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.

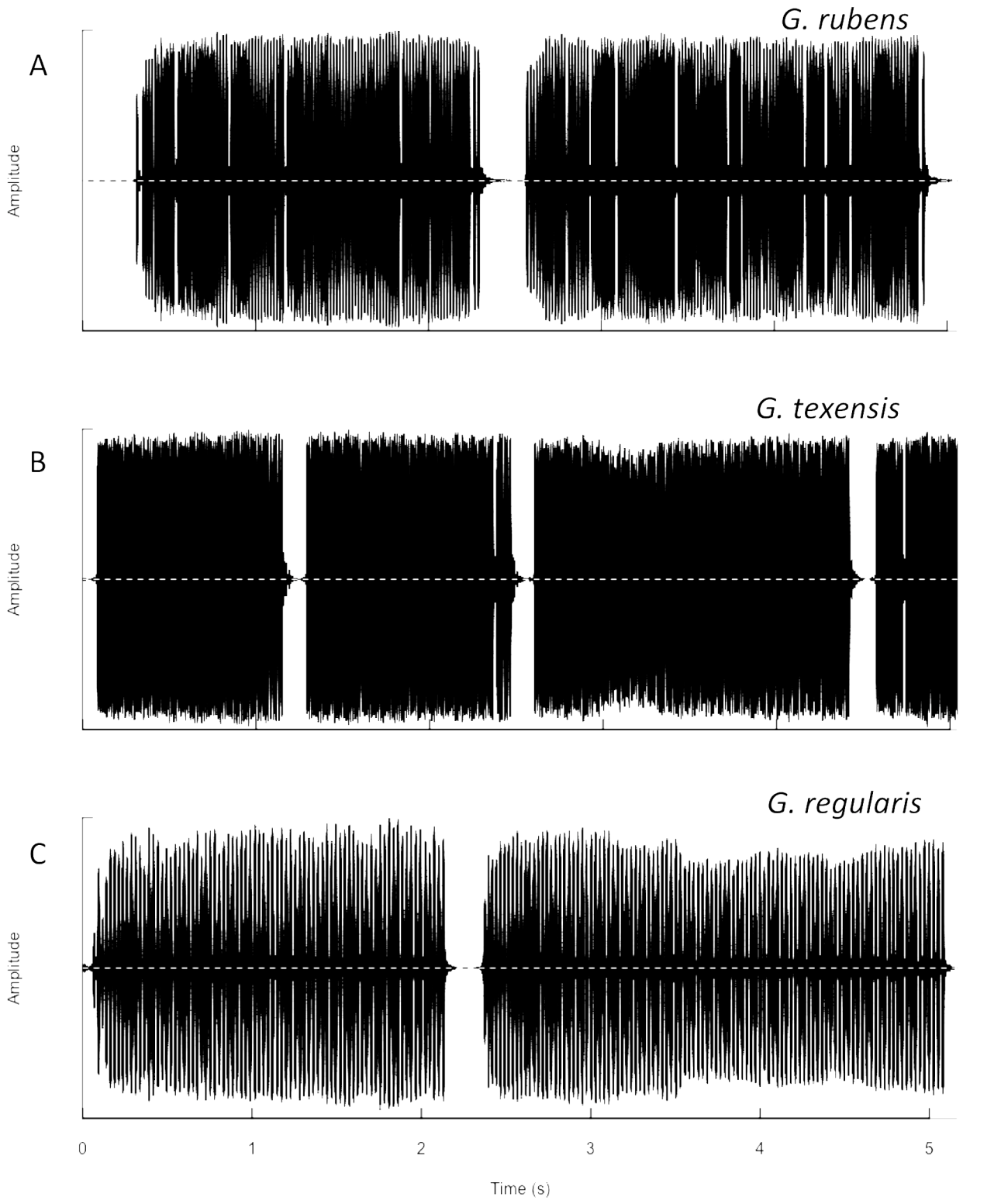

FIGURE 71. Five second waveforms of calling songs of (A) *G. rubens,* (B) *G. texensis*, and (C) *G. regularis*. (A) *G. rubens*: (R13-220) Tulsa, OK (S13-68), at 25°C; (B) *G. texensis*: (R13-224) Rio Hondo, TX (S13-44), at 26°C; (C) *G. regularis* (R99-211) Sinaloa, MX (S99-86), at 25.5°C.

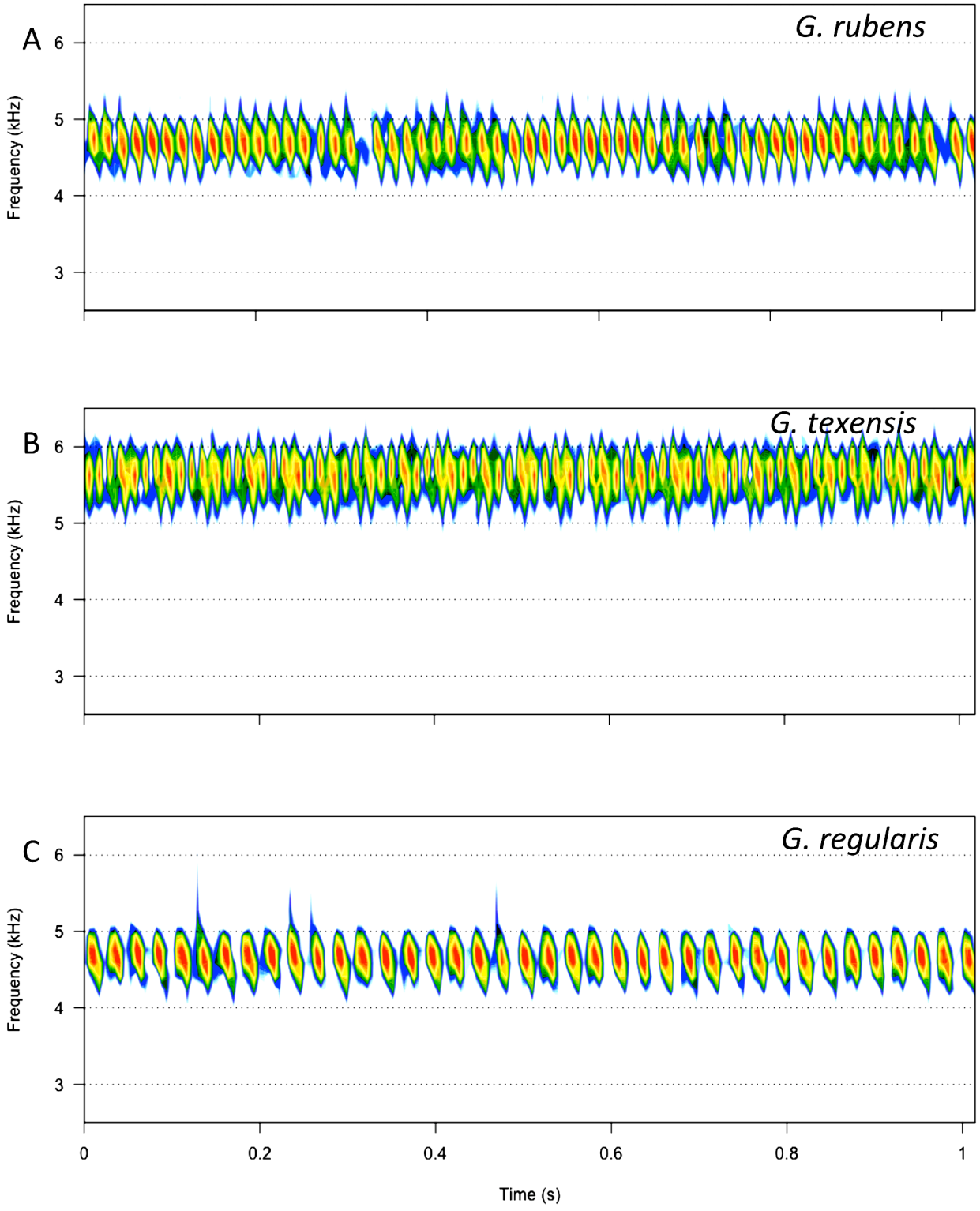

FIGURE 72. One second spectrograms of (A) *G. rubens,* (B) *G. texensis*, and (C) *G. regularis*, same males as in Fig. 71.

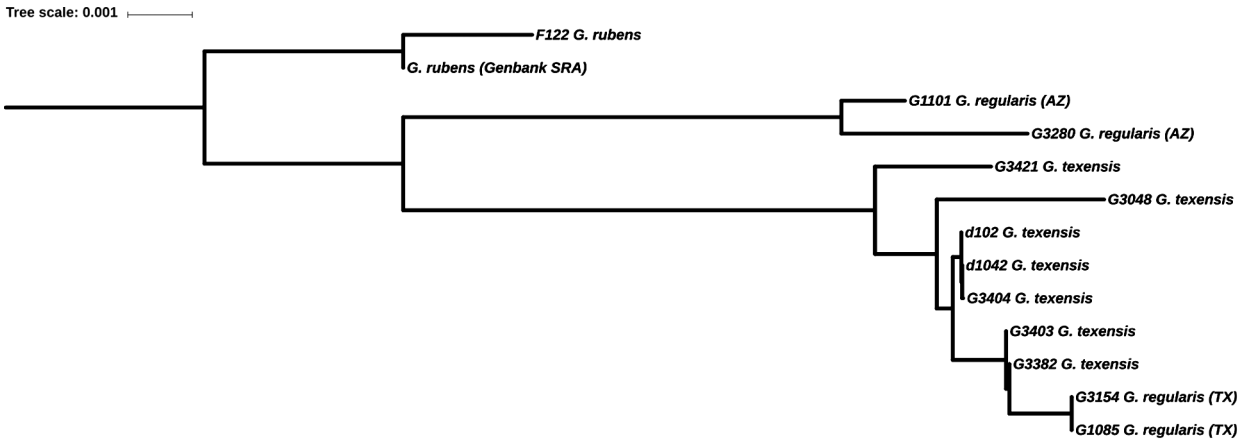

FIGURE 73. ITS2 gene tree. ***G. rubens*** samples: Orlando, FL (F122); Lake City & Ocala, FL (Genbank SRA, Berdan *et al*. 2016); ***G. regularis*** samples: S07-2 (G1101); S07-41 (G1085); S15-67 (G3154); S15-102 (G3280); ***G. texensis*** samples: S15-43 (G3048); S16-12 (G3382, G3403, G3404, G3421);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

