

Additionally, it appears that the farther east one goes within the distribution of *G. armatus*, the higher percentage of males have introductory trills followed by 2p/c, although all 3 males from Texas, Bentsen-Rio Grande State Park (S02-34 and S07-27), where *G. armatus* occurs microsympatric with *G. texensis*, had 2p/c without an introductory trill.

Interestingly, two males changed their song with time. One male recorded (R91-143) in the field from Tuba City, AZ (S91-82), had a short introductory trill at 22°C and then 2p/c, consistent with *G. armatus*. Five days later in the laboratory at 25°C, this male sang (R91-155) without an introductory trill and with 2–3p/c, more consistent with *G. integer* song. He was not teneral upon capture. No DNA could be isolated more than 15 years later. A second male (2006-241) from Cordes Junction, AZ, was initially recorded at 20.8°C, with no introductory trill and 2p/c. A subsequent recording, at 22.4°, showed an introductory trill and 2 (rarely 3) p/c.

Rare field collected adult males of *G. armatus* sing a pure trill song of 1p/c: Coolidge Dam (S81-43) and Buckeye (S11-102), AZ; Las Cruces, NM (S82-99); and Baker, CA (S05-110)], or predominantly so (Cottonwood Cove, NV [S90-44]; Globe, AZ [S82-103]; Las Cruces, NM [S83-103]; and Van Horn, TX [S91-48]) but, in all cases, the fast PR separates them from other trillers *G. regularis* and *G. cohni* in the Southwest, *G. rubens* in Texas, but not from *G. texensis* in Texas (see discussion in next paragraph).

G. armatus is sympatric with the Southeast fast trilling field cricket, *G. texensis*, at the Texas localities of Alpine (S91-44, S07-41, along with the slower triller *G. regularis*); Brackettville (S91-40, S07-32, S10-63); Rio Hondo (S13-44); town of Van Horn (S91-48); Big Springs (S09-72); Rio Grande Village in Big Bend National Park (S91-43, S02-34); and Bentsen-Rio Grande State Park (S02-34, S07-27); in Kansas at Dodge City (S89-71); and in New Mexico at Eunice (S10-62). When both *G. armatus* and *G. texensis* are singing adjacent to each other, and *G. armatus* is singing with 2 or 3p/c, differences in song, especially evenness and pitch, are apparent to “young” ears. When singing isolated from each other, we do not appreciate such song differences as easily. Because some 22% of adult *G. texensis* have short hind wings, the taxa can sometimes be separated in the field even though both have PR between 70-100 at 25°C

The population of crickets from Aguila, AZ, studied by Hedrick and Kortet (2006) under the name *G. integer*, is most likely *G. armatus*.

The tachinid *Ormia ochracea* recovered from *G. armatus* from single males collected at Havasu Lake, CA (S11-84) and Wenden, AZ (S11-87).

The Vernalis Group

Gryllus vernalis Blatchley; *Gryllus fultoni* (Alexander); *Gryllus cayensis* Walker

Sister species of crickets that inhabit forest or forest edges in the central and southern US (*G. vernalis* and *G. fultoni*) and southern Florida (*G. cayensis*). *G. cayensis* does not normally produce a calling song. Separable by morphology (Table 1, p. 18), song (Figs 113, 114) and ITS2 DNA (Fig. 115); multilocus DNA (Gray *et al.* 2019) places *G. cayensis* closer to *G. fultoni* than to *G. vernalis*.

Gryllus vernalis Blatchley

Northern Wood Cricket

Figs 57, 113–122, Table 1

1903 *Gryllus americanus* Blatchley. Blatchley 1903, p. 433.

1920 *Gryllus assimilis vernalis* Blatchley, nomen novum since *G. americanus* was preoccupied. Blatchley 1920, p. 704.

1930 *Gryllus assimilis vernalis* Blatchley. Blatchley 1930, p. 72. Lectotype female (Fig. 116, photos courtesy of Jennifer Zaspel and Gareth Powell, Purdue University Entomological Collection, where the types are deposited) chosen by Blatchley: Red label “Type”. Crawford Co., Ind. W.S.B. 5-11-(18)99. Allolectotype male (Fig. 117) with the following data: White label “type” Crawford Co. Ind. W.S.B. 6/28/ (19)02. Blatchley chose a female as the lectotype because he thought the length of the ovipositor and shape and position of the female tegmina at rest [somewhat separated] were both good characters for separating *G. vernalis* from the sympatric *G. pennsylvanicus* (actually = *G. veletis*) (Blatchley 1903, p. 434; repeated verbatim in Blatchley 1920, p. 706).

1957 *Acheta vernalis* (Blatchley). Alexander (1957).

1964 *Gryllus vernalis* Blatchley. Randell (1964).

Distribution. Known from several central and southern US states (see maps in Capinera *et al.* 2004, Walker 2019), both east and west of the Mississippi River.

Recognition characters and song. Smallest species of *Gryllus*, on average, in US, although some male North Dakota *G. veletis* (from Mirror Pool, Richland Co.) are smaller than the smallest *G. vernalis* males. A morphologically distinctive cricket based on a combination of characters: always with short hind wings, head usually narrower than pronotum (Fig. 118), *song* (Fig. 119, R03-104) usually 3 (rarely 4) p/c, 135–250 c/m, PR 24–31.

