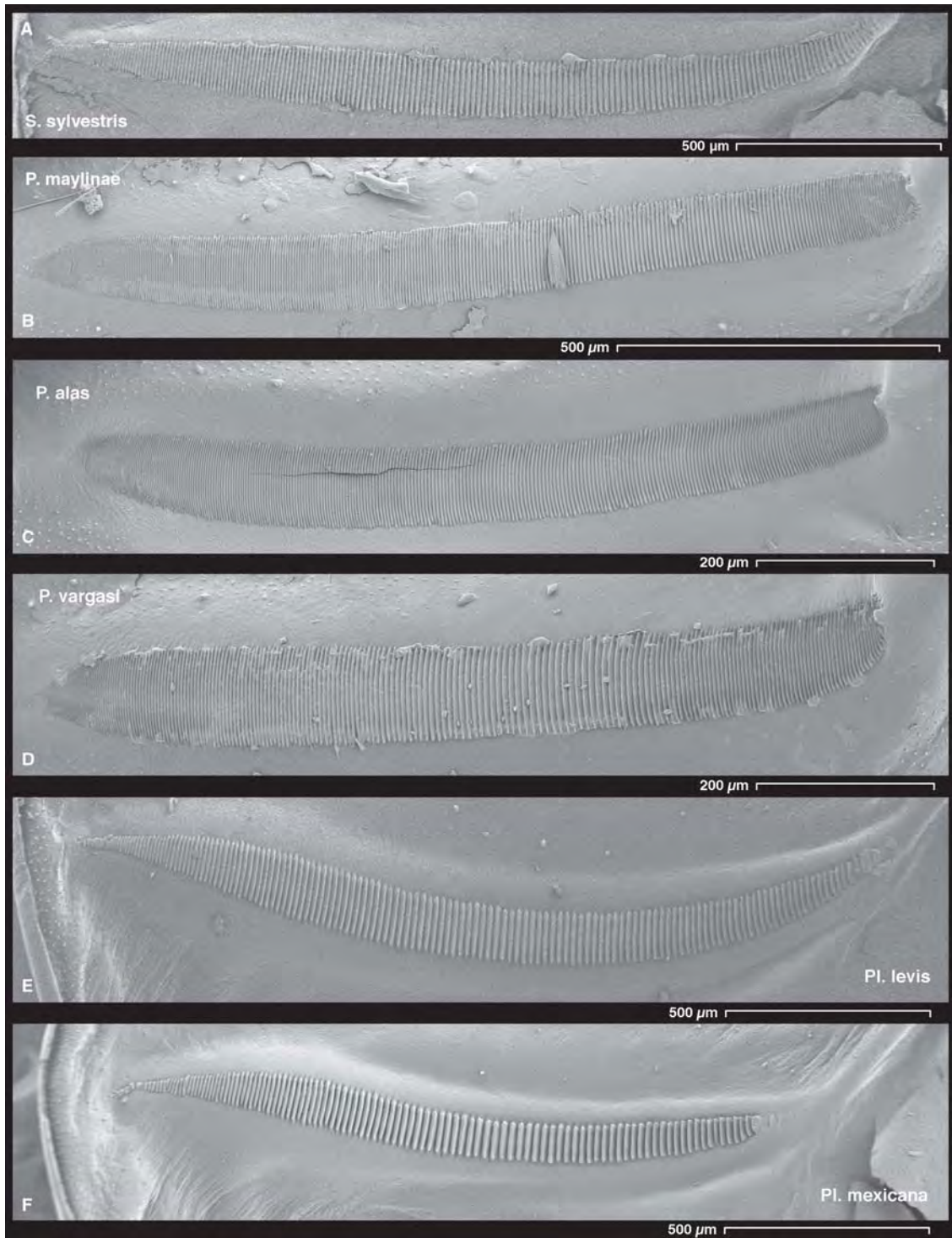


FIG. 51. Stridulatory files of Costa Rican species of Conocephalinae s. l. A. *Subria sylvestris*, C. *Podacanthophorus mayllinae*, C. *Podacanthophorus alas*, D. *Podacanthophorus vargasi*, E. *Pluviasiloa levis*, F. *Pluviasiloa mexicana*.