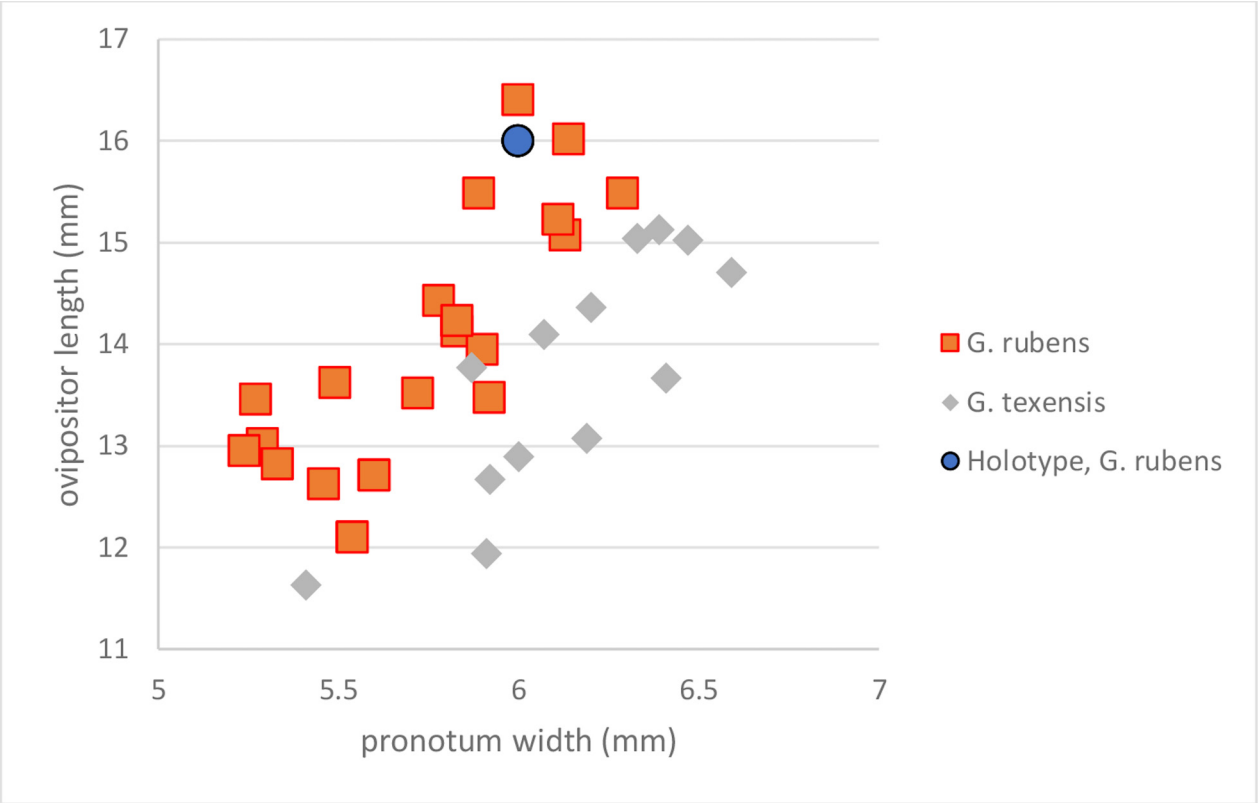

FIGURE 75. Regression of pronotum width vs. ovipositor length in the only two trilling eastern US taxa shows that holotype most consistent with *G. rubens.*

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).

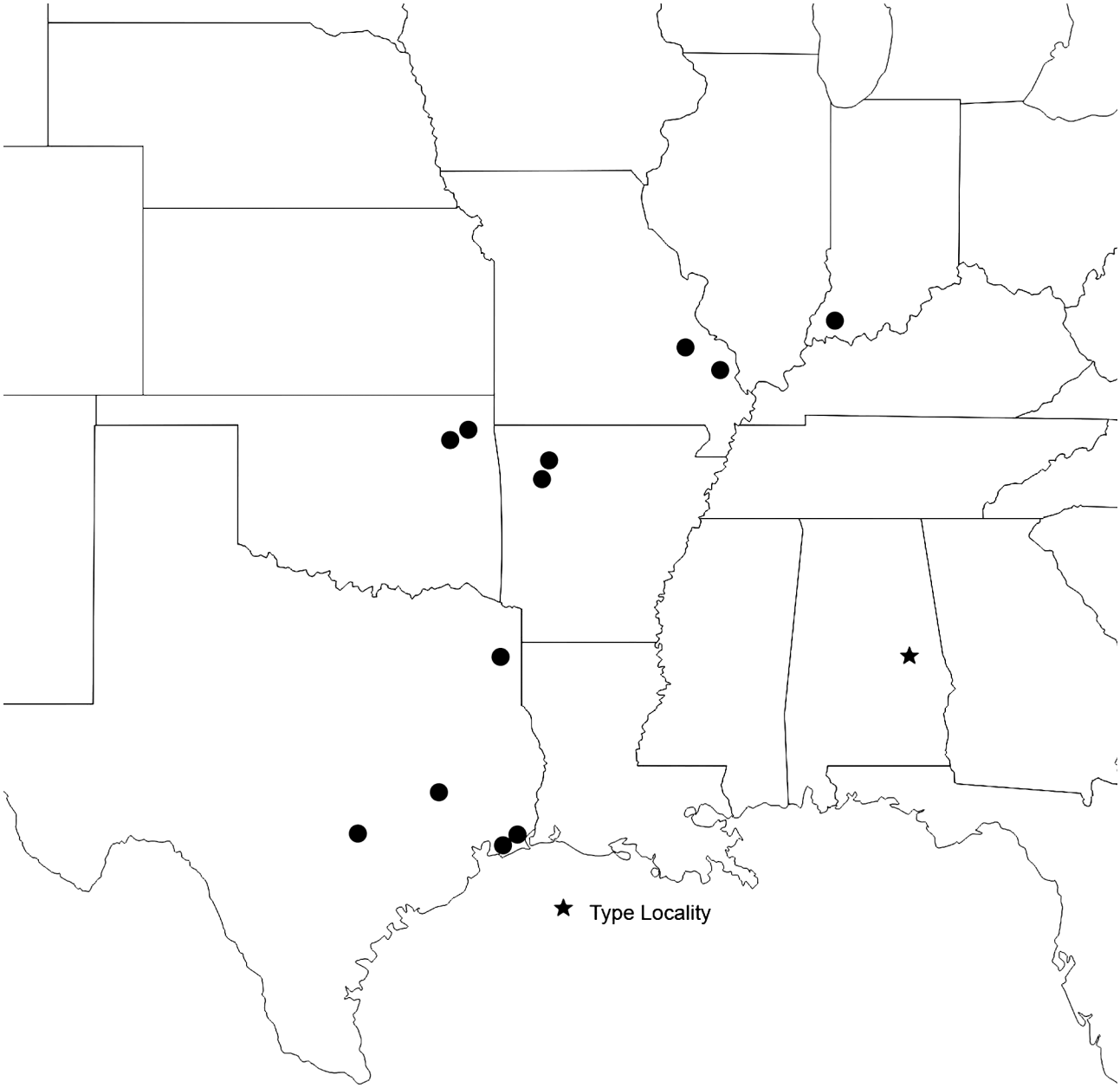

FIGURE 76. Populations of *G. rubens* that we studied.

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."

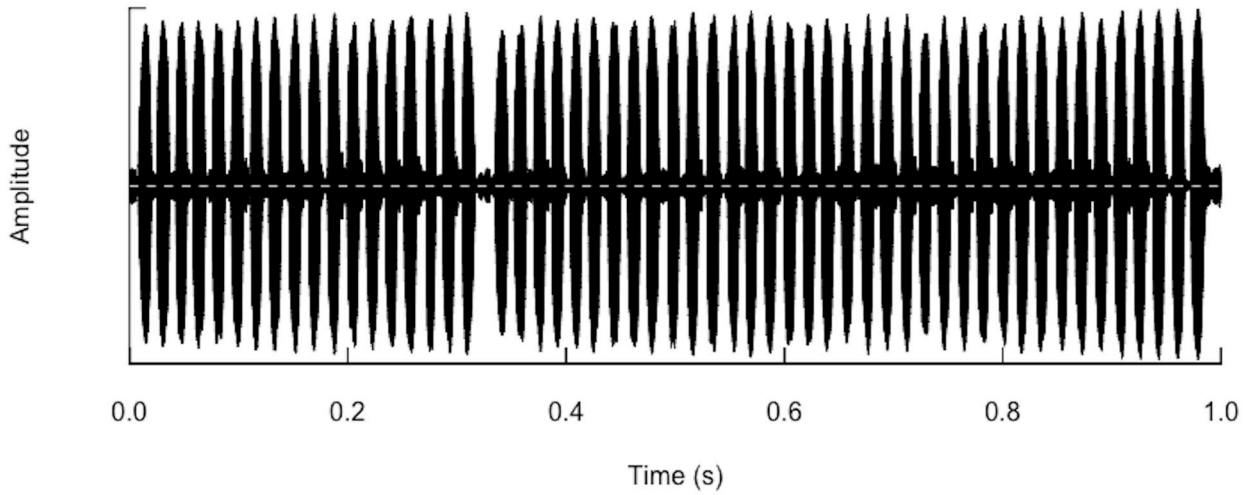

FIGURE 77. One second waveform, pulse rate of 56, of calling song of *G. rubens*: (R13-220) Tulsa, OK (S13-68), at 25°C.

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).