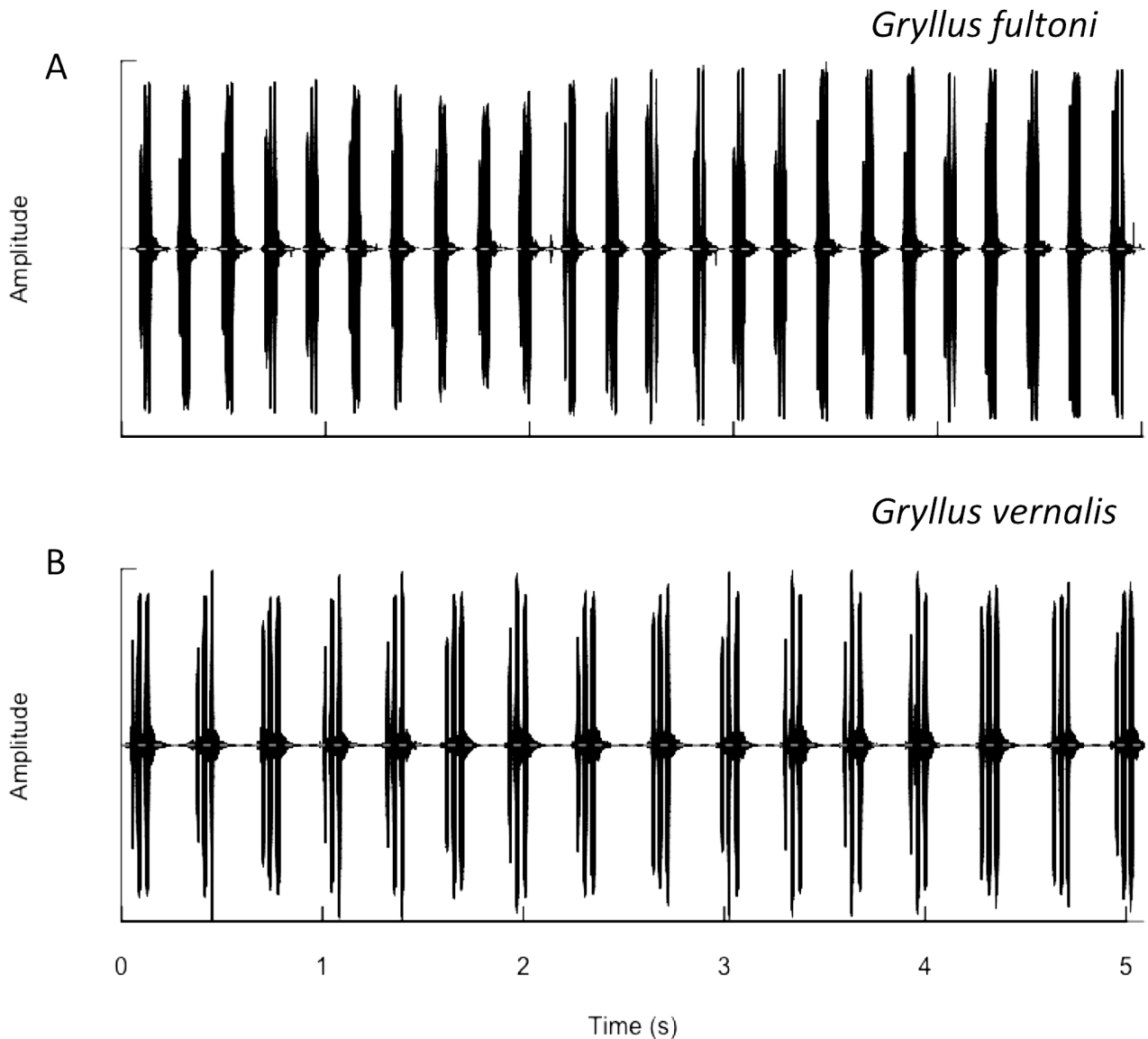


FIGURE 113. Five second waveforms of calling songs of (A) *G. fultoni* and (B) *G. vernalis*. *G. fultoni*: (R03-86) Hocking Co., OH (S03-64), at 25°C; *G. vernalis*: (R03-104) Jefferson Co., MO (S03-56), at 24.5°C.

Differs from sympatric Missouri (S03-56) and Indiana (S03-62) sister species *G. fultoni* in being smaller (Fig. 120), tegmina always black vs. brown and black with tegminal bar in *G. fultoni*, no overlap in file teeth and teeth/mm (Table 1, p. 18), tegmen length, PR slower (can hear difference in field when both species singing at same temperature), and yellow cerci rare (usually the norm in live *G. fultoni*).

Differs from sympatric Iowa *G. veletis* (S03-55) in *G. vernalis* having head frequently narrower than pronotum, proportionately longer cerci, based on body length, smaller size, fewer p/c, and slower PR. Differs from more western, allopatric *G. veintinueve* in no overlap in teeth/mm (Table 1, p. 18), length of cerci, male tegminal length, and

multilocus DNA (Fig. 6, p. 28; Gray *et al.* 2019). *G. veintinueve* is only found west of 94° longitude. Differs from allopatric sister species *G. cayensis* because the latter is taciturn and restricted to southern Florida.

Derivation of name. “vernalis” means “of springtime,” in reference to its appearance as the first singing *Gryllus* species in Indiana (Blatchley 1903, 1920).