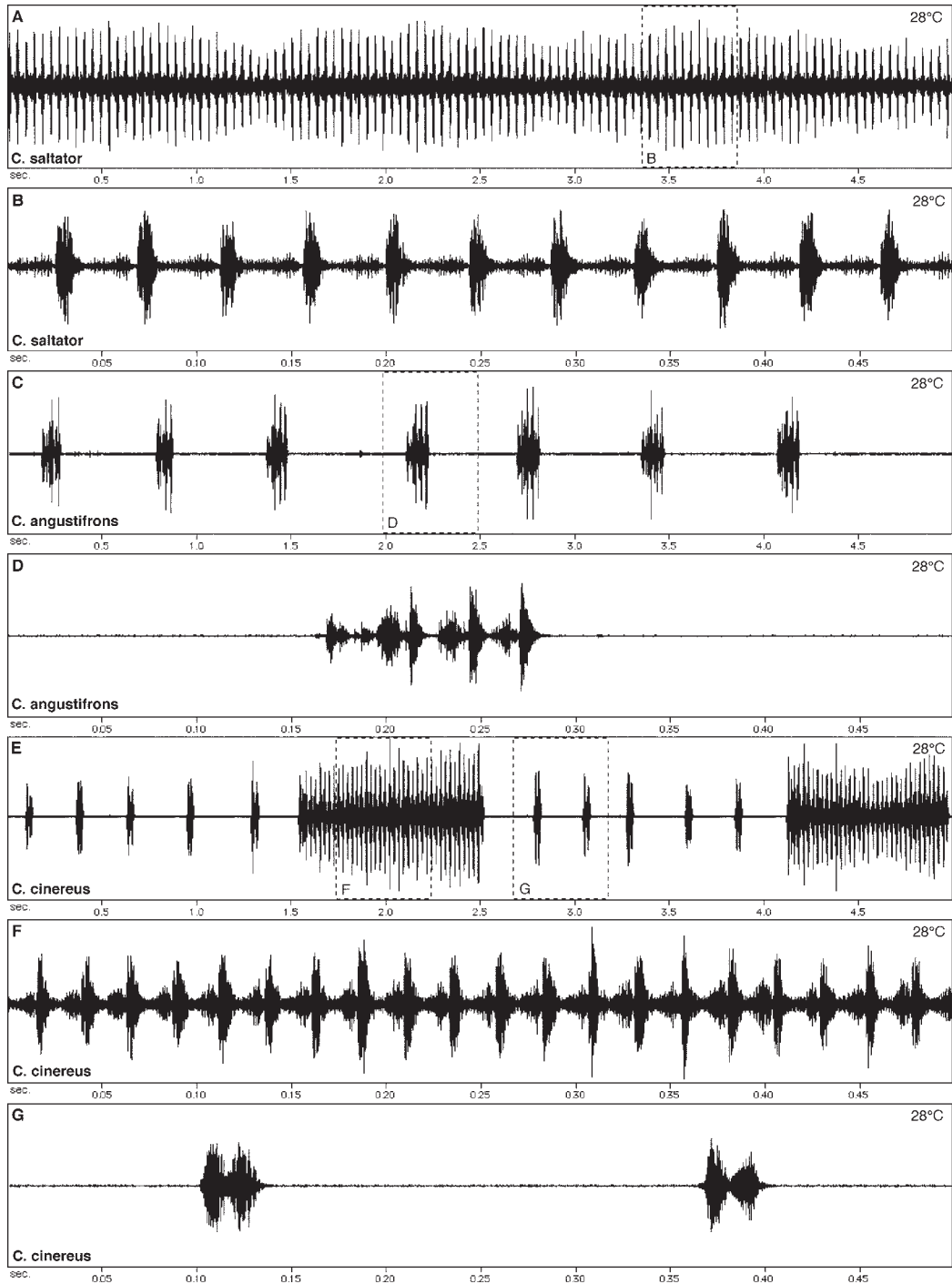


FIG. 52. Oscillograms of male airborne calls of Costa Rican species of *Conocephalus*. A. *C. saltator*, B. ditto, 0.5 s fragment, C. *C. angustifrons*, D. ditto, 0.5 s fragment, E. *C. cinereus*, F. ditto, 0.5 s fragment, continuous part, G. ditto, 0.5 s fragment, slow part.