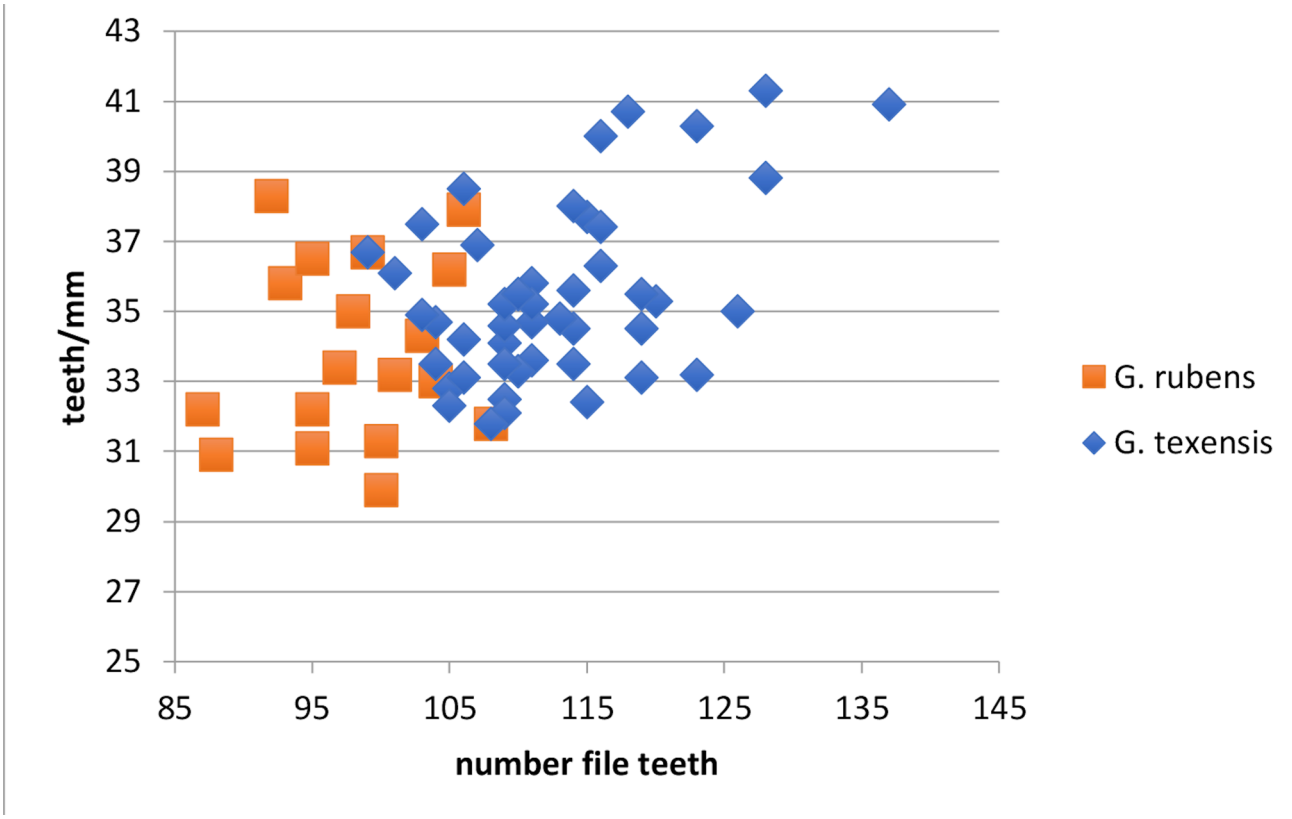

FIGURE 79. Regression of number file teeth vs. teeth/mm showing separation of sympatric *G. rubens* from *G. texensis*.

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).

FIGURE 80. Color variation in *G. rubens,* all three individuals from Cape Girardeau Co., MO (S02-58).

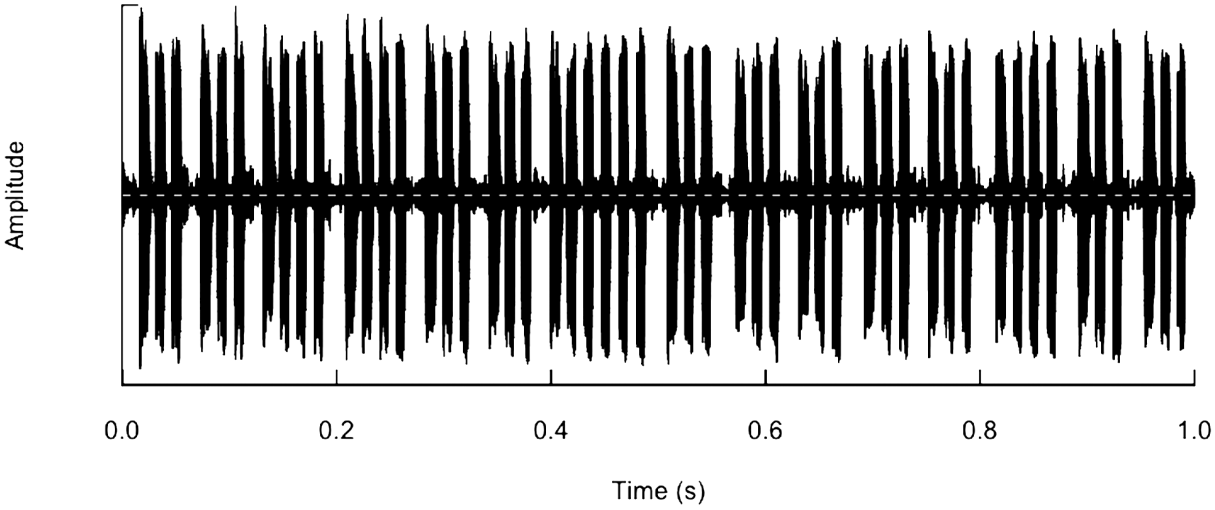

FIGURE 81. Atypical *G. rubens* calling song: (R02-74) Cape Girardeau Co., MO (S02-58), at 26°C.

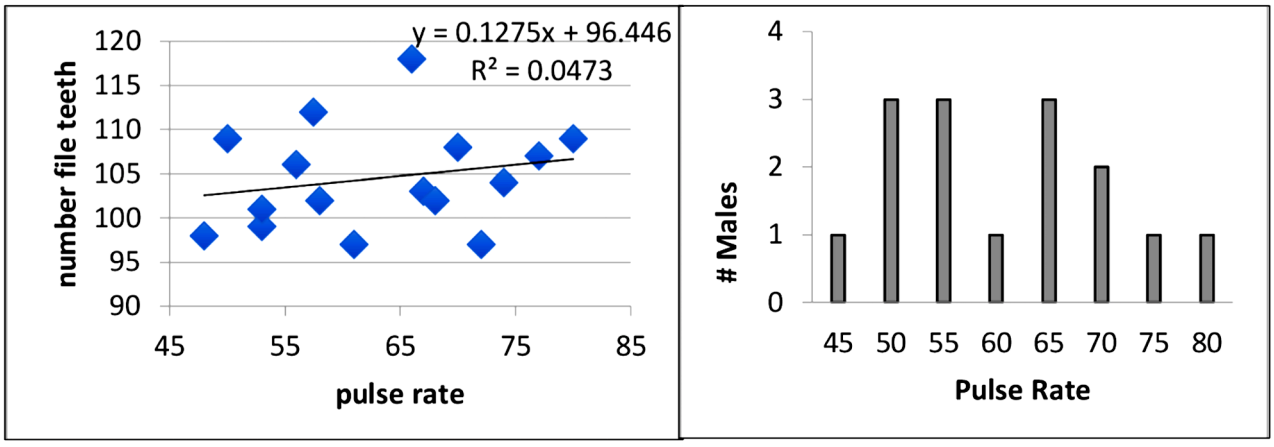

FIGURE 82. Left: Regression of sympatric *G. rubens* and *G. texensis* from Tulsa, OK (S13-68) showing lack of separation in individuals for pulse rate vs. file teeth number. Right: Histogram of pulse rates of these same males.

FIGURE 83. Neotype male, *G. texensis*, specimen and labels.

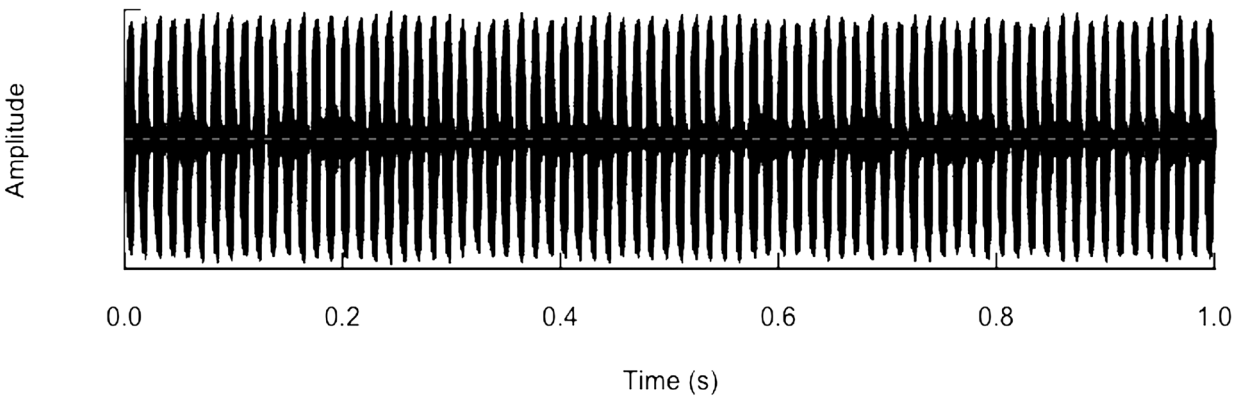

FIGURE 84. One second waveform, pulse rate of 75, of calling song of *G. texensis*: (R13-224) Rio Hondo, TX (S13-44), at 26°C

There is no one morphological or song character that always separates *G. texensis* from *G. rubens*. Interestingly, 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; see under *G. rubens* (p. 88) for further discussion.