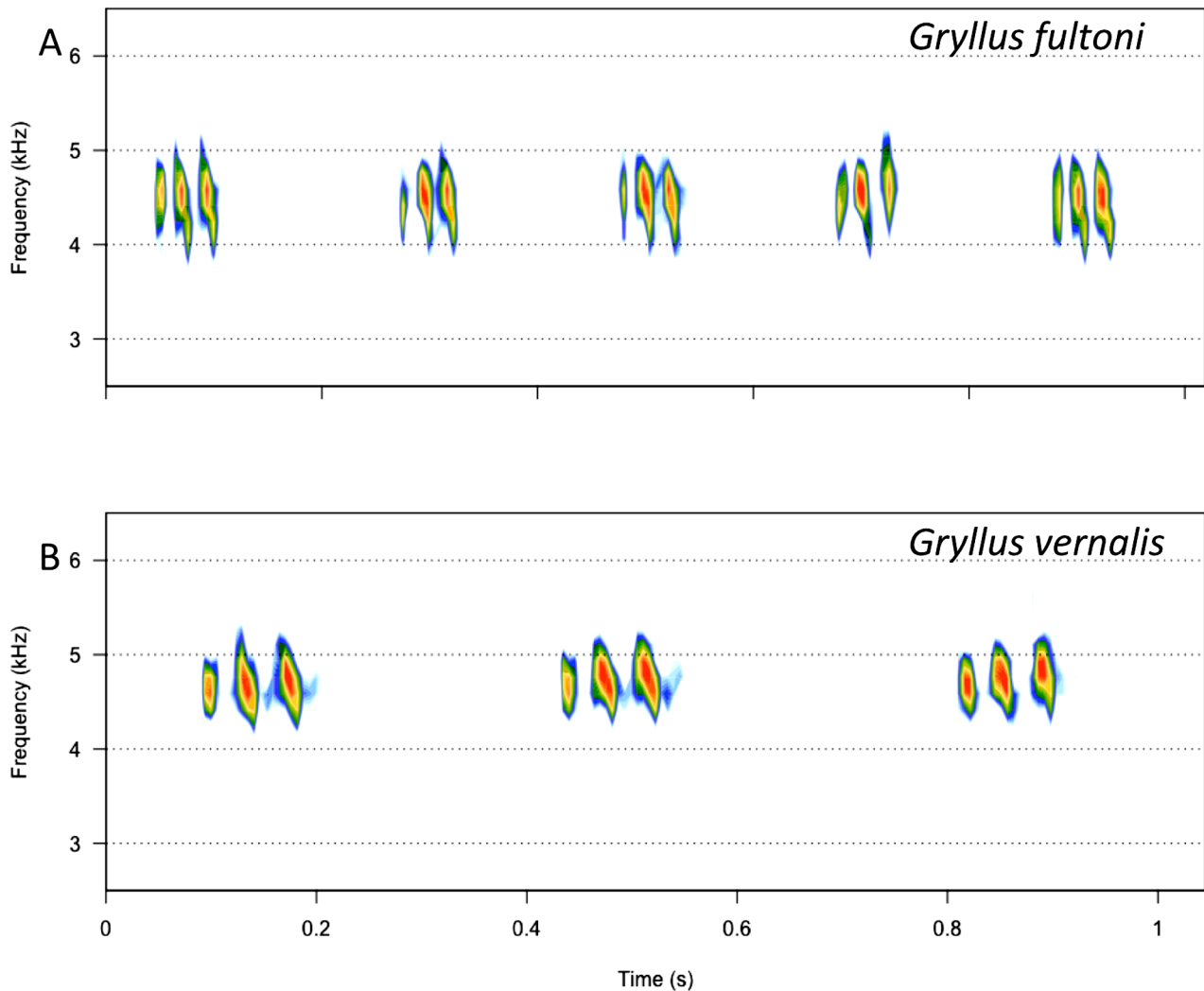


FIGURE 114. One second spectrograms of (A) *G. fultoni* and (B) *G. vernalis*, same males as in Fig. 113.

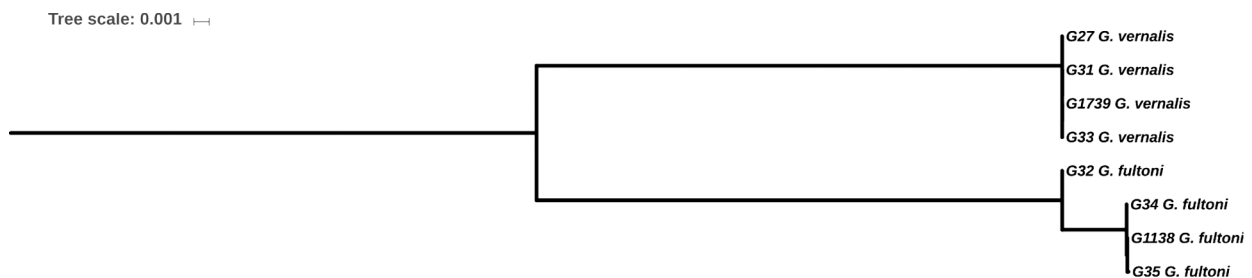


FIGURE 115. ITS2 gene tree. *G. vernalis* samples: S03-56 (G27, G1739); S03-62 (G31, G33). *G. fultoni* samples: S03-62 (G32, G34); S03-64 (G35), S07-22 (G1138).

Geographic range. (Fig. 121). Some literature citations (e.g. Jang & Gerhardt 2006a, 2006b, for eastern Oklahoma and eastern Texas) probably refer to morphologically similar *G. veintinueve*, a species discussed elsewhere (p. 70) in this paper. Besides our localities (see below), also known from Alabama, Mississippi, and Kentucky (Walker 2019; Jang & Gerhardt 2006a, 2006b).



FIGURE 116. Lectotype female, *G. vernalis*, specimen and labels.



FIGURE 117. Allolectotype male, *G. vernalis*, specimen and labels.

Habitat. An obligate woodland, and edge of woodland, species. Males can frequently be heard singing from undergrowth abutting woodlands but can be difficult to collect even when using oatmeal trails.

Life cycle and seasonal occurrence. No egg diapause. One generation/year. Adults from early May (Blatchley, 1903) until mid-summer, and overwinter as late instars.

Variation. **Head size:** Of the specimens from Indiana near the type locality, 0 of 3 males and 3 of 4 females had the head narrower than the pronotum. From Missouri 5 of 8 males and both females had the head narrower. From Tennessee, 5 of 7 males and all 7 females had the head narrower. No specimens were captured in Iowa or Ohio, although they were heard singing from dense vegetation. **Cerci color:** Rare (1 of 31) individuals with yellow cerci

when alive. This color darkens upon death. **Pulses/chirp:** Usually 3 p/c but 1 (S03-56) of 17 recorded males with a rare chirp with 4 pulses. **Are female tegmina widely separated?** Usually, but not always in *G. vernalis*, and this “diagnostic” condition (Blatchley 1903) is also seen in some *G. fultoni* females.



FIGURE 118. Pair of *G. vernalis* from Crawford Co., Indiana (S03-62). Note separation of tegmina of female (left).

Specimens examined. **Arkansas:** Polk Co., Wilhelmina State Park, 17-vi-1995, T.J. Walker, 1♂. **Illinois:** Johnson Co., Ferne Clyffe State Park 1.4 m S Goreville, 170m, 8-vii-2014 (S14-35), 2♂, A. & D. Wood. **Indiana:** Crawford Co., Hwy 62 11.6 m W of Hwy 135. 750', 4-vi-2003 (S03-62) 3♂ 4♀. **Missouri:** Jefferson Co., Edmond A. Babler State Park, 750', 2-vi-2003 (S03-56) 8♂ 2♀. **Tennessee:** Coffee Co., Old Stone Fort State Park, 13-v-2003 (S03-57) 7♂ 7♀, Y. Jang.

