

The Vocalis Group

Gryllus vocalis Scudder and *Gryllus cohni* Weissman

Sister species of field crickets: *G. vocalis* typically associated with mesic areas (including human watered landscapes) and with riparian areas in the interior western US; *G. cohni* in the Sonoran Desert from Arizona into Mexico. Song a fast series of regular (3 pulses/chirp, *G. vocalis*) or highly irregular (*G. cohni*) numbers of pulses (Figs 155, 156). Well separated by ITS2 (Fig. 157).

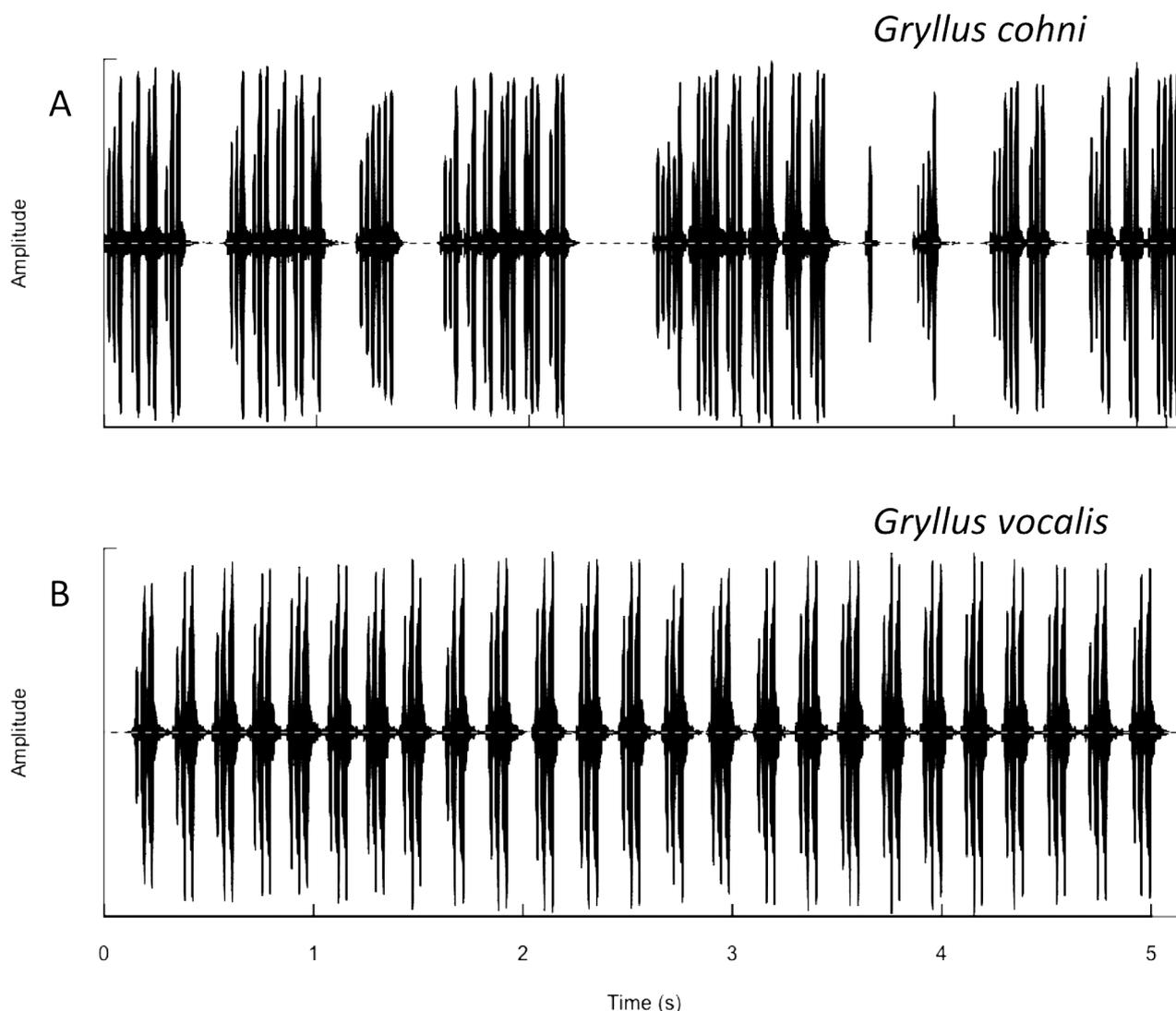


FIGURE 155. Five second waveforms of calling songs of (A) typical *G. cohni* and (B) *G. vocalis*. *G. cohni*: (R15-289) Pima Co., AZ (S15-108), at 25.3°C; *G. vocalis*: (R09-17) San Diego Co., CA (S09-18), at 23.5°C.

Gryllus vocalis Scudder

Damp-Loving Field Cricket

Figs 155-163, Table 1

1901 *Gryllus vocalis* Scudder, Psyche 9: 268. Lectotype male (Fig. 158), courtesy of J. Weintraub) designated by Weissman *et al.* (1980): “L. Angeles, Calif., July 29, 1897. *Gr. vocalis*, Scudder’s type 1901. Red type label, type 14070.” Deposited in ANSP.

1902 *Gryllus alogus* Rehn. Proc. Acad. Nat. Sci. Philadelphia 54: 726. Holotype female: “Albuquerque, 1902. N. M. T.D.A. Cockerell/Red type label *Gryllus alogus* Rehn Type No. 5067.” Adult type (Fig. 159, courtesy of J. Weintraub) with black

head and pronotum, pronotum hirsute, tegmina tan, hind wings short, all legs orange brown. Head narrower than pronotum. Some brown-red markings in area of lower face. Body 17.2, hind femur 10.9, ovipositor 14.8, head width 5.2, pronotum width 5.7, pronotum length 3.4.

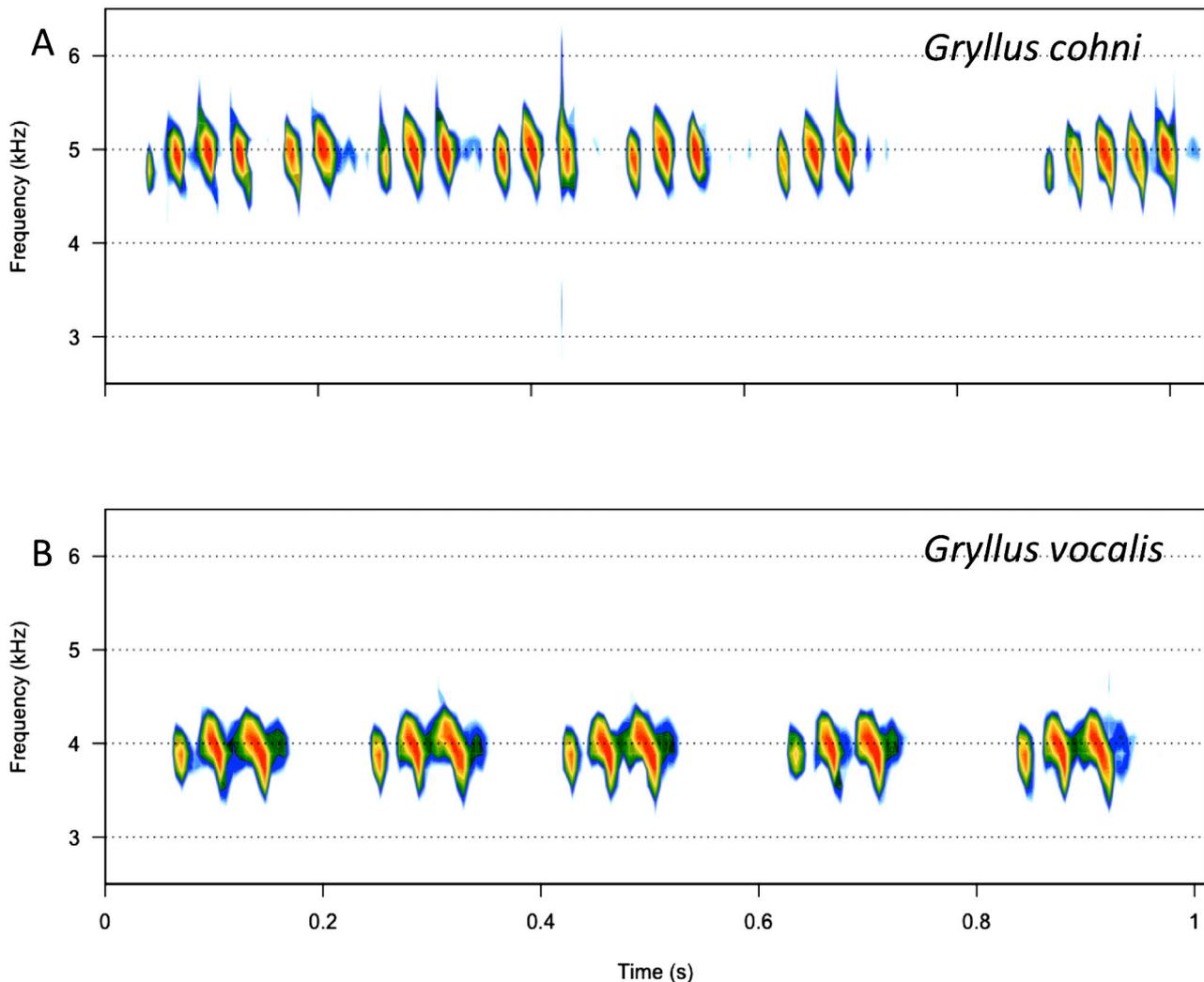


FIGURE 156. One second spectrograms of (A) *G. cohni* and (B) *G. vocalis*, same males as in Fig. 155.