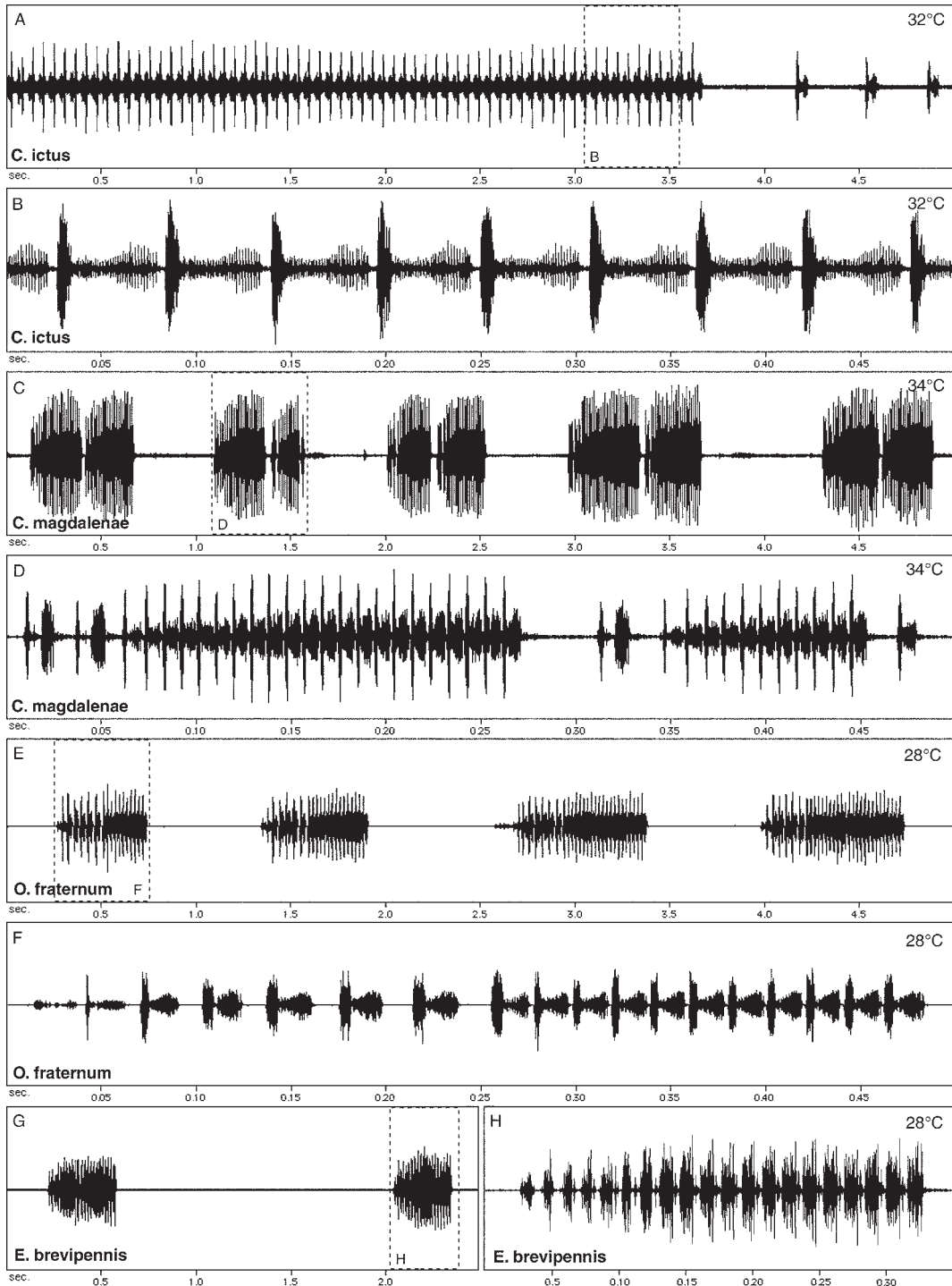


FIG. 53. Oscillograms of male airborne calls of Costa Rican species of Conocephalinae s.l. A. *Conocephalus ictus*, B. ditto, 0.5 s fragment, C. *C. magdalenae*, D. ditto, 0.5 s fragment, E. *Orchelimum fraternum*, F. ditto, 0.5 s fragment, continuous part, G. *Erioloides brevipennis*, H. ditto, 0.35 s fragment.

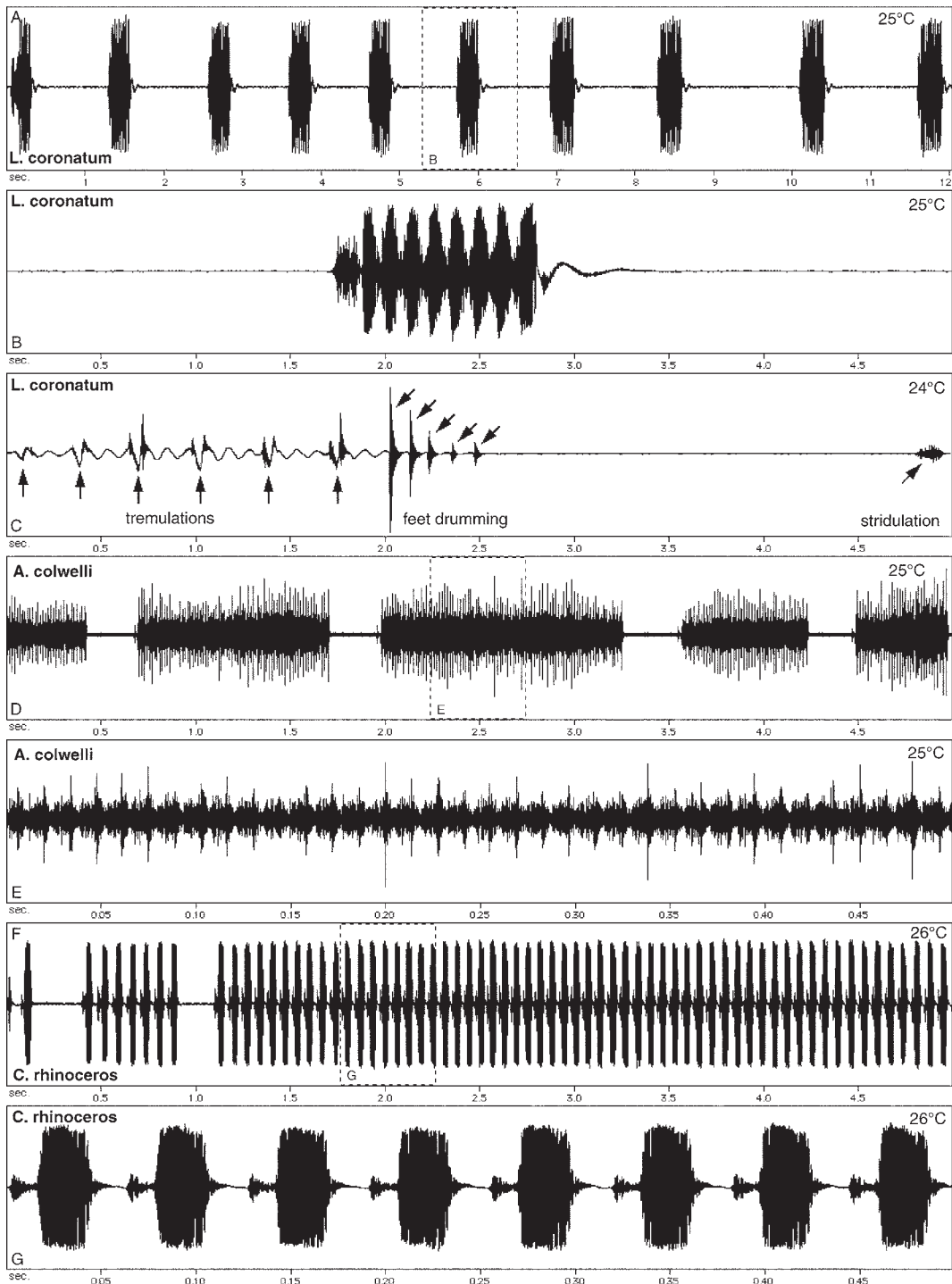


FIG. 54 Oscillograms of male airborne calls and substrate tremulations of Costa Rican species of Conocephalinae s. l. A. *Lirometopum coronatum*, airborne call, B. ditto, 0.5 s fragment, C. ditto, substrate tremulations and feet drumming, D. *Acantheremus colwelli*, E. ditto, 0.5 s fragment, F. *Copiphora rhinoceros*, G. ditto, 0.5 s fragment.