Song only records. **Iowa:** Fremont Co., Waubonsie State Park, 1250' 1-vi-2003 (S03-55). **Ohio:** Hocking Co., Hwy 33 9 m S Lanchester, 750' 5-vi-2003 (S03-64).

DNA. We found two 16S clades (Figs 121, 122). Clade 1 included 3 individuals (G31, G33, G440) from near the type locality in Indiana (S03-62). Clade 2 included 4 individuals (G26, G27, G1739, G1740) from Missouri (S03-56); 4 individuals (G28, G1700, G1701, G1738) from Tennessee (S03-57); and 2 individuals (G2754, G2755) from Illinois (S14-35). ITS2 mapping of two Clade 1 individuals (G31 and G33) and two Clade 2 individuals (G27

and G1739) all mapped together (Fig. 115, p. 121). Multilocus G31 (Clade 1, Indiana, S03-62) and G2754 (Clade 2, Illinois, S14-35) have these two 16S clades map together and also identifies *G. fultoni* and *G. cayensis* as sister species (Gray *et al.* 2019).

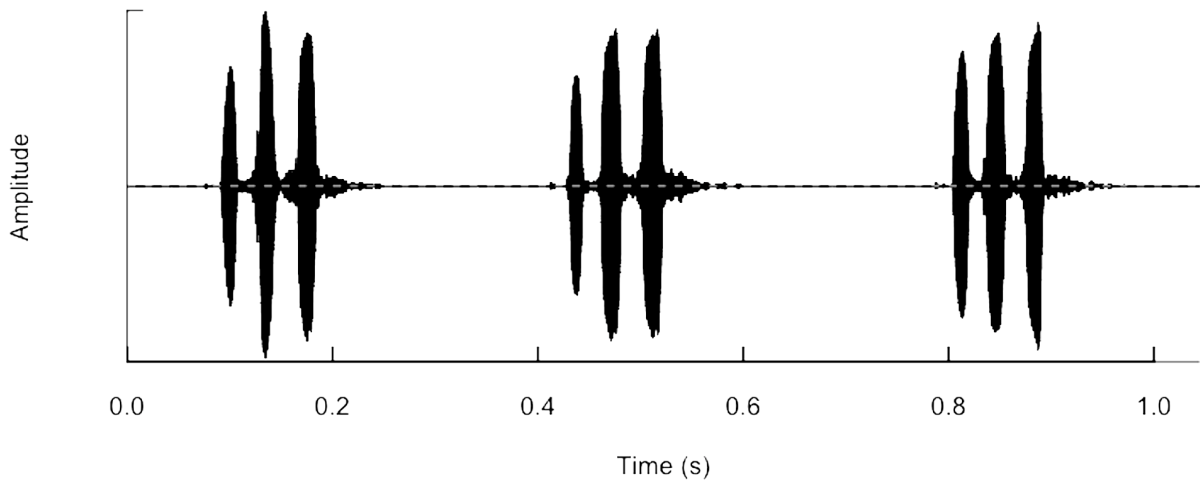


FIGURE 119. Calling song (R03-104) of *G. vernalis* from Jefferson Co., MO (S03-56), recorded at 24.5°C.



FIGURE 120. Size and color comparison of *G. vernalis* (left, S03-56, Jefferson Co., MO) vs. *G. fultoni* (right, S03-62, Crawford Co., IN).

