DNA. Multilocus species tree G1414 (S09-103, Gila Bend) *G. multipulsator* is a sister species of *G. assimilis*—see DNA comparisons in Weissman *et al*. (2009) and in Gray *et al.* (2019). Also, closely related to *G. locorojo* and *G. veintinueve* (Fig. 6, p. 28).

Discussion. When we described this taxon in 2009, it was thought to have the highest number of p/c of any *Gryllus*. Otte (1987) described *G. mzimba* from Malawi with 17p/c and Martins (2009) discussed an undescribed *Gryllus* from southern Brazil (his *G*. n. sp. 2) that has from 13-21 p/c. Because *G. multipulsator's* distribution ends in central Mexico (Weissman *et a*l. 2009), Martins' undescribed cricket will be the new record holder for p/c once published.

Tachinid *Ormia ochracea* emerged from 2 males collected in Yuma, AZ (2003-333 and 334).

The Rubens Group

G. rubens Scudder; *G. texensis* Cade & Otte; *G. regularis* Weissman & Gray, n. sp.

Sister species of trilling field crickets distributed from south-central Arizona into far western Texas (*G. regularis*), from western Texas and the southern Great Plains eastwards to western Florida (*G. texensis*), and from eastern Texas eastwards to Florida and the southeastern Atlantic states (*G. rubens*). The only regular trilling species of *Gryllus* in the US (*G. cohni* is more of an irregular triller), differing from each other most notably in pulse rate (Figs 71 & 72) with *G. regularis* 30-50; *G. rubens* 45-65; and *G. texensis* 62-91. Geography, female morphology, and genetics also useful (Fig. 73, and Gray *et al.* 2019).

Gryllus rubens Scudder

Southeastern Field Cricket
Figs 71–82, 85, 86, 90, Table 1

1902 *Gryllus rubens* Scudder. Psyche 9: p. 295. Holotype female, Auburn, Alabama. Type in ANSP, photos (Fig. 74) courtesy of J.D. Weintraub, ANSP. Plotting Scudder's female holotype measurements of pronotal width of 6 mm and ovipositor length of 16 mm (Scudder 1902) falls within *G. rubens* measurement cluster (Fig. 75).
1957 *Acheta rubens* (Scudder). Alexander, 1957. p. 586.
1964 *Gryllus rubens* Scudder. Randell 1964.

Distribution. One (Fig. 71, R13-220) of only two trilling US *Gryllus* found between 99° longitude (central Texas) and the Atlantic coast. See Walker (2019) and Gray (2011) for additional eastern localities.

Recognition characters and song. Medium sized, short or long hind winged crickets with an average PR of ~55 at 25°. Distinguished from morphologically similar and trilling, sometimes sympatric, *G. texensis* in that the latter has an average PR of ~80 at 25° (Figs 71, 84), more teeth in the file (Figs 78, 79), a shorter ovipositor (Gray *et al*. 2001), and frequently, but not always, shorter bursts of pulses. Pulse rate at a given temperature faster, but with greater separation from *G. texensis*, in the late summer/fall generation than in the spring generation (Walker 1998).

Along coastal Texas, in 2013, we found no overlap in dominant frequency, in many males, which was <5000 Hz in *G. rubens* but >5000 HZ in *G. texensis*. Yet around Tulsa, Oklahoma (S13-68), there is overlap and we wonder if this might reflect hybridization, environmental effects during development, or both. Additionally, Blankers (pers. comm.) stated that dominant frequency values that he used in Blankers *et al.* (2015) had a range of 4.18–5.88 KHz in *G. rubens* and 4.66–5.56 KHz in *G. texensis.* Unfortunately, these measured males were all from laboratory generations with unknown effects on the song.

Derivation of name. "rubens" apparently for the general reddish and rufo-testaceous markings on Scudder's unique, long tegmina female specimen.

Geographic range. (Fig. 76.) Most of our collection localities are near the western and northwestern boundaries of *G. rubens'* distribution. See Gray (2011) and Walker (2019) for more complete eastern US distribution maps. Our most western locality is Bastrop State Park (S91-23), Texas, where *G. rubens* occurred with *G. texensis*. There we collected one male *G. rubens* (R91-39) with a PR of 53 at 25°C and with 100 file teeth and three *G. texensis*

(R91-5, 6, 7) with PRs from 80–100 at 25°C and with 110–121 file teeth. We could not distinguish these two songs in the field.

