

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).

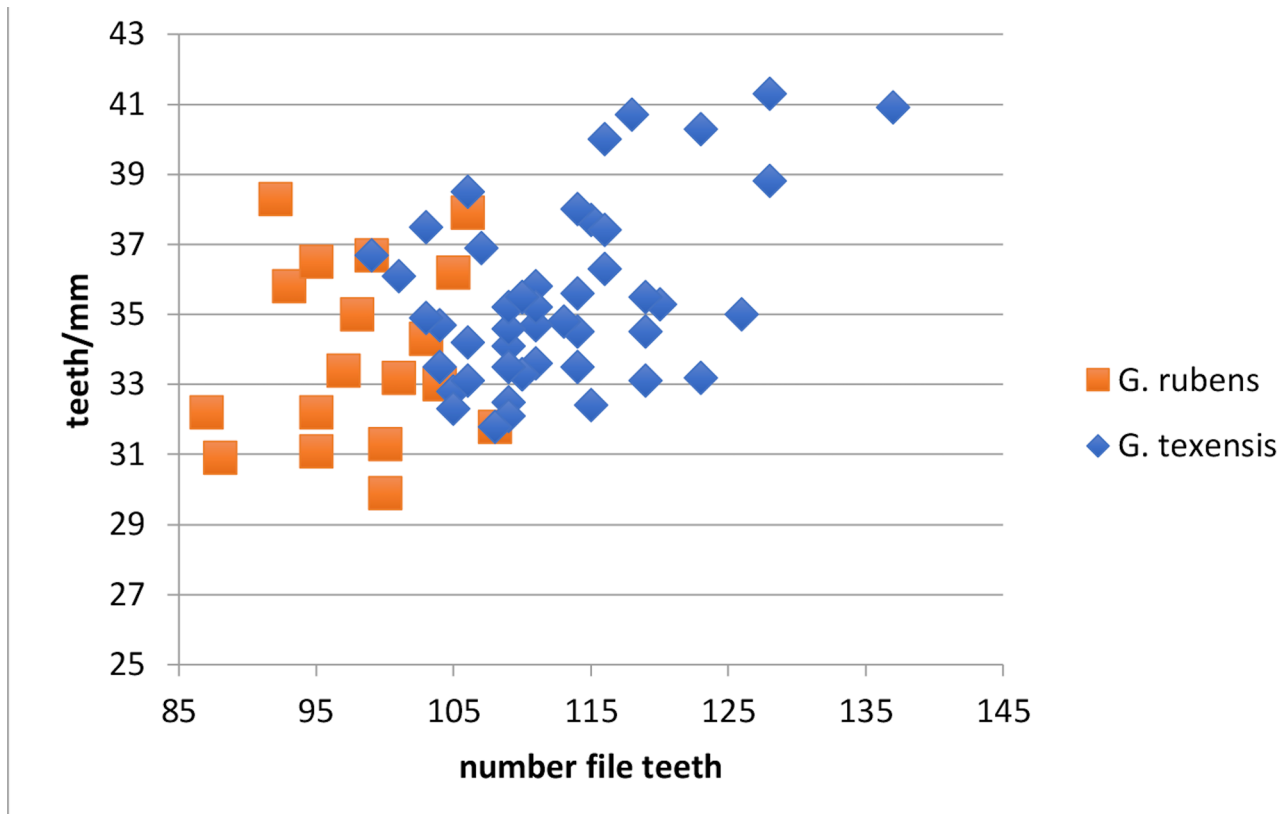


FIGURE 79. Regression of number file teeth vs. teeth/mm showing separation of sympatric *G. rubens* from *G. texensis*.

