

in addition to periods of irregular trills. Our documentation (Weissman *et al.* 1980, Fig 10a, b) in Baja California, where calling songs at higher temperatures tended to go from discrete bursts to longer trains of trills, has not been seen in populations elsewhere.

DNA. Multilocus G101, Baja California, type locality (S95-81); G2776 Mazatlán, Mexico (S14-53); and 2016-041 Agua Fria National Monument are all sisters to 2016-036, Los Angeles Co., type locality of *G. vocalis*; G3335, Albuquerque, NM, type locality of *G. alogus*; and G3227 from Gila Bend, AZ (S15-111), locality of ‘*G. arizonensis*’ (Gray *et al.* 2019) (and see under *G. vocalis* for discussion of *G. alogus* and ‘*G. arizonensis*’). We caution that type locality leg G101, used in both 16S and multilocus sequencing, was removed in 2003 from a pinned specimen, eight years after collection. In both sequences, the leg mapped consistent with other *G. cohni* and sister species *G. vocalis* specimens.

Discussion. Of the US species discussed in this paper, *G. cohni* is the only one whose type locality is in Mexico. Because of its disjunct distribution (Fig. 169), we were initially uncertain if we were dealing with one taxon. But we were unable to separate, morphologically and song-wise, those from the Cape Area of Baja California Sur from those on the adjacent Mexican mainland and those from Arizona. Most importantly, 3 geographically separated samples of *G. cohni* (from Baja Sur, Sinaloa, and Arizona) map together and are well supported for both ITS2 (Fig. 157, p. 155) and in the multilocus genetic analysis (Gray *et al.* 2019). Also, 3 geographically separated, and well supported samples of *G. vocalis* (from Los Angeles, Albuquerque, and Arizona) map together (Fig. 157) and separate from sister species *G. cohni*.

We wonder if some variation on this possible historic narrative might have occurred in central Arizona to explain the complicated situation re hind wing length and songs containing 3 pulses/chirp: long hind winged (and probably able to fly), irregular trilling *G. cohni* typically is a cricket of dry habitats (before the summer monsoon rains come) and would not normally occur microsympatrically with usually short hind winged, 3p/c *G. vocalis*, since the latter prefers riparian areas in the Southwest. The spread of human habitation and the formation of cities like Ajo and Why, AZ, subsequently brought these two environments into proximity, which brought these two-sister species together and possibly facilitated hybridization and introgression. Thus, we find around central Arizona, short hind winged crickets that sing like *G. cohni* but also have periods of 3p/c in their calling songs as seen in *G. vocalis*. Consistent with this narrative is the fact that no *G. vocalis* are known along northern Sea of Cortez mainland Mexico and, hence, the widespread absence there of *G. cohni* with 3p/c song-periods. We have no data to support this scenario, but it is in principle easily testable using modern genomics.

Likewise, in this general Arizona geographical area, we find (normally rare elsewhere) long hind winged *G. vocalis* at Cottonwood Cove, NV (S81-31); Goodyear (S81-46), Buckeye (S11-102), and Gila Bend (S09-103), AZ; and Havasu Lake, CA (S83-62), although none have periods of trilling, regular or irregular song.

Given the variation in song produced by males in the same population, this species would be ideal for studies on female song preferences.

One male each from S86-15 (San Carlos Bay) and 2006-243 (Agua Fria) parasitized by tachinid *Ormia ochracea*. At the first locality, all 3 *Gryllus* species there (*multipulsator*, *staccato*, and *cohni*) were parasitized by this tachinid species.

The Lineaticeps Group

G. lineaticeps Stål, *G. personatus* Uhler, and *G. staccato* Weissman & Gray, n. sp.

Sister species of chirping field crickets with typically 6-9 pulses per chirp (Figs 170, 171). Separated from each other by geography (Fig. 172), song (Fig. 173), and DNA (Fig. 174).

Gryllus lineaticeps Stål

Variable Field Cricket

Figs 170–178, Table 1

1860 *Gryllus lineaticeps* Stål, 1861 [1860]. Kongliga Svenska fregatten Eugenie's Resa omkring jorden under befäl af C.A. Virgin åren 1851–1853. Zoologi 1. p. 314.

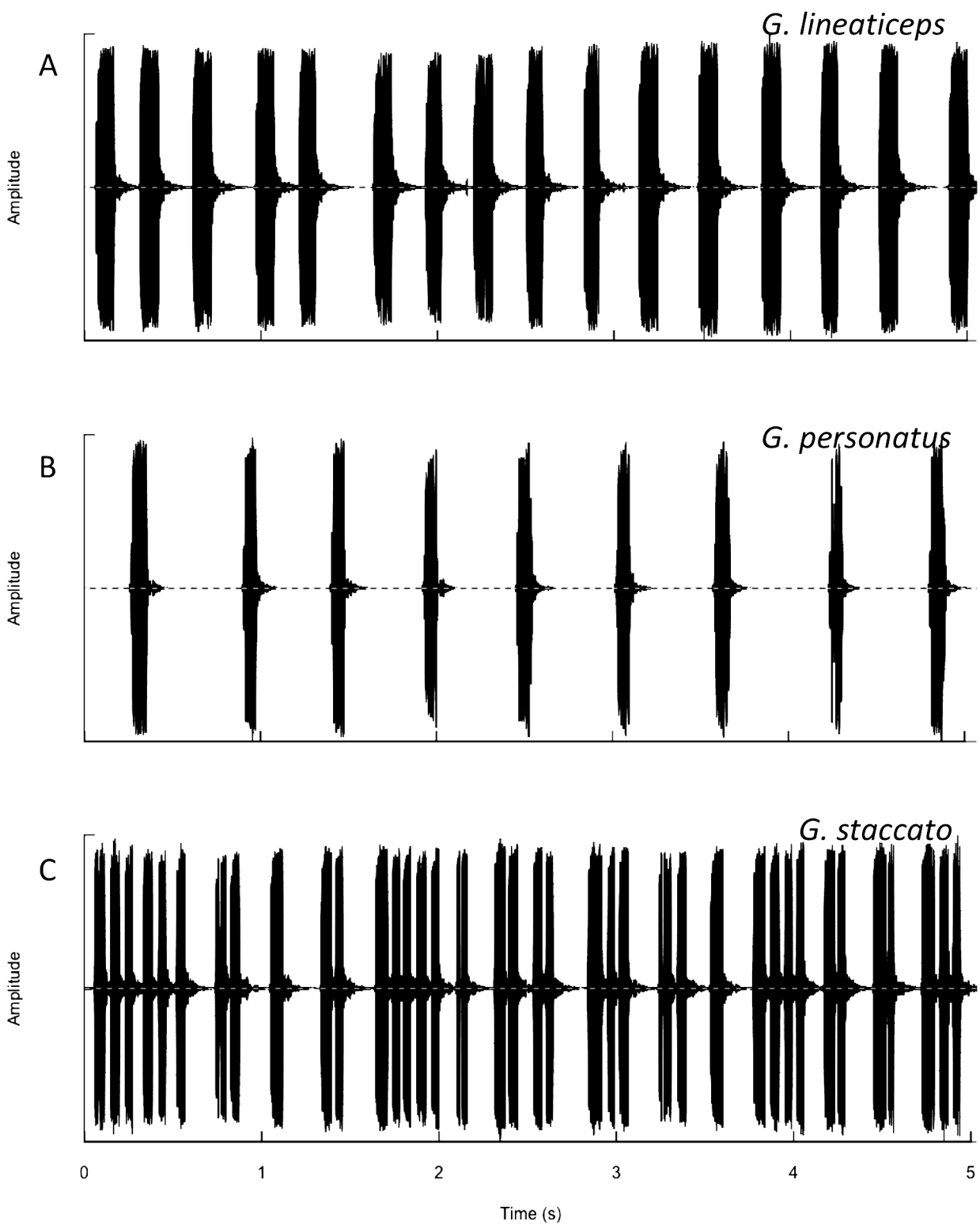


FIGURE 170. Five second waveforms of typical calling songs of (A) *G. lineaticeps*, (B) *G. personatus*, and (C) *G. staccato*. (A) *G. lineaticeps*: (R11-15) Mendocino Co., CA (S11-22), recorded at 24°C; (B) *G. personatus*: (R07-74) from Alpine, TX (S07-41), recorded at 25°C; (C) *G. staccato* (R15-291) from Gila Bend, AZ (S15-111), recorded at 25.1°C.

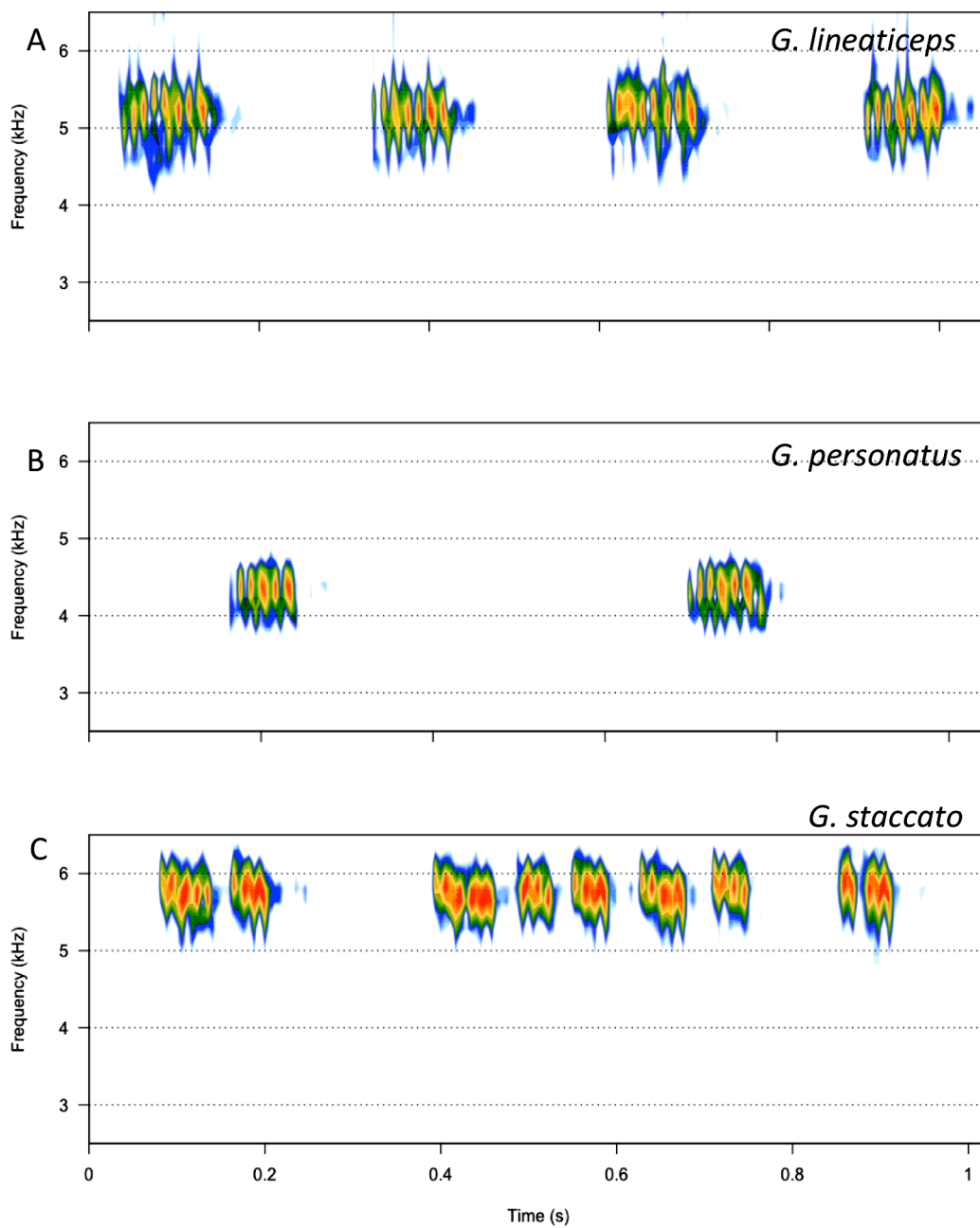


FIGURE 171. One second spectrograms of typical calling songs of (A) *G. lineaticeps*, (B) *G. personatus*, and (C) *G. staccato*, same males as in Fig. 170.