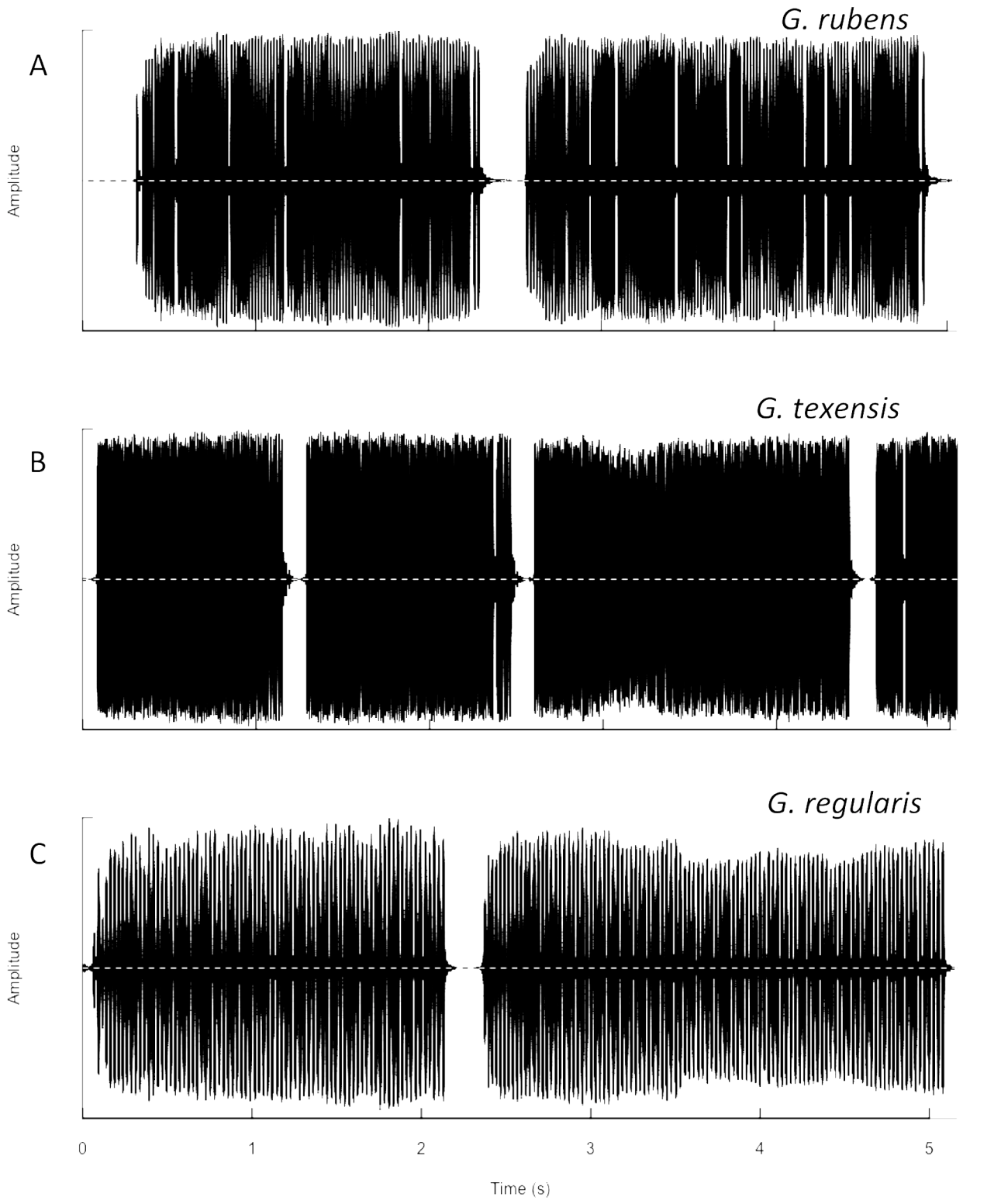

FIGURE 71. Five second waveforms of calling songs of (A) *G. rubens,* (B) *G. texensis*, and (C) *G. regularis*. (A) *G. rubens*: (R13-220) Tulsa, OK (S13-68), at 25°C; (B) *G. texensis*: (R13-224) Rio Hondo, TX (S13-44), at 26°C; (C) *G. regularis* (R99-211) Sinaloa, MX (S99-86), at 25.5°C.