### *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).

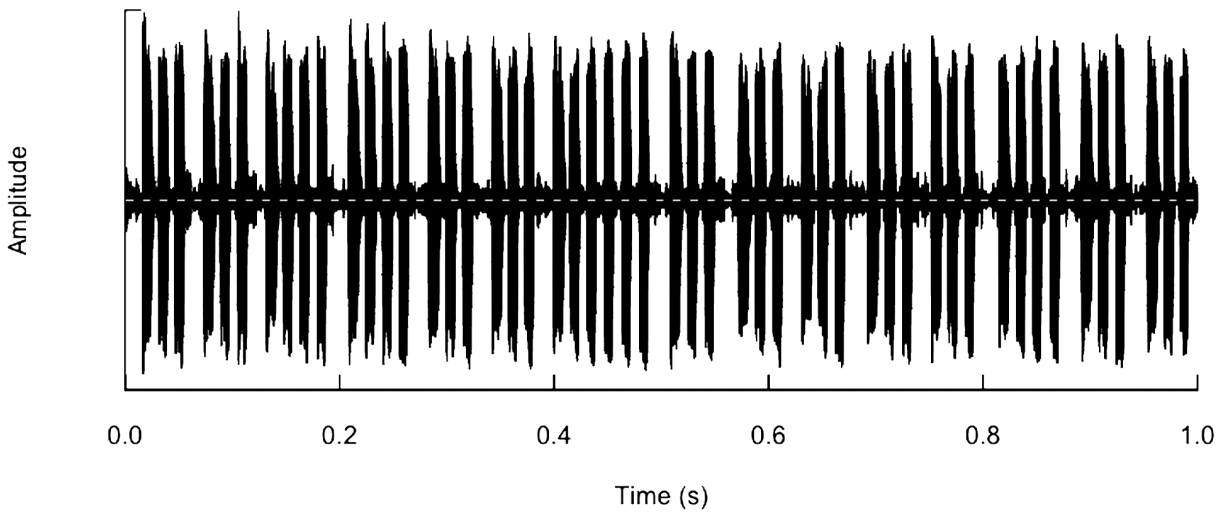


FIGURE 81. Atypical *G. rubens* calling song: (R02-74) Cape Girardeau Co., MO (S02-58), at 26°C.

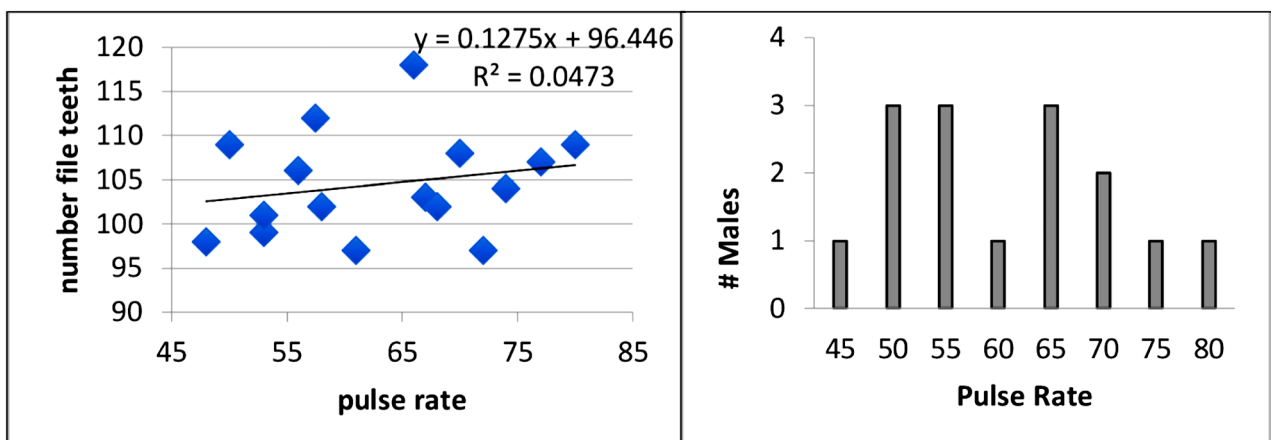


FIGURE 82. Left: Regression of sympatric *G. rubens* and *G. texensis* from Tulsa, OK (S13-68) showing lack of separation in individuals for pulse rate vs. file teeth number. Right: Histogram of pulse rates of these same males.