Distinguished from sympatric (western Texas only at Alpine [S07-41]), sister species *G. regularis* which has non-overlapping PR of 29–50 at 25°. In its most western distribution, *G. texensis* can be sympatric with *G. armatus* and while their songs are difficult to separate in the field, unless males are singing near each other when a difference in "evenness" and pitch may be appreciated, the two can be separated by song analysis (2 or 3 p/c in *G. armatus* vs. a trill in *G. texensis*), and by number of file teeth vs. hind femur length (Fig. 87).

Derivation of name. Originally named after the type locality of Texas because much of the early biological research on this taxon was performed in that state.

Geographical range. (Fig. 88.) Eastern limits in Gray *et al*. (2008). Also into adjacent Mexico.

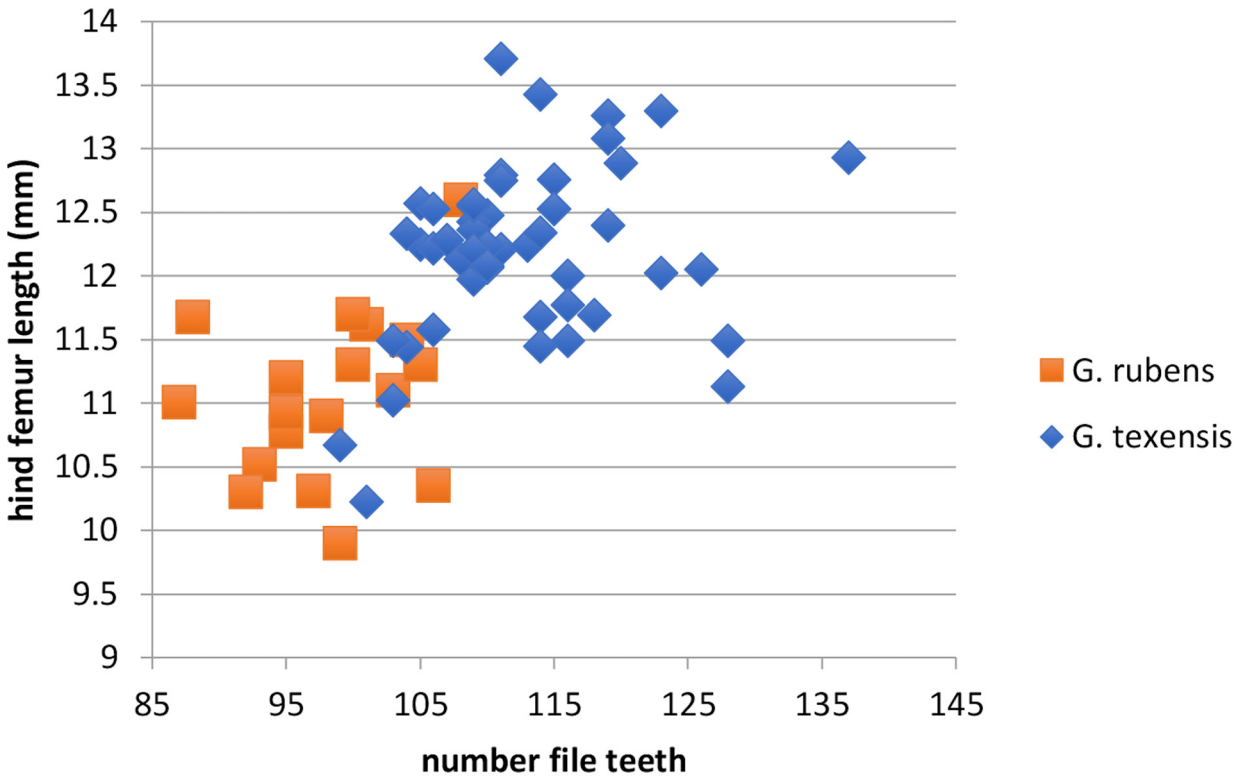

FIGURE 85. Regression of file teeth number vs. hind femur in *G. texensis* vs. *G. rubens* showing overlap but lower number of teeth in latter.

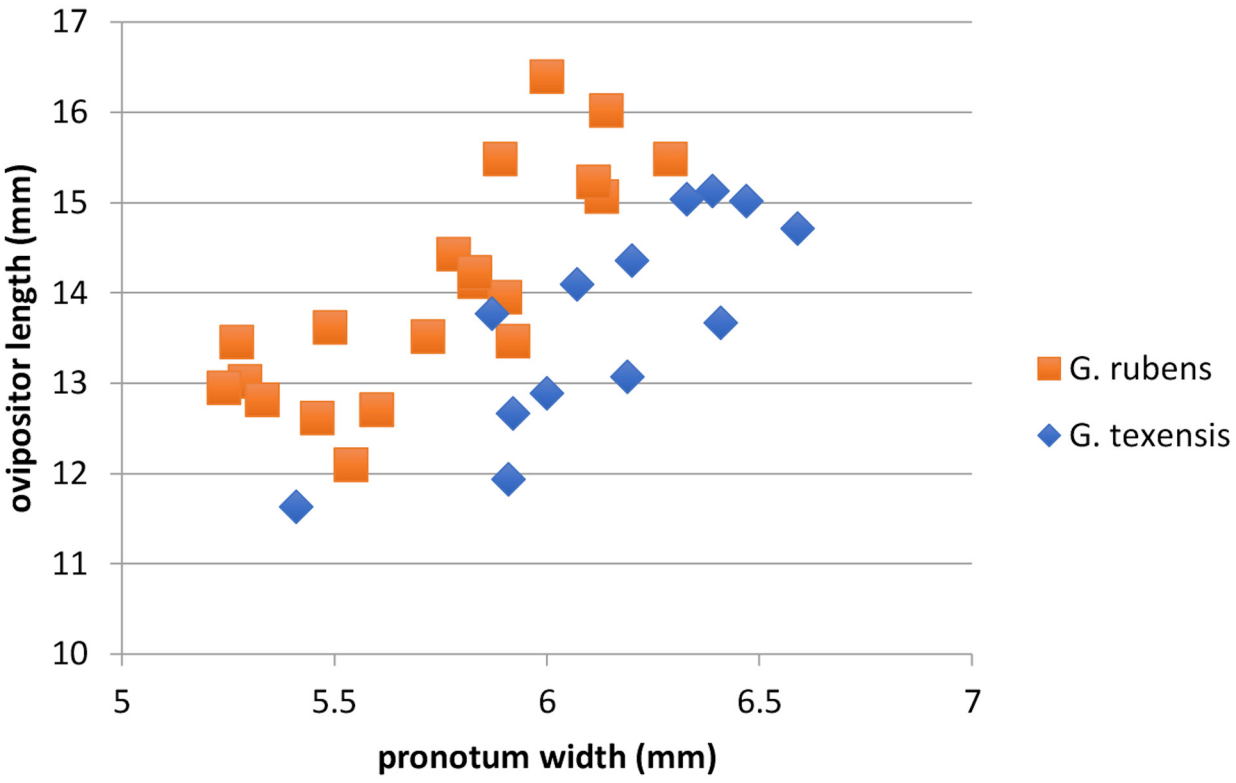

FIGURE 86. Regression of pronotum width vs. ovipositor length in *G. texensis* vs. *G. rubens* showing generally shorter ovipositor length in former.

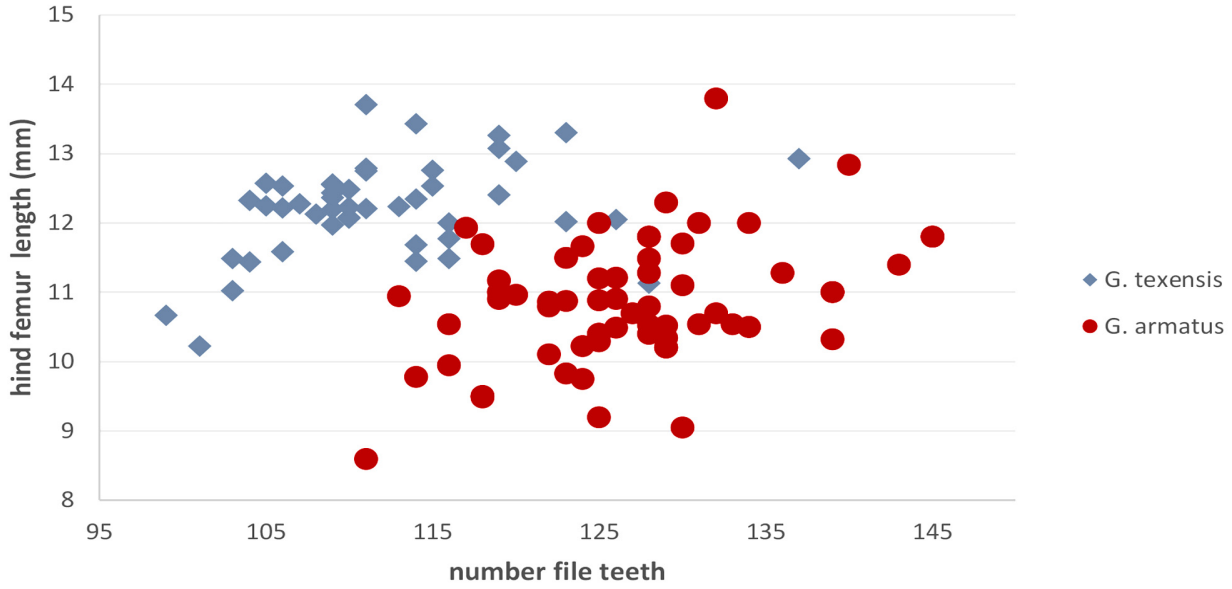

FIGURE 87. Regression of file teeth number vs. hind femur length in *G. texensis* vs. *G. armatus* showing overlap but generally more teeth in latter.