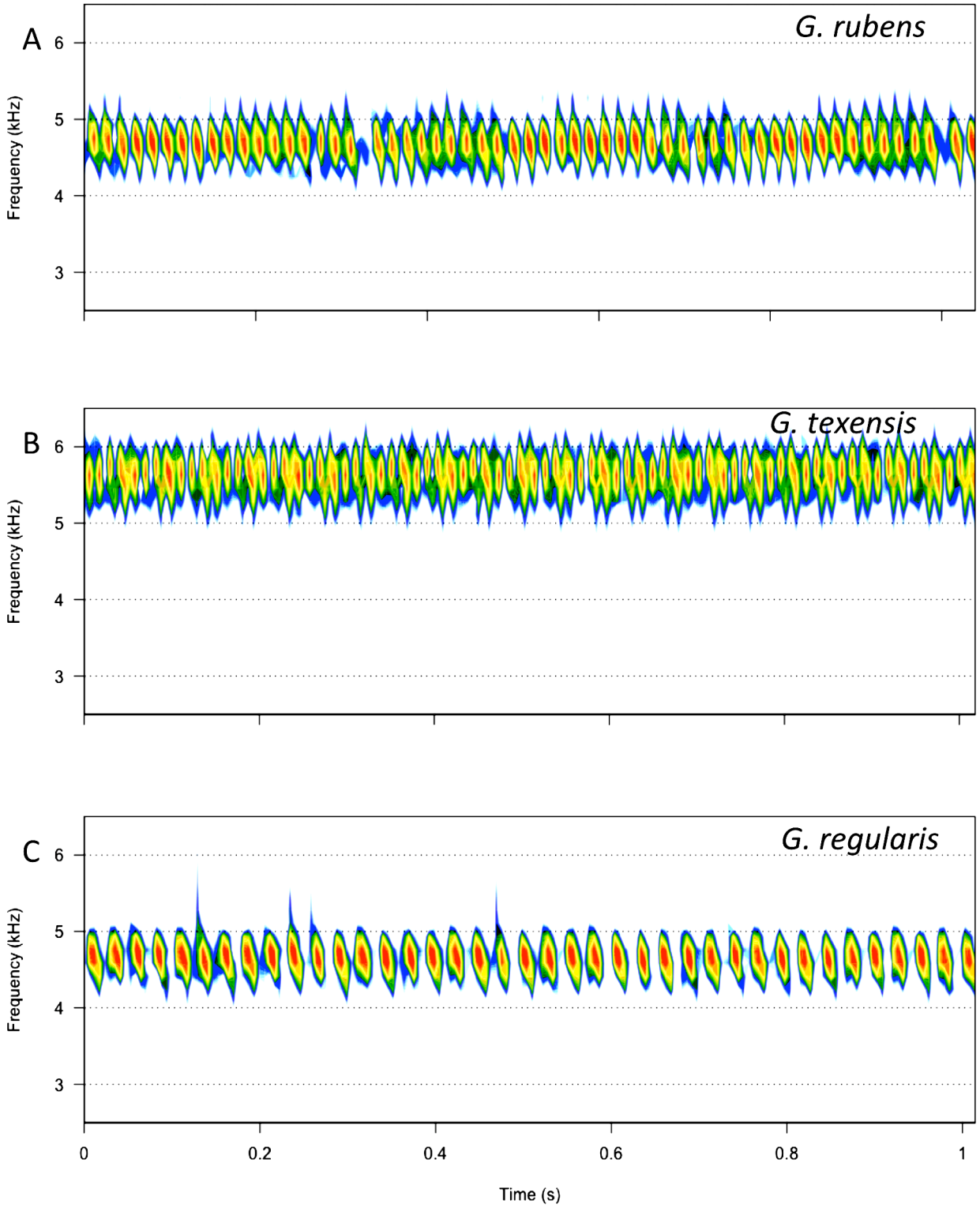

FIGURE 72. One second spectrograms of (A) *G. rubens,* (B) *G. texensis*, and (C) *G. regularis*, same males as in Fig. 71.