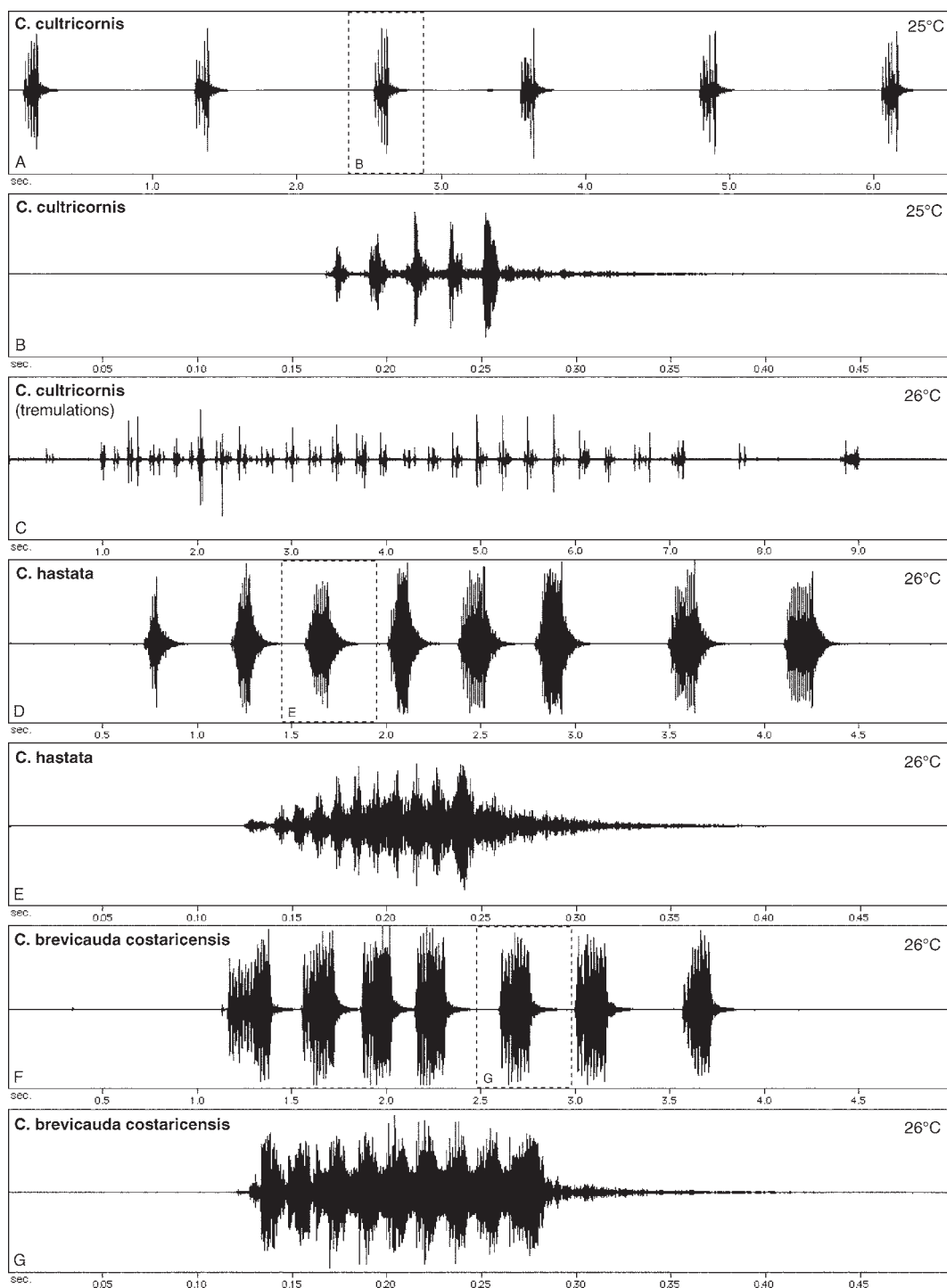


FIG. 55. Oscillograms of male airborne calls and substrate tremulations of Costa Rican species of Conocephalinae s. l. A. *Copiphora cultricornis*, airborne call, B. ditto, 0.5 s fragment, C. ditto, substrate tremulations, D. *Copiphora hastata*, E. ditto, 0.5 s fragment, F. *Copiphora brevicauda costaricensis*, G. ditto, 0.5 s fragment.