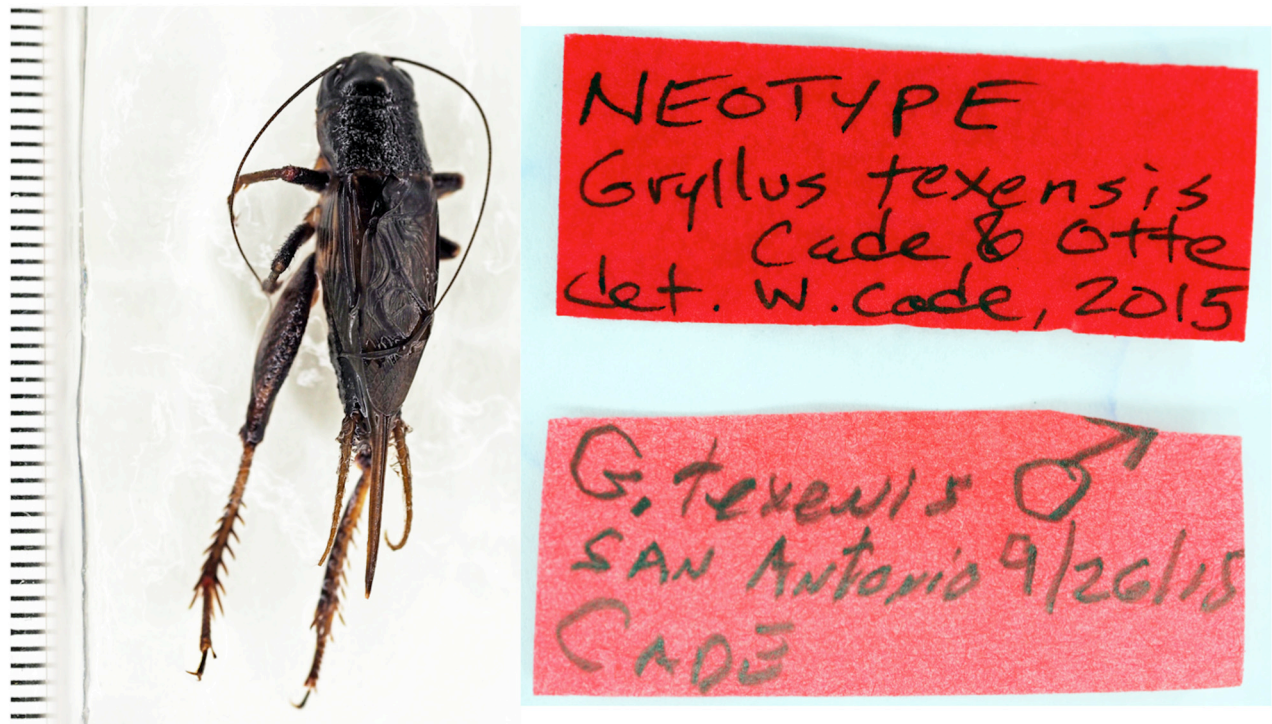


FIGURE 83. Neotype male, *G. texensis*, specimen and labels.