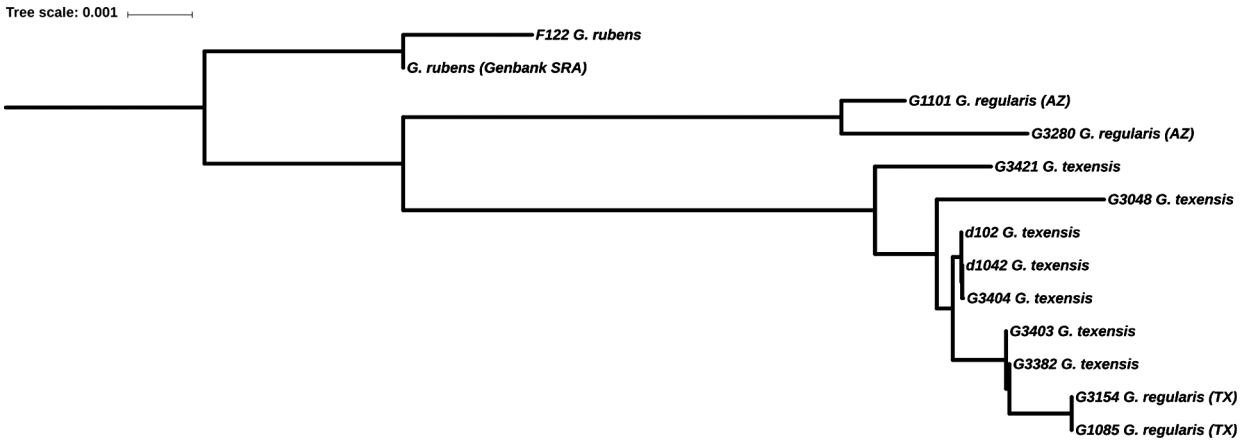

FIGURE 73. ITS2 gene tree. ***G. rubens*** samples: Orlando, FL (F122); Lake City & Ocala, FL (Genbank SRA, Berdan *et al*. 2016); ***G. regularis*** samples: S07-2 (G1101); S07-41 (G1085); S15-67 (G3154); S15-102 (G3280); ***G. texensis*** samples: S15-43 (G3048); S16-12 (G3382, G3403, G3404, G3421); Uvalde, TX (d102); Bastrop, TX (d1042).

FIGURE 74. Holotype female *G. rubens, with labels.*

Habitat. Lawns, pastures, and grassy roadsides.

Life cycle and seasonal occurrence. No egg diapause. Two generations/year even at the northern extremes of its range (Capinera *et al*. 2004). Adult peak abundances in spring and fall, representing the separate generations. Continuous generations in Florida (Vélez & Brockmann 2006). Can be locally common.

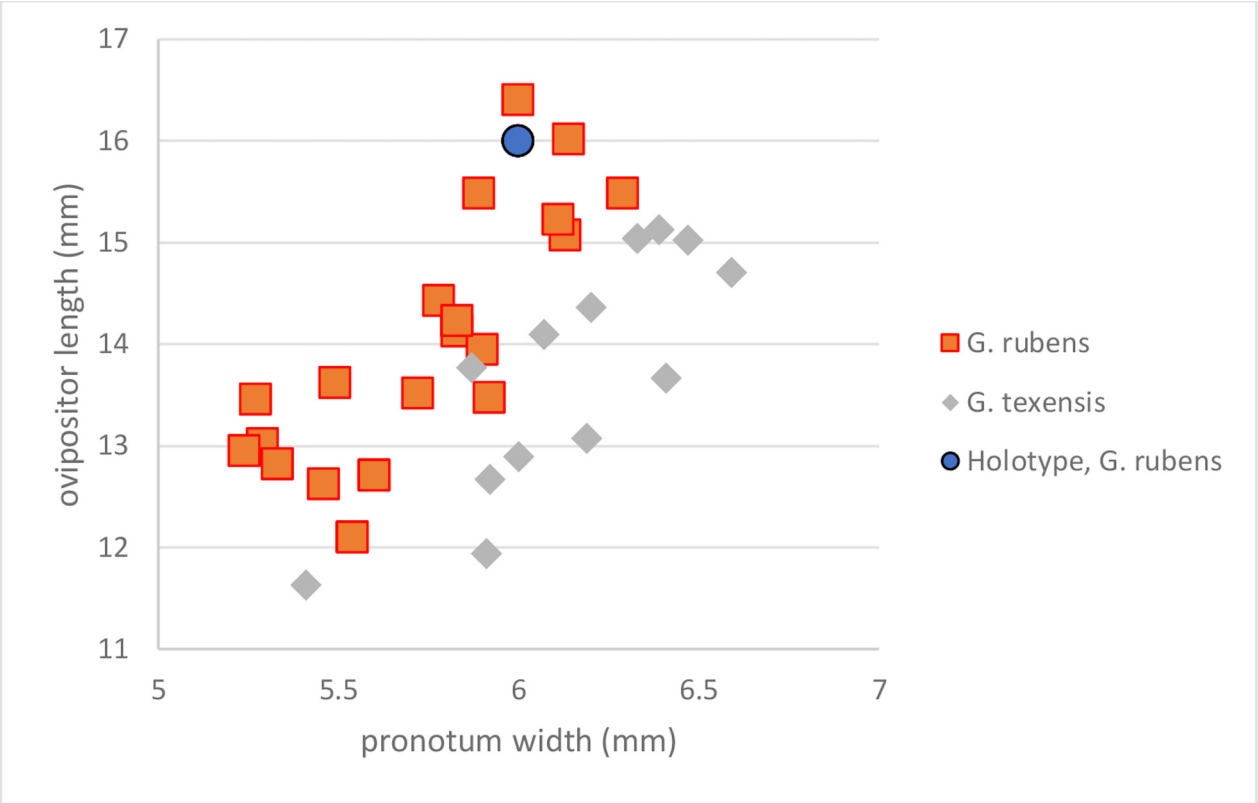

FIGURE 75. Regression of pronotum width vs. ovipositor length in the only two trilling eastern US taxa shows that holotype most consistent with *G. rubens.*