Type locality: California, San Francisco. Type female lost according to Alexander (1957). Neotype male (Fig. 175) designated by Weissman *et al.* (1980): "California, Santa Clara Co., Palo Alto, Stanford University campus, Lake Lagunita, 4-vii-1979. David B. Weissman," CAS Entomology type #13221. Body length 23.7 mm; right tegmen removed, file with 136 teeth, 3.9 mm long.

1977 'Gryllus III'. Weissman & Rentz (1977a).

1980 *Gryllus lineaticeps* Weissman *et al.* (1980).

1981 'Gryllus III'. Rentz & Weissman (1981).

'Gryllus #3' of DBW notebooks.

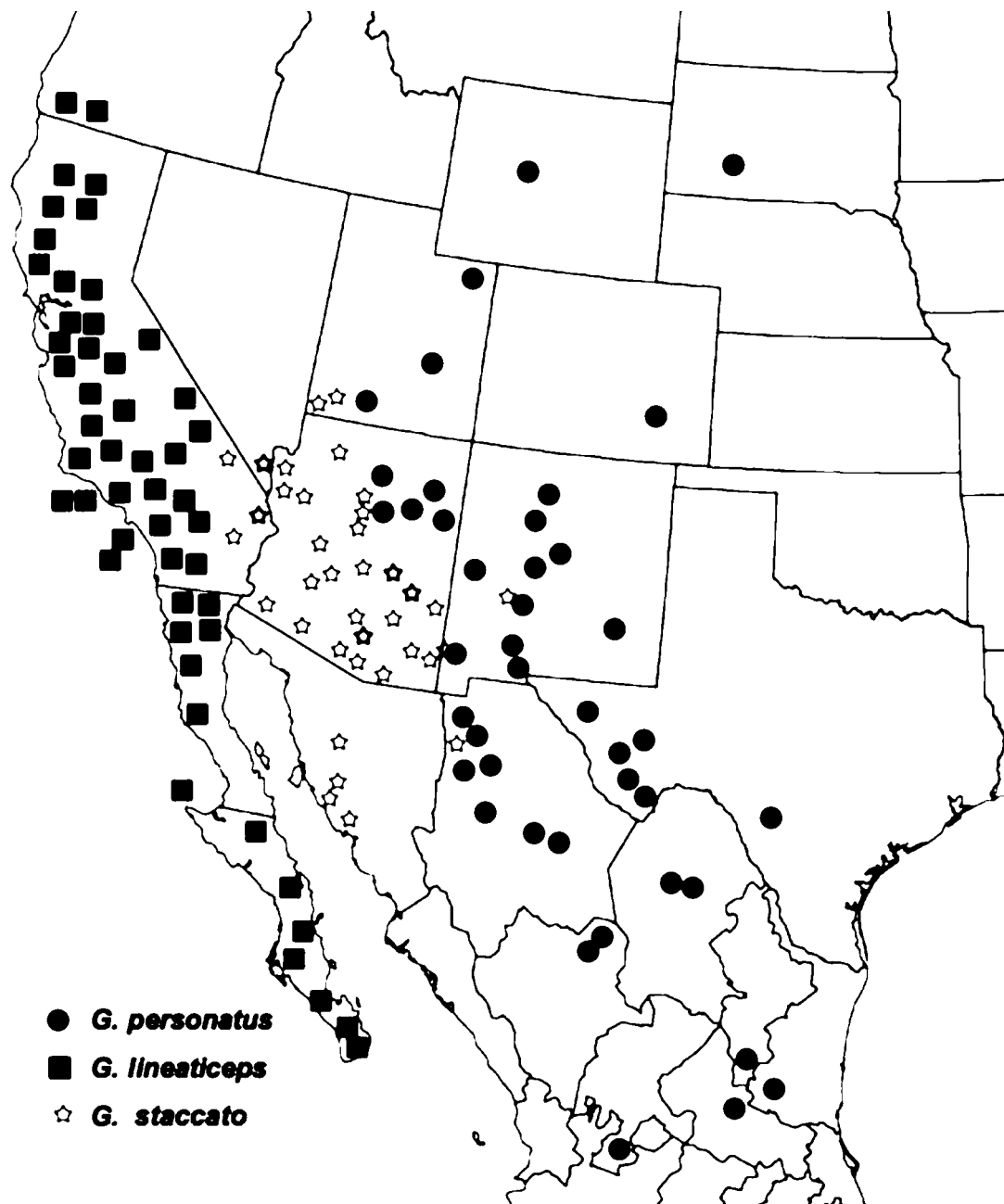


FIGURE 172. Known distribution (from Gray *et al.* 2016b) showing, basically, allopatric localities of the three Lineaticeps Group taxa.

Distribution. Restricted to southwestern Oregon, California (including all of the 8 California Channel Islands except San Miguel), and most of Baja California, Mexico.

Recognition characters and song. Medium to very large crickets (see Table 1, p. 18), widespread and ecologically diverse but prefer grassland habitats. *Song* (Fig. 176) loud, unique within its range: fast chirper, at 25°C, typically with 6 to 9 (range 5-11) pulses, frequently 150 to 250 chirps/min, pulse rate usually between 40-65 (range 32 to 83), dominant frequency 5 kHz. Two generations/year. Color variable, from red (Fig. 177) to black, within a population and between generations: first generation winter and spring adults usually darker (many black) than summer adults (many tan to reddish brown). Among western US taxa with a similar song, differs from sometimes sympatric *G. multipulsator* which has more pulses/chirp, slower chirp rate, dull (hirsute) pronotum and different microhabitat. Differs from allopatric sister species *G. personatus* which has a pale area around eye, longer ovipositor, slower chirp rate and essentially complete separation in dominant frequency (Fig. 173 and Gray *et al.* 2016b). Differs from allopatric sister species *G. staccato* which has variable pulses/chirp and faster pulse rate (Fig. 173 and Gray *et al.* 2016b).

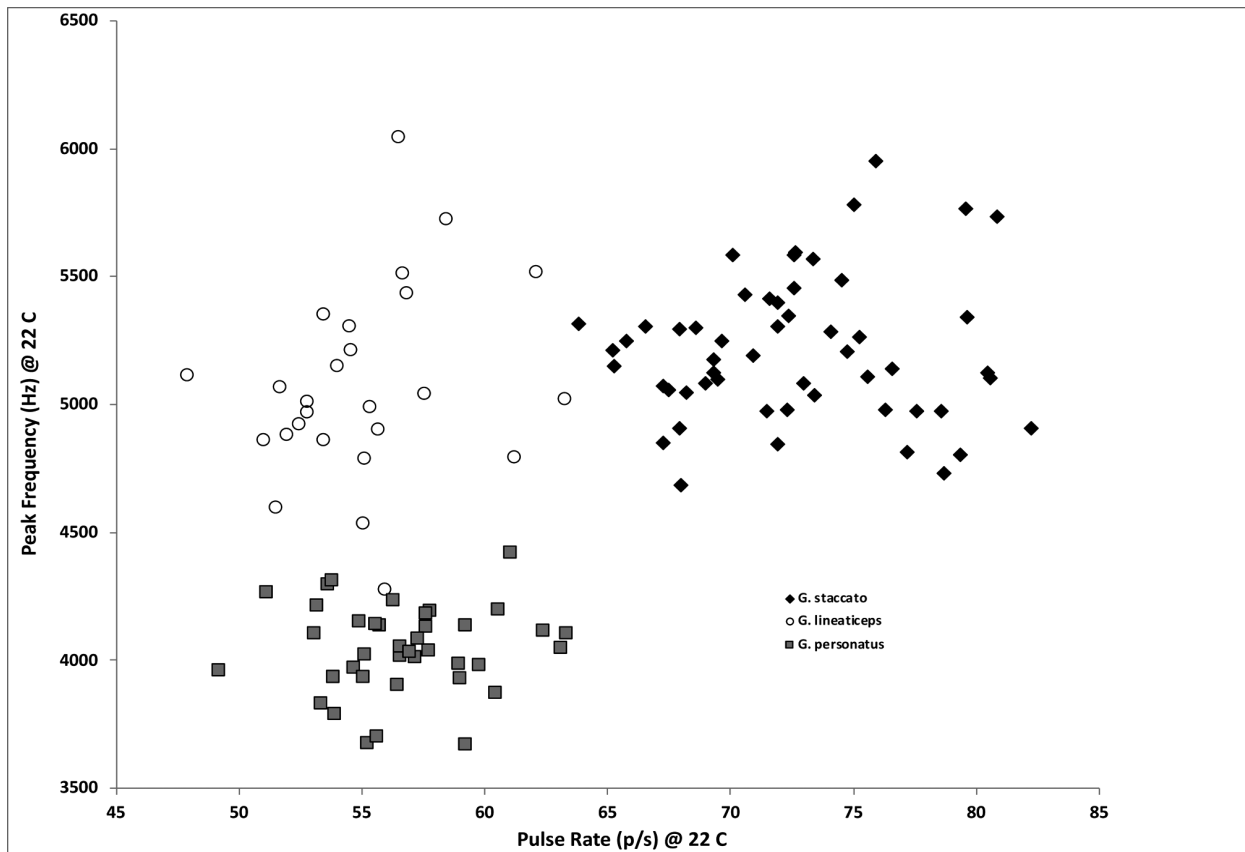


FIGURE 173. Separation of species within the Lineaticeps Group by song (from Gray *et al.* 2016b). Most points represent lab-reared individuals; therefore, it is possible that field-caught individuals (see Table 1, p. 18) would show somewhat less clear separation given known effects of developmental temperature on song in field crickets (Walker 2000).