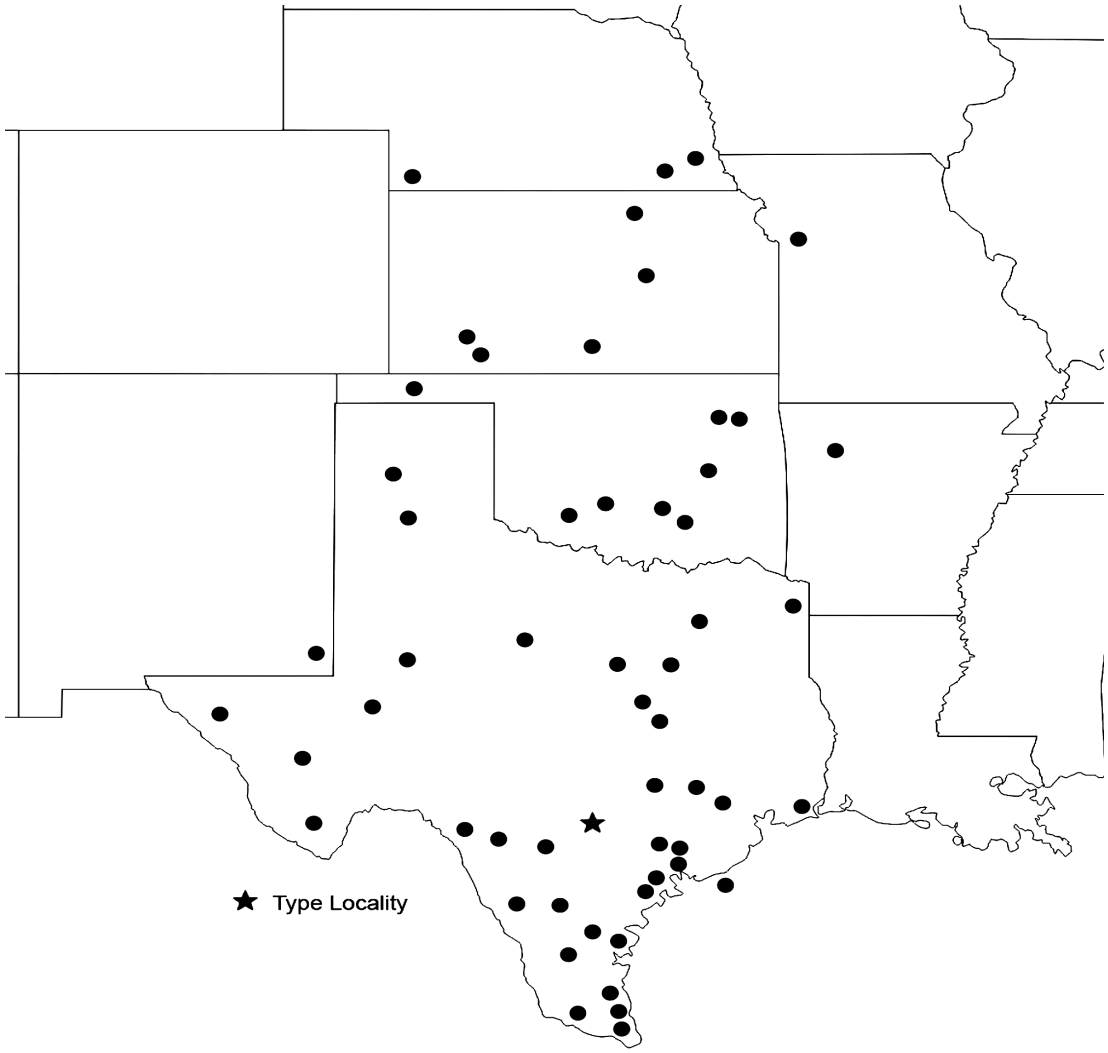

FIGURE 88. Populations of US *G. texensis* that we studied.

Habitat. Characteristic of pastures, lawns, and other open, grassy areas from sea level to 1300m.

Life cycle and seasonal occurrence. No egg diapause. Two generations/year, second generation more numerous than first and can be locally very common: responsible for cricket outbreaks in Waco, Texas, in early October, 2012 (S12-119, G2432, live specimens courtesy of S. Halvorson, Drug Emporium, Waco)): http://www.npr.org/2012/10/01/162110687/plague-of-crickets-bring-nuisance-stink-to-waco; Norman, Oklahoma, in early September, 2013: https://www.huffingtonpost.com/2013/09/04/oklahoma-cricket-invasion_n_3866683.html; and central Texas in 2015: http://www.cnn.com/2015/09/20/us/cricket-swarm-season-invades-central-texas/index.html.

Variation. **Color:** Besides black of neotype, individuals can be lighter in color (Fig. 89). **Hind wing length:** Of 335 adults, 74 (22%) have short hind wings. Females frequently have tegmina bars. **Song:** A male from Arkansas, Yell Co. (S93-47), was recorded on 19-vi-1993, in the field, (R93-14) at 24.5°C singing with a PR of 49 and pulses grouped into 2's and 3's. This same male was re-recorded in the laboratory, while trilling, on 28-vi at 25°C (R93-43) with a PR of 65 and without any grouping of pulses. This male has 121 teeth in his file, 41.7 teeth/mm, and a hind femur length of 11.4 mm, all parameters placing it within *G. texensis* (see Fig. 87 and Fig. 90). We wonder if this male had recently molted to adult and had an "immature" song when first field recorded, even though he did not appear teneral when captured.

FIGURE 89. Color variation in *G. texensis,* both pictured individuals from Brackettville, TX (S10-63).

A male from Texas, Travis Co. (S85-63), singing at 24°C (R85-46), had a small peak before each large peak, and a PR of 80. Walker (1998) documents that first and second-generation males of *G. texensis* have different mean modal pulse rates because of both developmental conditions and parental effects. Duration of trills usually shorter in *G. texensis* than *G. rubens* but some individuals of *G. texensis* had long series in Brackettville (S10-63) and Tulsa (S13-68).

Specimens examined. (Total: 224♂ 109♀) [No paratypes designated, or localities cited in original description]. **Arkansas:** *Yell Co.,* Ola, 19-vi-1993, 500' (S93-47). **Kansas:** *Barber Co.,* Medicine Lodge, 23-vi-1987 (S87-68).

Clark Co., Ashland, 27-viii-1989, 1950' (S89-70); 12.2 m E Ashland, 27-viii-1989 (S89-69). *Cloud Co.,* Concordia, 7-viii-2002, 1100' (S02-50). *Ford Co*., Dodge City, 27-viii-1989, 2400' (S89-71). *Salina Co.,* Salina, 7-viii-2002, 1100' (S02-49). **Missouri:** *Jackson Co*., Kansas City, 8-viii-2002, 860' (S02-54). **Nebraska:** *Fillmore Co.,* Geneva, 7-viii-2002, 1420' (S02-51). *Lancaster Co.,* Lincoln, 7-viii-2002, 940' (S02-52). *Red Willow Co.,* McCook, 28-viii-1989, 2500' (S89-74). **New Mexico:** *Lea Co.,* Eunice, 6-ix-2010, 3420' (S10-62). **Oklahoma:** *Atoka Co.,* 2.5 m NE Stringtown, 16-vi-1988, 600' (S88-47). *Carter Co*., Lake Murray State Park, 24-vi-1993, 900' (S93-58). *Comanche Co.,* Medicine Park, 6-viii-2002, 1200' (S02-47). Wichita Mts. Wildlife Refuge, 6-viii-2002, 1300' (S02-46). *Oklahoma Co*., Oklahoma City, 6-viii-2002, 1000' (S02-48). *Texas Co.,* Guymon, 1-vii-2009, 3380' (S09-77). *Tulsa Co.,* Keystone State Park, 15-vi-1988, 600' (S88-42); 23-vi-1993 (S93-56). Lake Keystone Dam area, 22-v-2001, 650' (S01-47). Tulsa, 23-vi-1993, 500' (S93-57); 9-vi-2007 (S07-22); 15-vii-2013 (S13-68). **Texas:** *Bastrop Co.,* Bastrop State Park, 31-v-1991, 700' (S91-23). *Bosque Co.,* Clifton, 10-vi-1988, 400' (S88-29). *Brewster Co*., Alpine, 4270', 5-vi-1991 (S91-44), 12-vi-2007 (S07-41). Big Bend National Park, Rio Grande Village, 9-vi-1985, 2100' (S85-56); 5-vi-1991 (S91-43); 28-v-2016 (S16-12). *Calhoun Co*., Magnolia Bay, Indian Point Historic Park, 4-viii-2002 (S02-36); Port Lavaca, 12-vii-2013, 18' (S13-57); 26 m S Victoria, 4-viii-2002, 20' (S02-37). *Cameron Co.,* Brownsville, 3-vi-1991, 0' (S91-38); Harlingen, 3-vi-1991 (S91-39); Rio Hondo, 10-vii-2013, 8m (S13-44); FR510 at intersection with FR 2480, 10-vii-2013, 0' (S13-43); FR510 E near intersection FR100W, 10-vii-2013, 0' (S13-42). *Cass Co.,* 3 m S Queen City, 18-vi-1993, 400' (S93-43). *Culberson Co.,* Van Horn, 6-vi-1991, 4100' (S91-48). *Dallas Co.,* DWF Airport, 23-v-2001 (S01-49). Dallas, 23-v-2001 (S01-50). Irving, 10-vi-1988, 400' (S88-25). *Dimmit Co.,* Carrizo Springs, 11-vi-2007, 660' (S07-28). *Duval Co.,* Freer, 25-v-2001, 980' (S01-52). 4.5 m E Freer, 30-vi-1986 (S86-58). *Fayette Co.,* Schulenburg, 380', 4-viii-2002 (S02-38), 13-vii-2013 (S13-65); 2.3 m S Schulenburg, 9-ix-2010, 440' (S10-65). *Gillespie Co.,* Fredericksburg, 1-vii-1986 (S86-65). *Harris Co.,* Cypress, 148', 13-vii-2013 (S13-64). *Hidalgo Co.,* Bentsen-Rio Grande Valley State Park, 3-viii-2002, 120' (S02-34); 10-vi-2007 (S07-27). *Howard Co.,* Big Springs VA Hospital, 30-vi-2009, (S09-72). *Jefferson Co.,* Port Arthur, 1-vi-1991, 0' (S91-31). *Jim Wells Co.,* Alice, 11-vii-2013, 171' (S13-48, 49, 50). *Kinney Co.,* Brackettville, 1100', 10-vi-1985 (S85-61); 27-vi-1986 (S86-47); 4-vi-1991 (S91-40); 12-vi-2007 (S07-35); 7-ix-2010 (S10-63). *Matagorda Co.,* Hog Island, 13-vii-2013, 5' (S13-59). *McLennan Co.,* Waco, 400', 10-vi-1988 (S88-26), 3-x-2012 (S12-119), S. Halvorson. Intersection of Hwy 6 and Hwy 35, 10-vi-1988 (S88-27). *Nueces Co.,* Corpus Christi, 29-vi-1986 (S86-56); 2-vi-1991 (S91-35); 12-vii-2013 (S13-53). *Potter Co*., Amarillo, 12-vi-1988, 3600' (S88-38). *Tarrant Co.,* Fort Worth Nature Center & Refuge, 5-viii-2002, 600' (S02-39). Grapevine Lake Dam, 23-v-2001 (S01-48). *Randall Co.,* Palo Duro Canyon State Park, 12-vi-1988, 3600' (S88-37). *Refugio Co.,* Tivoli, 12-vii-2013, 12' (S13-56). *Taylor Co.,* Abilene, 11-vi-1988 (S88-35). *Tom Green Co.,* San Angelo, 11-vi-1988, 1900' (S88-30). *Travis Co.,* Austin, 11-vi-1985 (S85-63). *Uvalde Co.,* Uvalde, 10-vi-1985 (S85-62). 2.3 m W Uvalde 11-vi-2007, 940' (S07-29). 6.9 m W Uvalde, 11-vi-2007, 940' (S07-30). *Val Verde Co*., Del Rio, 11-vi-2007, 1000' (S07-33)*;* 7-ix-2010 (S10-64). Del Rio on Amistad Lake some 5 m N Del Rio, 10-vi-1985, 1200' (S85-60). 5 m E Del Rio on Hwy 90, 27-vi-1986 (S86-49). *Ward Co.,* Monahans, 2-vii-1986 (S86-69). *Washington Co.,* Brenham, 31-v-1991, 300' (S91-26); 6-ix-1992 (S92-123); 24-v-2001 (S01-51). *Webb Co.,* 20-48 m W Freer on Hwy 44, 30-vi-1986 (S86-61).