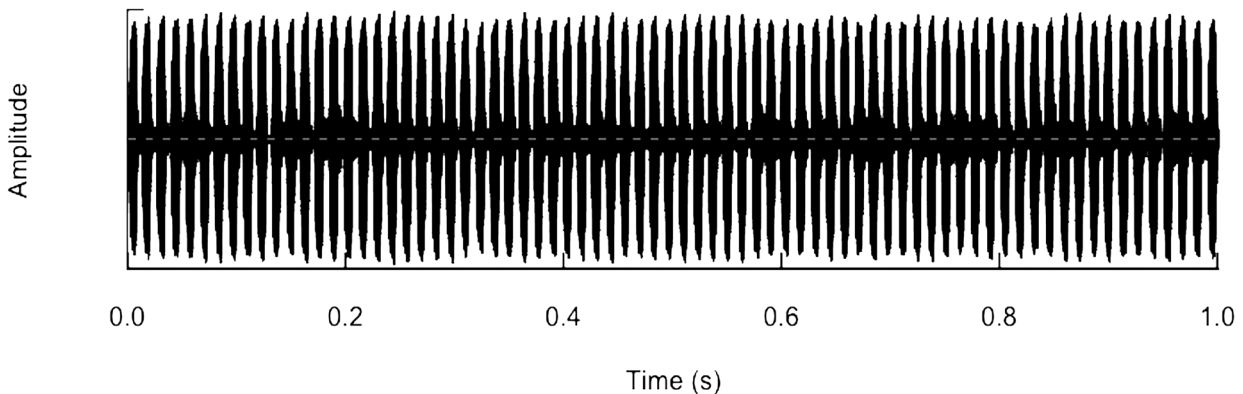


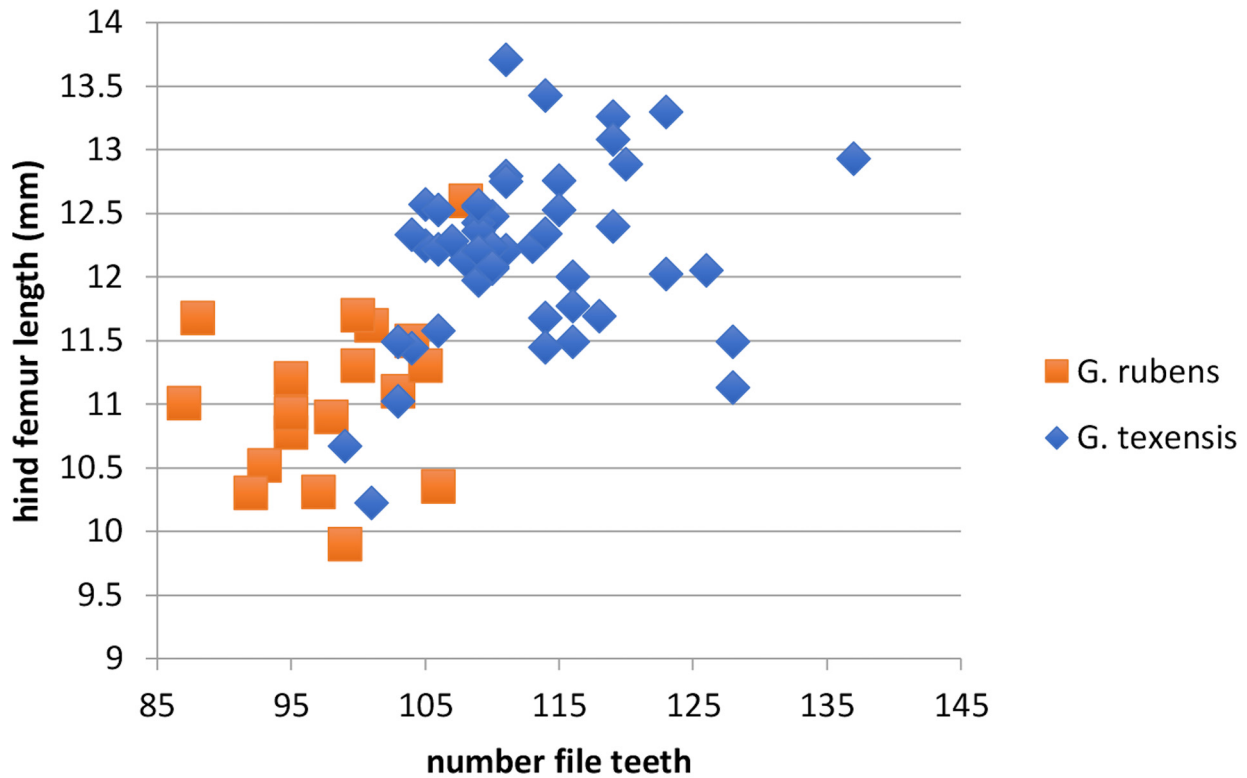
FIGURE 84. One second waveform, pulse rate of 75, of calling song of *G. texensis*: (R13-224) Rio Hondo, TX (S13-44), at 26°C

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.