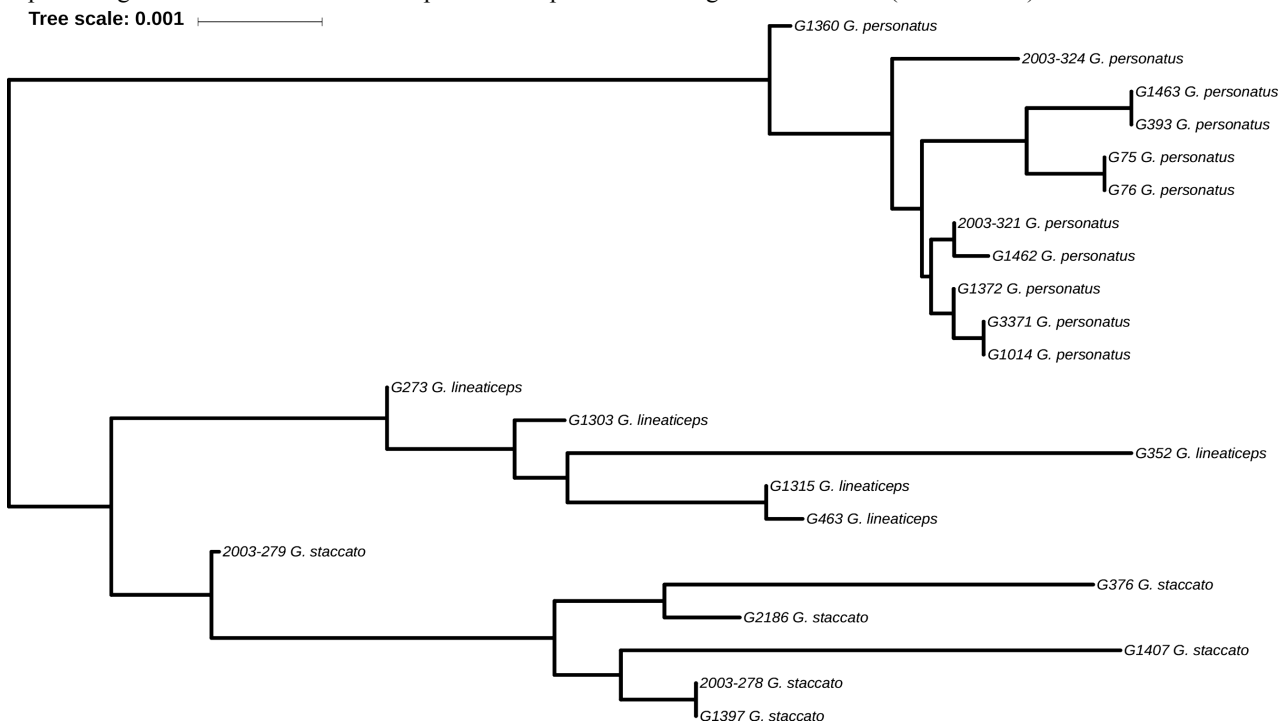


FIGURE 174. ITS2 gene tree. Collection stop numbers for *G. lineaticeps* samples: S00-15, Guadalupe Island, Mexico (G273); S04-64 (G352); S05-39 (G463); S09-28 (G1303); S09-37 (G1315). Collection stop numbers for *G. personatus* samples: S99-84, Durango, Mexico (G393); S03-127, from Coahuila, Mexico (G75, G76); S07-41 (G1014); S09-58 (G1372); S09-151, from near Janos, Mexico (G1462, G1463); S16-6 (G3371). Collection stop numbers for *G. staccato* samples: S04-121 (G376); S09-54 (G1397); S09-103 (G1407); S11-102 (G2186). See also Gray *et al.* (2016b).



FIGURE 175. Neotype male of *G. lineaticeps*, with labels.

Derivation of name. “line” = line; “ceps” = head or “lines on the head,” indicating that perhaps the lost holotype appeared as such. Second generation specimens (including the neotype, which is from Palo Alto, CA, or some 50 km south of the type locality), especially those light-colored individuals from hot, dry locales, frequently have dark, linear stripes on the head. This condition is also commonly found in the sister taxa *G. personatus* and *G. staccato* but is not restricted to these *Gryllus* species, or even to the genus *Gryllus* in the Gryllidae.

Geographic range. See Fig. 178. Generally west of the Sierra Nevada but individuals east of the Sierra Nevada collected at Mono Lake (S78-125), Lone Pine (S78-117) and in the Mohave Desert at Barstow (S98-58 & S98-77) and the town of Mohave (S05-117). Collected on all of the 8 California Channel Islands except for San Miguel.

Habitat. Easily the most common and loudest, low elevation, California summer grassland field cricket west of the Sierra Nevada. In winter and spring, late instars and newly molted adults of the first generation found under rocks and boards. In summer, males of the second generation sing from substrate cracks in grasslands, chaparral, coastal sage, oak-woodlands and around human habitation. Usually found below 1000 m elevation, but found over 2400 m in Mexico (Weissman *et al.* 1980).

Life cycle and seasonal occurrence. No egg diapause (checked from Santa Clara Co., CA, S92-44) in either generation. Two generations/year (as least as far north as Santa Clara Co.). Overwinters as late instars with first adults in warmer parts of southern California singing during daytime as early as December. On 17-xii-1996, a few newly molted adult males and females, plus hundreds of late instars, found at California, Monterey Co., Hwy 198 at mile post 15.0 (S96-111), 411-457 m elevation. Second generation numbers larger with adult males heard starting in early summer. Unknown if a second generation occurs in northern California and southwestern Oregon localities.

Variation. Color (see Fig. 177): body, pronotum, head, wings, and hind femur usually variable between black to red within individuals at one locality. First generation individuals usually dark. Second generation, especially from dry, hot areas like the Central Valley, usually more reddish. Beach specimens generally light colored all over. **Pulses/chirp.** One male (San Clemente Island, R18-16, S18-24) with 11 pulses/chirp, more than seen elsewhere for

this taxon. **Wing length:** Variable. Of 80 males, 16 had long hind wings. Of 60 females, 18 had long hind wings including all 10 females collected from California, Fresno Co., Coalinga (S98-86), 29-vii-1986.

Specimens of note (mostly from edges of distribution). Complete locality list not given because *G. lineaticeps* is common and widely distributed wherever it occurs.—**CALIFORNIA:** *El Dorado Co.*, Finnon Reservoir, 29-iii-2005, 2340' (S05-39). *Fresno Co.*, Coalinga, 29-viii-1998 (S98-86); Jacalitos Canyon, 29-viii-1998 (S98-82 & 98-83). *Inyo Co.*, Lone Pine, 5-viii-1978 (S78-117). *Kern Co.*, Mohave, 1-ix-2005 (S05-117); Tehachapi, 28-v-2009, 3320' (S09-28). *Mendocino Co.*, 4 m E Longvale, 2-viii-1980, 1000' (S80-59). *Mono Co.*, Mono Lake, 7-viii-1978 (S78-125). *San Bernardino Co.*, Barstow, 16-viii-1998, 2420' (S98-58) & 21-viii-1998 (S98-77). *San Joaquin Co.*, Tracy, 52', 10-ix-2016, RE Espinoza. *San Mateo Co.*, Stanford University's Jasper Ridge Biological Preserve, 2-v-1992 (S92-44). *Shasta Co.*, Shasta Dam, 4-viii-1980 (S80-66). *Yolo Co.*, I5 near intersection Hwy 505, 19-viii-2006, 130' (S06-77). **OREGON:** *Jackson Co.*, Emigrant Lake Recreational Area, 27-vii-1992, 1800' (S92-82). Hwy 66 ~12 m E I5, 2900', 27-vii-1992. *Josephine Co.*, Hugo, 25-vi-1978, D.C. Lightfoot.

DNA. Multilocus 2016-033 (Tracy, CA). Two sister species (Gray *et al.* 2019) are *G. personatus* (multilocus G1357 from Otero Co., Colorado) and *G. staccato* (multilocus 2016-034 from Yavapai Co., AZ). 16S and ITS2 (Fig. 174) gene trees yields nice separation from sister species *G. personatus* and *G. staccato*. In our early work, CO1 gave less clear separation between species, but also showed highly suspect signs of pseudogene amplification.

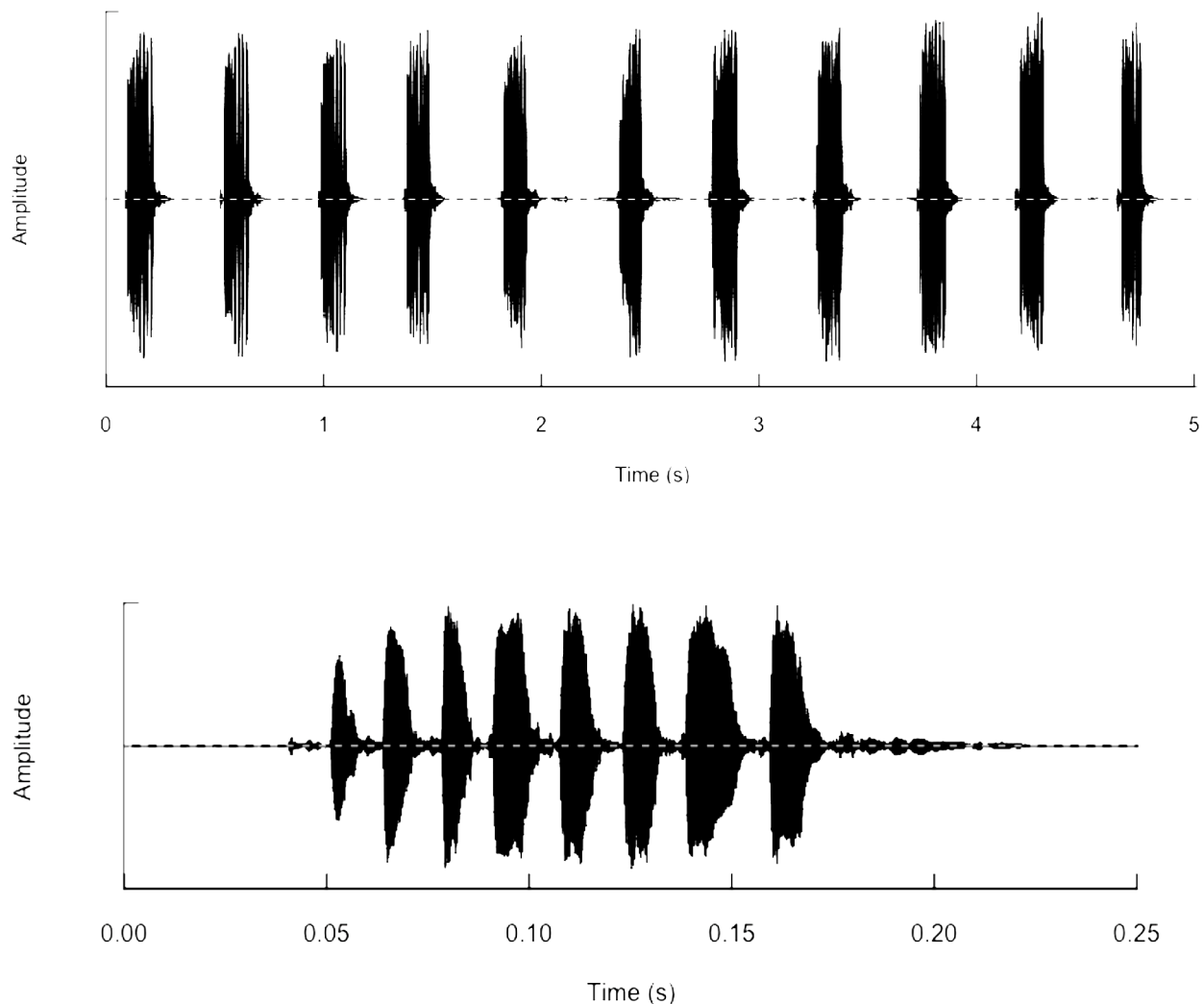


FIGURE 176. Calling song (R11-15) of *G. lineaticeps* from Mendocino Co., CA (S11-22), recorded at 25°C; lower panel shows structure of a single chirp.