Because the holotype is a female without intact cerci, we don't have the benefit of male file characters or cerci length to help in determining which species this is. The following five *Gryllus* species occur either in the city of Albuquerque or its vicinity (we considered a geographical area wider than Albuquerque since many old collecting localities were frequently "assigned" to the nearest town): *G. armatus*, *G. longicercus*, *G. veletis*, *G. lightfooti*, and *G. alogus*. We eliminate *G. armatus* because the body colors of the holotype of *G. alogus* are different, her pronotum is too long and hirsute, and she has short hind wings. We eliminate *G. longicercus* because the ovipositor to hind femur ratio in New Mexico specimens (Fig. 160) is wrong, the pronotum is hirsute, and the head is narrower than the pronotum, the last two qualities not seen in *G. longicercus*. We eliminate both *G. veletis* and *G. lightfooti* because their pronotums are not hirsute or minimally so, and the body, tegmina, cerci and legs of the latter two taxa are generally black and not orange brown, as in the holotype. This elimination process leaves only *G. alogus*. Deposited in ANSP. **New synonymy.**

1981 'Gryllus IV', Rentz & Weissman (1981).
 'Gryllus #10, #18', 'arizonensis' and *alogus* of DBW notebooks.
 'Regular stutter-triller' of Sakaguchi & Gray (2011).

Distribution. Widespread (Fig. 163) across the Southwestern US from southern California up along the eastern side of the Sierras, through southwestern Nevada, southern Utah, Arizona, New Mexico, and east to Big Bend, Texas.

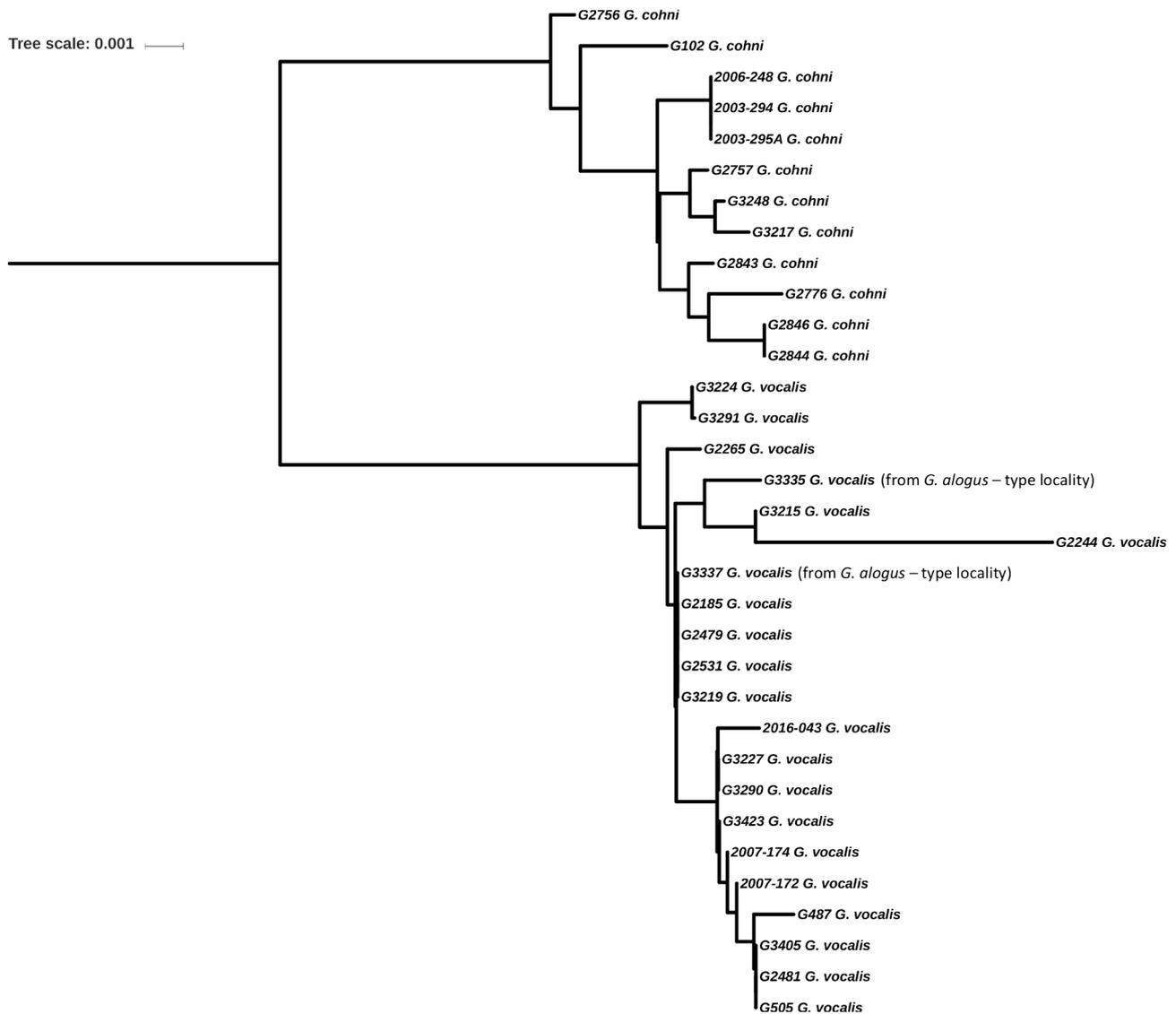


FIGURE 157. ITS2 gene tree. *G. coхни* samples: S95-81 (G102); S14-53, 20 km S Mazatlán, Mexico (G2756, G2757, G2776, G2843, G2844, G2846); S15-107 (G3248); S15-108 (G3217); Cordes Junction, Yavapai Co., AZ (2003-294, 2003-295A); Bloody Basin x Pueblo la Plata, Agua Fria National Monument, Yavapai Co., AZ (2006-248). *G. vocalis* samples: S05-68 (G487); S05-99 (G505); S11-102 (G2185); S12-20 (G2244); S12-26 (G2265); S13-13 (G2531); S13-14 (G2479); S13-16 (G2481); S15-110 (G3215); S15-111 (G3219, G3224, G3227, G3290, G3291); S16-18 (G3405); S16-28 (G3423); Wet Beaver Creek Campground, Yavapai Co., AZ (2007-172, 2007-174); California State University Northridge, Los Angeles Co., CA (2016-043). *G. alogus*, type locality, Albuquerque, NM (G3335, G3337).

Recognition characters and song. While geographically widespread, *G. vocalis* has a narrow microhabitat and is almost always associated with wet, verdant habitats such as coastal salt marshes (Cardiff by the Sea, S80-48, 49), along seasonal (Whitewater, S09-21 and Agua Fria, S13-14) and year-round streams (Furnace Creek, Death Valley, S80-32, S83-60, S03-36; and Zion National Park, S01-33), in seasonal ponds with *Distichlis* salt grass (7.2 km N Beatty, NV, S80-34), and in gardens (Gila Bend, S15-111) and artificially watered areas. Medium to large crickets that almost invariably have a dark head, pronotum and tegmina (Fig. 161) from coastal California east to the borders of the Mohave Desert, while those from Owens Valley (Big Pine and Bishop) are also dark. East of the Mohave Desert, individuals in most populations usually with dark heads and pronotum but light colored tegmina. *Song* (Fig. 162, R09-17) unique within the western US: 3 p/c (range 2-4), PR 23-45 at 25°C, 5-10 c/s evenly delivered. Their song can only be confused with certain western US individuals of *G. coхни* from central-southern Arizona and we extensively discuss how to separate the 2 taxa on p. 162. Males singing at 30+°C in Gila Bend, sounded more like

G. armatus than *G. vocalis* because of their increased chirp rate and shortened pulse period when that warm. *G. vocalis* and *G. cohni* are apparently only microsympatric at Ajo, Arizona (S98-72). Song of 3p/c also similar to more eastern *G. fultoni* and *G. vernalis* but CR faster in *G. vocalis* and nowhere sympatric. Distinguished from allopatric *G. veintinueve* by faster chirp rate and almost non-overlapping and faster pulse rate in *G. vocalis*, in addition to different DNA.



FIGURE 158. Holotype male *G. vocalis*, with labels.