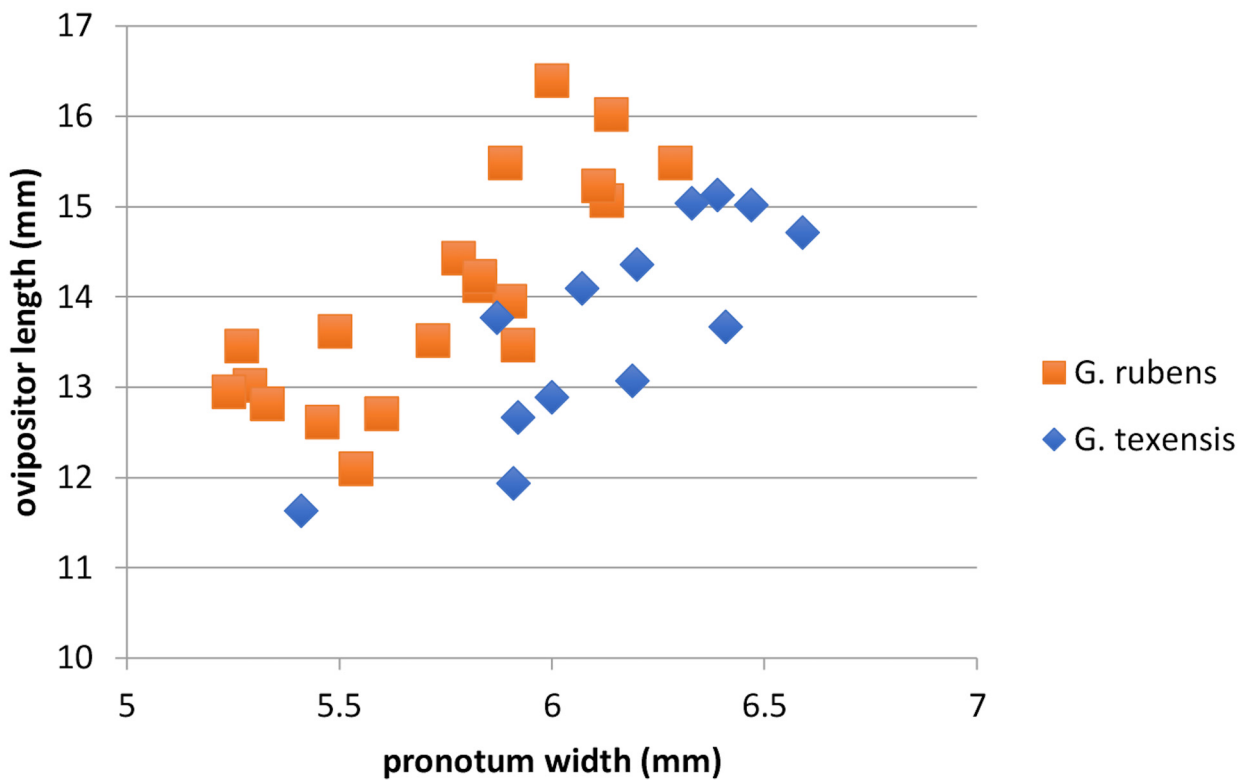
Distinguished from sympatric (western Texas only at Alpine [S07-41]), sister species *G. regularis* which has non-overlapping PR of 29–50 at 25°. In its most western distribution, *G. texensis* can be sympatric with *G. armatus* and while their songs are difficult to separate in the field, unless males 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.

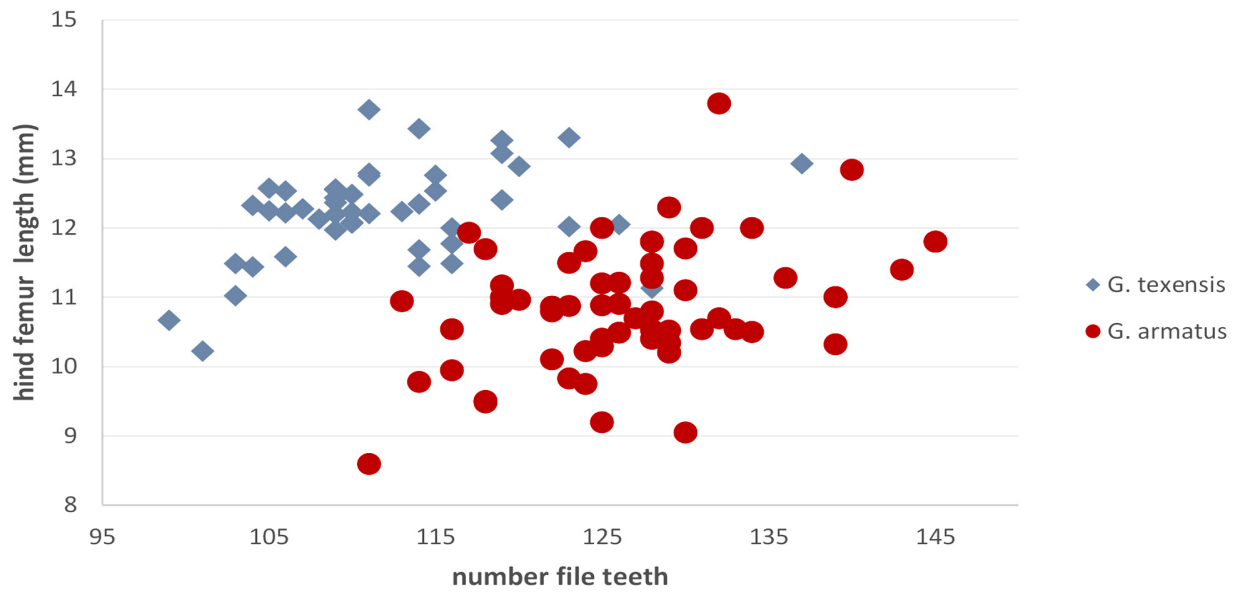
*Geographical range.* (Fig. 88.) Eastern limits in Gray *et al.* (2008). Also into adjacent Mexico.