Discussion. An ecologically diverse and morphologically variable species, although song, file characters and DNA consistent for one species. Responsible for periodic outbreaks in California's Central Valley with documented episodes in Coalinga as follows: 1967, R.E. Love, pers. comm.; Lindgren (1978); Caruba (1980), and DBW (un-

publ.) on 28-vii-1998; where millions of macropterous, flying individuals can become a summer nuisance. This is probably the species responsible for the outbreak in Knightsen, Contra Costa Co., CA, in 2001 (<https://www.sfgate.com/bayarea/article/Knightsen-crawling-with-crickets-Vacuums-2872987.php>).

Those summer males singing from grassland cracks are usually impossible to flush with water given the extensive nature of the cracks. Oatmeal trails there will usually attract females and occasionally males.



FIGURE 177. Color variation in *G. lineaticeps*: Reddish male (A) and female (C) from Madera Co., CA (S15-91); black male (B) from Tuolumne Co., CA (S10-13).

Not all *Gryllus* species with long hind wings are good flyers. *G. lineaticeps* seems to be a very capable flyer as evidenced by its presence on seven of eight California Channel Islands (Weissman *et al.* 1980), and Cedros and Guadalupe Island, Mexico, the latter some 240 km west of the Pacific coast of Baja California (DBW, unpubl.), although other means of colonization are possible.

This species has been the subject of a series of studies of sexual communication, e.g. Hoback & Wagner (1997), Wagner & Harper (2003), Wagner & Basolo (2007a), and Tolle & Wagner (2011) as well as studies of tachinid fly parasitism, e.g. Gray *et al.* (2007), Wagner & Basolo (2007b), Martin & Wagner (2010), Paur & Gray (2011a), and Beckers & Wagner (2012, 2018), and female reproductive benefits (Wagner 2005).

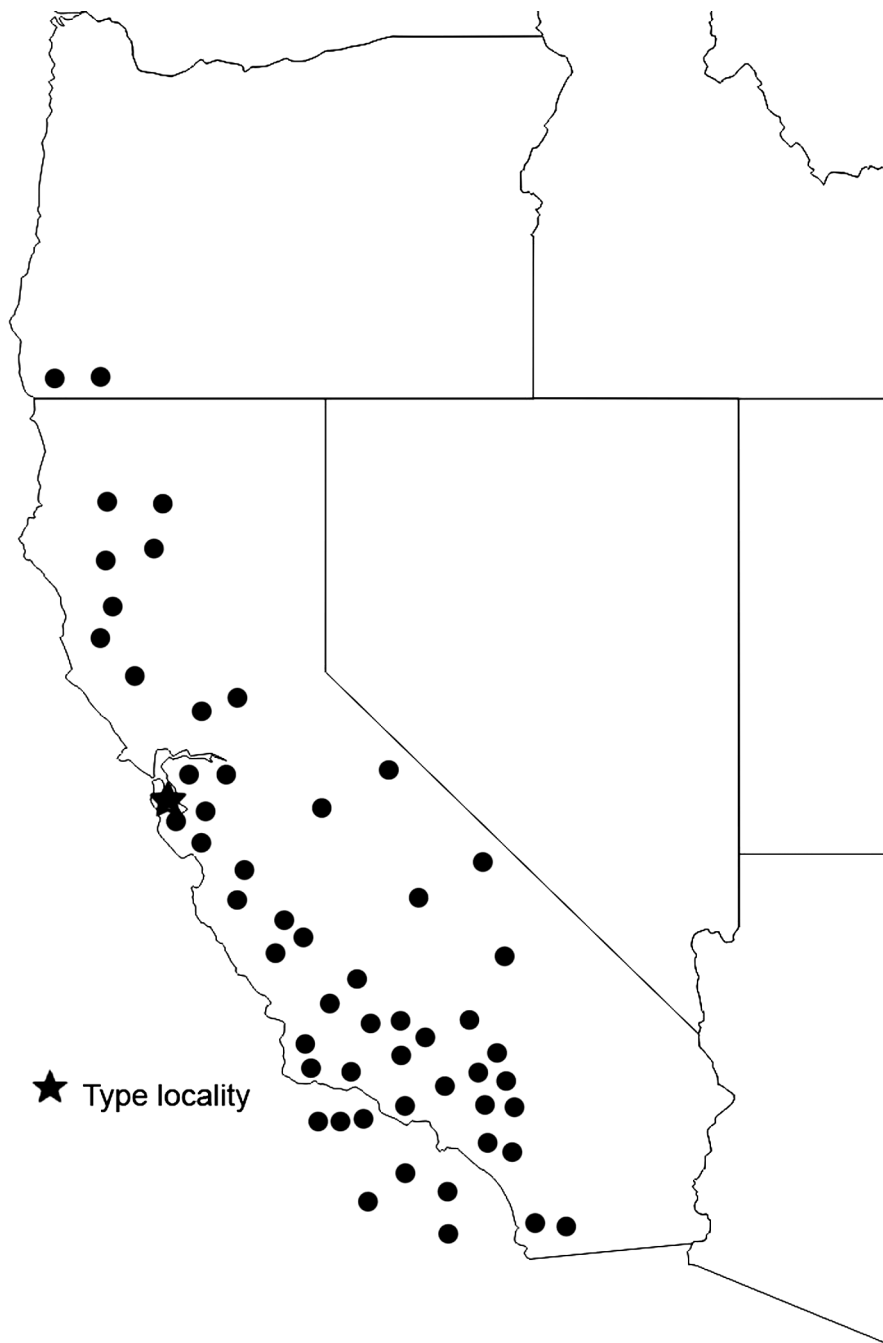


FIGURE 178. Known US distribution of *G. lineaticeps*.

***Gryllus personatus* Uhler**

Badlands Field Cricket

Figs 170–174, 179–182, 185, Table 1

1864 *Gryllus personatus* Uhler, Proc. Ent. Soc. Philadelphia 2: p. 547. Type locality: Kansas. Holotype female (Fig. 179): “Collection of P. R. Uhler. *Gryllus personatus*_Kans. Uhler. Red type label, 14066.” In addition, there is a pink circular label without writing. Deposited at ANSP. Body length 14.6 mm, hind femur length 10.3 mm, pronotum 3.5 mm long and 5.3 mm wide. Holotype is a shriveled female once preserved in alcohol but now pinned. The head and pronotum are brown, area below eye straw brown or cream, short traverse band between the eyes, fastigium of vertex with three prominent straw brown streaks, entire lateral pronotal lobe straw brown, all legs uniform straw brown. The tegmina are darker yellow brown and almost reach the tip of the abdomen. Ovipositor curved and longer than hind femur.

‘Gryllus #17’ of DBW notebooks.



FIGURE 179. Holotype female of *Gryllus personatus*, with labels.

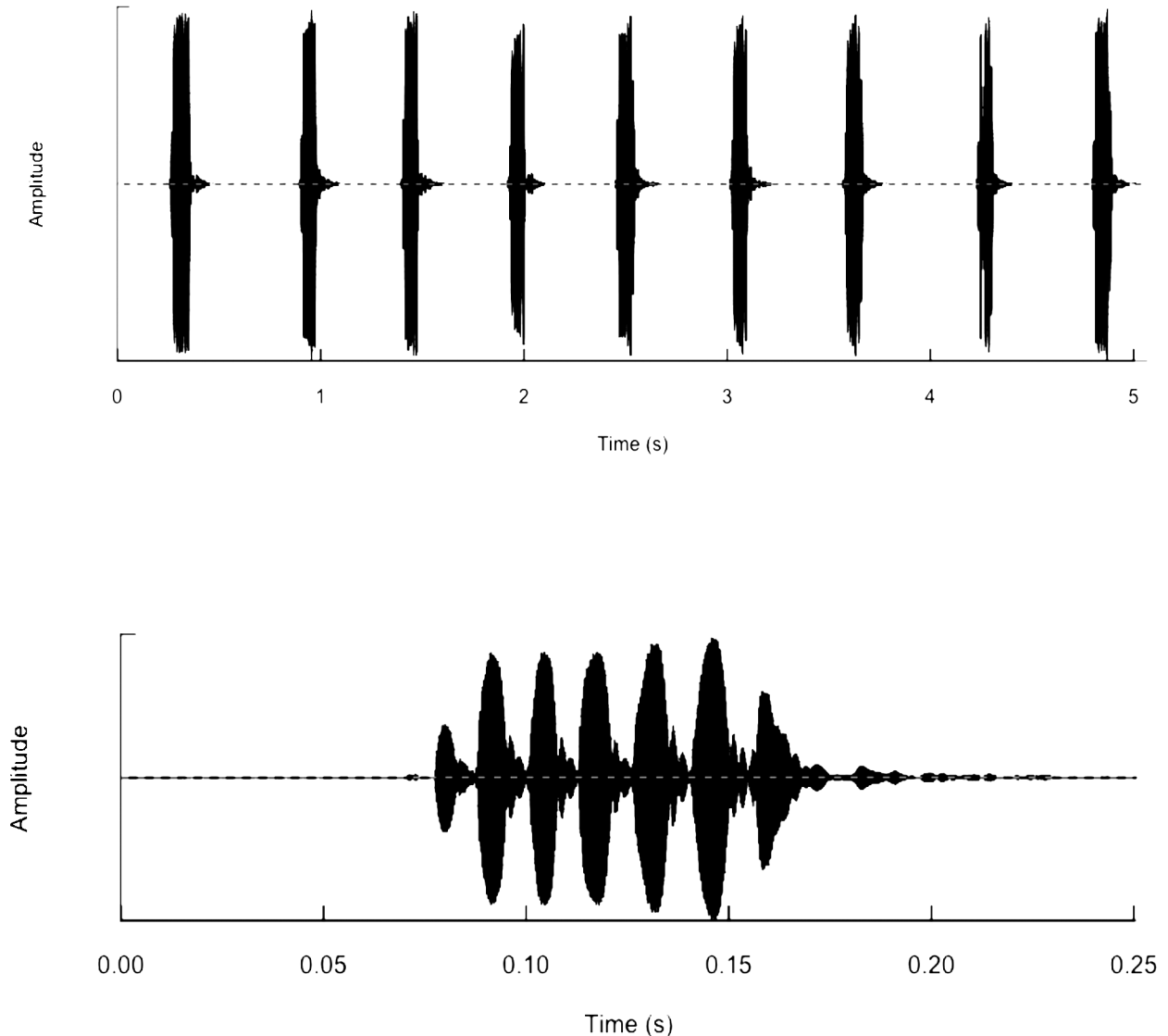


FIGURE 180. Calling song (R07-74) of *G. personatus* from Alpine, TX (S07-41), recorded at 25°C; lower panel shows structure of a single chirp.