Variation. **Hind wing length:** Populations variable for short and long hind winged individuals of both sexes (Veazey *et al*. 1976, Walker 1987). **Color:** Within a population (e.g. S02-58, Missouri), individuals (Fig. 80) may have black hind femurs and tegmina compared to more typical brown/reddish ones. **Pronotum:** Usually very shiny in males, possibly less so in females. **Song:** Usually an evenly spaced trill but one male from Missouri, with 95 file teeth, (Fig. 81, R02-74, S02-58) with variable grouping of pulses.

Specimens examined. (Total: 54♂ 27♀). **Arkansas:** *Garland Co.,* Jessieville, 19-vi-1993, 750' (S93-46) 1♂. *Yell Co.,* Dardonelle, 19-vi-1993, 400' (S93-48) 2♂. **Florida:** *Alachua Co.,* Gainesville, 2-x-1986 (S86-128), TJ Walker, 20♂ 7♀. **Indiana:** *Warrick Co.,* 4 m S Dale 4-vi-2003, 650', 38° 7.228' -87° 1.591' (S03-61) 1♂. **Maryland:** *Prince George Co.,* College Park, 30-v-2004, 500' (S04-35) 2♂. **Missouri:** *Cape Girardeau Co.,* Millersville, 9-viii-2002, 320' (S02-58) 6♂ 9♀; *Iron Co.,* Pilot Knob, 9-viii-2002, 840' (S02-57) 2♂ 1♀. **Oklahoma:** *Texas Co.,* Guymon, 1-vii-2009, 3380' (S09-77) 1♂. *Tulsa Co.,* Lake Keystone Dam area, 22-v-2001, 650', 36° 9.092' -96° 15.043' (S01-47) 1♂; Tulsa, 15-vii-2013, 775' (S13-67, 68) 9♂. **Texas:** *Bastrop Co.,* Bastrop State Park, 31-v-1991, 700' (S91-23) 1♂. *Galveston Co.,* High Island, 10-vi-2011, 5' (S11-28) 4♀. *Harris Co.,* Cypress, 148', 13-vii-2013 (S13-64) 3♂. *Jefferson Co.,* Sabine Pass, 10-vi-2011, 20' (S11-31) 3♂ 5♀; Sea Rim State Park, 10-vi-2011, 5' (S11-29) 1♀; *Marion Co.,* Caddo Lake State Park, 18-vi-1993, 300' (S93-42) 1♂. *Orange Co.,* Beaumont, 1-vi-1991, 50' (S91-32) 1♂.

DNA. Multilocus d437 from Florida, Jackson Co., Marianna, 28-ix-1999, 117', 30.774°, -85.227°, pulse rate in this male 53 at 25°C. Closest relatives (Gray *et al.* 2019): *G. texensis* (see Gray 2006; Gray *et al.* 2006) and *G. regularis*. See also Blankers *et al.* (2018), which compared transcriptomic genetic variation in *G. rubens* and *G. texensis*. In that study, several loci were fixed for genetic differences between *G. rubens* and *G. texensis*, so in principle there are diagnostic genetic differences between these taxa, but they are not applicable in any practical sense.

*Discussion.*When standing near simultaneously trilling males of *G. rubens* and *G. texensis*, one can sometimes hear subtle differences between the two songs, probably reflective of the different pulse rates and dominant frequencies. Currently, there is no single, definitive morphological character that separates male *G. rubens* from male *G. texensis* (Walker 1998, Gray *et al*. 2006), although we do present new data (Fig. 79) showing promise when

comparing number of file teeth vs. teeth/mm. In the past, positive male identification has been exclusively linked to differences in song PR. Unfortunately, the ability of this one song parameter to separate the two species gets murky in some populations. Gray & Cade (2000a) demonstrated an increase in PR in *G. rubens* of ~3 for each 1°C rise in temperature and an increase in PR in *G. texensis* of ~5 for each 1°C rise. Martin *et al*. (2000) demonstrated an increase in PR of 3.5 for every 1°C increase in recording temperature in *G. texensis* (called "*G.* integer" by Martin *et al*. 2000). We applied a modification of this temperature correction (+4 pulses for each 1°C difference from 25°C because we did not want to prejudge which species that we decided that we were recording) to 16 males from Tulsa, OK (S13-68) recorded in the laboratory between 22–28°C and whose PR we normalized to 25°C: we find no unambiguous separation at this locality and get only a modestly bimodal PR (Fig. 82).