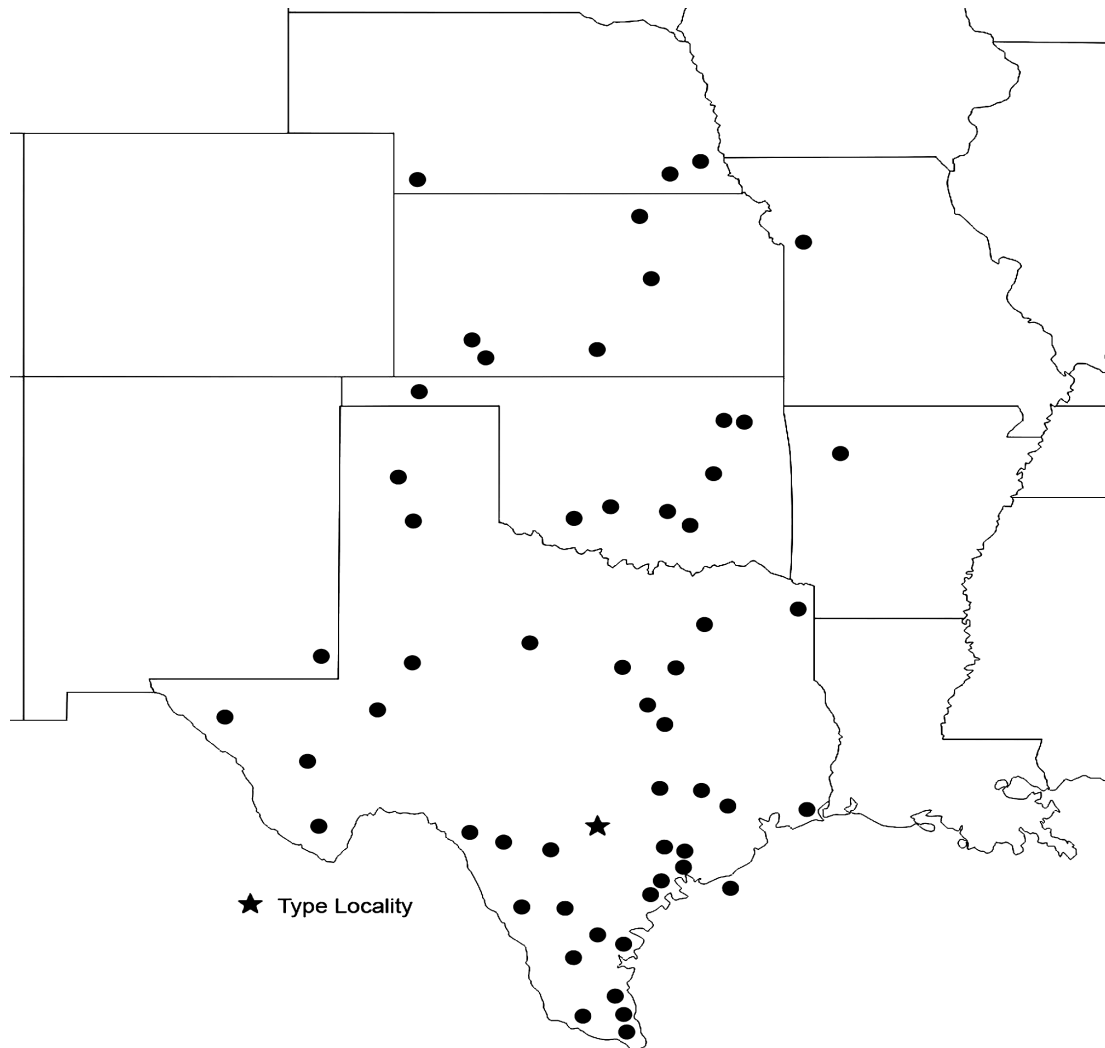
**FIGURE 85.** Regression of file teeth number vs. hind femur in *G. texensis* vs. *G. rubens* showing overlap but lower number of teeth in latter.