FIGURE 159. Holotype female of *G. alogus*, with labels.

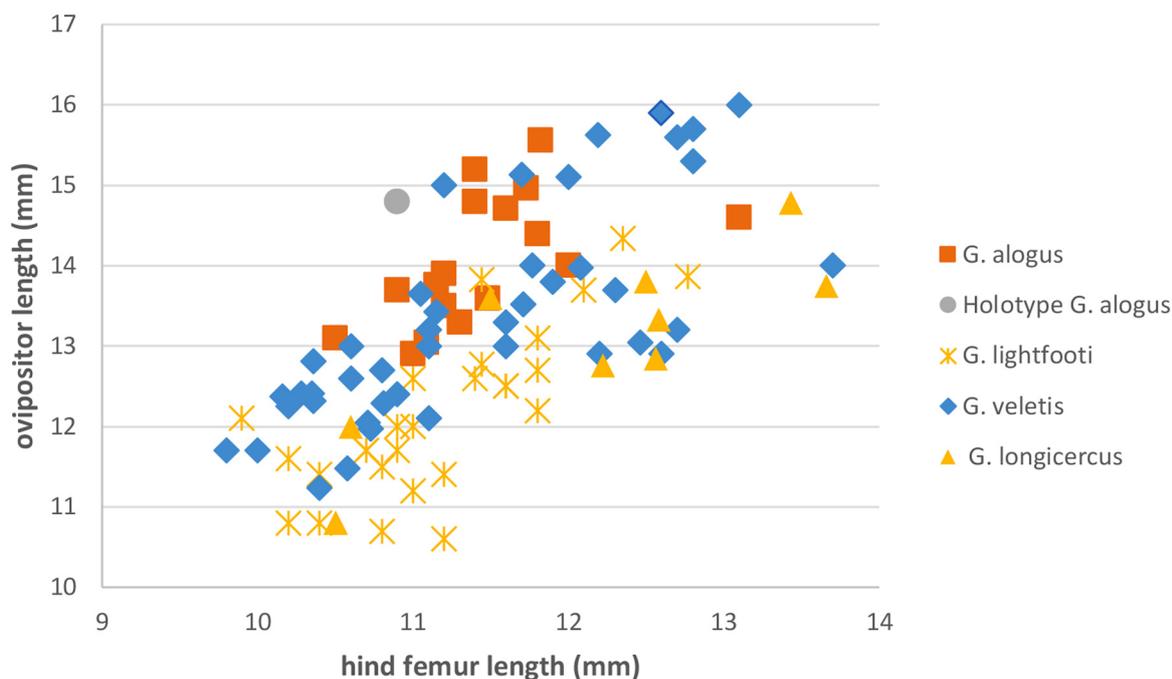


FIGURE 160. Regression of hind femur length vs. ovipositor length for all *Gryllus* species in the Albuquerque, NM, area, which is the type locality of *G. alogus*.

Derivation of name. “voco” is Latin for call, perhaps referring to the distinctive fast chirp rate and loud calling song of this species. Which raises the interesting question of who collected the lectotype and did this person subsequently relate such information to Scudder? In 1896, Scudder developed Parkinson’s disease (aka paralysis agitans) and started to prepare for his decline and demise (Mayor 1919), such that we assume that he did not visit Los Angeles in July, 1897 when the lectotype was collected. Scudder retired in 1902 and died in 1911. No further collection information is available at ANSP (J. Weintraub, pers. comm. to DBW, June, 2018).

Geographic range. Fig. 163. Also into northern Baja California Norte, Mexico.

Habitat. Individuals with an impressive temperature tolerance and almost always associated with wet habitats: Salt marshes (Cardiff by the Sea, S80-48, 49) and freshwater marshes (Shoshone, S85-27), irrigated gardens, cultivated ivy, along desert streams and ponds and, rarely, in railroad track rocks (near UC Riverside, S03-40). In San Diego (S97-60), 1 male singing 3m above ground in hole in tree with a long hind winged female near him. In a nearby palm tree, another male singing from 1.5m above ground. At coastal Ballona Wetlands (Los Angeles Co., S92-58) in ice plant on sandy substrate. While easy to approach, singing males can be very difficult to collect because they sing from dense vegetation. Oatmeal trails and checking under available rocks and trash can assist in such situations.

Life cycle and seasonal occurrence. No egg diapause: **Arizona:** S15-111 (Gila Bend). **California:** S92-60 (Shoshone), S95-112 (Big Pine), S03-73 (Barstow). **Nevada:** S90-44 (Cottonwood Cove). Apparently one or two generations/year depending on locality. In coastal California, a definite late winter—early spring species probably with one generation/year as those March, Orange Co. specimens (S05-28 and S05-29) were collected as late instars and no adults were heard after June at these localities.

S. Gershman (pers. comm. to DAG, 18-xi-2014) reports for inland and warmer Riverside, California: “I found a few calling males (of *G. vocalis* at the UCR Botanic Garden—S03-39) even in the winter. Here’s what I think is happening. Eggs do not diapause under summer conditions in the lab. Eggs are fairly constant in development time. Adults do not differ much in longevity. But, even in the lab under constant light and temperature, there is a huge range in development times of nymphs. Under lab summer conditions, some *G. vocalis* go from hatching to adult in 2 months. Others take more than 6 months. I assume that this spread causes individuals in nature to emerge as adults at random times throughout the year.”

Nevertheless, we have the following late summer collections in southern California: 3 adult males on 7-ix-2001

at Sepulveda Basin Wildlife Refuge in Los Angeles Co.; 1 adult male 11-ix-1977 in Orange in Orange Co.; and 2 adult males on 8-ix-2005 at Afton Canyon in San Bernardino Co. We wonder if certain California localities might have sporadic second-generation adults, as discussed for *G. veletisoides* (see p. 195), which make no genetic contribution to future generations.

In contrast, interior western US *G. vocalis* are often abundant in late summer and fall, e.g. at Zion National Park, Utah, 5-7-ix-2008, 5♂ 11♀. DAG recorded the following data for near Los Lunas, NM (S94-44 and S94-100), in 1994, which suggests 2 generations/year: Collecting in the last 2 weeks of June and the first 2 weeks of July showed adults abundant with some 80 collected. On July 25th, only one adult female seen; on August 8th, 8 adults; August 10th, 12 adults; August 23rd, 20 adults; August 24th, 35 adults; September 6th, 36 adults. In central Arizona, DAG has also observed both spring and fall adults: Agua Fria National Monument, Bloody Basin Road at Agua Fria river, Yavapai Co., 2 males 27-iii-2005, 2 females 1 nymph 16-iv-2010; Wet Beaver Creek Campground, Yavapai Co., 3 males 9 females 8-viii-2007; Oak Creek Canyon, Manzanita Campground, Coconino Co., 2 males 18-viii-2004.



FIGURE 161. Typical color in *G. vocalis*, this male from Shoshone, CA (S03-37).

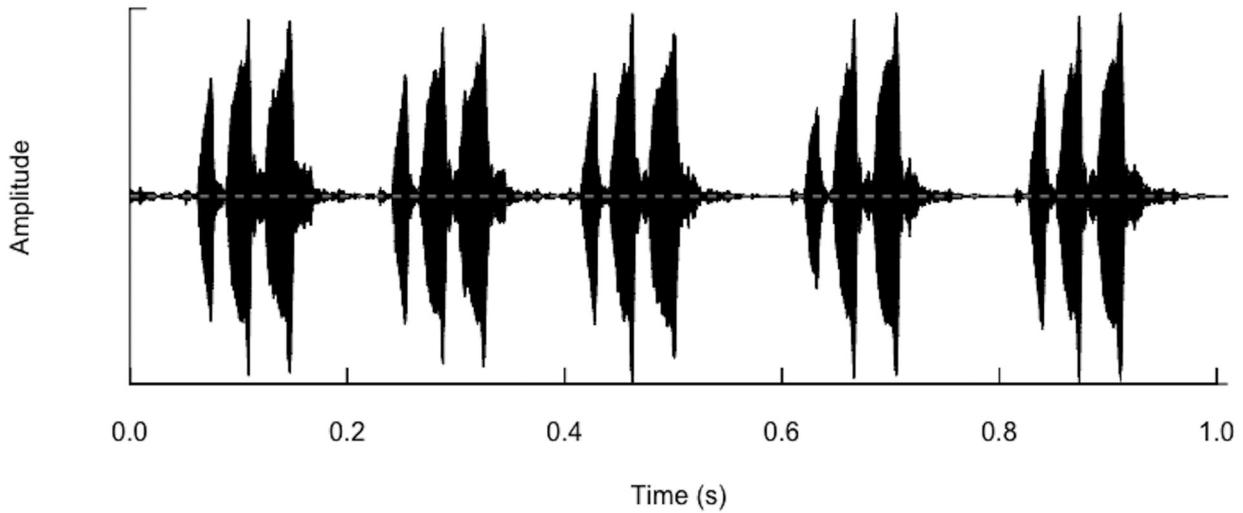


FIGURE 162. Calling song (R09-17) of *G. vocalis* from San Diego Co., CA (S09-18), recorded at 23.5°C.