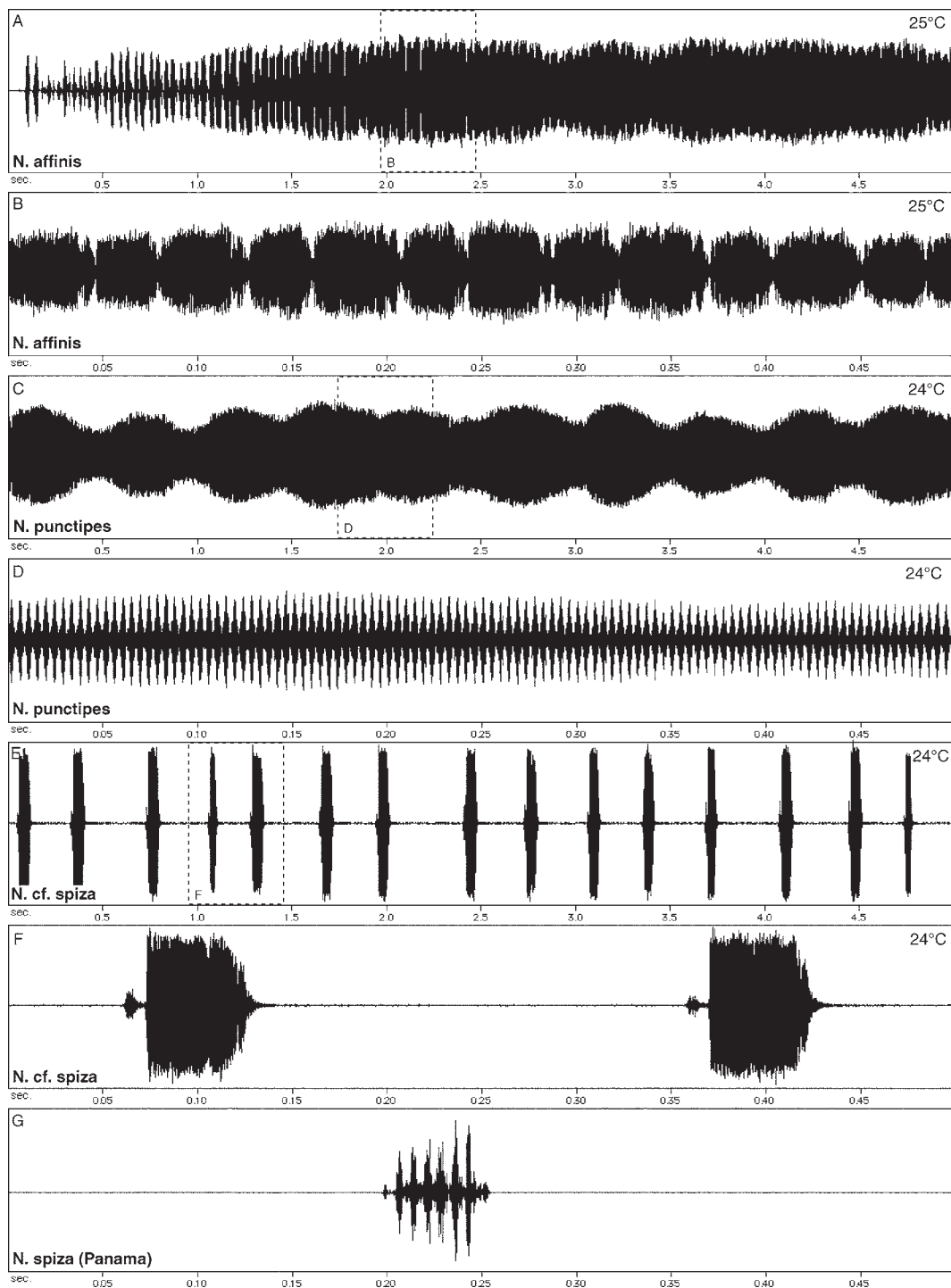


FIG. 56. Oscillograms of male airborne calls and substrate tremulations of species of *Neoconocephalus*. A. *N. affinis*, B. ditto, 0.5 s fragment, C. *N. punctipes*, D. ditto, 0.5 s fragment, E. *N. cf. spiza* (Costa Rica, Heredia Prov., Las Selva Biol. Sta.), F. ditto, 0.5 s fragment, G. *N. spiza* (Panama, Gamboa).

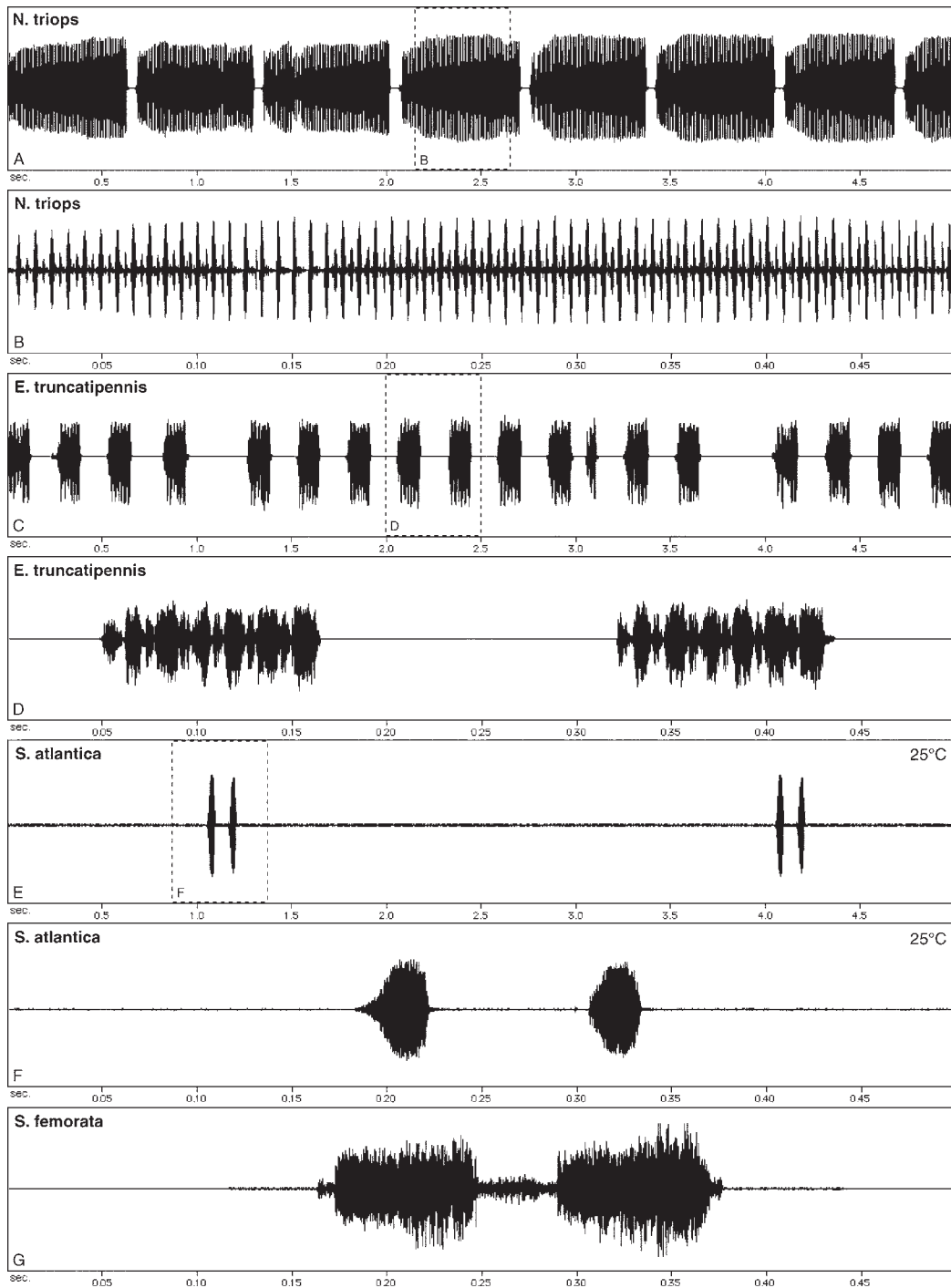


FIG. 57. Oscillograms of male airborne calls of Costa Rican species of Conocephalinae s. l. A. *Neoconocephalus triops*, B. ditto, 0.5 s fragment, C. *Eppia truncatipennis* (Panama, Gamboa), D. ditto, 0.5 s fragment, E. *Sphyrometopa atlantica*, F. ditto, 0.5 s fragment, G. *Sphyrometopa femorata*, 0.5 s fragment.