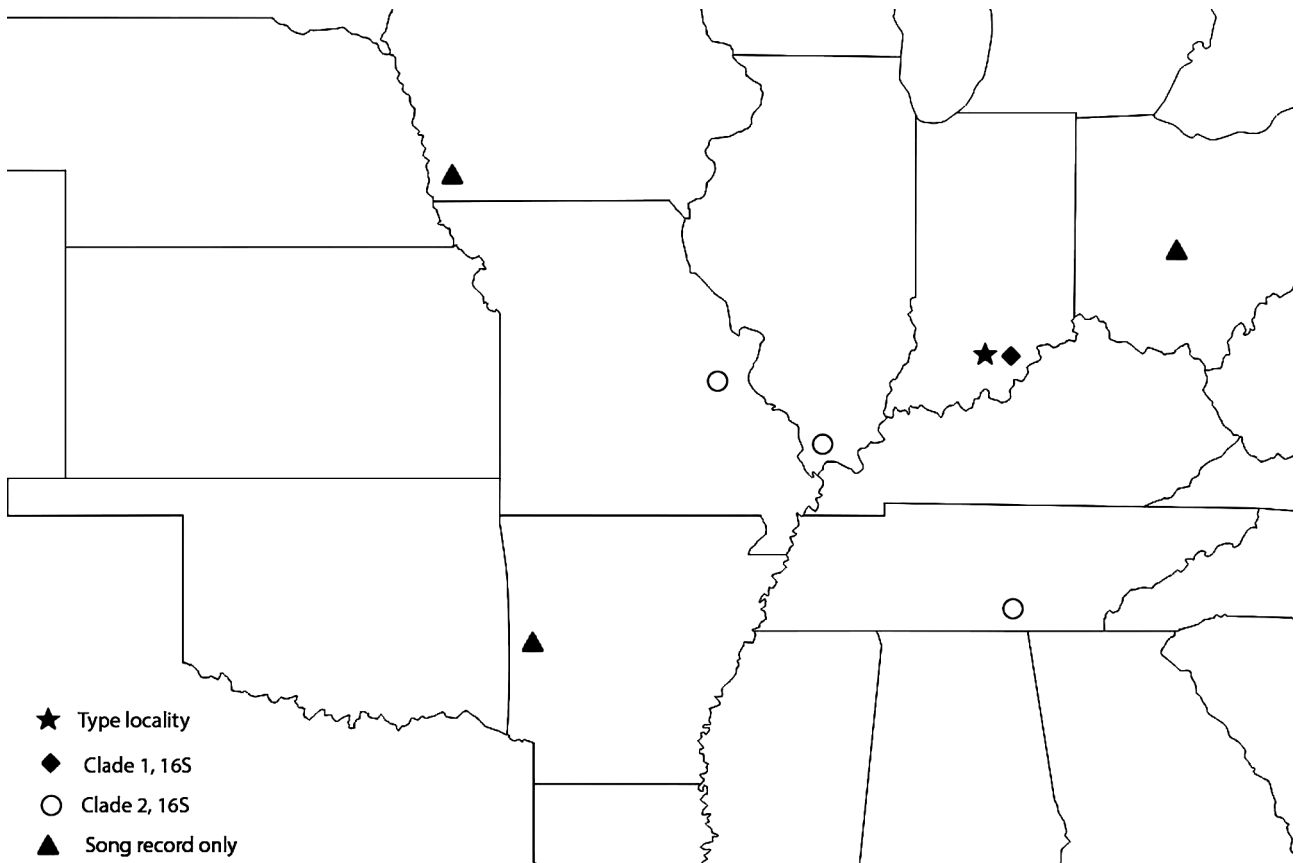


FIGURE 121. Populations of *G. vernalis* that we studied.

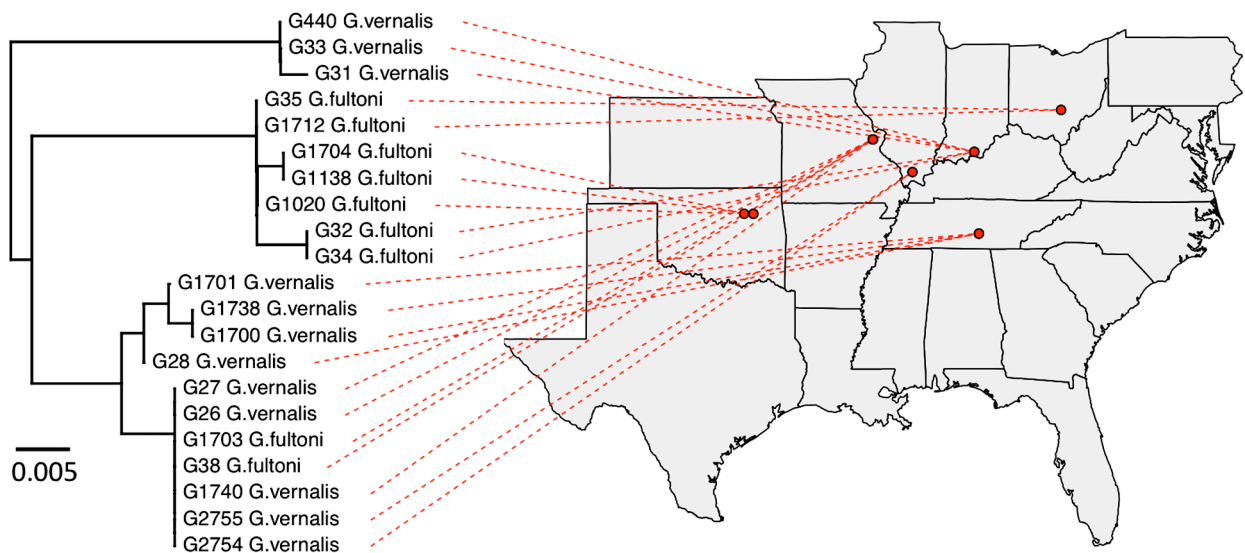


FIGURE 122. 16S gene tree and distribution map showing two 16S Clades for both *G. vernalis* and *G. fultoni* (the latter situation is discussed, below, under *G. fultoni*). *G. vernalis* samples: S03-56 (G26, G27, G1740); S03-57 (G28, G1700, G1701, G1738); S03-62 (G31, G33, G440); S14-35 (G2754, G2755). *G. fultoni* samples: S01-47 (G1704); S03-56 (G38, G1703); S03-62 (G32, G34); S03-64 (G35, G1712); S07-22 (G1020, G1138).

Discussion. First called the northern wood cricket by Alexander (1957) despite Blatchley’s name of “*vernalis*” meaning “of springtime.” In fact, Blatchley discussed (1903, p. 434) how *G. vernalis* is not just the first species of *Gryllus* to sing in the spring but “the first Orthopteran song of the season” appearing as early as May 5th, or about

two weeks before *G. veletis* sings in Indiana. However, in 1960, Alexander & Bigelow christened the latter the northern spring field cricket, now simply called the spring field cricket by Walker (2019).

G. vernalis occurs in many localities with either *G. fultoni* and *G. veletis*. With enough searching, we predict that one should find all three taxa sympatric. At such a locality, one could stand and hear and discriminate the three by song and microhabitat as follows: With an air temperature between 18–25° C, i.e. warm enough for males to sing, *G. vernalis* more likely into deeper woods where its individual three pulses/chirp can be counted. *G. fultoni* can be along the forest—adjacent grassland border area where its three pulses/chirp can't be counted because the PR is too high. *G. veletis* would be in the adjacent grassland only and although its pulses are too close together to be counted, one can hear that each chirp contains more than three pulses because of the chirp's longer duration. It is easier to appreciate the differences between *G. fultoni* and *G. vernalis*' pulse rates when the two species are heard singing together.

Near the type locality (S03-62) of *G. vernalis* in Indiana, both *G. vernalis* and *G. fultoni* occurred at high densities within an open area of dense forest that was clear-cut for electrical power lines. The songs of *G. vernalis* were softer than those of *G. fultoni*, not surprising given the shorter tegmina in *G. vernalis*. Many individuals of both sexes of both species were walking on the surface amid various limestone rocks and organic debris.

Jang & Gerhardt (2006a, b; 2007) and Jang *et al.* (2007) document calling song character displacement where *G. vernalis* and *G. fultoni* are sympatric; and aggressiveness related to habitat (Jang *et al.* 2008).

***Gryllus fultoni* (Alexander)**

Southern Wood Cricket

Figs 57, 113–115, 122–126, Table 1

1957 *Acheta fultoni*. Alexander (1957). Holotype male (Fig. 123, courtesy of M. O'Brien): Ohio, Hocking Co., Goodhope Township. Deposited at UMMZ. Types also photographed on OSF.