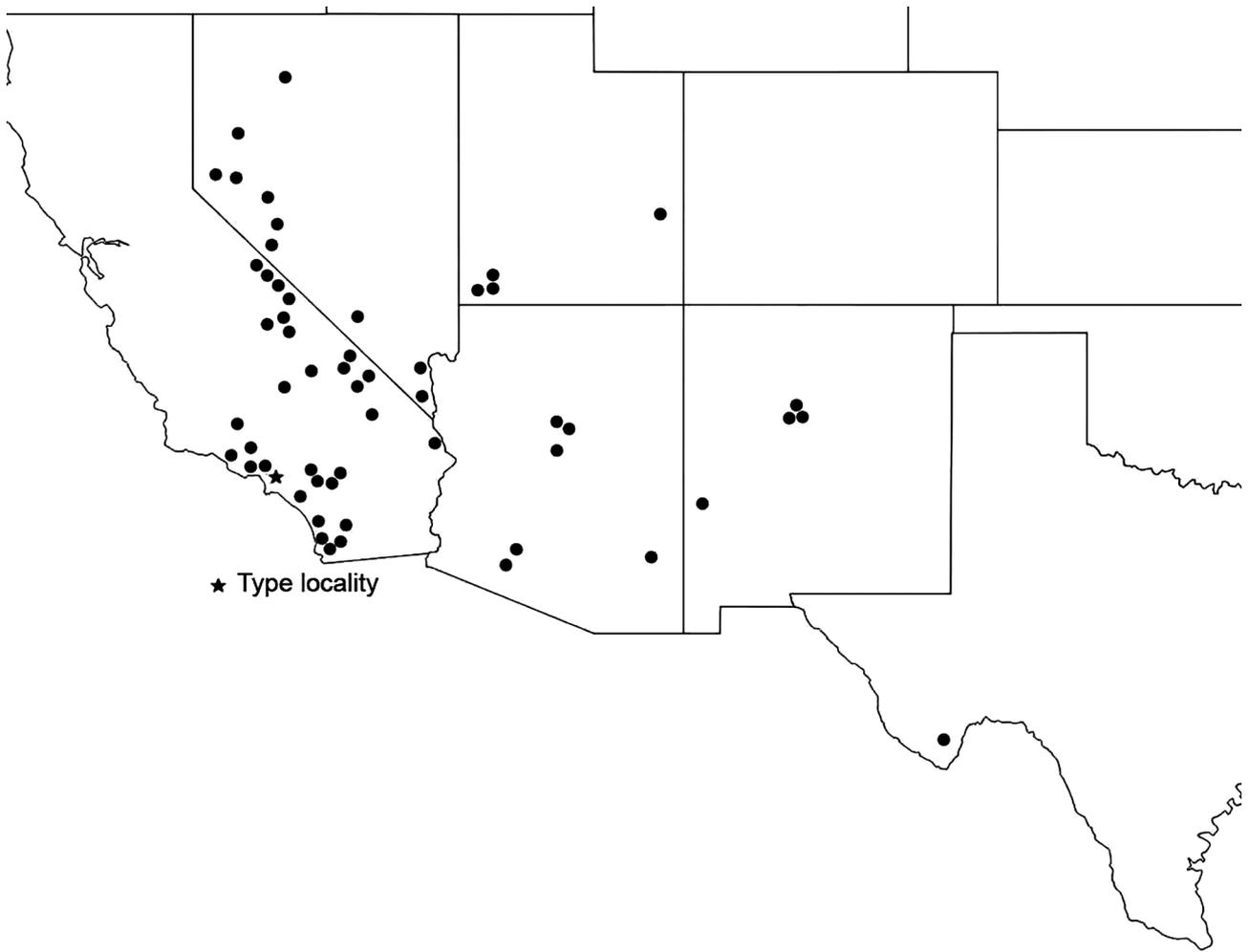


FIGURE 163. Known US distribution of *G. vocalis*.

Variation. **Pronotal hirsuteness:** variable resulting in shiny to dull surfaces within many populations. **Color:** varies as discussed under “Recognition characters.” Of 10 males and 3 females from Death Valley (S80-32 & S83-60), all 10 males and 1 female had light colored tegmina with male pronotums ranging from reddish to solid black.

In a large 1994 survey at Las Lunas, NM, DAG found most individuals with dark brown pronotums, although some definitely reddish. **Hind wing length:** All 80 first generation field (i.e. those collected before 8-viii-1994), Las Lunas, NM, individuals, with short hind wings. Second generation field individuals collected there after 8-viii-1994, showed 26 of 58 males and 22 of 53 females with long hind wings. All 7 individuals from Cottonwood Cove (S90-44) had long hind wings. Of 33 males and 19 females from the type locality of *G. alogus* (Albuquerque, NM), all but 2 females had short hind wings. All 16 males and 49 females from along permanent stream at Agua Fria (S13-14) had short hind wings. All 8 males and 9 females from the watered garden area at McDonald's in Gila Bend, Arizona, had long hind wings. One female was dealate. **Song:** males in some populations have long series of chirps (Albuquerque, S85-52) while others (Gila Bend, S15-111) have more broken up songs. **Tegmina length:** variable within and between populations.