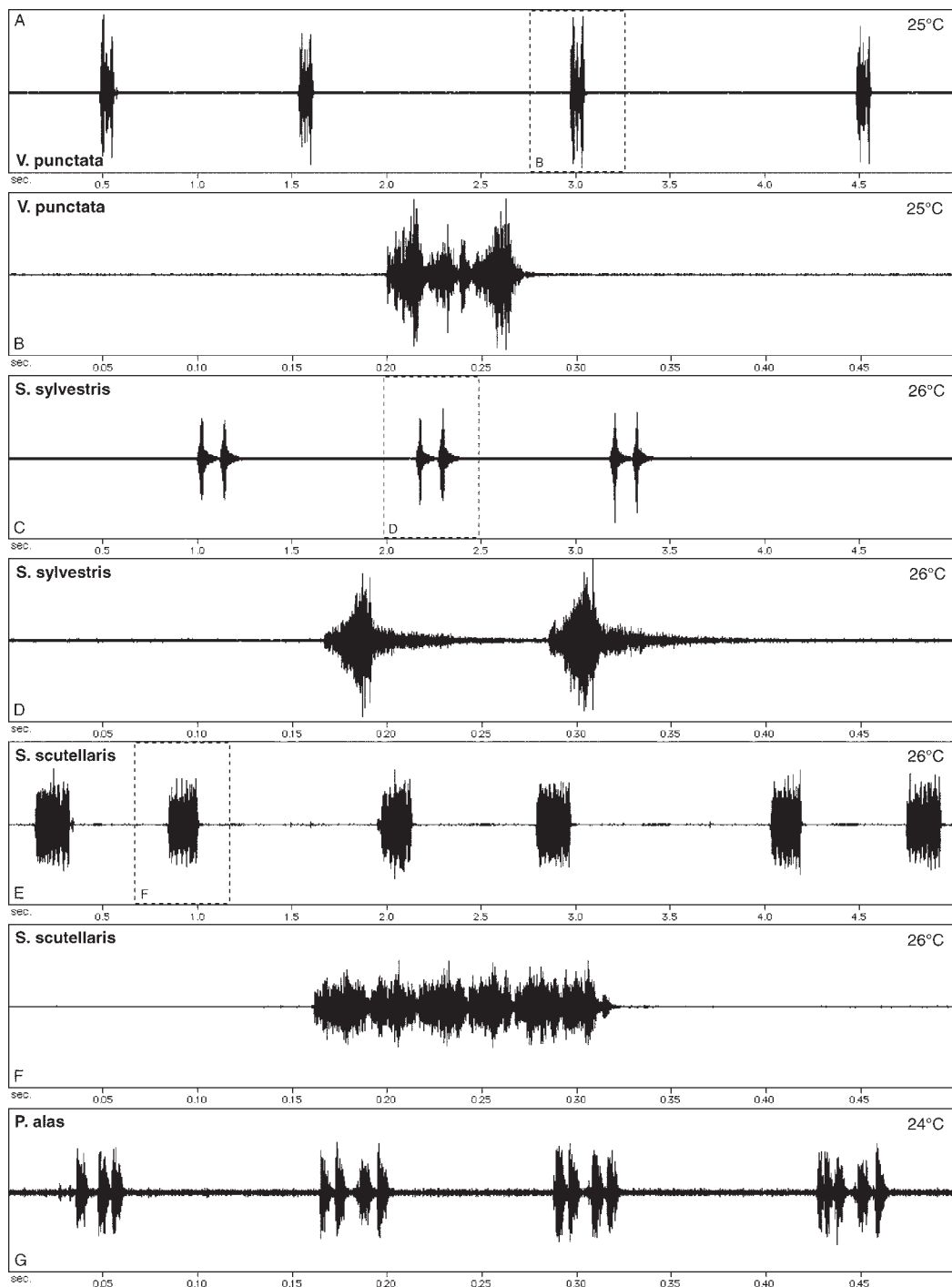
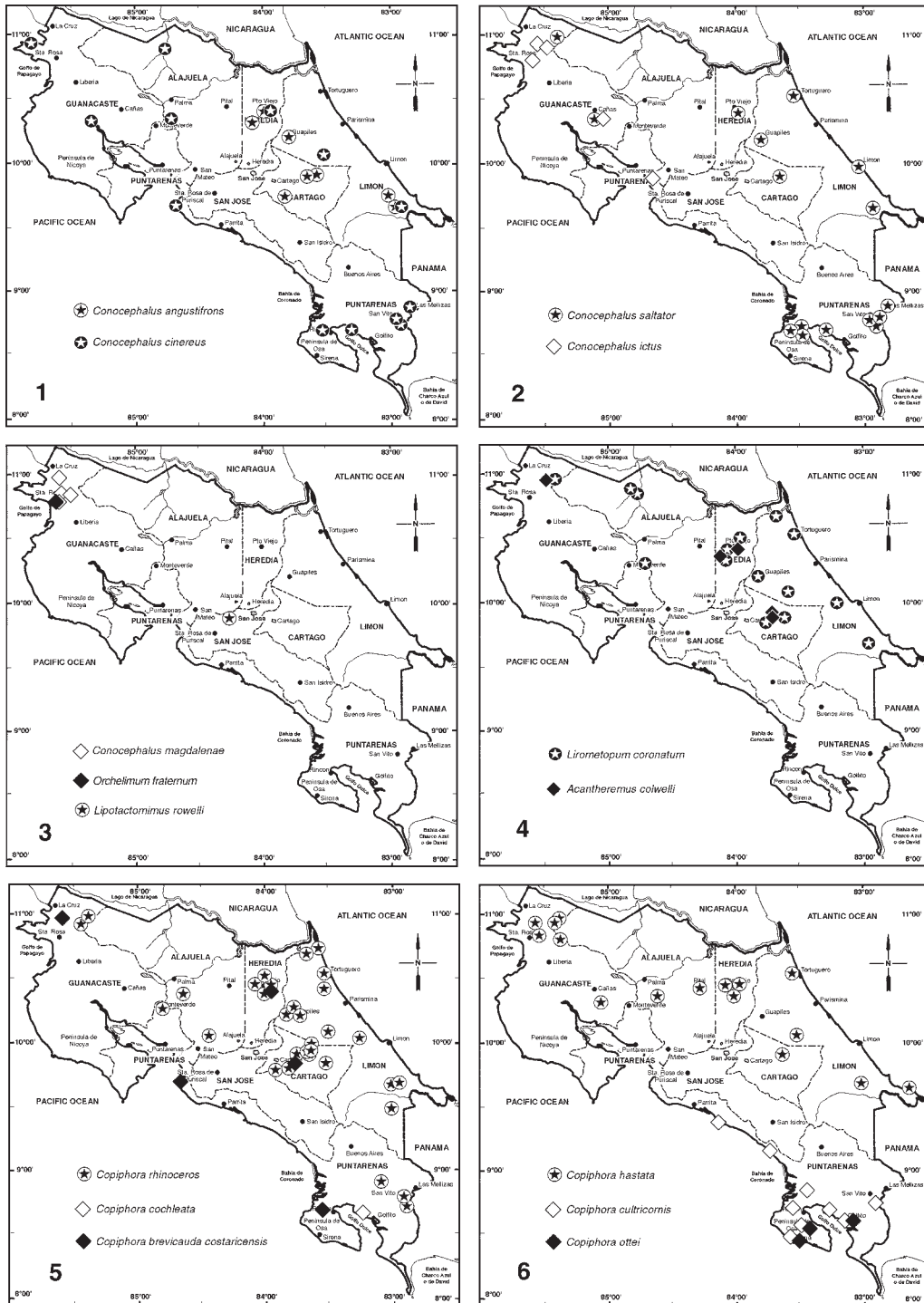
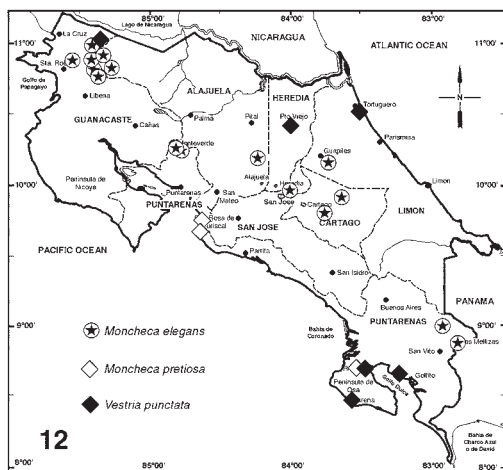
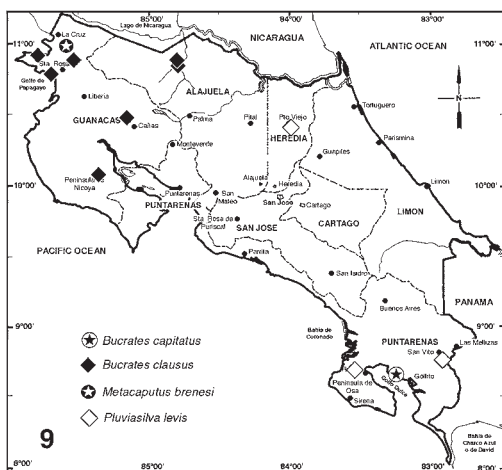
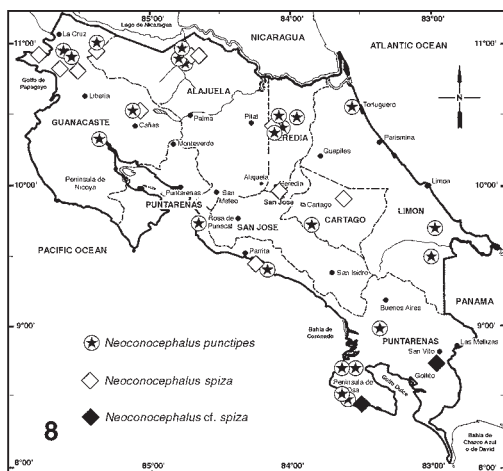
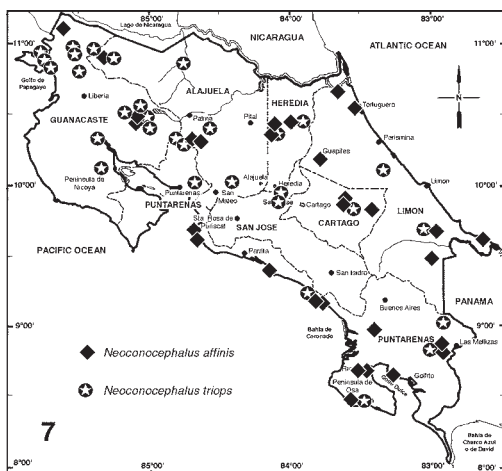