1964. *Gryllus fultoni*. Randell (1964).

'*Gryllus* #28' of DBW notebooks.

Distribution. East of 98° longitude in southern and central US, to the Atlantic coast and south into Florida.

Recognition characters and song. Small to medium sized cricket, always short hind wings, usually with contrasting yellow cerci when alive, head usually narrower than pronotum (Fig. 124). *Song* (Fig. 125) of 3p/c delivered at 250 to 360 c/m., PR 35–55. Usually lives in woods or on their edges but sometimes in short to long roadside grasses. Some males climb several feet into bushes and tree trunks to sing. One “effective” generation/year (see below under *Life cycle*). Differs from sympatric *G. vernalis* in not being a forest obligate, being slightly larger (Fig. 120), tegmina brown and black with tegminal bar vs. solid black in *G. vernalis*, no overlap in teeth/mm (Table 1, p. 18), PR faster (can hear difference in field when both species singing at same temperature), and yellow cerci common in live individuals (rare in *G. vernalis*). Differs from sympatric *G. veletis* in microhabitat (woods vs. grassland), *G. fultoni* frequently having the head narrower than pronotum, longer cerci that are usually yellow, smaller size, fewer p/c, and faster PR and CR. Differs from sympatric *G. veintinueve* in *G. fultoni* usually having yellow cerci when alive, head narrower than pronotum, faster CR and fewer file teeth, no overlap in its faster PR and different DNA (Fig. 6, p. 28; Gray *et al.* 2019).

Derivation of name. Named, by Alexander, in honor of B. B. Fulton who was the first to recognize this species as distinct.

Geographic range. (Fig. 126). From eastern Texas, Oklahoma, and Kansas through the central US to the Atlantic coast and south into Florida (see maps in Walker 2019; Jang & Gerhardt 2006a, b).

Habitat. Usually in woods or along their borders where they live in leaf litter and can be difficult to collect. Never in open fields. Also in holes in the ground under trees where they are easily flushed with water. Occasionally in short roadside grasses (Kansas, S87-69 & 70) with an open tree cover. In eastern Oklahoma males climb into bushes and trees to sing—we collected males singing 1.5–2m above ground on the side of a tree at Keystone State Park (S88-42) and in Tulsa (S07-22).

Life cycle and seasonal occurrence. No egg diapause (checked from Kansas, S87-70; Oklahoma, S88-42; and Missouri, S00-16), with first field adults in mid-late May. Walker (1974) notes that northern Florida can have second generation *G. fultoni* adults, similar to the situation seen in *G. veletisoides* in California (see p. 195), *G. veletis* in Mich-

igan (Alexander 1957, p. 592), and *G. firmus* in Florida (Walker 1980). The functionality of this second generation in Florida is unknown but apparently non-contributory to the gene pool (T.J. Walker pers. comm. to DBW, 2011).



FIGURE 123. Holotype male (upper) *G. fultoni* and allotype female (bottom), with labels.