DNA. Multilocus G3382, Big Bend (S16-12), PR 79 at 25°C. Sister species are *G. rubens* and *G. regularis* (Gray *et al.* 2019). See Gray *et al.* (2008) for results for many specimens east of our main study area. 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. Probably the most common and widespread *Gryllus* species in Texas. Sympatric with *G. rubens* at Bastrop State Park, Texas (S91-23), and Lake Keystone State Park (S01-47) and Tulsa (S13-68) in Oklahoma. Sympatric with *G. armatus* at Texas localities of: Big Springs (S09-72); Big Bend (S91-43); Brackettville (S85-61 & S91-40); Monahans (S86-69); Alpine (S91-44); Van Horn (S91-48) and Kansas, Dodge City (S89-71). Microsympatric with both *G. armatus* and *G. regularis* at Alpine, Texas (S07-41).

We found males parasitized by tachinid *Ormia ochracea* from these Texas localities: 5 8 km E Del Rio on Hwy 90 (S86-49), Brownsville (S91-38), Bentsen-Rio Grande Valley State Park (S02-34), Schulenburg (S02-38), and Cameron Co. (S13-43). The Cade lab (Cade *et al.* 1996, Gray & Cade 2000b) has done much work on *Ormia* parasitism of *G. texensis* in Texas.

Other published studies on *G. texensis* include those on sexual selection (Gray & Cade 1999b, Gray & Cade 2000a, Bertram 2002a, b); aggression (Sandford 1987), fine-scale temperature effects on calling song (Martin *et al*.

2000) which demonstrated an increase in PR of 3.5 for every 1°C increase in recording temperature; influence of photoperiod on signaling (Bertram & Bellani 2002); female cricket mating preferences (Wagner *et al*. 1995, Blankers *et al.* 2015); life history trade-offs (Guerra & Pollack 2007); hybridization studies (Cade & Tyshenko 1990); predator-induced stress responses (Adamo *et al.* 2013), courtship songs (Fitzpatrick & Gray 2001); peripatric speciation (Gray *et al*. 2008, Blankers *et al.* 2018); and interactions between temperature, reproduction and immune function (Adamo & Lovett 2011).

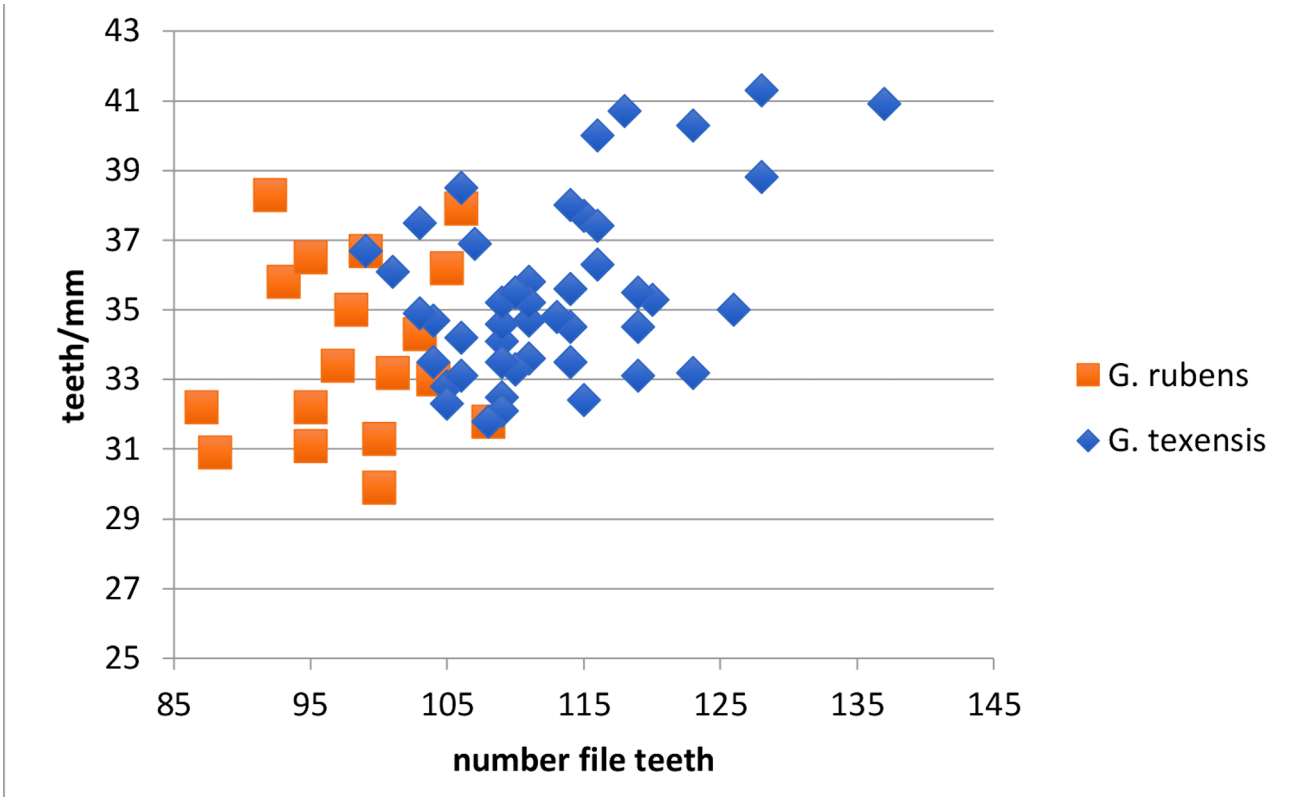

FIGURE 90. Regression of file teeth vs. teeth/mm showing separation of sympatric *G. rubens* from *G. texensis.*

***Gryllus regularis* Weissman & Gray, n. sp.**
Southwest Regular-Trilling Field Cricket
Figs 71–73, 91–95, 168, Table 1

'Gryllus #14' in DBW notebooks.
'Arizona triller' of Sakaguchi & Gray (2011).
'G. #14' of Blankers *et al.* 2015.

Distribution. Known from central-southeastern Arizona, southwestern New Mexico, and western Texas.

Recognition characters and song. Medium to large, usually short hind winged crickets with a broad and usually shiny pronotum. *Song* (Fig. 91, R99-211) a long trill with pulses evenly spaced, PR 30–45 at 25°C. Distinguished from the two other sympatric, trilling *Gryllus*, as follows: from *G. cohni,* the latter is smaller and has an irregular trill with groupings of 2 to 11 pulses that results in a slower CR, usually has long hind wings, and a narrower (Fig. 92), hirsute and slightly dull pronotum.

Trilling *G. texensis* is sympatric with sister species *G. regularis* only at Alpine, TX (S07-41), but the former has a PR above 70 at 25°C. The only other western US trilling *Gryllus* is the always allopatric, sister species *G. rubens* from central Texas to Florida and which, while also medium to large in body size, has a higher PR (45–65), non-overlapping file teeth number, and narrower pronotum. Rarely, Arizona males of *G. armatus* trill (see Fig. 109, p. 115), but can be separated from *G. regularis* by their higher pulse rate (60–100), narrower pronotum and file characters.