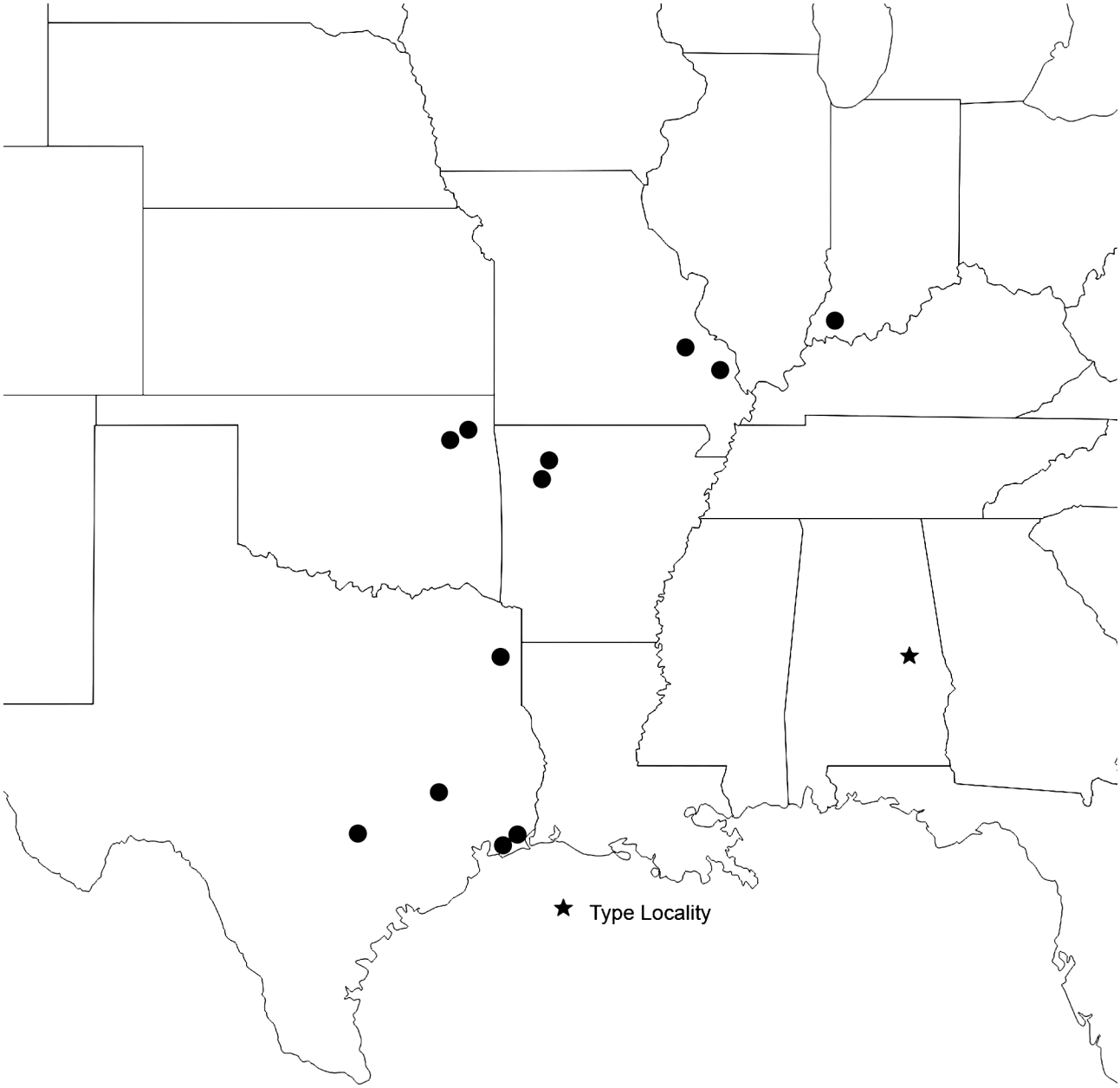

FIGURE 76. Populations of *G. rubens* that we studied.