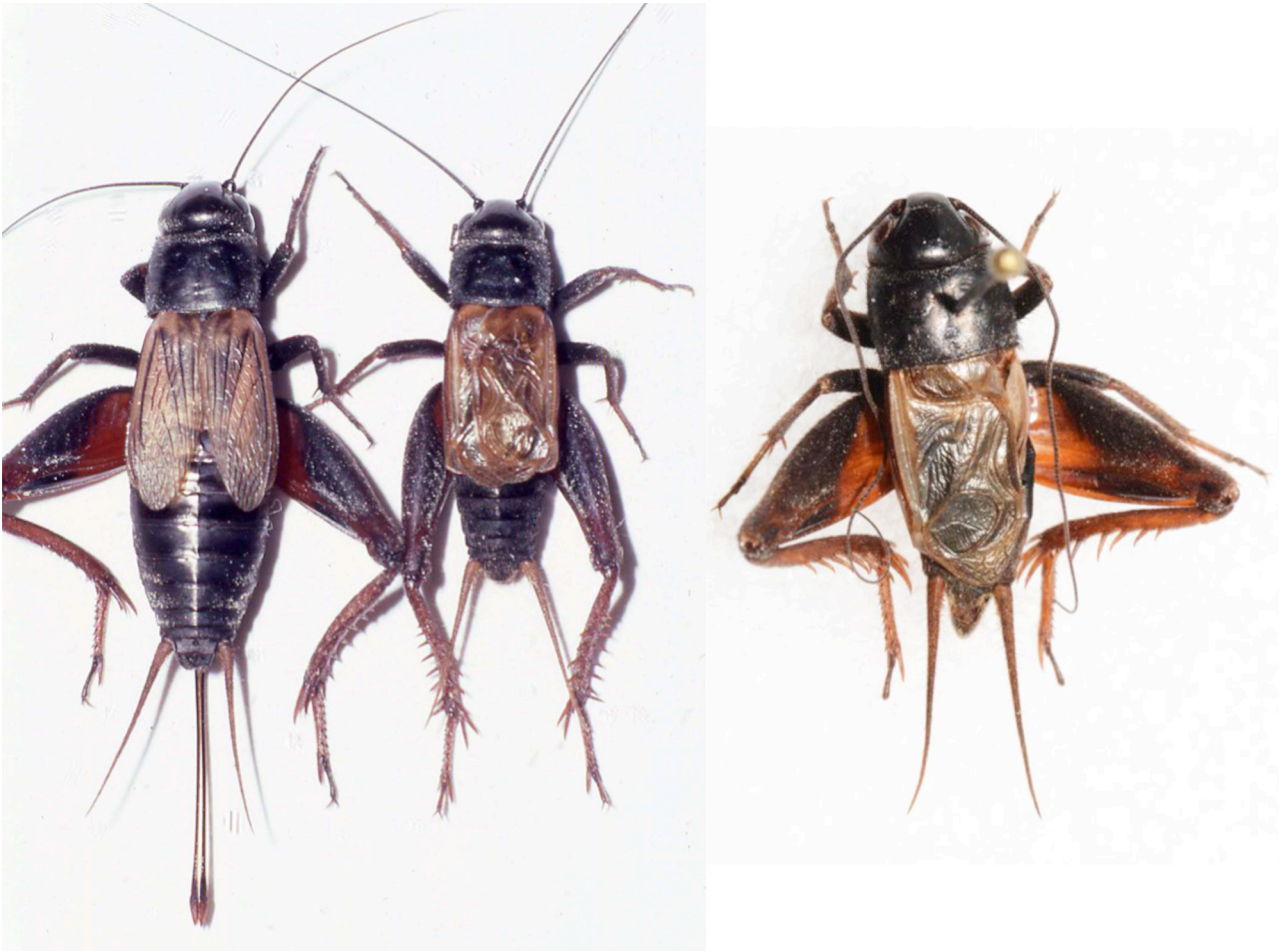


FIGURE 124. Color variation in *G. fultoni*: female (left) and both males (middle and right), all three from Crawford Co., IN (S03-62). Note narrow heads, especially in male on right, and separation of female tegmina.

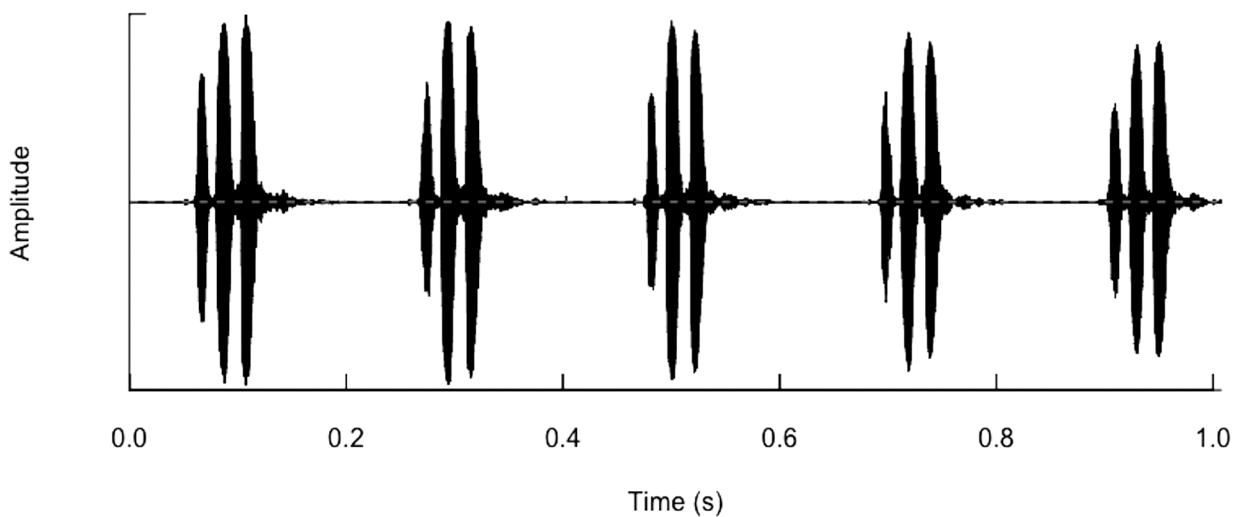


FIGURE 125. Calling song (R03-86) of *G. fultoni* from Hocking Co., Ohio (S03-64), recorded at 25°C.

Variation. Color: See Fig. 124 above. **Head width:** 28 of 36 males with head narrower than pronotum while 29 of 31 females with head narrower than pronotum. **Size:** Florida specimens are larger than more northern ones.

Specimens examined. Arkansas: Garland Co., Lake Ouachita State Park, 16-vi-1995, T.J. Walker. **Indiana:** Crawford Co., Hwy 62 11.6 m W intersection with Hwy 135, 750', 4-vi-2003 (S03-62). **Kansas:** Barber Co., 1 m

W Medicine Lodge on Hwy 160, 23-vi-1987 (S87-69). 27 m W Medicine Lodge on Hwy 160, 1750' 23-vi-1987 (S87-70). **Missouri:** *Hickory Co.*, Pomme de Terre State Park, 1000', 20-vii-1993 (S93-49). *Jefferson Co.*, Edmond A. Babler State Park, 750' 2-vi-2003 (S03-56). *Stone Co.*, Table Rock Dam Visitor Center, 31-v-2000 (S00-16) T.J. Walker. **Ohio:** *Hocking Co.* (near type locality), Hwy 33 9 m S Lanchester, 750', 5-vi-2003 (S03-64). **Oklahoma:** *Atoka Co.*, Jack Fork Mts. 3 m SW Daisy on Hwy 43, 750', 1-v-1988 (S88-46). *Osage Co.*, near Walnut Creek State Park, 600' 15-vi-1988 (S88-43). *Tulsa Co.*, Keystone State Park, 600', 15-vi-1988 (S88-42); Lake Keystone Dam Area 650', 27-v-2001 (S01-47); Tulsa, at intersection I44 and Hwy 244, 680', 9-vi-2007 (S07-22); near Tulsa, Exit 238 off I44 2 m E Tulsa city limit, 796', 15-vii-2013 (S13-68), 36° 09' 37.4 -95° 47' 33.1". **Texas:** *Bastrop Co.*, Bastrop State Park, 700' 31-v-1991 (S91-23). *Marion Co.*, Caddo Lake State Park, 300', 18-vi-1993 (S93-42).