Specimens examined. (Total: 333♂ 216♀). **Arizona:** *Coconino Co.*, Sedona, 4500', 15-vi-1990 (S90-49) 1♂; 5-viii-1991 (S91-78) 5♂; 30-vi-1994 (S94-35) 1♂. *Graham Co.*, 4.5 m S Safford, 3180', 10-vi-2012 (S12-20) 1♂. *Maricopa Co.*, Buckeye, 840', 18-ix-2011 (S11-102) 1♂. Gila Bend, garden area at McDonald's, 32° 56' 38.5" - 112° 43' 57.5", 712', 1-viii-2009 (S09-103) 3♂; 18-ix-2011 (S11-101) 1♂; 30-vii-2015 (S15-111) 4♂ 10♀. Hwy 85 E Goodyear, 980', 31-vii-1981 (S81-46) 3♂. *Yavapai Co.*, Agua Fria National Monument, stream crossing 4.9 m SE of pavement end, 989m, 34° 15' 27.57" - 112° 03' 50.5", 27-iii-2005, 2♂; 16-iv-2010, 2♂; 12-vi-2012 (S12-26) 1♀; 31-v-2013 (S13-14) 16♂ 49♀. Wet Beaver Creek Campground, 8-viii-2007, 3♂ 9♀. Hwy 179 eastern side Sedona, 4000', 31-v-2013 (S13-16) 2♂. **California:** *Inyo Co.*, Big Pine, 10-ix-1995, 4000' (S95-112) 1♂ 1♀. Bishop, 5-vi-1983, 4450' (S83-56) 1♂; 28-viii-2005 (S05-99) 3♂. 9 m N Bishop on Hwy 395, 1430m, 4-vi-1983, (S83-55) 13♂ 1♀; 26-vi-1992 (S92-64) 4♂ 5♀. Death Valley National Park, Furnace Creek, -190', 23-vi-1980 (S80-32) 5♂ 3♀; 5-vi-1983 (S83-60) 5♂; 5-v-2003 (S03-36) 1♀. Little Lake 20 m S Olancho, 3400', 5-v-2003 (S03-33) 8♂ 7♀. Lone Pine, 3650', 5-viii-1978 (S78-117) 1♂, 29-viii-2005 (S05-105) 1♂. Shoshone, 12-iii-1985 (S85-27) 2♂ 6♀; 25-vi-1992 (S92-60) 10♂ 10♀; 5-v-2003 (S03-37) 3♂ 3♀. Hwy 127 0.6 m N Shoshone, 1600', 6-vi-1983 (S83-61) 13♂ 6♀. 3 m W Lone Pine on Whitney Portal Rd, 5-viii-1978 (S78-119) 1♂. *Kern Co.*, Frazier Park, 16-vi-1978, 4600', 1♂. Kern River area across from CSU Bakersfield, 5-viii-1980 (S80-70) 1♂. Mojave, 2757', 5-viii-1988 (S88-70) 2♂. *Los Angeles Co.*, Ballona Wetlands, 24-vi-1992 (S92-58) 6♂ 2♀. CSU Northridge, 810', 8-v-2003, (S03-47) 3♂; early April, 2004 (S04-27) 2♂ 1♀. Malibu near Big Rock and Rockport Rds., 26-vi-1976, 2♂ 1♀; Malibu Canyon Rd. near Pacific Coast Hwy, 1-vii-1976, 1♂. Santa Monica Mts., Cold Creek, 2-v-2002, 3♂ 2♀. Sepulveda Basin Wildlife Refuge, 7-ix-2001, 3♂. Sherman Oaks, 28-vi-1976, 2♂. *Mono Co.*, 9 m N Laws at western base of White Mts., 26-vi-1992, 4500' (S92-63) 5♂ 4♀. *Orange Co.*, Costa Mesa, Talbert Nature Preserve, 15-iii-2005, 20' (S05-28) 1♂. Irvine near UCI Medical Center, 6-iv-1978, 2♂ 2♀. Newport Beach, Backbay Rd., 7-vii-1976, 5♂ 6♀. Orange, 9-iv-1978, 7♂ 1♀; 11-ix-1977, 1♂. Peters Canyon Regional Park, 16-iii-2005, 620' (S05-29) 1♂. *Riverside Co.*, Riverside, mid-July, 2001 (S01-96) 2♂ 1♀. UC Riverside Botanic Garden, 6-v-2003 (S03-39) 6♂. Near UC Riverside, railroad tracks, 6-v-2003 (S03-40) 2♂. Whitewater Canyon ca. 2.5 m N I10, 1-iv-1978, 1300' 2♂ 2♀; 26-v-2009 (S09-21) 1♂. *San Bernardino Co.*, Afton Canyon, Mojave River, 1400', 35.03920° -116.38260°, 2-v-2004, 4♂ 4♀; 1-v-2005 (S05-50) 7♂ 4♀; 8-ix-2005, 2♂. Barstow, 2300', 16-viii-1998 (S98-58) 1♂; 28-vi-2003 (S03-73) 1♀. Cherry Valley, 4-iv-1991, 4000' (S91-12) 1♂ 1♀. Rancho Cucamonga, 10-iii-1998 (S98-9B) 1♂. San Bernardino Mts., Mill Creek Ranger Station, 25-vii-1981 2800' (S81-27) 1♂. *San Diego Co.*, Camp Pendleton, 10-vii-1976, 4♂ 1♀. Cardiff by the Sea, Manchester Ave., 27 & 28-vi-1980 (S80-48, 49) 28♂ 15♀; 7-v-2003 (S03-42) 3♂. San Diego, Mission Bay Hilton, 18-vi-1994 (S94-34) 3♂ 1♀; 5-vi-1997 (S97-60) 5♂ 1♀. Hwy 79 0.8 m S Warner Springs, 26-v-2009, 3000' (S09-18) 2♂. Hwy 79 23.8 m E 15, 17-iii-2005, 2820' (S05-32) 1♂ 1♀. Hwy S22 2.1 m W Anza Borrego, 4000', 17-iii-2005 (S05-34) 2♀. *Ventura Co.*, Ojai Valley Swim and Spa Club, 3-iv-1999, 1000' (S99-5) 2♂. **Nevada:** *Churchill Co.*, Fallon, Churchill Community Hospital, 4000', 16-ix-1998 (S98-95) 5♂ 1♀. Hwy 95 2.5 m N Fallon, 3900', 21-vi-2005 (S05-69) 1♂ 1♀. Hwy 50 Alt. 12.8 m NW Fallon at Bench Rd intersection, 19-iii-1993, 3900' (S93-7) 2♂ raised from 9 collected mid-instars. *Clark Co.*, Cottonwood Cove, 800', 14-vi-1990 (S90-44) 3♂ 4♀. Echo Bay, Lake Mead, 1600', 7-vi-1989 (S89-33) 2♂. *Lyon Co.*, 0.5 m N Fernley on Hwy 50, 4-vi-1983, 1311 m (S83-51) 1♂. *Mineral Co.*, Hwy 95 near Mina, 4600', 3-vii-2005 (S05-68) 2♂. *Nye Co.*, Hwy 95 0.5 m N Beatty, 20-vi-2005 (DL05-16) 1♂ 1♀. Hwy 95 4.5 m N Beatty, 3500', 24-vi-1980 (S80-34) 1♂. **New Mexico:** *Bernalillo Co.*, Albuquerque, 5300', late May, 1984 (S84-25) 6♂; 6-vi-1985 (S85-52) 5♂ 6♀; 18-vii-1985 (S85-95) 4♂; 13-vi-1986 (S86-34) 12♂ 9♀; 23-vi-1993 (S93-59) 7♂ 5♀. Rio Grande Nature Center, June, 2005, D.C. Lightfoot, 1♂; 11-vii-2012, DC Lightfoot, 5♂. *Catron Co.*, Village of Reserve, 5770', 3-vii-1994 (S94-50) 4♂ 2♀. *Sierra Co.*, Caballo Reservoir State Park, 7-vi-1986 (S86-38) 3♂ 1♀. *Valencia Co.*, Los Lunas,

1 m S Los Lunas Bridge, 1-vii-1994 (94-44) 2♀; early September, 1994 (S94-100) 6♂ 5♀. **Texas:** Brewster Co., Big Bend National Park, Rio Grande Village, 2100', 9-vi-1985 (S85-56) 5♂ 2♀; 5-vi-1991 (S91-43) 3♂ 2♀. **Utah:** Grand Co., Moab, 25-iv-2006 (S06-21) 4♂. San Juan Co., 12 m W Farmington, 19-vi-1987 (S87-80) 1♂. Rest station 12 m S Moab, 21-vi-1987 (S87-59) 4♂ 4♀. Washington Co., Hurricane, 3420', 20-iv-1999 (S99-12) 1♂ 3♀. La Verkin, 3420', 11-ix-2004 (S04-121) 1♂. Springdale, 4000', 9-viii-1991 (S91-94) 2♂. St. George, 3040', 19-v-1995 (S95-39) 6♂ 1♀. Zion National Park, near turnoff to Zion Narrows, 4200', 19-v-1995 (S95-38) 1♂; Zion Museum, 3980', 19-v-2001 (S01-33) 2♀. 1 m W entrance to Zion National Park, 4060', 10-vi-1996 (S96-56) 1♀.

Uncertain placement. **Arizona:** Pima Co., Ajo, plaza area, 520m, 20-viii-1998 (S98-72) 1 male (R98-28). This long hind winged male has 3p/c delivered evenly and probably represents *G. vocalis*. If true, this site is the only documented locality where *G. cohni* and *G. vocalis* occur microsympatrically. Hwy 85 13 m N Ajo, 1255', 30-vii-2015 (S15-110) 1 female. This female has ITS2 DNA that agrees with *G. vocalis* despite the absence of water. No males heard singing in area.

Song records only. **Nevada:** Pershing Co., Rye Patch State Recreational Area, 4050', 27-vi-1992 (S92-67) 3 males heard. **California:** Ventura Co., McGrath State Beach, 24-vi-2007.

DNA. ITS2 and multilocus 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' all map together (Gray *et al.* 2019) and are all sister species to multilocus *G. cohni* G101, Baja California Sur, type locality (S95-81); G2776 Mazatlán, Mexico (S14-53); and 2016-041 Agua Fria National Monument. We caution that *G. cohni* 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 near sister species *G. vocalis* specimens. A singleton male from 7.2 km S Safford (S12-20, G2244) had a unique 16S haplotype but mapped with all other *G. vocalis* for ITS2 gene.

Discussion. We initially divided *G. vocalis* into four groups mainly separated by geographic regions. We discuss our early thinking here so that future researchers can revisit these results and reexamine some of our uncertainties. *G. vocalis* (with a type locality of Los Angeles, California) was defined by Weissman *et al.* (1980) as those dark 3p/c crickets in southern coastal California that extended through the Mohave Desert and into the Owens Valley east of the Sierras. *G. alogus* (aka 'G. #18') (with a type locality of Albuquerque, New Mexico) is a light colored 3p/c cricket of the Rocky Mountains that extends southeast into Big Bend, Texas. 'G. #10' is the light colored 3p/c cricket that occurs in the northern Mojave Desert, Great Basin Desert and Arizona between *G. vocalis* and *G. alogus*. 'G. arizonensis' was restricted to Gila Bend, AZ, where all individuals had long hind wings. While 1 out of 7 Gila Bend males had a broken song, although still with 3p/c, his ITS2 DNA, along with 5 other adults from there, all clustered with *G. vocalis* (Fig. 157). Thus, after failing to find physical or genetic characters to reliably separate these initial groupings, we merged them. On the other hand, we still see a definite dichotomy in that almost all individuals of *G. vocalis* discussed in Weissman *et al.* (1980), are dark colored with probably one generation/year; while almost all specimens to the east, including those from the Mohave Desert, are light colored and some may have two generations/year. We were also able to cross one male of *G. vocalis* from Riverside Co. (S03-39) with a female of 'G. #10' from Inyo Co. (S03-37) and got good egg hatches.

At Furnace Creek in Death Valley National Park, there were good numbers of *G. vocalis* singing in both 1980 and 1983, but only one male was heard in 2003 (Weissman *et al.* 2012). While *G. vocalis*, and sympatric *G. staccato*, *G. saxatilis*, and *G. armatus*, which we also heard on earlier visits, were all declining there, non-native *Acheta domesticus*, which was rare in the early 1980's, had increased significantly and suggests competitive exclusion.

