Oecanthus rohiniae sp. nov. (Gryllidae: Oecanthinae): A new chirping tree cricket of the rileyi species group from Mexico

NANCY COLLINS¹, ISABEL MARGARITA CORONADO-GONZÁLEZ², AURORA Y. ROCHA-SÁNCHEZ², BRUNO GOVAERTS², WILBUR HERSHBERGER⁴

1 Waterford, Racine County, Wisconsin, USA.
2 Fraccionamiento Vista Real, Corregidora, Querétaro, Mexico.
3 Hospital Regional de Alta Especialidad de Ciudad Victoria “Bicentenario 2010”, Victoria, Tamaulipas, Mexico.
4 Hedgeville, Berkeley County, West Virginia, USA.

Corresponding author: Nancy Collins (ycnancy2k@hotmail.com)

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Abstract

A new species of Oecanthus is described from Mexico. Oecanthus rohiniae sp. nov. occurs in central Mexico in the understory of tropical deciduous forest and is currently known only from Mexico. This new species has the coloring, antennal markings, slightly widened tegmina, and calling song that are found in the rileyi species group. Although morphologically very similar to Oecanthus fultoni, the shapes of the distal hooks on the male copulatory blades differ between the two species. There are also differences in the song pulse patterns and chirp rate response to temperature. This new species has been given the common name Cri-Cri tree cricket. Video and song recordings are available online.

Keywords

bioacoustic, biodiversity, Querétaro, tropical deciduous forest

Introduction

According to the Orthoptera Species File (Cigliano et al. 2020), the subfamily Oecanthinae Blanchard, 1845, is represented by nine genera: Oecanthodes Toms & Otte, 1988; Oecanthus Serville, 1831; Viphys Otte, 1988; Leptogryllus Perkins, 1899; Prognathogryllus Brunner von Wattenwyl, 1895; Thaumatogryllus Perkins, 1899; Neoxabea Kirby, 1906; Xabea Walker, 1869; and Paraphasius Chapard, 1927. Two of these genera occur in Mexico—Oecanthus and Neoxabea. Twenty of the species of Oecanthus in North America, Central America, and the Caribbean are divided into four main species groups: nigricornis, niveus, varicornis, and rileyi (Walker 1962, 1963, Walker and Collins 2010). Four species in the rileyi species group are currently known to occur in North America, Central America and the Caribbean (Walker 1967, Collins et al. 2014): O. alexanderi Walker, 2010 (Walker and Collins 2010); O. allardi Walker & Gurney, 1960; O. fultoni Walker, 1962; and O. rileyi Baker, 1905.

In 1960, Walker and Gurney published the description of O. allardi and included details of ten specimens of snowy tree cricket from Tamaulipas and Michoacán, Mexico. In 1965, Richard D. Alexander traveled throughout Mexico and recorded Orthoptera and other singing animals. Notes from his recordings include six tapes that mention ’fultoni’ with adjectives such as slow, fast, and grouped or not grouped (Suppl. material 1: historical recordings). No further investigations of chirping tree crickets are known to have occurred in Mexico until the description of O. mhatreae Collins & Coronado, 2019 (Collins et al. 2019).

In 2019, a photograph accompanied by a sound recording (iNaturalist 2020) posted on iNaturalist.org from the central Mexican state of Querétaro led to the investigation of a new species of Oecanthus tree cricket. The chirping song pattern, widened tegmina, and orange area on the head are characters found in the rileyi species group. Although other photos from Mexico of tree crickets resembling the rileyi species group have been posted on iNaturalist, none had previously been accompanied by recordings of their songs. After reviewing all material, it was discovered that the samples did not correspond to any of the described taxa. This paper describes a new species of Oecanthus collected in Querétaro.