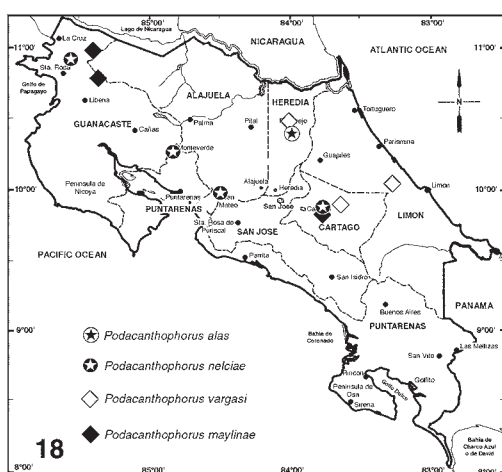
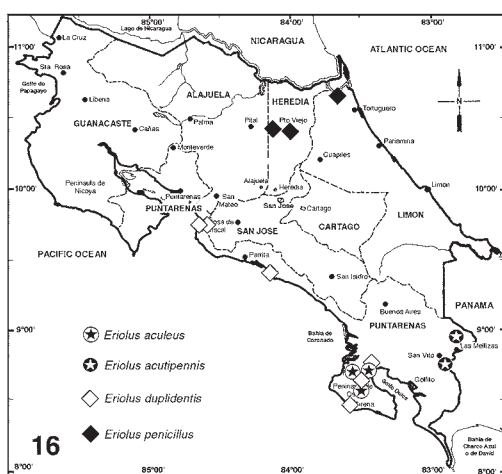
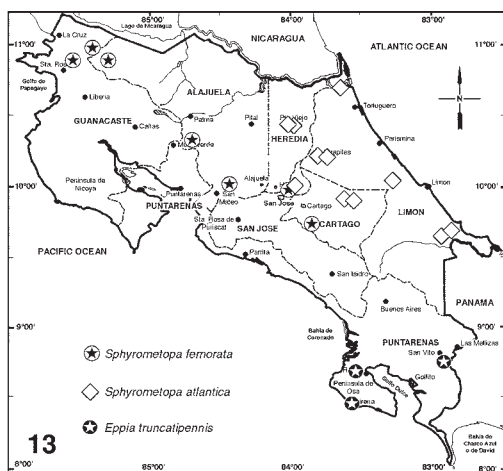
FIG. 58. Oscillograms of male airborne calls of Costa Rican species of Conocephalinae s. l. A. *Vestria puncta*, B. ditto, 0.5 s fragment, C. *Subria sylvestris*, D. ditto, 0.5 s fragment, E. *Subria scutellaris*, F. ditto, 0.5 s fragment, G. *Podacanthophorus alas*, 0.5 s fragment.