Holotype. Male (Fig. 93). USA, Arizona, Yavapai Co., Sedona, Sky Ranch Lodge Motel grounds by Sedona

Airport. 15-vi-2007. 5120'. 34° 51.146', -111° 47.415'. D.B. Weissman, D.C. Lightfoot. S07-61, R07-11, DNA sample G1098. 16S GenBank accession # MK446613. BL 20.48, HF 11.43, RC 10.21. Right tegmen removed: 120 teeth, file length 3.35, TL 12.1, TW 4.55. Type deposited in CAS, Entomology Type #19270.

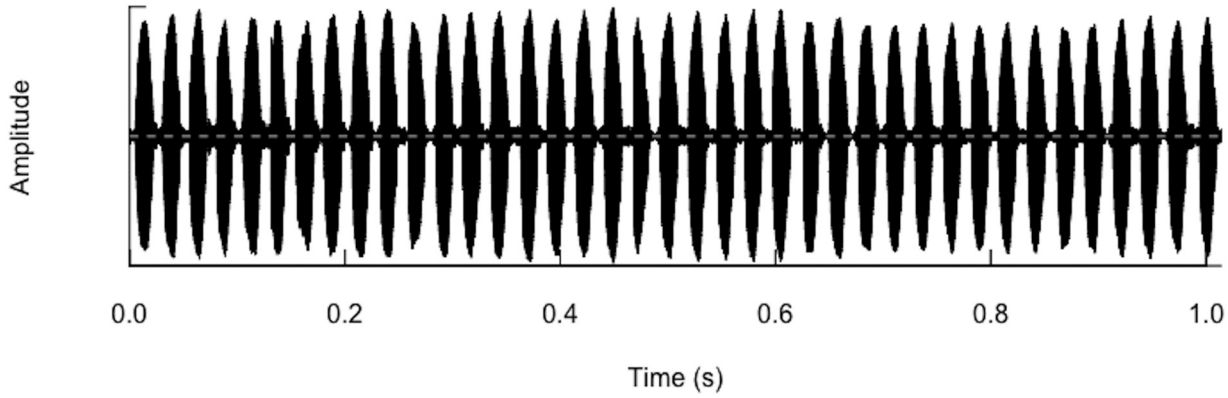

FIGURE 91. One second waveform, pulse rate of 39, of calling song of *G. regularis* (R99-211) from Sinaloa, MX (S99-86), recorded at 25.5°C

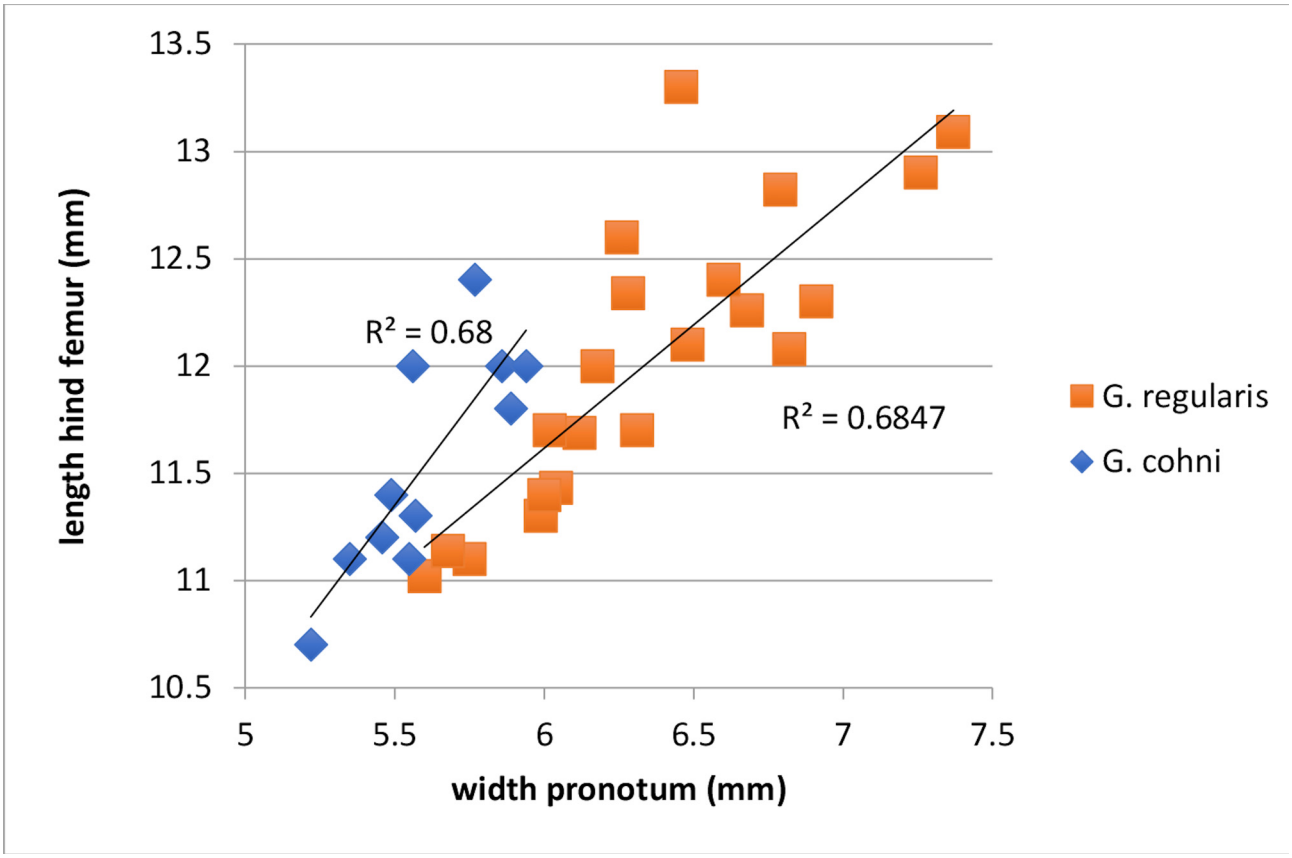

FIGURE 92. Regression of width pronotum vs. hind femur length in *G. regularis* vs. *G. cohni* showing narrower pronotum in the latter.

Paratypes. (Total: 25♂ 11♀). **Arizona.** *Coconino Co.,* Sedona, north end of town, 4400', 25-vi-1980 (S80-45) 3♂ 2♀; 15-vi-1990 (S90-49) 1♂; 5-viii-1991 (S91-78) 2♂; 30-vi-1994 (S94-35) 1♂. *Gila Co.,* Globe, 3544', 25-viii-1982 (S82-103) 1♂. *Graham Co.,* Hwy 366 near intersection Hwy 191, 3333', 32° 43' 04.6" -109° 43' 34.9" 28-vii-2015 (S15-102) 1♂. *Yavapai Co.,* Agua Fria National Monument 3705', 34° 14' 25.0" -112° 01' 33.4", 19-ix-2011 (S11-105) 1♂; 12-vi-2012 (S12-24) 1♂. Agua Fria National Monument 3200', 34° 14' 50.2" -112° 03' 28.5",

12-vi-2012 (S12-25) 1♀. Camp Verde, 3151', 21-viii-2012 (S12-107) 1♂. Cordes Junction, gas station, 3802', 18-viii-2004, 2004-115, 1♀. Sedona, Sky Ranch Lodge Motel grounds by Sedona Airport, 5120', 12-vi-1996 (S96-61) 5♂ 4♀; 15-vi-2007 (S07-61) 5♂ 2♀. Forest Road 525 near Sedona, 4507', 16-viii-2004, 34.91855° -111.91090°, 2004-111, 1♀. 2.5 m W Clear Creek "Bull Pen", 3502', 11-viii-2011, 34.54646° -111.74417°, 2011-097, 1♂. **Texas.** *Brewster Co.,* Alpine, 12-vi-2007, 4270' 30° 35' 49.86" -103° 53' 11.81" (S07-41) 1♂. *Jeff Davis Co.,* Fort Davis, Fort Davis National Historic Site, 4852', 30° 35' 49.86" -103° 53' 11.81", 1-vii-2015 (S15-67) 1♂.

Song records only. **Arizona.** *Cochise Co.,* Apache Pass, 5106', 10-vii-2002, Recording DAG2002-044. 1♂. Subsequent collecting here 2-vi-2013 yielded only nymphs of *G. lightfooti.* **New Mexico.** *Hidalgo Co.,* Coronado National Forest Road 63 (Geronimo Trail), 5330', 31.529° -108.897°, 12-iv-2013. No recording. 1♂ heard.

Derivation of name. "regularis" in reference to the regular spacing of pulses in the trilling song.

Geographic range. Fig. 94. Also into adjacent Mexico.

FIGURE 93. Holotype male (left) and paratype female (right), both from the type locality (S07-61).

Habitat. Mostly known from areas of human disturbance (including rangeland disturbed by cattle grazing), usually in cracks in the soil or in shelter associated with structures, from 960-1560m. Population at type locality fairly dense with deep cracks providing good refuge for singing males.

Life cycle and seasonal occurrence. Adults known from June through October. The Double Tank area (34° 14' 23.64" -112° 01' 37.49") of Agua Fria National Monument, AZ, has two large, man-made cisterns for cattle water in an area of open Sonoran Desert scrub. The 3 common species (*staccato, cohni,* and *regularis*) of *Gryllus* there have been part of a multiyear study on parasitoid tachinid *Ormia* flies (Sakaguchi & Gray 2011). As such, we have multiple collection dates for this area which indicate that there are apparently two field generations/year based on the following collections: (1) adults and late instar nymphs collected in mid-June, 2012, and molting to adult late June and early July and (2) 9 male and 11 female late instars collected 9-x-2010 molting to adult mid-November through early December, 2010. Agreeing with this pattern, from the type locality (S96-61) on 12-vi-1996, adults and many late instars attracted to oatmeal with the nymphs molting to adult in late June/early July that same year.

We also suspect that rainfall patterns can significantly affect these schedules. In the laboratory, no diapause at any developmental stage (Agua Fria, AZ) where they can have 3 or 4 generations/year.