Distribution. Known from seven western US states (see Fig. 181) and adjacent Mexico.

Recognition characters and song. Medium to very large crickets (see Table 1, p. 18). *Song* (Fig. 180, R07-74), at 25°C, unique within its range: chirps typically with 5-8 pulses, although all three males from Brackettville, TX, (S10-63), had 4 p/c. Usually from 100 to 180 c/m, pulse rate usually between 50-70 (range 48-91), dominant frequency 4 kHz. Probably two generations/year in southern distribution. Among western US taxa with similar songs, differs from sympatric (at Brackettville and Big Bend, Texas) *G. assimilis* that has a slower CR, more p/c, dull (hirsute) pronotum, inhabits moister areas such as lawns, and almost no light brown/straw colors on body. Differs from more western allopatric sister species *G. lineaticeps* which has a faster CR, higher dominant frequency (Fig. 173 and Gray *et al.* 2016b) and lacks cream colors on the head or body. Differs from usually allopatric sister species *G. staccato* that has variable p/c, a faster pulse rate and chirp rate, a higher dominant frequency (Fig. 173 and Gray *et al.* 2016b), a shorter ovipositor (Table 1, p. 18), more file teeth and teeth/mm, and occurs in hotter, dryer areas. Some male *G. staccato* can have very uniform number of pulses/chirp but can be separated from similar sounding *G. personatus* by the presence of some chirps with variable number of pulses. *G. personatus* and *G. staccato* have been found microsympatric only at the abandoned gas station at Road Forks, New Mexico (S81-38) near the southeastern Arizona border. Even there, separated by microhabitat as *G. staccato* within the confines of the abandoned gas station while *G. personatus* is in cracks in the clay-soil fields surrounding the gas station. Both taxa can have

linear head stripes, cream colored areas completely around the eyes frequently extending onto the lower, adjacent half of pronotum, and speckles on face between eyes. *G. personatus* usually at higher elevations.

Derivation of name. “persona” = mask; “tus” = having the nature of, which nicely describes the similarity seen in the holotype and many of our specimens that have facial and pronotum markings as seen in Fig. 179.

Geographic range. Fig. 181. Known from east and west of the Rockies from 335–2005m. Despite much collecting effort in the type locality of “Kansas,” we have not found this species there. It does occur near the western Kansas border at La Junta, Colorado (S09-82). Given the amount of land usage change in Kansas in the 150 years since the type was described, its absence in that state is not surprising. Fortunately, the distinctive coloration and color pattern of the holotype female leave us confident that this ID is correct. While we document 6 species of *Gryllus* in Kansas, none look like the holotype of *G. personatus*.

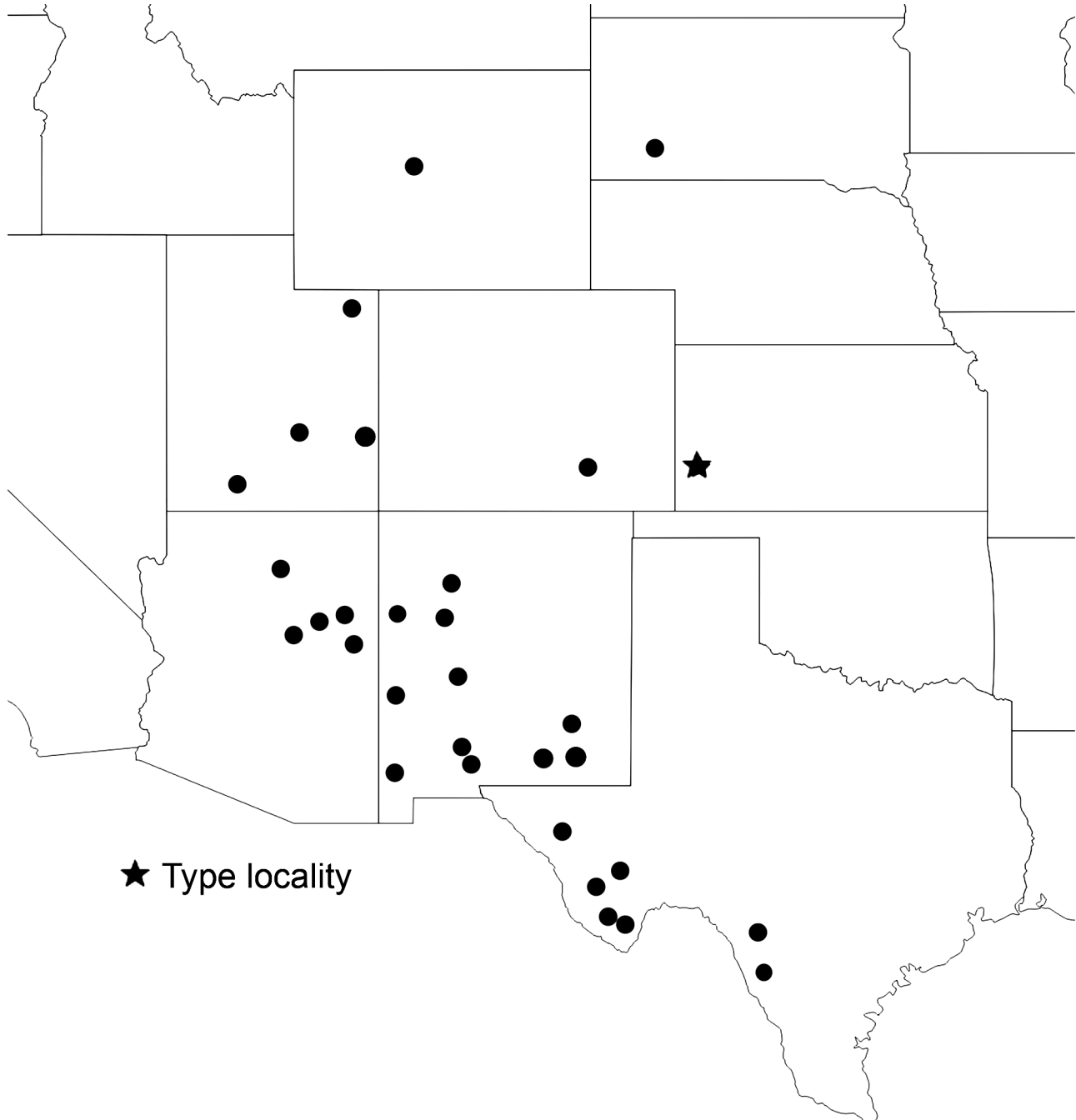


FIGURE 181. Known US distribution of *G. personatus*.

Habitat. When far from human habitation, this cricket frequently associated with clay-type badlands (Road Forks, NM, S81-38; near Dinosaur National Monument, CO, S99-128; and Badlands National Park, SD, S09-89), usually living in deep cracks and the only *Gryllus* resident there, except at Badlands where it occurs with *G. mak-*

hosica. Found within ~100 meters of *G. saxatilis* in San Juan Co., UT (38.399167, -109.401148, on 26-v-2017), but separated by microhabitat (clay soils v. rocky slope). Also occurs around human structures in towns away from clay soils.

Life cycle and seasonal occurrence. No egg diapause (checked from Las Cruces, NM, S83-103; and Tom Green Co., TX, S88-31). Probably 2 generations/year in southern distribution (e.g. Big Bend, Texas [S85-39]), but undoubtedly one generation in Badlands National Park, South Dakota. Adults known from mid-March into September but we have not collected areas where it could occur outside of this time period.

Variation. Color: Variable from light colored bodies, frequently with linear head stripes (Fig. 182) similar to those seen in *G. staccato*, to individuals almost pure black except for a light-colored patch below the eyes (Fig. 182) as seen in one male from Badlands National Park, SD, S93-53 and one female from Alpine, TX, S07-41). Females can have a light tegminal stripe along the fore wing angle (Fig. 182). **Pulses/chirp:** see "Discussion". **Wing length:** Of 155 individuals of both sexes, 56 had long hind wings.



FIGURE 182. Color variation in *G. personatus*, moving left to right: Navajo Co., AZ (S91-86); Navajo Co., AZ (S91-88); Navajo Co., AZ (S91-86); Tom Green Co., TX (S88-31); Alpine, TX (S07-41).