**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-cricket-bring-nuisance-stink-to-waco>; Norman, Oklahoma, in early September, 2013: [https://www.huffingtonpost.com/2013/09/04/oklahoma-cricket-invasion\\_n\\_3866683.html](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).

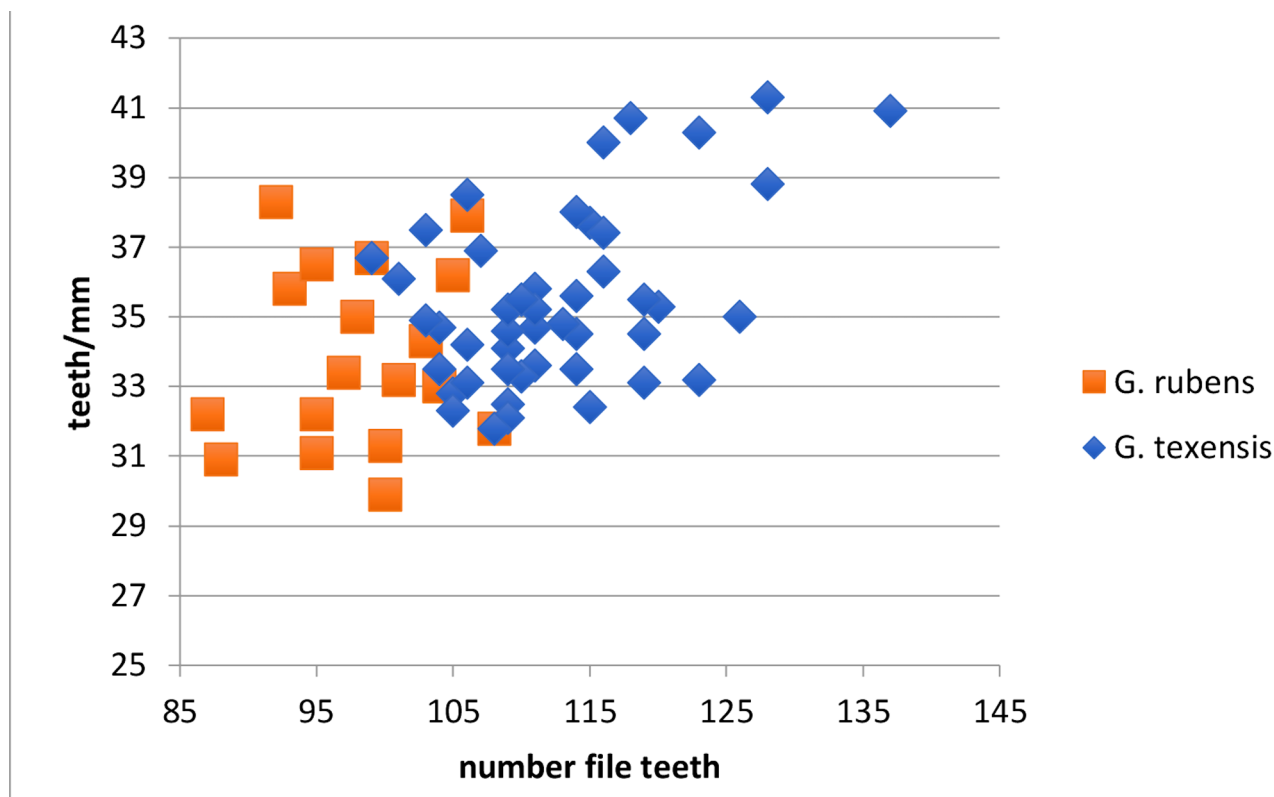


FIGURE 90. Regression of file teeth vs. teeth/mm showing separation of sympatric *G. rubens* from *G. texensis*.

***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