While we did not find this ambiguity, in pulse rate, to be geographically widespread, it is also not unique: For instance, Walker (1998, p. 175) notes:

"…songs I attributed to *G. rubens* had a slightly higher average pulse rate in the zone of overlap [with *G. texensis* between western Florida and eastern Texas] than farther east and both species varied more in pulse rate between individuals from the same site and for the same individual from time to time than in the many other cricket species

I had studied. *G. rubens* and *texensis* [called *'G. integer'* by Walker in 1998] were not as clearly separated by their songs as other sympatric pairs of sibling species of crickets."

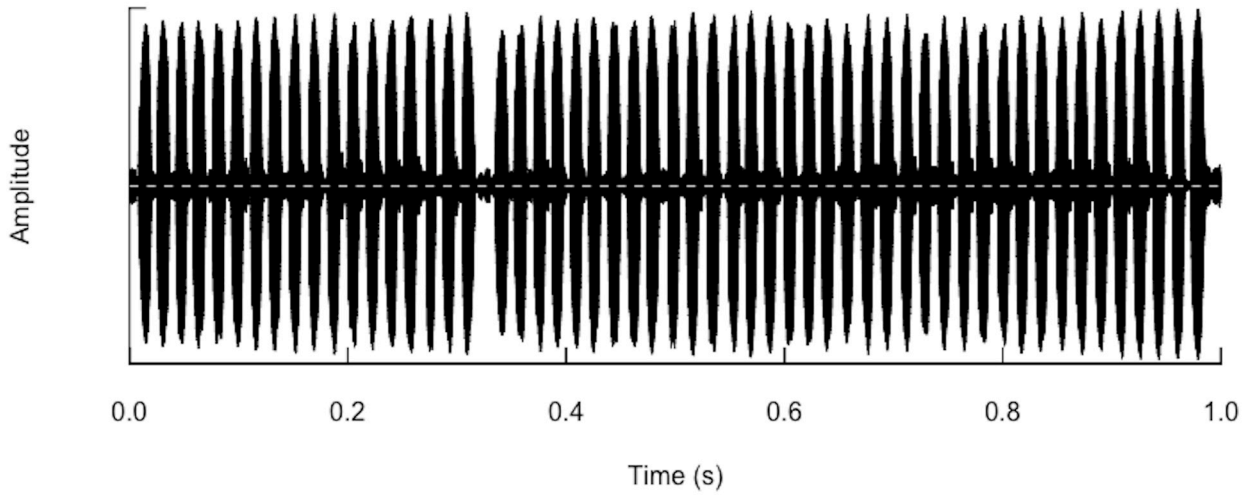

FIGURE 77. One second waveform, pulse rate of 56, of calling song of *G. rubens*: (R13-220) Tulsa, OK (S13-68), at 25°C.

FIGURE 78. Regression of number file teeth vs. hind femur length showing separation of sympatric *G. rubens* from *G. texensis.*

Instead of finding character displacement where they overlap, Walker (1998) found the opposite and concluded that the two species may hybridize in areas of overlap in western Florida. Such hybridization is achievable in the laboratory (Smith & Cade 1987), but, based on song phenotype, appears to be rare in sympatry (Izzo & Gray 2004). Nonetheless, we wonder if they may be hybridizing at our Tulsa, OK, site (S13-68), as discussed above. Using transcriptomic data, Blankers *et al.* (2018) found no evidence of interspecific gene flow more recently than ca. ~18K years, but, it must be noted, the source populations for that study were from allopatry. Additionally, Walker (1998)

documented that different generations have different pulse rates, now further investigated by Beckers *et al.* (2019), so variable environmental effects are certainly possible.

G. rubens has been used in hybridization studies (Smith & Cade 1987; Cade & Tyshenko 1990), tachinid fly parasitism (Vélez & Brockmann 2006), effect of temperature on pulse rates (Doherty & Callos 1991; Walker 2000), female phonotaxis (Doherty & Callos 1991), song character displacement (Walker 1998; Izzo & Gray 2004), courtship song divergence (Fitzpatrick & Gray 2001) and impact on potential for hybridization (Gray 2004), peripatric speciation (Gray *et al*. 2008, Blankers *et al.* 2018), genetics of speciation (Blankers *et al.* 2019), aggressiveness related to habitat (Jang *et al.* 2008), and male response to conspecific song (Jang 2011). Past research is summarized in Gray (2011).