Material and methods

Specimens.—Adults and nymphs of Oecanthus were collected from a private property and immediate surrounding areas of Fraccionamiento Vista Real, Corregidora, State of Querétaro, Mexico. This locality is near Parque Nacional El Cimatario, on the southern slope of Cerro de Cimatario. Specimens were initially located by the song of the males and collected manually. Females and...
nympha were found in the same area. Tree crickets were brought indoors in plastic containers (15 × 15 × 20 cm) with holes on the side for ventilation. The males and females were kept alive and separated to be recorded and then preserved in 70% ethyl alcohol for morphological studies. Photographs and measurements of diagnostic characters were made with a Jusion Digital Microscope Model USB, magnification 40× to 1000× (ovipositor, cerci, and metanotal gland), MOTIC-SWZ168739 stereo-microscope at 40× and equipped with a 10 mp digital camera (internal genitalia). Characters considered for description are as follows: body length, head colors, antennal colors and markings, pronotum in dorsal view, tegmina length and width, stridulatory file, metanotal gland, cerci, subgenital plate, and internal genitalia (copulatory blades). Additional characters for females included the ovipositor, subgenital plate and cerci. The following measurements were made: body length—from the tip of the labrum to the apex of the subgenital plate; pronotum length (from anterior to posterior margin along midline); pronotum width (at the widest distal portion in dorsal view); tegmina length (from the thorax joining point to distal end of tegmina along midline); tegminial width (measured at the widest section of tegmina at rest); hind femur length; and cerci length. The females’ ovipositors were measured from the base (closest portion to the abdomen) to the distal tip. Copulatory blades (Fulton 1915) project from the male genitalia complex and are situated just above the subgenital plate. These genitalia structures have also been referred to as pseudepiphallus (Chopard 1961, 1969). Lophi medians [middle lobes] (Desutter 1987), or main lobe of pseudepiphallus (Zefa et al. 2012). The genitalia of Mexican specimens were treated with an aqueous solution of 10% potassium hydroxide (Rocha-Sánchez et al. 2018, Barrientos-Lozano and Rocha-Sánchez 2013). No chemicals were used on the O. fultoni specimen from the USA. Genus determination was made with keys from (Walker 1967) and SINA (2020a) and review of taxa of Oecanthus in the Orthoptera Species File (Cigliano et al. 2020).

Calling song recording and analyses.—The male acoustic signal was recorded in the field and indoors using a Samsung Galaxy Tab S4 tablet model SM-T830, the app Grabadora Amazing, and a MixMart 8 GB, PCM, 1536 kbps digital voice recorder. Audio devices were tested for calibration by recording a reference time audio file with reference tones and comparing the results to the original file. The recording devices were kept at a distance of approximately 10 cm from the individual. Analyses of song recordings were made with the Raven Pro 1.6 program (Cornell Lab 2020). Audio waveforms were created using the programs Raven Lite 2.0 or Raven Pro 1.6 (Cornell Lab 2020). Grouped pulse patterns were determined by counting individual pulses within each chirp. A chirp consists of varying numbers of pulses, and each pulse corresponds to a single closure of the tegmina (Walker and Collins 2010). Ten randomly chosen chirp periods were measured for each recording to determine the chirps per minute rate for that sample. Additional recordings (Suppl. material 2: source recordings) from the Macaulay Library of Cornell Lab (2020) were used for the preparation of two graphs to compare chirps per minute vs temperature and carrier frequency vs temperature, with additional species in the rileyi group. Regression lines for the sampled O. rohiniae sp. nov. population were calculated in Microsoft Excel for Mac, Version 16.16.22 (200509) (2016). The slopes of the regression lines for O. rohiniae sp. nov. and O. fultoni were compared using the t-test procedure for paired samples from Wonnacott and Wonnacott (1977).

Results

Oecanthus rohiniae Collins & Coronado-González, sp. nov.
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Material examined.—Holotype: MEXICO • ♂; Querétaro, Corregidora: 2130 MASL; 30.xi.2019; 20°52′20″N, 100°38′80″W; I. Coronado leg.; deposited Universidad Nacional Autónoma de México (IB-UNAM). Paratypes: MEXICO • 2 ♂, 3 ♀; same locality as holotype; 2 ♂, 2 ♀; deposited Tecnológico Nacional de México-Instituto Tecnológico de Ciudad Victoria (TecNM-ITCV); 1♀ deposited IB-UNAM.

Etymology.—Specific epithet in recognition of Rohini Balakrishnan whose research involves bioacoustics, animal behavior, ecology, and systematics. Her list of publications includes several that focus on or include tree crickets. The common name, Cri-Cri tree cricket, is named for Cri-Cri: El Grillito Cantor (Cri-Cri: The Little Singing Cricket), which was a character created by Francisco Gabilondo Soler, a Mexican composer and performer of children’s songs. Additionally, the sound this tree cricket makes is written as “cri, cri…” in Spanish.

Holotype measurements.—Body length 13.0 mm; tegminal length 13.0, tegminal width 6.0; pronotal length 2.0, distal pronotal width 2.0; hind femur length 7.0; cerci 5.0; stridulatory file length 1.8. Right tegminal stridulatory teeth total 46.

