ties: Mt. Graham (S12-19), Mt. Lemmon (S12-23), and Fort Bowie (S13-19), despite these localities being lower and warmer than the New Mexico *G. vulcanus* sites. (2) Lava flows are not a typical *Gryllus* habitat, as confirmed by our extensive checking of such areas. *G. leei,* from west-central Utah, appears to be another lava exception and is isolated to the Black Rock Desert of western Utah.

Although we treat *G. vulcanus* here as separate from *G. longicercus*, further work is clearly warranted. Especially given the similarity in song, pre-zygotic reproductive isolation, to the extent that it exists, may be driven solely by ecology and/or phenology. Given that the two known lava flow localities in New Mexico are not connected and are of very different ages, we suspect that the two flightless *G. vulcanus* populations represent separate derivations from *G. longicercus*; this also could be tested in future work. DNA markers more sensitive than ITS2 and 16S would be required (e.g. SNPs).

The type locality is part of the 3,000-year-old McCarty lava flow: http://geoinfo.nmt.edu/tour/federal/monuments/el_malpais/zuni-bandera/pahoehoe.html (Laughlin *et al*. 1993). However, volcanism in adjacent areas dates as far back as 115,000 years (Laughlin *et al.* 1994). There are many deep lava cracks and fissures from which *G. vulcanus* sing, making their song soft and the crickets difficult to collect, despite their boldness. With patience, singing males can frequently be coaxed from deep cracks with a slim twig, as they do not dive down. Nevertheless, collecting time is better spent walking the edges of the lava flow at night after laying of an oatmeal trail there during the late afternoon. One male singing from a crack in the ground several meters from lava's edge at El Malpais (S96-68).

Many fewer singing males at Valley of Fires in 2007 (S07-46) than in 1994. At Valley of Fires State Park, there are fewer and more shallow cracks in the surface lava and more dirt and grassy areas within the lava flow area when compared to the type locality. This lava flow has been dated to ca. 5,200 ±700 years of age (Dunbar 1999). At Valley of Fires all crickets were in the open with many males singing totally exposed away from cracks but still on lava. They were also easy to approach while singing and active jumpers. Many singing males had females near them. In 2007 (13-vi-2007, S07-46), several medium instar nymphs, and adult females, were seen walking around.

The Saxatilis Group

G. saxatilis Weissman & Gray, n. sp.; *G. leei* Weissman & Gray, n. sp.; *G. makhosica* Weissman & Gray, n. sp.; *G. navajo* Weissman & Gray, n. sp.

Sister species of western chirping crickets with similar songs (Figs 236, 237). Most easily separated from each other by habitat and geography: *G. saxatilis* widespread in dry rocky areas west of the Rockies; *G. leei* restricted to lava in Utah; *G. makhosica* restricted to badlands clay habitats in South Dakota; *G. navajo* restricted to the red sandstone region of the Colorado Plateau in Utah and Arizona. At least three additional cryptic species may exist within the Saxatilis Group. Poorly separated by ITS2 DNA (Fig. 238); both COI and 16S likewise proved unhelpful.

Gryllus saxatilis Weissman & Gray, n. sp.

Western Rock-Loving Field Cricket
Figs 205, 236–246, 248, Table 1

Gryllus pennsylvanicus of Weissman *et al*., 1980.
'Gryllus #2' of Rentz & Weissman, 1981.
'G. #2, #11, #22, #38', 'G. mojave', 'G. tulare', 'G. mormoni' of DBW notebooks.

Distribution. Widespread in the western US, west of the Rocky Mountains.

Recognition characters and song. A small to large, short or long hind winged, medium-long cerci rarely longer than ovipositor in situ, slow chirping cricket usually associated with rocky habitats. *Song* (Fig. 239, R15-372) with 3–5 p/c (range 2–7), 50–280 c/m, PR 14-25. Separated from the following western slow chirping *Gryllus* as follows: From *G. longicercus*, which has a distinctive, non-overlapping lower PR, and has more file teeth, longer cerci, and different DNA. From *G. lightfooti* which has a tegminal bar in females, shorter male tegmina, not usually associated with rocks, faster chirp rate, fewer file teeth, and different DNA. From *G. montis* which occurs at higher elevations