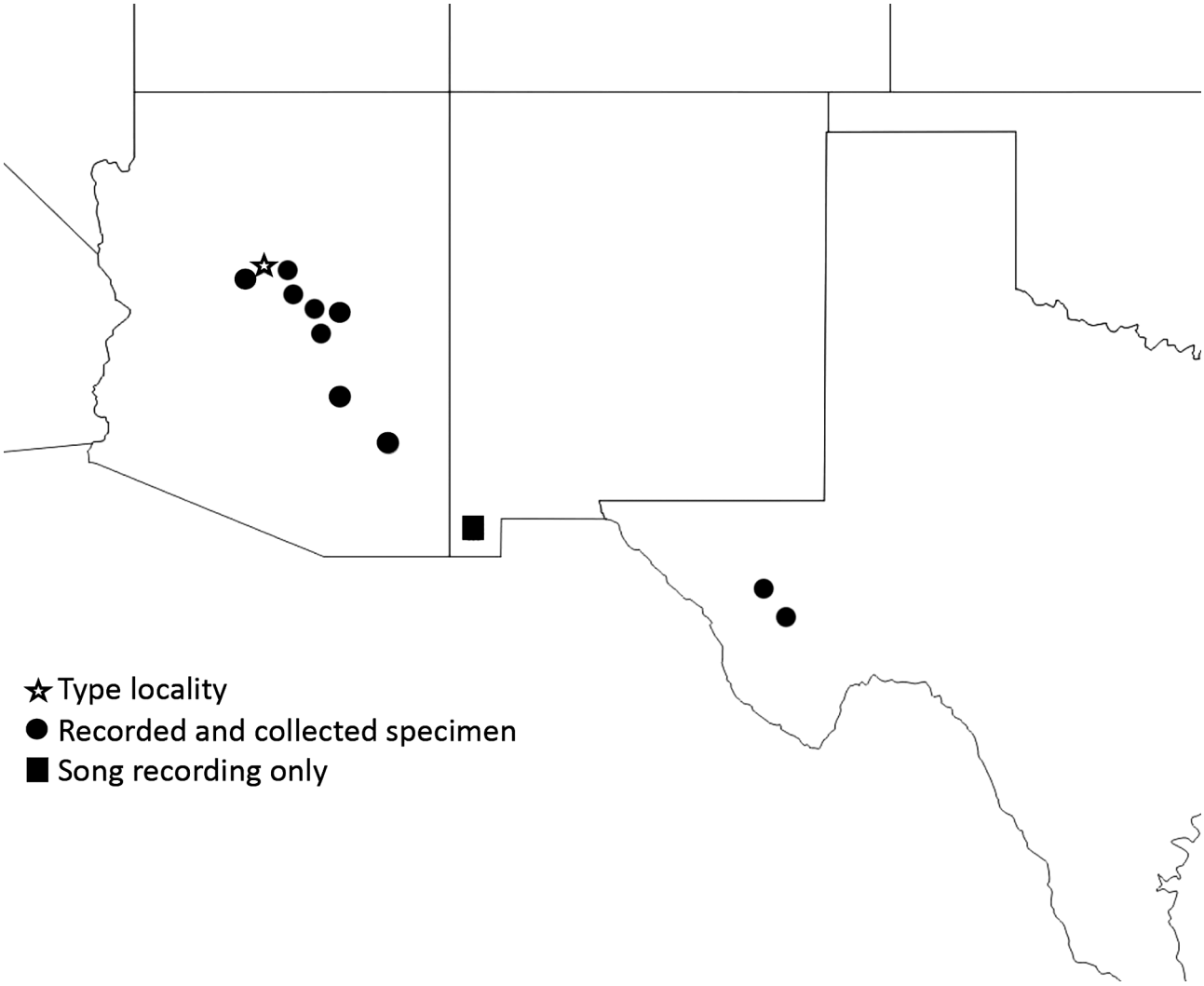

FIGURE 94. Known US distribution of *G. regularis*.

Variation. **Color:** Generally black head and pronotum with dark brown tegmina. **Hind wing length:** Of 37 total field collected adults, only 1 male each from the Arizona localities of Globe (S82-103), Camp Verde (S12-107) Clear Creek (2011-097), and Graham Co. (S15-102) long winged. Late instars brought into the laboratory, usually molt to adult with short hind wings. In contrast, adults reared from eggs, in the laboratory, are all, or almost all, long hind winged. **Song:** Of 27 recorded males, all with 1 p/c except for a male (Fig. 95, R11-167) from Agua Fria (S11-105). This male had short bursts of a "pure" trill of 1 p/c and then switched to 2 p/c. His 16S gene (G2443) mapped with *G. regularis* from other Arizona localities.

DNA. Multilocus 2016-037 from Agua Fria National Monument, 9-viii-2016. Nearest multilocus relatives (Gray *et al.* 2019) are *G. rubens* and *G. texensis.* In the ITS2 gene tree (Fig. 73), the two samples from west Texas (G3154, S15-67, Jeff Davis Co.; and G1085, S07-41, Brewster Co.) appear closer to *G. texensis*. Without further data, we are not sure how to interpret this result.

Discussion. Singing males frequently located deep in extensive soil cracks at Agua Fria and Sedona Airport localities and almost impossible to flush with water. Oatmeal trails through the habitat of singing males can help pull in wandering adult females, nymphs, and occasionally adult males. At the north end of Sedona, Arizona, *G. regularis* occurs with 5 other species of *Gryllus*.

In Alpine, TX (S07-41), *G. regularis* occurred with both faster trilling *G. texensis* and 2p/c *G. armatus*. We have only collected *G. regularis* there once and its distinctive long trilling song and short hind wings were recognized when collected and documented in field notes.

Males are easy to approach in the field and sing well in the laboratory. Because of a similar dominant frequency and long, uninterrupted trills, we have confused this *Gryllus*, in the field, with sympatric trilling *Oecanthus* tree crickets.

Male *G. regularis* parasitized by tachinid *Ormia ochracea* at Agua Fria (Sakaguchi & Gray 2011).

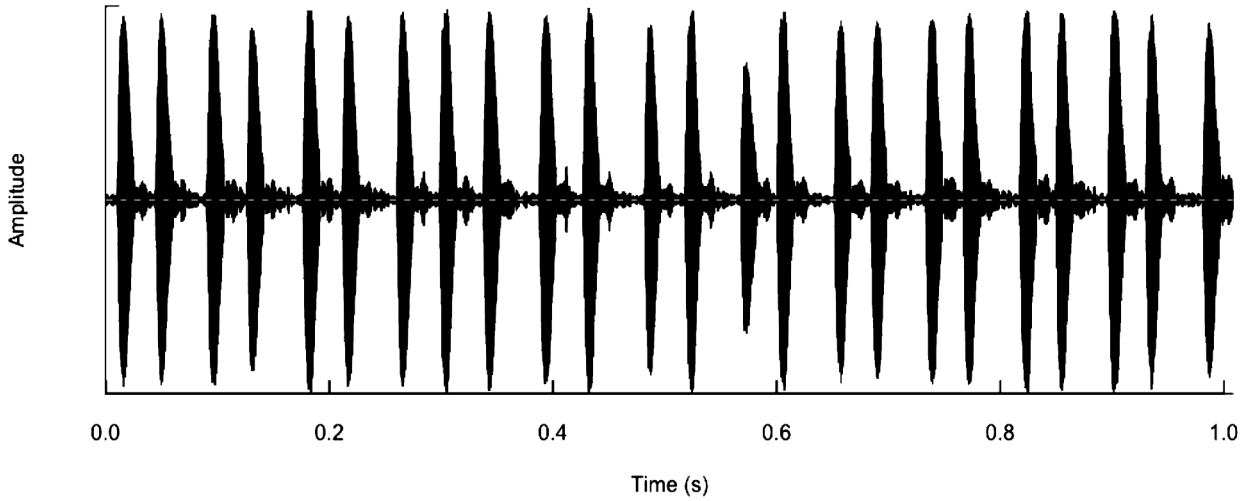

FIGURE 95. *G. regularis* with subtle pairing of pulses (R11-167), from Yavapai Co., AZ (S11-105), at 21°C.

The Integer Group

G. integer Scudder and *G. armatus* Scudder.

Sister species with a series of very fast 2-3 pulse chirps concatenated together (Fig. 96) such that they can sound like an irregular 'stutter-trill' despite not being a true trill as defined here (p. 25). Separated by geography (Fig. 100), DNA (Fig. 98), and song differences (Fig. 96).

***Gryllus integer* Scudder**

Mud Crack Field Cricket
Figs 96–104, 106, Table 1

1901 *Gryllus integer* Scudder. Psyche 9: p. 268. Lectotype male (Fig. 99) designated by Weissman *et al*. 1980: "W. Berkeley, Calif., Aug 20, 1897. S.H. Scudder coll. *Gr. integer,* Scudder's type 1901. Red label, type 14065." Specimen labeled Weissman and Rentz cotype #1). Type in ANSP.
'Gryllus VI' of Weissman & Rentz (1977a) and Rentz & Weissman (1981).
G. integer (in part) of Weissman *et al.* (1980).
'Gryllus #6' of DBW notebooks.

Distribution. California (except for southeastern deserts) north into Washington, east into Idaho and Wyoming and south into western Colorado, northern and central Utah, and Nevada (Fig. 100). Also known from 5 California Channel Islands.

Recognition characters and song. A medium sized, short hind femur, always solid black headed, long and narrow tegmina, long hind winged cricket. Song usually with intermittent bursts of 3 (range 2–4) p/c, usually without an introductory, short trill (Figs 101, 102; R16-60, S16-21), 1000 c/m, PR usually >70. But these general patterns are not fixed in that many populations are a composite of calls including individuals with a pure trill (discussed below), a short introductory trill that changes to 3p/c, and a 2p/c song. Morphologically indistinguishable from sister species *G. armatus* but separated by habitat and geography, slight song differences, and consistent DNA differences, as follows: (1) *G. armatus* is from hotter, more southern desert US locations (see Fig. 100); (2) Most, but not all *G. armatus*,