Description.—Face pale; head with area of pale orange (Figs 4, 5). Scape translucent orange, pedicel translucent whitish (Fig. 6), and remainder of antennomers translucent whitish. Ventral face of pedicel and scape each with one ovoid or rounded black mark on white field (Figs 3, 19). Eye color pale cream to violet. Palpi pale golden orange with whitish tips. Pronotum light green. Tympanic membrane on fore tibiae whitish. Wing color greenish. Ventral abdomen whitish with blotches of light green (Fig. 8). Tarsi, tibiae, and femora translucent pale green; some individuals with blackish thin line down inner femora. Cerci straight and translucent pale green.

Males.—Hind wings and cerci extend beyond distal edge of tegmina (Fig. 1). Tegmina with veins as in Fig. 7. Climate.—Temperatures were measured using an ELMeco DTM2 digital thermocouple thermometer with a range of -50°C to 1000°C, with an accuracy of 0.1°C. Ambient temperature and rainfall ranges [climatologia/temperaturas-y-lluvias/resumenes-mensuales-de-temperaturas-y-lluvias] for 2018 and 2019 were taken from the National Water Commission weather website (NWC 2020). The light intensity was determined using a HIoki model 3422 digital luxmeter with a range of 0 to 2000 Lx (11Lx accuracy) and using data from the NWC website.
Figs 1–10. Oecanthus rohiniae sp. nov., male. 1. Habitus; 2. Singing male showing the tegmina in raised position; 3. Head in frontal view showing the antennal marks; 4. Rounded patch of color on head; 5. Notched patch of color on head; 6. Antennal base, lateral view; 7. Metanotal gland; 8. Subgenital plate in ventral view; 9. Internal genitalia in ventral view; 10. Internal genitalia in dorsal view.
Morphological diagnosis.—*Oecanthus rohiniae* sp. nov. can be distinguished from *O. rileyi* by differences in antennal markings and from *O. fultoni* by differences in the distal hooks of the copulatory blades of the male genitalia. The antennal markings of *O. rohiniae* sp. nov. are centered and fairly equal in size (Figs 3, 20). The antennal marking on the pedicel of *O. rileyi* is positioned at the top of the segment, and is approximately one-half the size of the marking on the scape (Fig. 22). A drawing in Walker and Gurney (1960) of male genitalia shows that the distal ends of the copulatory blades of *O. fultoni* appear rounded with sharply pointed medially opposing hooks (Fig. 27). The distal ends of the copulatory blades of *O. rohiniae* sp. nov. are more blunted, and the tips of the hooks are less pointed (Fig. 23). A second drawing in Walker and Gurney (1960) shows an undetermined *rileyi* species group tree cricket from Tamaulipas, Mexico (Fig. 24) with hook position similar in appearance to *O. rohiniae* sp. nov. Photos of the lateral view of the blades of *O. rohiniae* sp. nov. (Fig. 25) and *O. fultoni* (Fig. 28) highlight the hook tip differences.

Female description.—(Figs 11–13) Latticed vein pattern on translucent greenish wings. Body length 11.5 mm; pronotal length 2.0, distal pronotal width 2.0; hind femur length 7.0; cerci 4.5; ovipositor length 3.5. The length of the hindwings is variable. The tip of the ovipositor does not extend beyond the tips of the cerci.
Nymphs.—(Figs 14, 15) Straight rows of white rounded marks on the abdomen, black speckles on the hind femora, and evenly spaced black rings on the antennal filaments. Nymphs of various instar stages, as well as adults, were encountered year round.

Distribution and habitat.—Cri-Cri tree crickets have only been collected in the type locality in the biogeographic province of the Trans-Mexican Volcanic Belt, in the State of Querétaro, located in the Central-South part of Mexico. The vegetation was categorized by dry shrubland with cacti (crassifolia), grassland (matatorial), reinvading natural vegetation on disturbed land (ruderal), and introduced plants. A total of 33 plant species were able to be identified in the type locality (Calderón de Rzedowski and Rzedowski 2001, Martínez-Sandoval 2017). Adults and nymphs of this new species of tree cricket were observed on 14 of these plant species and were witnessed feeding on eight plant species (native plants: Asclepias curassavica L., Croton cilatoglandulifer Ort., Justicia candicans (Nees) L.D., Lantana camara L., Lantana hirta Graham, Colubrina triflora Brogn Ex Sweet (also oviposition) and introduced plants: Calendula officinalis L., Crinidoscolus multilobus (Pax) I. M. Johnst, Ruta graveolens L., and Thunbergia alata Bojer Ex Sims). An ovipositing female as well as nymphs were found on Colubrina triflora Brogn. Ex Sweet, a native plant. Nymphs were found on three native plants: Lantana hirta Graham, L. camara L., and C. cilatoglandulifer Ort.