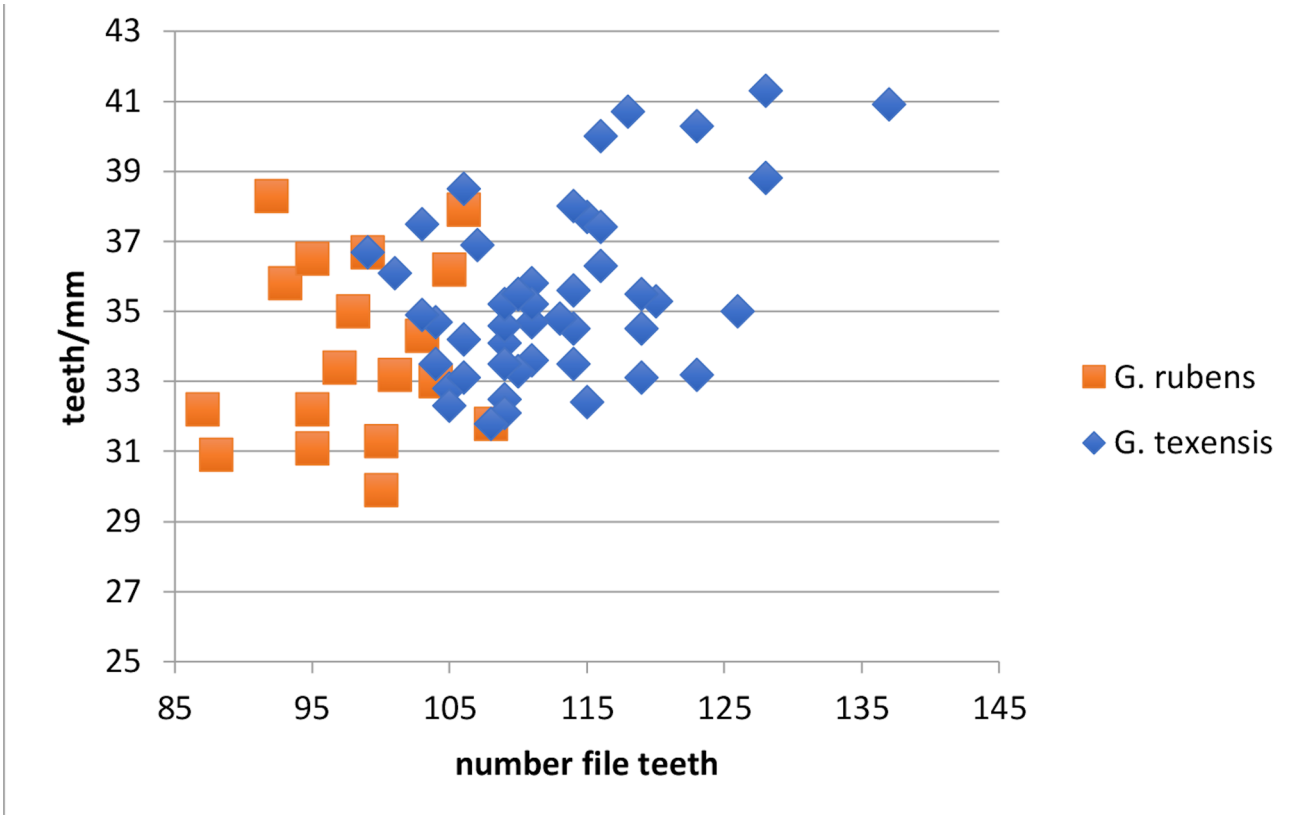

FIGURE 79. Regression of number file teeth vs. teeth/mm showing separation of sympatric *G. rubens* from *G. texensis*.

Gryllus texensis **Cade and Otte**

Southeast Fast Trilling Field Cricket

Figs 71–73, 78, 79, 82–90, Table 1

2000 *Gryllus texensis* Cade & Otte. Transactions of the American Entomological Society 126: p. 117. Holotype male, Austin, Texas. Holotype male noted as deposited in ANSP, but never done. Neotype male (in alcohol), since no paratypes listed in 2000, designated in 2016 by W. Cade (Fig. 83): Texas, San Antonio, 26-ix-2015, W. Cade. Deposited in ANSP (photos courtesy of J. Weintraub, ANSP).

'G. bivoltinus' or *G. integer* of pre-2000 DBW notebooks. 'G. bivoltinus' was an early manuscript name used by W. Cade for this taxon.

G. integer or '*G. integer'* in various published studies prior to 2000.

Distribution. One of three trilling US *Gryllus* found between western Texas and the Atlantic coast.

Recognition characters and song. Medium to large sized, short or long hind winged trilling crickets with an average PR between 70–80 at 25° (Fig. 84) (but see discussion below for exceptions). Distinguished from morphologically similar and trilling, sometimes sympatric, sister species *G. rubens* which has an average PR of 55 at 25° and fewer teeth in the file (Fig. 85) and a longer ovipositor (Fig. 86; Gray *et al.* 2001).