Specimens examined. Arizona. Coconino Co., 3.1 m SE Yuba City, 4800', 6-viii-1991 (S91-82), 1♀. Hwy 99 6.85 road m NW intersection US 40, 4900', 8-viii-1991 (S91-89) 1♀. *Navajo Co.*, Holbrook, 5080' 8-ix-1999 (S99-116) 1♂. Winslow, 4852', 10-viii-2003, 10♂ 9♀; 10-viii-2010, 4♂ 9♀; 27-vii-2012, 6♀. Hwy 77 0-12 m N US40, 5400', 7-viii-1991 (S91-86) 5♂ 5♀. Hwy 180 1 m S entrance Petrified Forest National Park, 5400', 8-viii-1991 (S91-88) 1♂; 8-ix-1999 (S99-114) 1♀. **Colorado. Crowley Co.,** Manzanola, 4200', 26-viii-1989 (S89-65) 1♂ 3♀. *Huerfano Co.*, 10 m E Walsenburg, 5800' 22-vi-1987 (S87-64) 1♂ 1♀. *Otero Co.*, La Junta 4100', 2-vii-2009 (S09-82) 2♂ 6♀. *Pueblo Co.*, Hwy 96 between Fowler and Hwy 50, 4300-4600', 26-viii-1989 (S89-64) 1♂. **New Mexico. Chaves Co.,** Roswell, 28-vi-2009 (S09-58) 2♂. *Cibola Co.*, Grants, 6340' 1-vii-1994 (S94-43) 2♂. *Dona Ana Co.*, Las Cruces, 26-vi-1983 (S83-103) 5♂ 2♀; Las Cruces, University New Mexico, 23-viii-1982 (S82-99) 2♂. *Eddy Co.*, Artesia, 3428', 30-vi-2015 (S15-58) 1♂ 1♀. Hope, 4095' 30-vi-2015 (S15-57) 1♂ 1♀. *Hidalgo Co.*, Road Forks, 4000', 29-vii-1981 (S81-38) 2♂. *McKinley Co.*, Gallup, 2005m, 27-vii-2003, 35° 31' 56.9" -108° 39' 57.8 (DAG2003-31) 1♂. *Sandoval Co.*, San Ysidro, 5600' 6-vi-1985 (S85-51) 1♂. *Socorro Co.*, Socorro 4460' 13-vi-2007 (S07-50) 3♂ 2♀; 29-vi-2015 (S15-54) 1♂ 1♀. **South Dakota. Jackson Co.,** Badlands National Park, Big Badlands Overlook, 3100', 22-vi-1993 (S93-53) 12♂ 3♀; 30-vii-1997 (S97-90) 1♂. Cedar Pass, 2700' 29-viii-1989 (S89-75) 1♂; 3-vii-2009 (S09-89) 4♀. **Utah. San Juan Co.,** Blackridge, 3.1 m E Hwy 191, 5849', 38.399167, -109.401148, 26-v-2017, 1♀. *Uintah Co.*, Hwy 149 1 m S entrance Dinosaur National Monument, 5000' 10-ix-1999 (S99-128) 1♂. *Washington Co.*, W border of Zion National Park, 4060' 10-vi-1996 (S96-55) 1♂ 1♀. *Wayne Co.*, Hanksville, 4500' 1-viii-1992 (S92-109) 1♂. **Texas. Brewster Co.,** Alpine, 4200', 5-vi-1991 (S91-44) 1♂ 3♀; 12-vi-2007 (S07-41) 6♂ 4♀. Big Bend National Park, Rio Grande Village, 2100' 11-iii-1985 (S85-39) 4♂ 4♀; 9-vi-1985 (S85-56) 4♂ 2♀; 5-vi-1991 (S91-43) 2♂ 2♀; 28-v-2016 (S16-12) 5♂ 6♀. 12 m SW Marfa, 19-viii-1984 (S84-53) 1♂. Hwy 118 near Terlingua, 2566' 2-vii-2015 (S15-71) 5♂ 2♀. *Culberson Co.*, Van Horn, 4100' 6-vi-1991 (S91-48) 5♂ 2♀. *Dimmit Co.*, 19-viii-1964, TJ Walker, 2♂. *Kinney Co.*, Brackettville, 1160' 7 and 8-ix-2010 (S10-63) 4♂ 6♀. *Presidio Co.*, Presidio, 2400' 26-vi-1986 (S86-46) 1♂; 27-v-2016 (S16-5, 6) 2♂ 2♀. *Tom Green Co.*, near junction Hwy 277 and 67, 1900' 11-vi-1988 (S88-31) 2♂ 1♀. **Wyoming. Fremont Co.,** Shoshoni, 4849', 18-vii-2011 (S11-72) 1♂.

DNA. Multilocus G1357, La Junta, CO, S09-82. Two sister species are *G. lineaticeps* (multilocus 2016-033) and *G. staccato* (multilocus 2016-034) (Gray *et al.* 2019). 16S DNA groups all 3 species together (also see Gray *et al.* 2016b).

Discussion. *G. personatus* typically has between 5-8 p/c, except for the 3 collected males from Brackettville, Texas (S10-63), its most eastern locality, where each had 4 p/c. *G. assimilis* has similarly spaced chirps but with 6-9 p/c, and it is generally separated ecologically from the former. We initially wondered if calling-song character displacement might be operative in reducing the p/c in this Brackettville *G. personatus* population? We subsequently discovered both species also sympatric at Rio Grande Village (S16-12) in Big Bend National Park, TX, where *G. assimilis* sang its typical song and the 5 recorded males of *G. personatus* had 6-7 (range 5-8) p/c.

G. personatus has been used in several recent investigations: Gray *et al.* 2016b, Gabel *et al.* 2016, Hennig *et al.* 2016, Blankers *et al.* 2016.

***Gryllus staccato* Weissman & Gray, n. sp.**

Stutter-Chirping Field Cricket

Figs 170–174, 183–188, Table 1

‘*Gryllus* #15’ in DBW notebooks.

‘G15’ and irregular chirping cricket in Sakaguchi & Gray 2011, Blankers *et al.* 2016.

‘*G. staccato*’ in Gray *et al.* 2016b, Gabel *et al.* 2016, Hennig *et al.* 2016.

Distribution. Arizona and adjacent deserts of California, Nevada, Utah, and New Mexico.

Recognition characters and song. Most variable calling song of any US *Gryllus*. A medium to large sized cricket with a shiny pronotum generally at low elevations in some of the hottest, driest desert areas of the southwestern US, including most of Arizona (except for the northeast corner). **Song** loud, unique for New World *Gryllus*: many individuals produce a highly irregular “stuttered” series of chirps (Fig. 183, R15-291) with high variability in inter-chirp interval. Chirps at 25°C with variable p/c (typically 3-9; range 1 to 10), variable CR (typically 120-240; range 100-720) depending on p/c and inter-chirp interval, pulse rate 70-110, dominant frequency 5.25 kHz. Within most populations, 10 to 60% of males sing with a more or less constant number of p/c and uniform inter-chirp interval (Fig. 184A, R11-124) with some males (see Fig 184B, R09-147) singing both regular and irregular segments. Color usually light (Fig. 186) but dark individuals (Fig. 187) known even in summer. If male singing irregular stutter-chirp song, then can be confused with no other US *Gryllus*. If singing with constant p/c and uniform inter-chirp intervals in the Southwestern US, then only has to be distinguished from *G. lineaticeps*, *G. personatus*, and *G. multipulsator*. From allopatric sister species *G. lineaticeps*, no overlap in distribution (Fig. 172), DNA (Fig. 174), and pulse rate (Fig. 173). From allopatric sister species *G. personatus*, which it most closely resembles morphologically and which it geographically broadly overlaps in only north-central Arizona and SW New Mexico (but has been only found microsympatric with *G. personatus* at Road Forks [S81-38 and S12-104] and Socorro [S07-50], New Mexico), *G. staccato* is distinguished by a combination of characters (Table 1, p. 18): more file teeth and more teeth/mm on average, shorter ovipositor relative to body size (Fig. 185), microhabitat different (dirt substrate vs. clay substrate), although both can occur at gas stations that have bright night lights, no overlap in dominant frequency (Fig. 173), irregular pulses/chirp, faster PR and CR, and differences in DNA. Both taxa can have linear head stripes, cream colored areas completely around the eyes frequently extending onto the lower, adjacent half of pronotum, and speckles on face between eyes. *G. personatus* usually at higher elevations. From *G. multipulsator*, which it overlaps in distribution in southeastern CA, southern NV, and west-central AZ, the latter has more p/c, slower CR and a hirsute (dull) pronotum and general absence of linear lines on the head.

Holotype. Male (Fig. 186). USA. Arizona, Pima Co., Ajo. 1-viii-2009. 520m. D.B. Weissman. S09-102, R09-149, DNA sample G1410. 16S ribosomal RNA gene GenBank accession # MN136664. Body 25.3, HF 12.88, LC 13.09. Right tegmen removed: 149 teeth, file length 3.45, TL 14.8, TW 4.6. Type deposited in CAS, Entomology Type #19271.

Paratypes. (Total: 132♂ 109♀) **Arizona.** *Cochise Co.*, Benson, 1240m, 27-vi-2009 (S09-54) 1♂. Wilcox Playa, 4155', 29-vii-2015 (S15-104) 32° 11' 55.5" -109° 52' 42.4", 2♂ 1♀. *Coconino Co.*, Sedona, 4400', 25-vi-1980 (S80-45) 4♂; 15-vi-1990 (S90-49) 1♂; 30-vi-1994 (S94-35) 1♂; 12-vi-1996 (S96-61, at airport) 1♀; 15-vi, 2007 (S07-61) 1♂ 5♀. *Gila Co.*, Coolidge Dam, 2400', 30-vii-1981 (S81-43) 2♂. Globe, 3548', 30-vii-1981 (S81-44)

3♂. *Graham Co.*, Safford, 2920': 16-vi-1990 (S90-51) 6♂ 1♀; 28-vii-2015 (S15-103) 1♂ 2♀. 4.5m S Safford, 3180', 10-vi-2012 (S12-20) 1♀. Hwy 366 near intersection with Hwy 191, 3333', 28-vii-2015 (S15-102) 4♂ 2♀. *La Paz Co.*, Wenden, 550m, 14-ix-2011 (S11-87) 2♂ 2♀. *Maricopa Co.*, Aguila 2100' 23-vii-1990 (S90-71) 2♂ 2♀. Buckeye, 260m, 18-ix-2011 (S11-102) 5♂ 6♀. Gila Bend, 220m: 31-vii-1981 (S81-47) 1♂ 4♀; i-viii-2009 (S09-103) 2♂ 2♀; 18-ix-2011 (S11-101) 2♂; 30-vii-2015 (S15-111) 28♂ 23♀. Goodyear, 31-vii-1981 (S81-46) 1♂. Phoenix, 30-vii-2015 (S15-113) 1♂ 1♀. *Mohave Co.*, Hwy 68 2m E California border, 1000', 24-vi-1980 (S80-38) 1♂. Kingman, 3700', 2-viii-1992 (S92-113) 3♂ 2♀; 16-vi-2007 (S07-68) 1♂. 3 m SE Kingman on road to Hualapai Mt. Park, 3950', 3-viii-1991 (S91-67) 5♂ 2♀. *Pima Co.*, Ajo, 540m, 20-viii-1998 (S98-72 & 74) 7♂ 3♀; 15-v-1999 (S99-26) 1♂; 17-ix-2011 (S11-99) 2♂ 1♀; 29-vii-2015 (S15-109) 1♂ 2♀. Catalina, 2940', 18-viii-1998 (S98-65) 2♂ 10♀. Robles Junction, 29-vii-2015 (S15-106) 1♀. Hwy 286 6.3 m S Robles Junction, 1100m, 17-ix-2011 (S11-95) 2♂ 1♀. Hwy 86 10.5 m W Hwy 286, 850m, 17-ix-2011 (S11-97) 3♂ 1♀. Sells, 29-vii-2015 (S15-107) 1♂ 2♀. Tucson, 930m, 27-vi-2009 (S09-53) 5♂ 2♀. Saguaro Rd into Tucson, 2200-2900', 28-vii-1981 (S81-35) 8♂ 3♀. Why, 1740', 20-viii-1998 (S98-71) 4♀. *Pinal Co.*, Picacho Peak State Park, 1780', 18-viii-1998 (S98-66) 1♂. *Yavapai Co.*, Agua Fria Nat. Monument, 1130m, 19-ix, 2011 (S11-105) 1♂ 8♀; 12-vi-2012 (S12-24) 1♀. Camp Verde, 22-viii-2012, (S12-107) 1♀. Cordes Junction, 1100m, 18-ix-2011 (S11-103) 2♂. *Yuma Co.*, Telegraph Pass, 210m, 15-ix-2011, (S11-92) 1♂. Yuma, Arizona Western College, 200', 18-vi-1990 (S90-54) 1♂ 1♀. **California.** *San Bernardino Co.*, Essex, 5.1 m W, 1500', 21-viii-1998 (S98-76) 1♀. Havasu Lake, 140': 6-vi-1983 (S83-62) 1♂ heard; 13-xi-2011 (S11-84) 3♂. **Nevada.** *Clark Co.*, Cottonwood Cove: 750', 24-vi-1980 (S80-36) 1♀; 26-vii-1981 (S81-31) 1♂. **New Mexico.** *Hidalgo Co.*, Road Forks, 4195', 29-vii-1981 (S81-38) 1♂; 21-viii-2012 (S12-104) 5♂ 9♀. **Utah.** *Washington Co.*, Hurricane, 1040m, 20-iv-1999 (S99-12) 1♂. La Verkin, 1040m, 11-ix-2004 (S04-121) 3♂.