Climate and light intensity.—National Weather Commission (NWC 2020) data for 2009–2019 showed the coldest months as December and January (lowest 4.0 °C) and the warmest months as April and May (highest 33.2 °C). The driest months tend to be November through March (lowest 0.0 mm) and the wettest months tend to be June through September (highest 207.0 mm). Males sing just before or after sunset with light measurements of 5 W/m² and temperatures as low as 11.0 °C.

Acoustics, chirp rates, frequencies, and slopes.—Recordings were made in the field and in captivity for O. rohiniae sp. nov. A sample recording can be heard in Suppl. material 3: WAV, and a stridulating male can be viewed in Suppl. material 4: MPG. After plotting the data of temperature vs chirps per minute and carrier frequency vs temperature, linear regression lines were calculated for O. rohiniae sp. nov., O. fultoni, and O. rileyi. The linear regression for tempera-
Chirp pulse pattern comparisons and diagnosis.—Visual inspection of song oscillograms revealed that *O. rohiniae* sp. nov. has chirps with grouped pulses. The chirp pulse grouping patterns of *O. rohiniae* sp. nov. are 2-2, 2-3, 2-3-2 or 2-3-3 (Fig. 19). Of the 601 individual chirps examined, 76.9% were 2-3 or 2-3-2 patterns. The predominant patterns for *O. fultoni* were 2-3 or 2-3-3. We found
two instances of apparent aborted chirps with a single 2-pulse grouping, but we found no recordings of a singing *O. fultoni* with a 2-3-2 pattern. Table 1 shows the percentage of occurrence for chirp pulse patterns for *O. rohiniae* sp. nov., *O. fultoni*, and *O. rileyi*. Since *O. rohiniae* sp. nov. has a total of 11 or less pulses per chirp, both *O. alexanderi* and *O. allardi* can be ruled out as their chirps consist of 17–23 or 29–35 pulses, respectively (Walker and Collins 2010). *Oecanthus mhatreae* does not have grouping of pulses in each chirp (Collins et al. 2019).

**Table 1.** Occurrence percentages of grouped pulses per chirp patterns of *O. rileyi*, *O. fultoni*, and *O. rohiniae* sp. nov. (n = number of individual chirps sampled).

| Species         | Pulse pattern usage percentage | Pattern | Percent |
|-----------------|--------------------------------|---------|---------|
| *O. rileyi*     |                                | 2-3-3-3 | 49.5    |
| (n=198)         |                                | 2-3-3  | 40.4    |
|                 |                                | 2-3-3-3 | 6.1     |
| *O. fultoni*    |                                | 2-3-3  | 78.4    |
| (n=679)         |                                | 2-3    | 16.2    |
|                 |                                | 2-3-3-3 | 1       |
|                 |                                | 2-3    | 0.7     |
|                 |                                | 3-3    | 0.15    |
| *O. rohiniae*   |                                | 2-3-3  | 41.9    |
| sp. nov.        |                                | 2-3-2  | 16.1    |
| (n=601)         |                                | 2-2    | 3.9     |

Other species comparisons.—The known members of the *nigricornis*, *niveus*, and *varicornis* species groups can be ruled out with non-matching song types, tegminal widths, antennal markings, or antennal coloring. Other western hemisphere species of *Oecanthus* can be ruled out for non-matching characters as in Table 2.

**Table 2.** Non-matching characters of western hemisphere *Oecanthus* species outside the species groups of *nigricornis*, *niveus*, *rileyi*, and *varicornis*.