MAPS 1-6. Distribution of species of Conocephalinae s. l. in Costa Rica. 1. *Conocephalus angustifrons*, *C. cinereus*, 2. *Conocephalus saltator*, *C. ictus*, 3. *Conocephalus magdalenae*, *Orchelimum fraternum*, *Lipotactomimus rowelli*, 4. *Lirometopum coronatum*, *Acantheremus colwelli*, 5. *Copiphora rhinoceros*, *C. cochleata*, *C. brevicauda costaricensis*, 6. *Copiphora hastata*, *C. cultricornis*, *C. ottei*.



MAPS 7-12. Distribution of species of Conocephalinae s. l. in Costa Rica. 7. *Neoconocephalus affinis*, *N. triops*, 8. *Neoconocephalus punctipes*, *N. cf. spiza*, 9. *Bucrates capitatus*, *B. clausus*, *Metacaputis brenesi*, 10. *Pyrgocorypha rogersi*, *P. hamata*, 11. *Caulopsis cuspidata*, *C. microprora*, 12. *Moncheca elegans*, *M. pretiosa*, *Vestria punctata*.



MAPS 13-18. Distribution of species of Conocephalinae s. l. in Costa Rica. **13.** *Sphyrometopa femorata*, *S. atlantica*, *Eppia truncatipennis*, **14.** *Erioloides longipennis*, *E. macrocephalus*, *E. longinoi*, *E. brevipennis*, **15.** *Erioloides consobrinus*, *E. acutidentis*, *E. laticobinus*, *E. sikesi*, **16.** *Eriolus aculeus*, *E. acutipennis*, *E. duplidentis*, *E. penicillus*, **17.** *Subria sylvestris*, *S. crassicerca*, *S. scutellaris*, **18.** *Podacanthophorus alas*, *P. nelciae*, *P. vargasi*, *P. maylinae*.

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APPENDIX: CD ROM

Included with this publication is a CD ROM containing additional color illustrations of species treated in "Katydids of Costa Rica: Volume 1" as well as the original sound recordings used to produce the oscillograms. The content of the CD ROM is produced in the HTML format (Hypertext Markup Language) and can be read by any computer capable of handling simple Internet web pages. This CD ROM can be used on any computer fulfilling the following requirements:

Macintosh

- a CD ROM drive (4x or higher)
- a web browser (Netscape® 3.0 or higher, Microsoft® Internet Explorer® 3.0 or higher)
- an Internet connection (optional; necessary for external links only)

Windows

- a CD ROM drive (4x or higher)
- a web browser (Netscape® 3.0 or higher, Microsoft® Internet Explorer® 3.0 or higher)
- a sound card (optional; necessary for listening to sound recordings)
- an Internet connection (optional; necessary for external links only)

The CD ROM is not playable on audio CD players. It is strictly a data CD ROM.

NOTE ABOUT PLAYING SOUND RECORDINGS

The sound recordings included on the CD ROM are saved in WAV (Microsoft® Wave) and AIFF formats (Audio Interchange File Format) playable on most computer platforms. Most web browser are capable of playing WAV and AIFF sound files without the need for any external applications. Users should be able to listen to them by simply clicking on the links to the sound files included on species pages. There are numerous plug-ins capable of playing WAV and AIFF sound files from within Netscape® or Microsoft® Internet Explorer®. Links to web sites where such plug-ins can be downloaded are included on the disk (an Internet connection required).

The sound files can also be opened and edited with numerous external applications. A list of some of the available sound editing programs is included on the CD ROM.