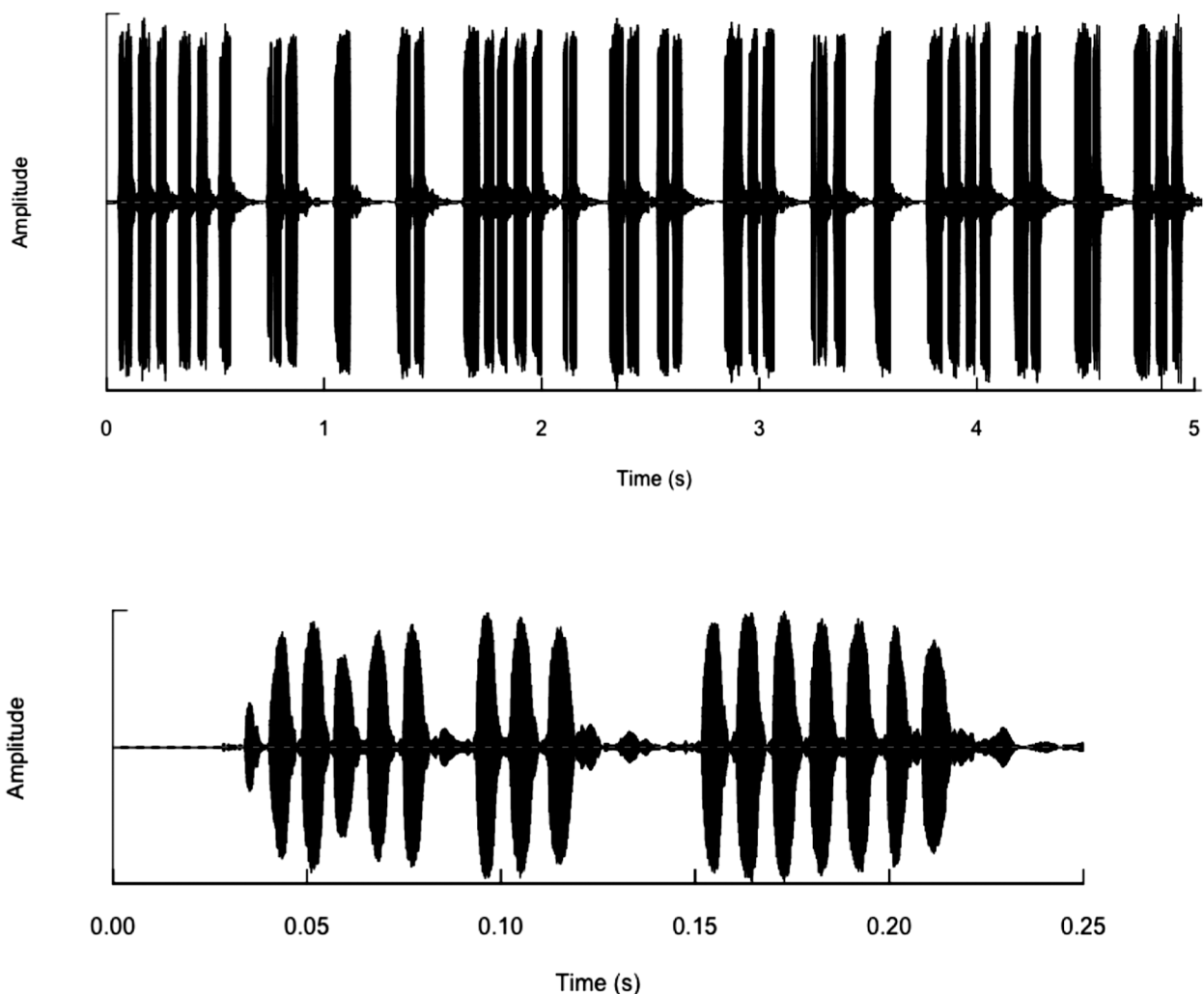


FIGURE 183. Typical (upper panel), irregular calling song (R15-291) of *G. staccato* from Gila Bend, AZ (S15-111), recorded at 25.1°C. Lower panel shows more detailed structure of the 'stutter-chirp'.

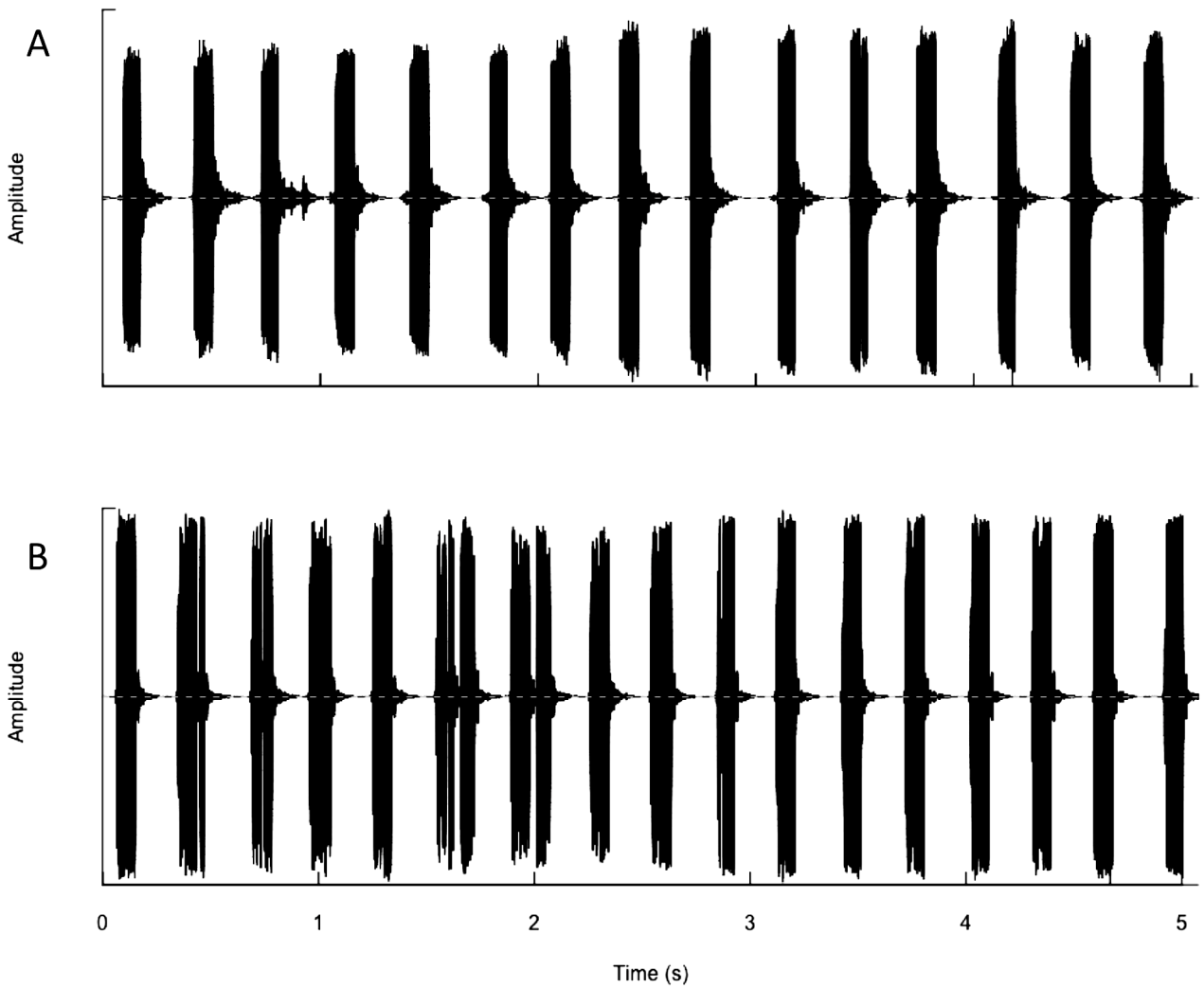


FIGURE 184. (A). Regularly spaced calling song (R11-124) of *G. staccato* from Buckeye, AZ (S11-102), recorded at 26°C. (B) Calling song (R09-147) of *G. staccato* from Tucson, AZ (S09-53), recorded at 27.5°C showing both regular and irregular spacing of chirps within the same individual.