| Oecanthus species | Nonmatching characters                  | Sources          |
|-------------------|-----------------------------------------|------------------|
| major             | Proximal antennal flagellum dark         | T. Walker 1967   |
| comma             | Comma-shaped mark on pedicel             | T. Walker 1967   |
| prolatus          | Linear mark on scape                     | T. Walker 1967   |
| lineolatus        | Linear antennal markings                | T. Walker 1967   |
| tenuis            | Linear antennal markings                | T. Walker 1967   |
| valensis          | Linear antennal markings                | Milach et al. 2016|
| minutus           | No or linear antennal markings           | T. Walker 1967   |
| immaculatus       | No antennal markings                     | T. Walker 1967   |
| narsus            | No antennal markings                     | T. Walker 1967   |
| peruvianus        | No antennal markings                     | T. Walker 1967   |
| pictipes          | Post-ocular lines                        | T. Walker 1967   |
| pallidus          | Bursts of trilling                       | Zefa et al. 2012 |
| pictus            | Trilling song                            | Milach et al. 2015|
| belti             | Trilling song                            | Collins et al. 2014|
| symesi            | Trilling song                            | Collins et al. 2014|
| jamaicensis       | Trilling song                            | T. Walker 1969   |
| bateri            | Trilling song                            | Collins et al. 2014|

Morphological comparisons.—Since both *O. rohiniae* sp. nov. and *O. fultoni* are members of the *rileyi* species group, it is not unexpected that no profound differences were evident in the following characters: coloring, antennal markings, metanotal gland, number of stridulatory teeth, tegmen venation, and subgenital plates. The pedicel of *O. rohiniae* sp. nov. has a centered black mark more than one half the size of that on the scape (Fig. 20), which is also found on *O. fultoni* (Fig. 21) but not on *O. rileyi* (Fig. 22). These markings can be either round or ovoid. The copulatory blades of *O. rohiniae* sp. nov. have distal hooks that appear somewhat blunted and are positioned at a slight angle (Fig. 23), while those of *O. fultoni* have hooks that are more sharply pointed with tips that reach further midline (Fig. 26). These differences can be compared to drawings in Walker and Gurney (1960) comparing male genitalia of a *rileyi* species group tree cricket from Tamaulipas, Mexico (Fig. 24) with a snowy tree cricket from Ohio (Fig. 27). While we cannot proclaim that the drawing of the Tamaulipas tree cricket in Fig. 24 is *O. rohiniae* sp. nov., the differences in the two drawings do affirm that more than one species of the *rileyi* group exists in Mexico. The difference in the appearance of the hooks on fresh specimens can be seen from a lateral view of the blades, as in Figs 25, 28.

Figs 20–22. Shapes and locations of black markings on pedicel and scape. 20. *O. rohiniae* sp. nov.; 21. *O. fultoni* (SINA 2020b); 22. *O. rileyi* (SINA 2020c).
Discussion

We described a new species of *Oecanthus* that falls into the *rileyi* species group. We were able to rule out other chirping species by the following characters: Size and position of the black mark on the pedicel rule out *O. rileyi*; short chirps (less than nine pulses per chirp) rule out *O. alexanderi* and *O. allardi*; and the grouping of pulses in each chirp rule out *O. mhatreae*.

*Oecanthus fultoni* is morphologically quite similar to *O. rohiniae* sp. nov., however the distal hooks on the male copulatory blades of *O. rohiniae* sp. nov. have a slightly blunted point, while the hooks of *O. fultoni* are more sharply pointed. Recorded chirps of *O. fultoni* do not include the 2-3-2 pulse pattern as in chirps of *O. rohiniae* sp. nov. T-test analysis of the regression lines for chirps/min rate as it varies with temperature for *O. rohiniae* sp. nov. and *O. fultoni* indicated a significant difference between the two species.

A list of recordings by Alexander, which includes notations of ‘fultoni’ tree crickets, can be viewed in Suppl. material 1: historical recordings. In 1966, Thomas J. Walker analyzed several of Alexander’s recordings. With his permission, we provide a table of these analyses in Suppl. material 5: analyses of historical recordings. These recordings shed light on the need for further investigation of chirping tree crickets in Mexico. Although the Cri-Cri tree cricket is currently only described from Querétaro, there have been other photos from Mexico of similar looking tree crickets submitted to iNaturalist.

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Supplementary material 4
Author: Bruno Govaerts
Data type: Video
Explanation note: MPG file with a video of a singing male *O. rhiniae* sp. nov. taken outdoors in Querétaro, Mexico. A singing *O. mhatreae* is in the background.
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Link: https://doi.org/10.3897/jor.30.50039.suppl4

Supplementary material 5
Author: Thomas J. Walker
Data type: Song Analyses
Explanation note: Song analyses by Thomas J. Walker in 1966 of Richard D Alexander’s 1965 recordings from Mexico, which included ‘*fultoni*’ tree crickets.
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Link: https://doi.org/10.3897/jor.30.50039.suppl5