Tachinid *Ormia ochracea* emerged from adult males collected at S91-78 (Sedona), S92-58 (Ballona Wetlands), S98-95 (Fallon—with 2 of 5 males parasitized), and S13-14 (Agua Fria—2 of 12 males parasitized). Most interestingly, from a mid-instar nymph collected under a cow pie on 19-iii-1993 (S93-7 at 20.6 km NW Fallon), a dead adult tachinid *Exoristoides johnsoni* was present in the rearing container on 6-v-1993. It is unknown when the larvae emerged from the cricket but this may represent a mechanism whereby tachinids can pass the winter at localities that experience freezing winter temperatures.

Gershman (2009, 2010) discussed aspects of mating in *G. vocalis*. Sandford (1987) studied aggression with crickets from Oklahoma: his '*G. alogus*' is uncertain, but not *G. vocalis* or *G. alogus* as understood here (because out of range) while his '*G. integer*' is probably *G. texensis*.

Gryllus cohni Weissman

Irregular-Trilling Field Cricket

Figs 155–157, 164–169, Table 1

1980 *Gryllus cohni* Weissman, Transactions of the American Entomological Society 106: 339. Holotype male (Fig. 164): Mexico, Baja California Sur, 0.5 km W Hwy 1 km 8 sign W La Paz, 16-vii-1978. S78-59, R78-90. Type in CAS, Entomology type # 13220.

'*Gryllus irregularis*', G. #20 of DBW notebooks.
Arizona stutter triller of Sakaguchi & Gray (2011).



FIGURE 164. Holotype male of *G. cohni*, with labels.

Distribution. Known from south-central Arizona and Mexican states of Sonora, Sinaloa, Nayarit, Jalisco and the Cape Area of Baja California Sur.

Recognition characters and song. Small to medium sized, small headed, usually long hind winged, pronotum moderately hirsute and slightly dull (Figs 164, 165). *Song* variable, which can make for difficult identification, but usually an irregular “trill” (Fig. 166, 2003-295, R15-289) with groupings of 1 to 13 pulses and a PR between 22 and 41 at 25°C. Some males (Fig. 167, R14-36) with much longer, uninterrupted trills. Some individuals, mainly from central Arizona, with sections where their pulses clustered in threes (see Fig. 167, recording 2006-260), resembling the song of morphologically indistinguishable sister species *G. vocalis*. Nevertheless, songs of *G. cohni* can be distinguished from those of *G. vocalis* since the latter produces long uninterrupted bouts of 3 pulse chirps, with little or no variation in pulse number, and pulses never grouped into trills as seen in other sections of recording 2006-260. The two-sister species are also usually separated ecologically with *G. vocalis* around moist environs and *G. cohni* in drier, more open desert situations. Both taxa were found microsympatric at only one location—a semi-garden area in Ajo, AZ (S98-72), although several subsequent visits to both Ajo and Why failed to yield more specimens

of either. Additionally, *G. vocalis* usually with short hind wings and a shiny pronotum and frequently at high densities in riparian corridors (see under *G. vocalis*) while *G. cohni* rarely common anywhere. *G. cohni* distinguished from other western US trilling *Gryllus* species as follows: From Arizona *G. regularis*, which is a larger, broader cricket with a shiny pronotum and short hind wings whose pulses are uniformly spaced and not grouped; females somewhat separable by ovipositor length relative to pronotal width (Fig. 168). From Arizona *G. staccato*, a larger cricket whose calling song can vary from an irregular trill with a faster pulse rate of 70-110, variable pulses/chirp, and different DNA. From Texas and eastward medium to large *G. rubens*, which has long series (> one second) of regularly-spaced trills delivered with a PR less than 60. From larger eastern New Mexico and eastward *G. texensis* that has regularly-spaced trills delivered with a PR >70. Rare western *G. integer* trill but with PR >70. Lastly, at very warm (>35°C) nighttime summer temperatures (easily reached in Ajo and Why, AZ) *G. cohni* males, when mainly singing with 3-4 p/c, can sound like *G. armatus*. They can be easily separated by recordings made closer to 25°C with differences in pulse rate and chirp rate diagnostic. Where they occur with *G. multipulsator* and *G. staccato* (e.g. near Mazatlán, S14-53), females too similar to separate except by DNA.



FIGURE 165. Female *G. cohni* from Pima Co, AZ (S98-71).

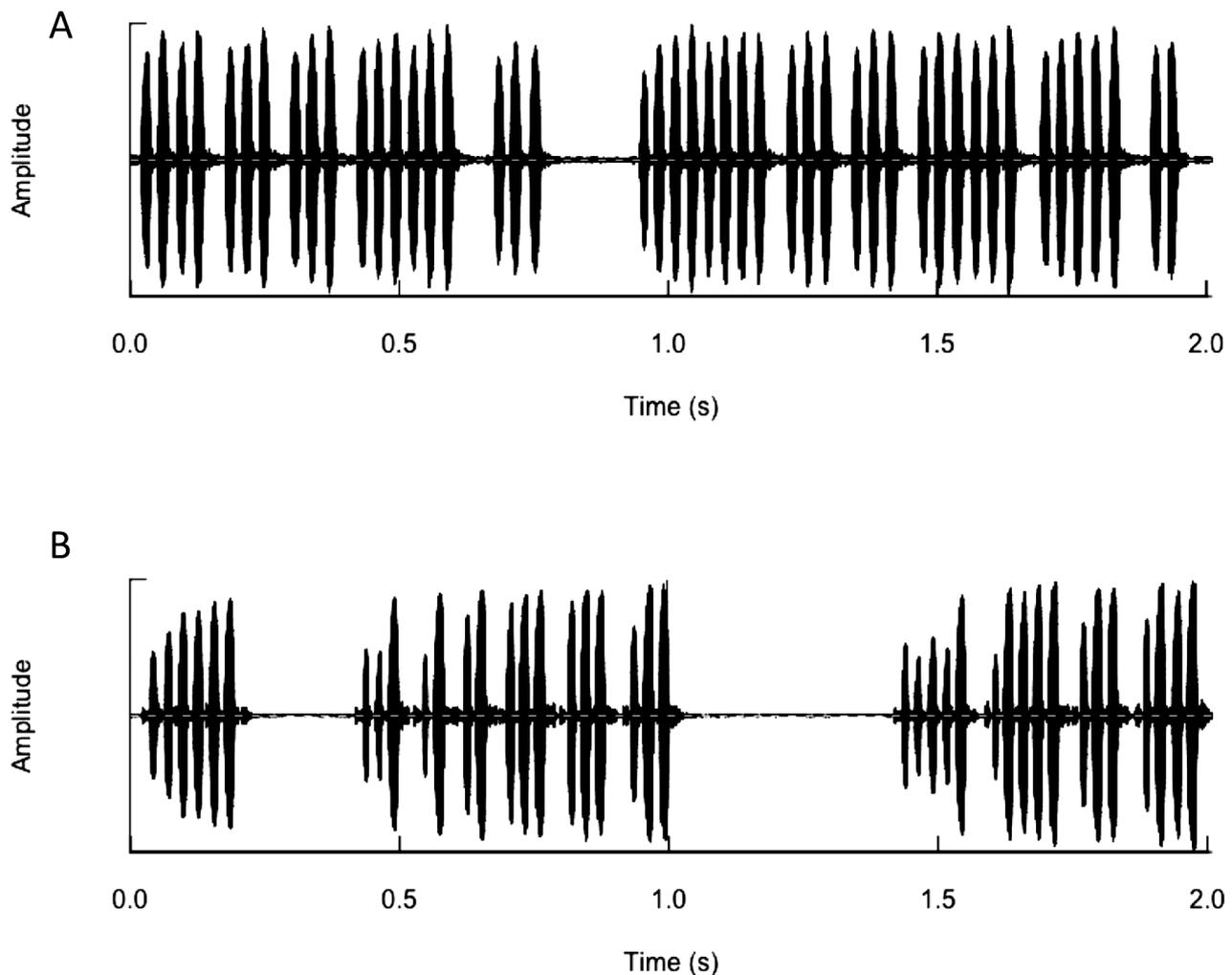


FIGURE 166. ‘Typical’ songs of *G. coхни* illustrating the extreme variability in pulse numbers both within and among individuals. (A) 2003-295 Cordes Junction, Yavapai Co., AZ, at 22.0°C. (B) R15-289 Pima Co., AZ (S15-108), at 25.3°C.