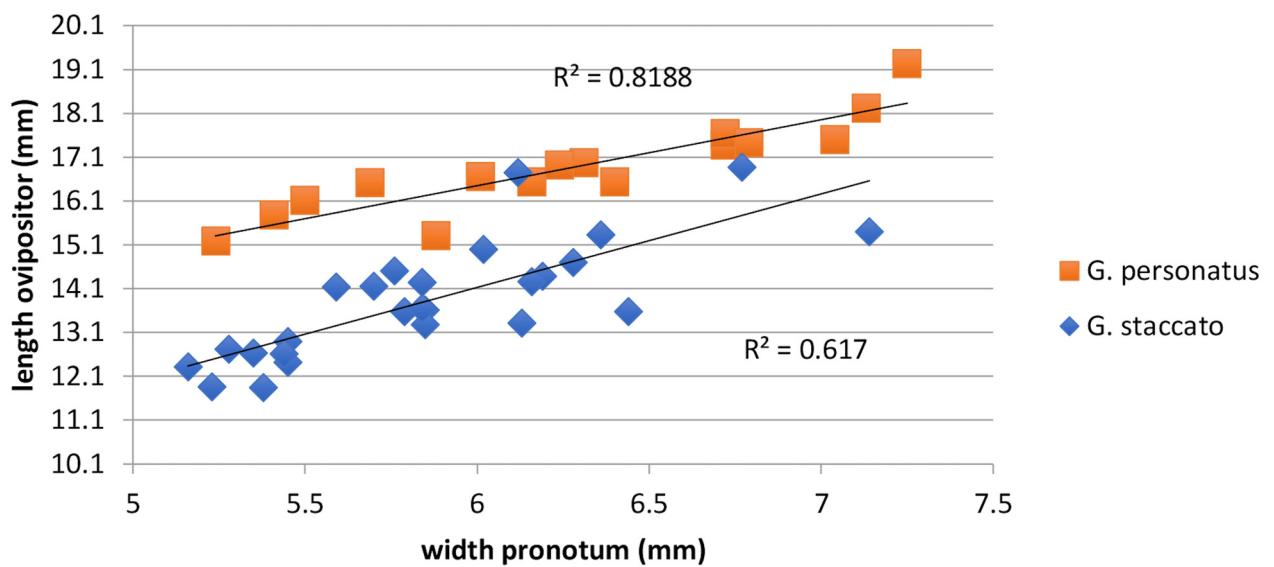


FIGURE 185. Regression of width pronotum vs. length ovipositor in *G. staccato* vs. *G. personatus*.



FIGURE 186. Holotype male (upper) of *G. staccato*. Female (lower) from Pima Co., AZ (S11-95). Note cream colored area, below eye, on male.

Song records only. (only one male heard at each locality): **Arizona**, Coconino Co., Flagstaff, 6900', 21-viii-1982 (S82-86); **California**, Inyo Co., Death Valley Nat. Park, Furnace Creek, -52m, 23-vi-1980 (S80-32). **New Mexico**, Socorro Co., Socorro, 4460', 13-vi-2007 (S07-50).

Derivation of name. Staccato means "something that is abruptly discontinuous or disjointed in quality or character," which describes the calling song of most males.

Geographic range. (Fig. 188). Also, south into the Mexican states of Sonora, Chihuahua, and Sinaloa.



FIGURE 187. Dark color variation in *G. staccato* from Colonia Juarez, Chihuahua, Mexico (S01-71).

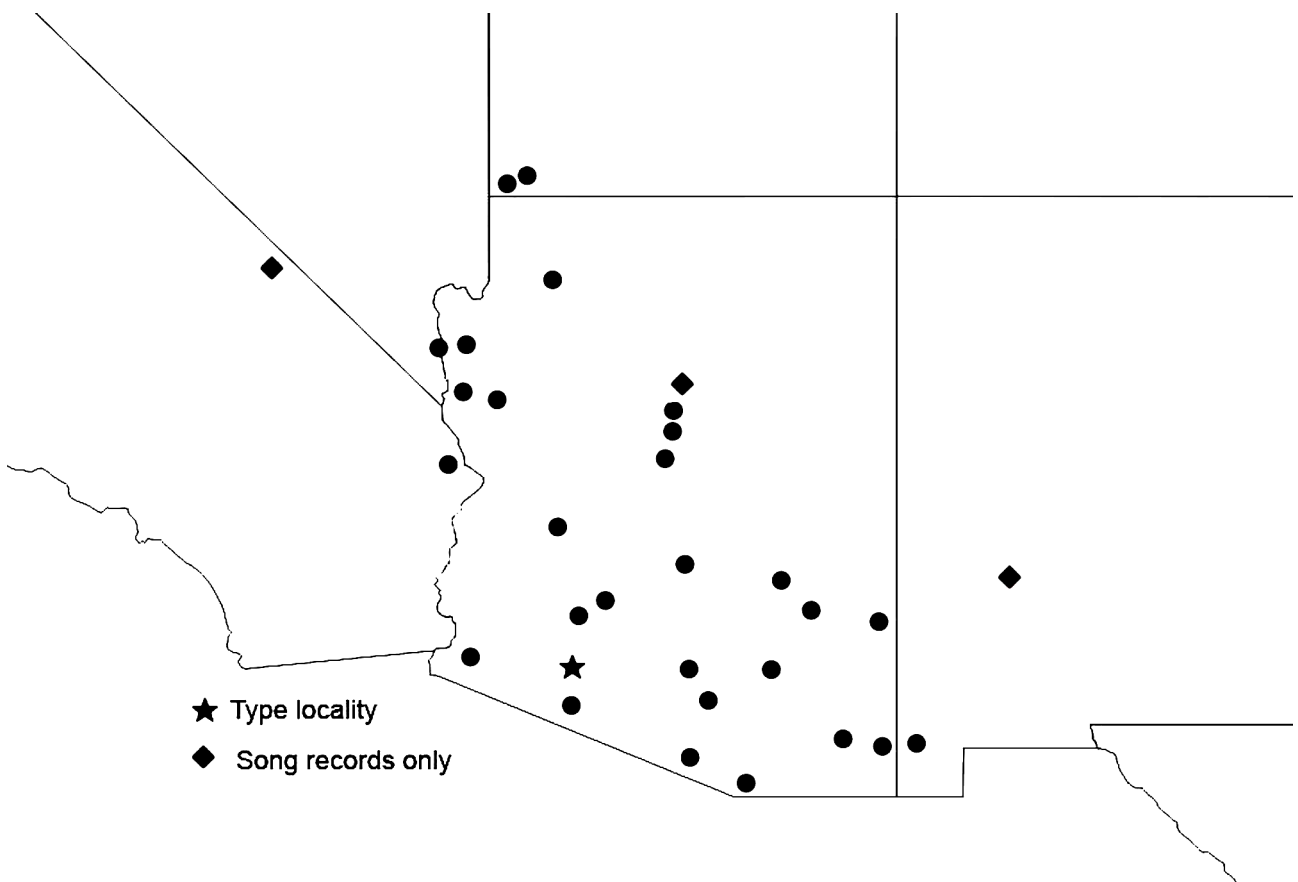


FIGURE 188. Known US distribution of *G. staccato*.

Habitat. Primarily open desert grassland/scrubland below 1220m but occasionally at higher elevations, e.g. mixed oak/juniper/pine woodland at 2026m (Schnebly Hill, ~5 m E Sedona, AZ, 7-vii-2003 [DAG 2003-305]) and 2103m within the town of Flagstaff, AZ (S82-86). Flies well and frequents lighted areas around human structures, especially gas stations with all night florescent lights. Can sing in the open or from cracks in the ground. Large population in rock garden area at McDonald's in Gila Bend (S15-111). Wilcox Playa, AZ, (S15-104) males sang in daytime 1 meter above ground, along with *G. lightfooti*, from within *Yucca elata* plants.

Life cycle and seasonal occurrence. No egg diapause in Arizona localities: Ajo (S11-99), Yuma (S90-54), and Safford (90-51). Probably 2 generations/year although may depend upon rainfall. Adults known from April to October, but months outside of these have not been checked. Breeds continuously under laboratory conditions.

Variation. See Table 1 (p. 18) for measurements. **Color:** Varies from light tan to almost solid black (Fig. 187), although face always with some areas of tan or cream. Most light-colored individuals with three longitudinal stripes on top of head, middle stripe sometimes broken. In very dark individuals, stripes not visible. **Hind wing length:** Variable in both sexes, with about 80% of all adults with long hind wings. Yet even in individuals whose hind wings don't extend beyond the tip of the abdomen, the hind wings present are longer than those in taxa that always have short hind wings. Of 62 individuals from Gila Bend (S81-47, S09-103, S11-101, S15-111), 60 had long hind wings and 2 had shed their hind wings. **Song:** *Chirp rate*—Within a population, both regular and irregular chirp rate songs are commonly heard. We found mixed song populations at several Arizona localities: Kingman (S91-67), Ajo (S98-74), Tucson (S09-53), Sedona (S94-35), Buckeye (S11-102), Gila Bend (S11-101) and Robles Junction (S11-95); and at Road Forks, New Mexico (S12-104). We have recorded a number of individuals that produce both regular and irregular songs (e.g. DAG 2004-006, Wickenburg, Maricopa Co., AZ, 4-iv-2004; DAG 2004-084, Organ Pipe Cactus National Monument, Pima Co., AZ, 8-iv-2004). DNA from individuals of *G. staccato* with both regular and irregular songs confirms that one species is involved (Fig. 174). **Pulse rate**—Since we measured pulse rate between the last two pulses in a chirp, the pulse rate decreases as the number of pulses increases. This phenomenon was illustrated in *G. multipulsator* (Fig. 69, p. 81, and Fig. 2B in Weissman *et al.* 2009) where a pulse-by-pulse analysis showed that the pulse period increases for each sequential pulse in a chirp, due to increasing pulse duration. Extrapolating this general finding (Weissman unpubl.) to *G. staccato* males with songs with 7-9 p/c and comparing their PR (calculated between the last two pulses in a chirp) to irregular songs with 2-8 p/c, shows a similar phenomenon: the PR in a chirp with 3 pulses is higher than the PR in a chirp with 8 pulses. Even so, the PR in *G. staccato* is higher than *G. personatus* chirps with the same number of pulses. Thus, an irregular-song *G. staccato* male with 3 p/c can have a PR of 111 at 25°C. This same male, in a chirp of eight pulses, can have a PR of 83 at the same temperature. For comparison, a *G. personatus* with 8 p/c would have a PR around 65 at 25°C.

DNA. Multilocus 2016-034 from Yavapai Co., AZ. Two sister species *G. lineaticeps* 2016-033 (Tracy, CA) and *G. personatus* G1357 (Otero Co., CO) (Gray *et al.* 2019).

Discussion. There were unusual sex ratios at some Arizona and New Mexico gas station collections: Catalina (S98-65), Why (S98-71), and Road Forks (S12-104). At these localities, night collecting mostly yielded adult females, possibly from two causes: (1) males were in better hiding places, especially if singing or (2) males were already dead because parasitized by tachinids. At Agua Fria National Monument (S11-105), on 19-ix-2011, only one male *G. staccato* heard but unable to collect since singing from deep soil crack. That same night we collected one male and eight females at oatmeal trails. This one collected male sang with 7-8 p/c with a variable CR. We wonder if this male survived the tachinid onslaught because he was taciturn or his song was not attractive to the fly parasitoids (see Sakaguchi & Gray 2011, for discussion).

Singing males are easy to approach. They should make excellent material for female choice studies given the variability in the calling song.

G. staccato and *G. personatus* can hybridize and backcross in the laboratory (DAG, unpublished) but different microhabitats, and geographic allopatry, probably prevent such events in nature, although they can be “brought together” at bright lights in gas stations (e.g. Road Forks, NM, S81-38).

Male *G. staccato* parasitized by tachinid *Ormia ochracea* were collected from the following Arizona localities: Catalina (S98-65); Wenden (S11-87); 6 m S Robles Junction (S11-95); Cordes Junction (S11-103), and Agua Fria (Sakaguchi & Gray 2011).