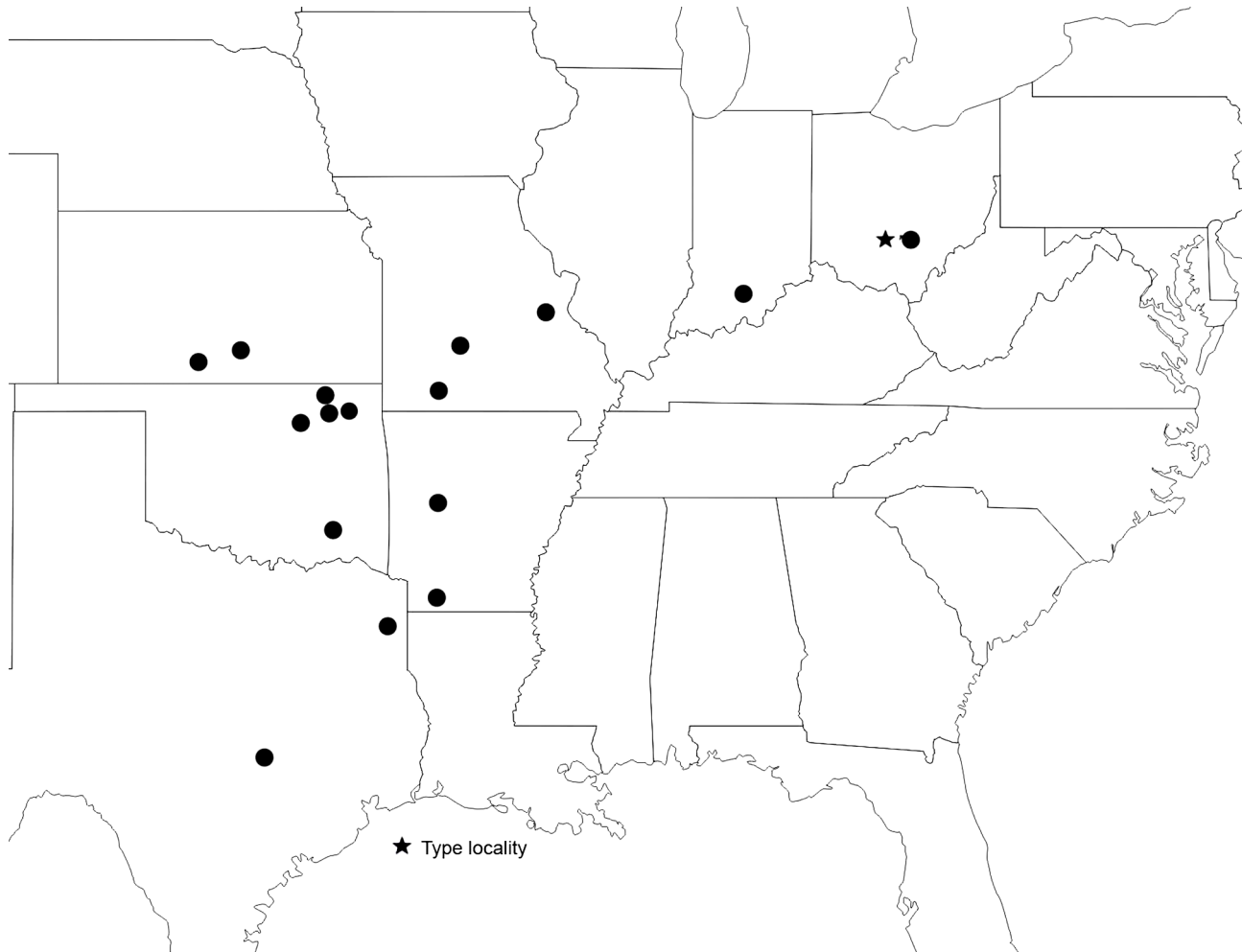


FIGURE 126. Populations of *G. fultoni* that we studied. See Walker (2019) for more eastern localities.

DNA. Multilocus G34 (Indiana, S03-62) sister species with *G. vernalis* and *G. cayensis* (Gray *et al.* 2019). ITS2 shows clear and complete separation between *G. fultoni* and *G. vernalis* (Fig. 115, p. 121), whereas two *G. fultoni* (Fig. 122, p. 125) from Missouri (G38 and G1703, both S03-56) have 16S sequences identical to microsympatric *G. vernalis*, suggesting the possibility of past hybridization.

Discussion. *G. fultoni* occurs microsympatric in Missouri (S03-56), Indiana (S03-62), and Ohio (S03-64) with *G. vernalis*; in Oklahoma (S88-42, S01-47 and S13-68) with *G. veintinueve*; and in Oklahoma (S13-68) with *G. veletis*. Thus, at the latter Oklahoma locality just east of Tulsa (S13-68), there are 3 *Gryllus* taxa synchronic and microsympatric that can have 3p/c with different PR and CR. Apparently females can discriminate between such small differences in songs.

Although called the southern wood cricket, the distribution of *G. fultoni* extends north of the northern wood cricket, *G. vernalis* (see Fig. 126 and Jang & Gerhardt 2006a, b).

Those males singing in woodlands and grassy areas can be difficult to catch because they sing from under dry

leaves and other vegetation. Those males singing in bushes and on tree trunks may jump on approach and get lost in the forest duff. A large butterfly net positioned beneath the male can help in these situations. Aggressiveness in this taxon studied by Jang *et al.* (2008).

Gryllus cayensis Walker

Keys Wood Cricket

Figs 127–129

2001 *Gryllus cayensis* Walker 2001. Florida Ent. 84: 700. Holotype male (Fig. 127); allotype female (Fig. 128) (all courtesy Kyle Schnepf): Florida, Monroe Co., Key Largo. Deposited in FSCA Florida State Collection.



FIGURE 127. Holotype male of *G. cayensis*, with labels.

Distribution. Known only from southern Florida (Walker, 2019), and probably extirpated from the Florida Keys by past mosquito spraying that started in 1972 (Walker 2001).

Recognition characters and song. No calling song. Only woodland inhabiting *Gryllus* species there although *G. assimilis*, *G. firmus*, and *G. rubens* also occur in southern Florida (Capinera *et al.* 2004).

DNA. Multilocus 2018-002, Florida, Monroe Co., Everglades National Park, Long Pine Key, 14-v-2018. 25.401352° -80.660966°. Closest (Gray *et al.* 2019) to sister species *G. fultoni* and *G. vernalis*.

Discussion. The reader is referred to Walker (2001, 2019) for further information, since our exposure is limited. When DAG looked for them in Everglades National Park, in May, 2018, he was rained out on 3 consecutive nights and felt lucky to get 1 adult female to an oatmeal trail (Fig. 129). At least some individuals survived the area's 2017 flooding from Hurricane Irma.



FIGURE 128. Allotype female of *G. cayensis*, with labels.



FIGURE 129. Photograph of live *G. cayensis* female used in multilocus sequencing.