Specimens examined. (Total: 64♂ 27♀). **MEXICO.** *Baja California Sur*, 0.5 km W Hwy 1 km 8 sign W La Paz, 16-vii-1978 (S78-59) 3♂ (including holotype) 7♀; 31-xii-1978 (S79-16) 2♂; 21-iv-1979 (S79-84) 1♂; 25-viii-1995 (S95-81) 2♂. First wash along road to Miraflores, off Hwy 1, 24-iv-1979 (S79-95) 1♂. *Jalisco*, Club Med Playa Blanca, Rincon de Careyes ~55 road km N Manzanillo, 29-xii-1984 (S85-1) 13♂ 4♀. Puerto Vallarta, 29-iii-1983 (S83-13) 2♂. *Nayarit*, Hwy 200 1.6 km NE turnoff for Alta Vista, km post 78.3, 26-vi-2011, 320', 21° 07' 57.4" -105° 10' 01.3" (S11-50) 1♂. *Sinaloa*, Mazatlán, 11-viii-1999 (S99-87) 1♂. ~20 km S Mazatlán, 23-vii-2014, 110', 23° 11' 49.4" -106° 11' 37.7" (S14-53) 6♂ 1♀. Hwy 40 2 km NE Hwy 15, 11-viii-1999 (S99-86) 2♂. *Sonora*, Alamos, 18-vii-2006, 390m, 27.0257338° -108.9403527° (DAG 2006-215) 2♂. Hermosillo, 24-vii-1990 (S90-77) 1♂. San Carlos Bay, Club Med, 22-29-iii-1986 (S86-15) 6♂. 12 km W San Carlos, 25-vii-1990 (S90-78) 2♂. **USA.** *Arizona.* *Pima Co.*, Ajo, north end town, 520m, 20-viii-1998 (S98-74) 6♂. Ajo, plaza area, 520m, 20-viii-1998 (S98-72) 2♂. Sells, 29-vii-2015 (S15-107) 1♂. Why, 530m, 20-viii-1998 (S98-71) 1♂ 6♀. Hwy 86 4.4 m NW Sells, 31° 57' 25.4" -111° 56' 46.4" 2276', 29-vii-2015 (S15-108) 1♂. *Yavapai Co.*, Agua Fria National Monument, Perry Mesa near intersection Bloody Basin Rd and Pueblo La Plata Rd, 3657', 34° 14' 8.56" -112° 01' 45.34", 16-viii-2006, DAG 2006-243, 4♂, 1 last instar male and 1 last instar female; 11-ix-2007, 1♂ 1♀; 11-ix-2012 6♀. Forest Service Road 525 west of Sedona, 4507', 16-viii-2004, 34.91855° -111.91090° 2♀, I17 near Cordes Junction, gas station, 6-viii-2003, 34° 19' 41.6" -112° 07' 8.3" (DAG 2003-294, 2003-295) 3♂.

Song records only. **MEXICO.** *Sinaloa*, Concordia, 320', 11-viii-1999 (S99-85) 2♂. El Fuerte, 23-vii-2006, 800', 26.42099° -108.61774° (2006-224) 1♂.

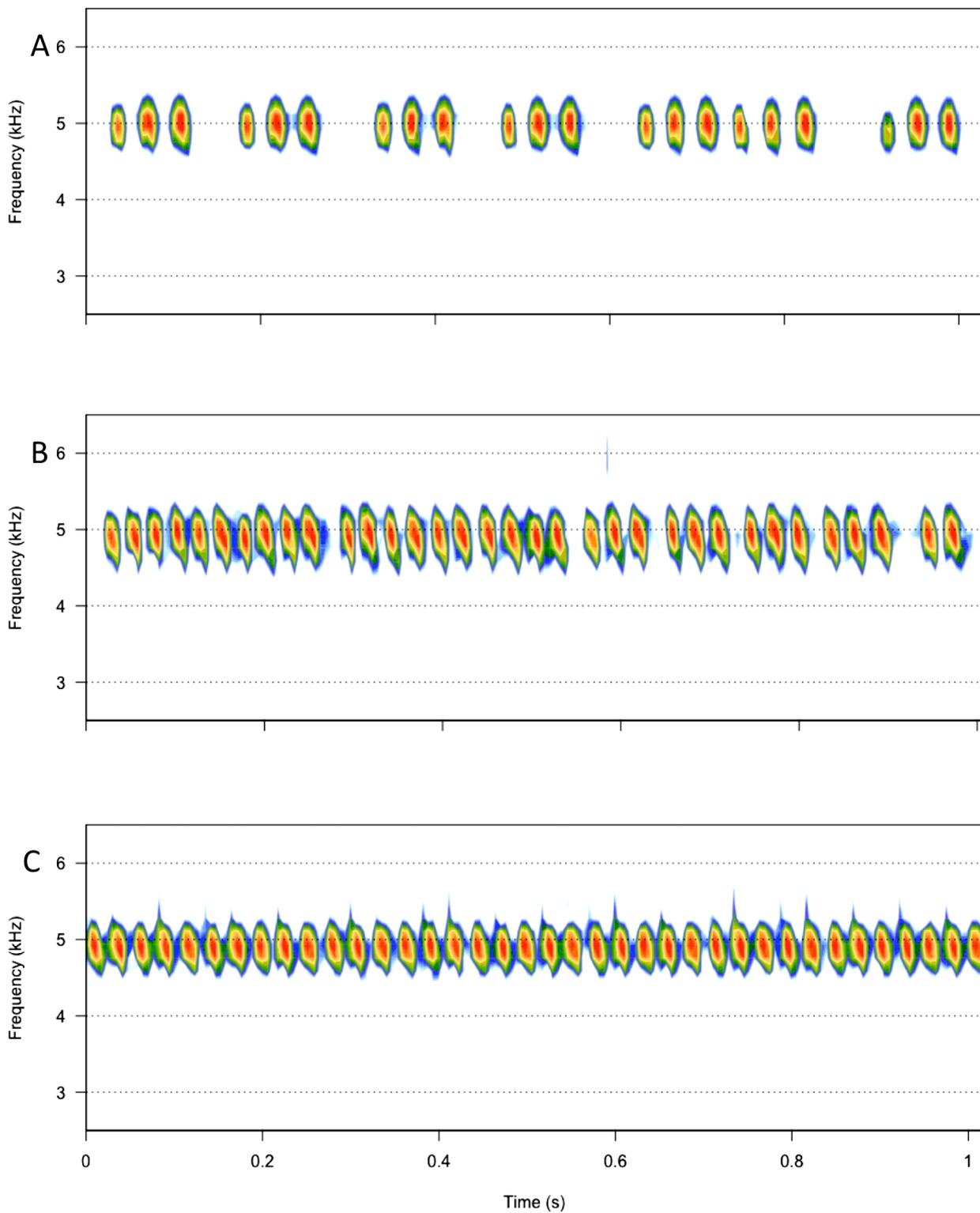


FIGURE 167. One second spectrograms of *G. coxni* showing atypical calling songs. (A) Agua Fria, AZ (2006-260), showing pulses grouped into 3s, at 22.8°C. (B) near Mazatlán, Mexico (R14-30, S14-53), showing an irregular trilling pattern, at 26°C. (C) near Mazatlán, Mexico (R14-36, S14-53), showing an almost uninterrupted trill, at 25.7°C.

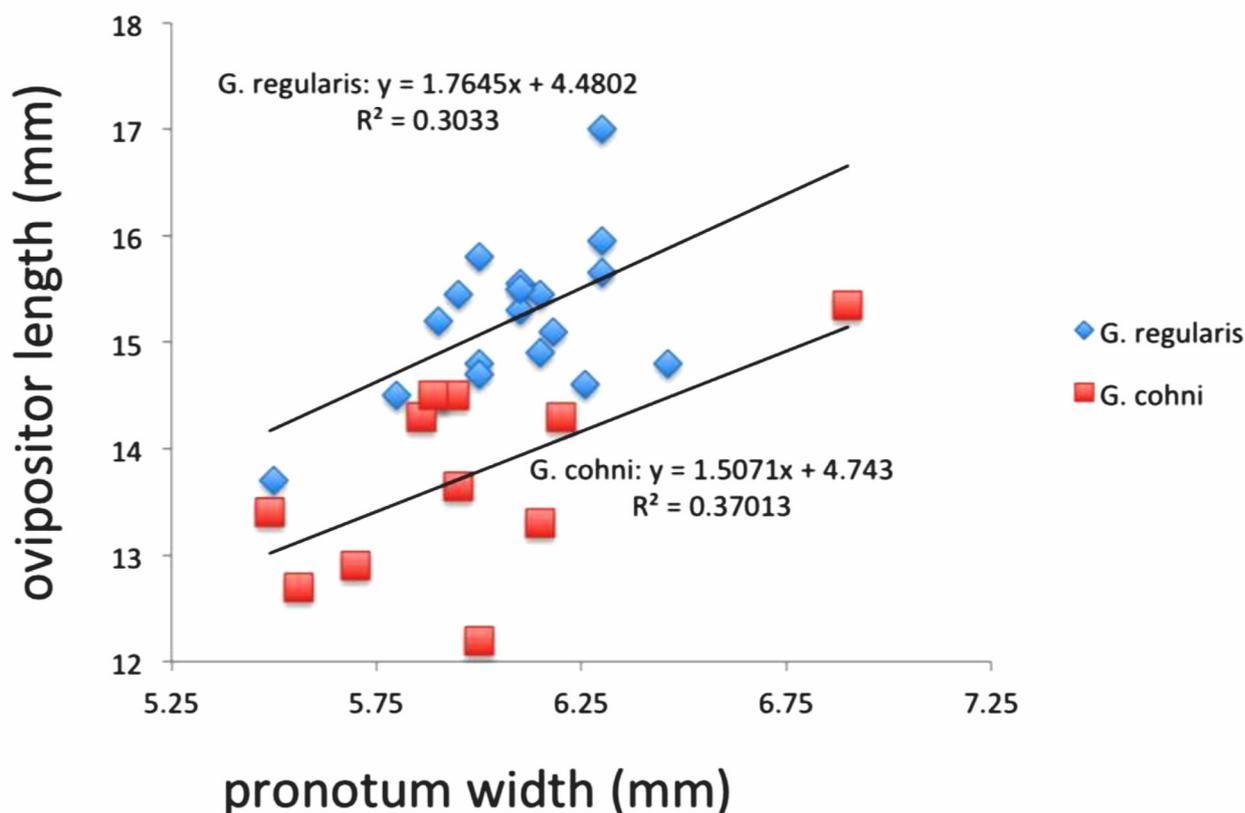


FIGURE 168. In sympatry in central Arizona, female *G. cohni* and *G. regularis* differ in relative ovipositor length, however not diagnostically so. All females are from Agua Fria National Monument, with species ID via song of lab reared sons.

Uncertain placement. Arizona: Pima Co., Ajo, plaza area, 520m, 20-viii-1998 (S98-72) 1♂ (R98-28). This long hind winged male has 3p/c delivered evenly and probably represents *G. vocalis*. If true, this site would represent the only locality where *G. cohni* and *G. vocalis* occur microsympatrically. Hwy 86 4.4 m NW Sells, 31° 57' 25.4" -111° 56' 46.4", 12276', 29-vii-2015 (S15-108) 1♂ (R15-289, G3217). This long hind winged specimen, the only male heard here, from open Sonora Desert, sang with 3 (5) p/c. His 16S DNA mapped in the tree where *G. vocalis* and *G. cohni* are intermixed. His ITS2 gene mapped (see Fig. 157) with other *G. cohni* and separate from *G. vocalis*. Such a dry habitat is usually associated with *G. cohni* although 3 males of the more mesic associated, always long hind winged *G. multipulsator* were also collected there. Perhaps these individuals all flew here after a localized monsoon rain?

Derivation of name. This cricket was originally named in appreciation of Theodore J. Cohn.

Geographic range. Fig. 169.

Habitat. From 520-1152m. The type locality is a wooded, thickly vegetated area subject to periodic flooding, where adult males did little singing and were most easily collected by an oatmeal trail. Found in both dry (open Sonoran Desert) and wet areas of human habitation, sometimes around lawns (San Carlos Bay, S86-15), at base of planted palm trees, irrigated garden areas, etc. Also at gas stations (Mazatlán, S99-87), cracks in structures and sidewalks and in deep, dry soil cracks (the latter away from human habitation at Agua Fria).

Life cycle and seasonal occurrence. Egg diapause absent (Agua Fria). Unsure if 1 or 2 generations/year and may vary between years depending on rainfall. Adults known from late March (San Carlos Bay, S86-15) through August. Nymphs collected at Agua Fria 16-viii-2006 (2006-257 & 2006-260). We have collected the Ajo-Why area on other occasions (16-v-1999 and 17-ix-2011) besides those listed under "Specimens examined" and not heard any *G. cohni* singing. Likewise collecting the Yavapai Co. localities of Agua Fria and Cordes Junction on 18-ix-2011, 12-vi-2012, 21-viii-2012, and 31-v-2013 yielded no singing males. There appears to be some unexamined interaction between monsoon rainfall and which *Gryllus* species are present, and when, in many areas of south-central

Arizona. Despite collecting 6 *G. cohni* males, flushed with water from a grassy area, none were heard singing at 20 km S Mazatlán (S14-53) when we arrived at 11:20 PM with temperatures at 31°C.

One question stands out: how long are *Gryllus* eggs viable in the soil, especially during periods of below average summer monsoon and winter rainfall?

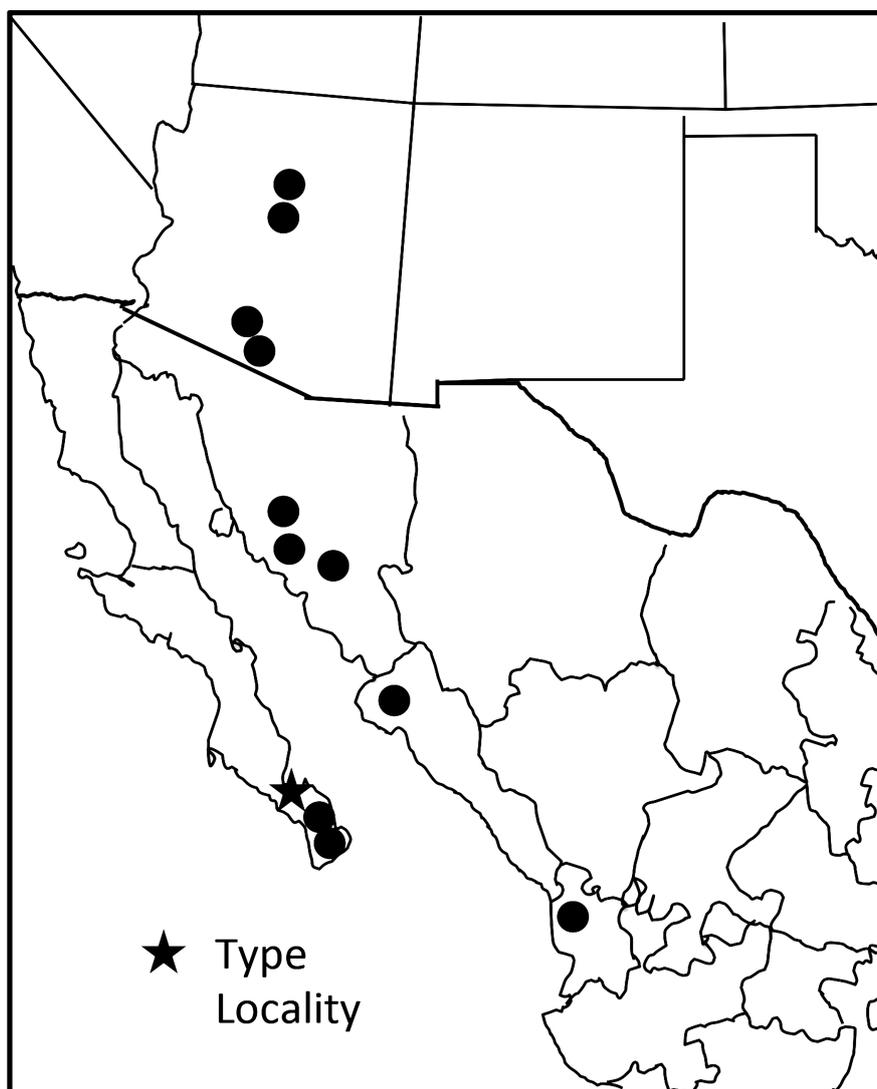


FIGURE 169. Known distribution of *G. cohni*.

Variation. Head width: All Mexican specimens from Playa Blanca (S85-1) and Puerto Vallarta (S83-13) with head narrower than pronotum, a condition infrequently seen in US specimens. **Hind wing length:** Of 39 individuals of *G. cohni* from Mexico, 37 have long hind wings and 2 males are dealate. In southern Arizona (Ajo and Why), all 13 collected individuals were long winged. In contrast, of the 7♂ and 8♀ from the Agua Fria National Monument area in north/central Arizona, 14 had short hind wings. **Body size:** Males from Agua Fria as small as 15.8 mm body length. In our small sample from Baja California Sur, Mexico, (Weissman *et al.* 1980), females were consistently larger than males, a characteristic also seen in those individuals from the Agua Fria area. **Song:** Number of p/c characteristically variable. Of 18 recorded males, 15 had an irregular trill with the exceptions being the single Nayarit (S11-50) specimen and 2 of 6 males from Mazatlán (S14-53). The Nayarit male was recorded twice: he had a short introductory trill and then groupings of 3-6 p/c at 27°C on 5-vii-2011, and no introductory trill with 3 or 4 p/c at 26° on 9-vii-2011. His DNA (G2074) mapped with that of other *G. cohni*. Of the 6 Mazatlán males (S14-53), 4 had an irregular trilling pattern (Fig. 167, R14-30) and 2 trilled more regularly (Fig. 167, R14-36). In southern Arizona (Ajo and Why), all 6 recorded males produced an irregular trill. Songs from Agua Fria were different from the general pattern seen in Mexico and southern Arizona in that some had significant stretches of 3p/c (Fig. 155, R15-289)

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.