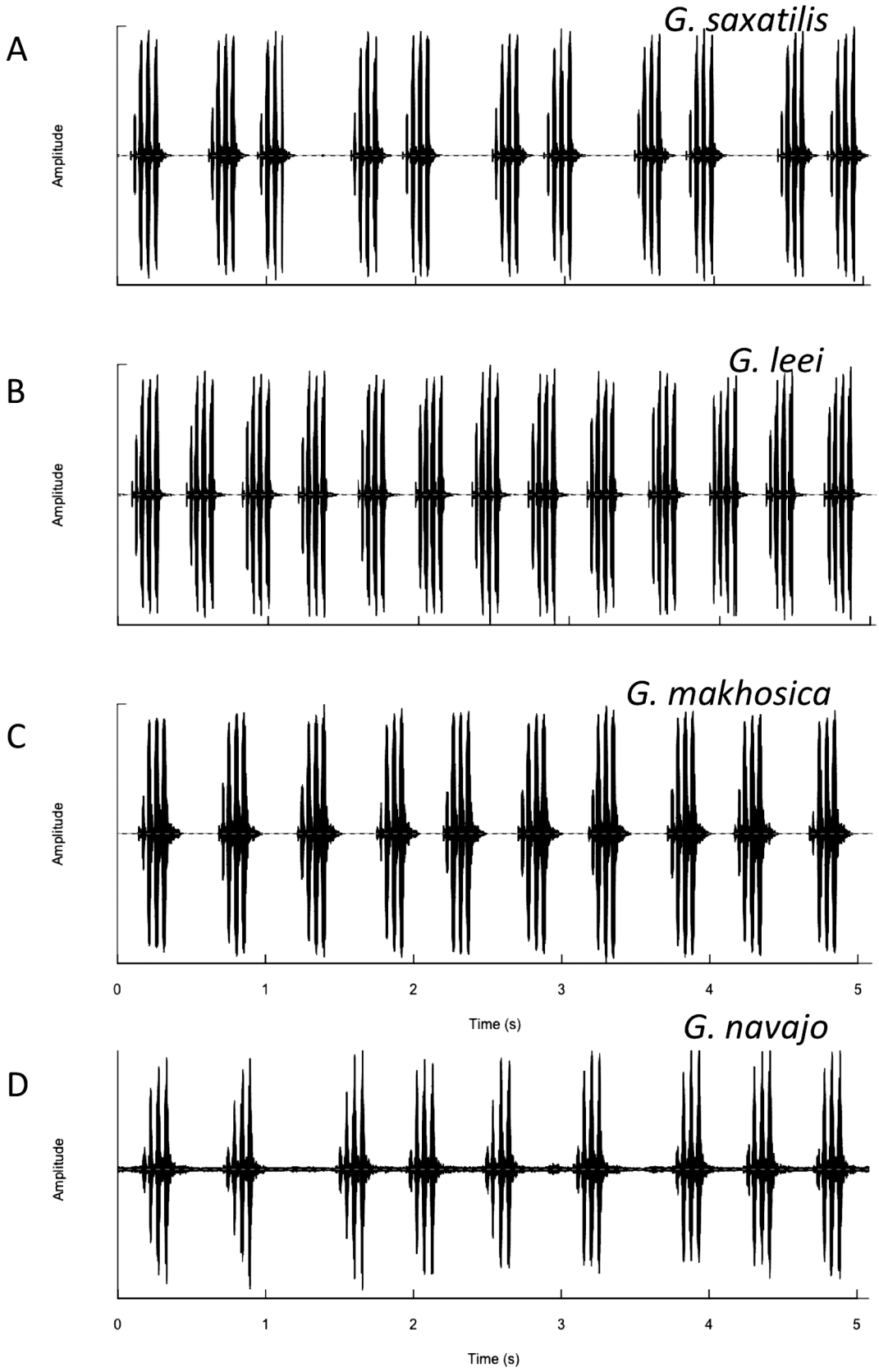

FIGURE 236. Five second waveforms of calling songs of (A) *G. saxatilis*, (B) *G. leei*, (C) *G. makhosica*, and (D) *G. navajo*. *G. saxatilis*: (R15-372) from type locality (S15-114), at 25.5°C. *G. leei*: (R17-7) from type locality (S17-6), at 24.5°C. *G. makhosica*: (R09-95) from type locality (S09-89), at 24.5°C. *G. navajo*: (R07-61) from Coconino Co., AZ (S07-56), at 25°C.

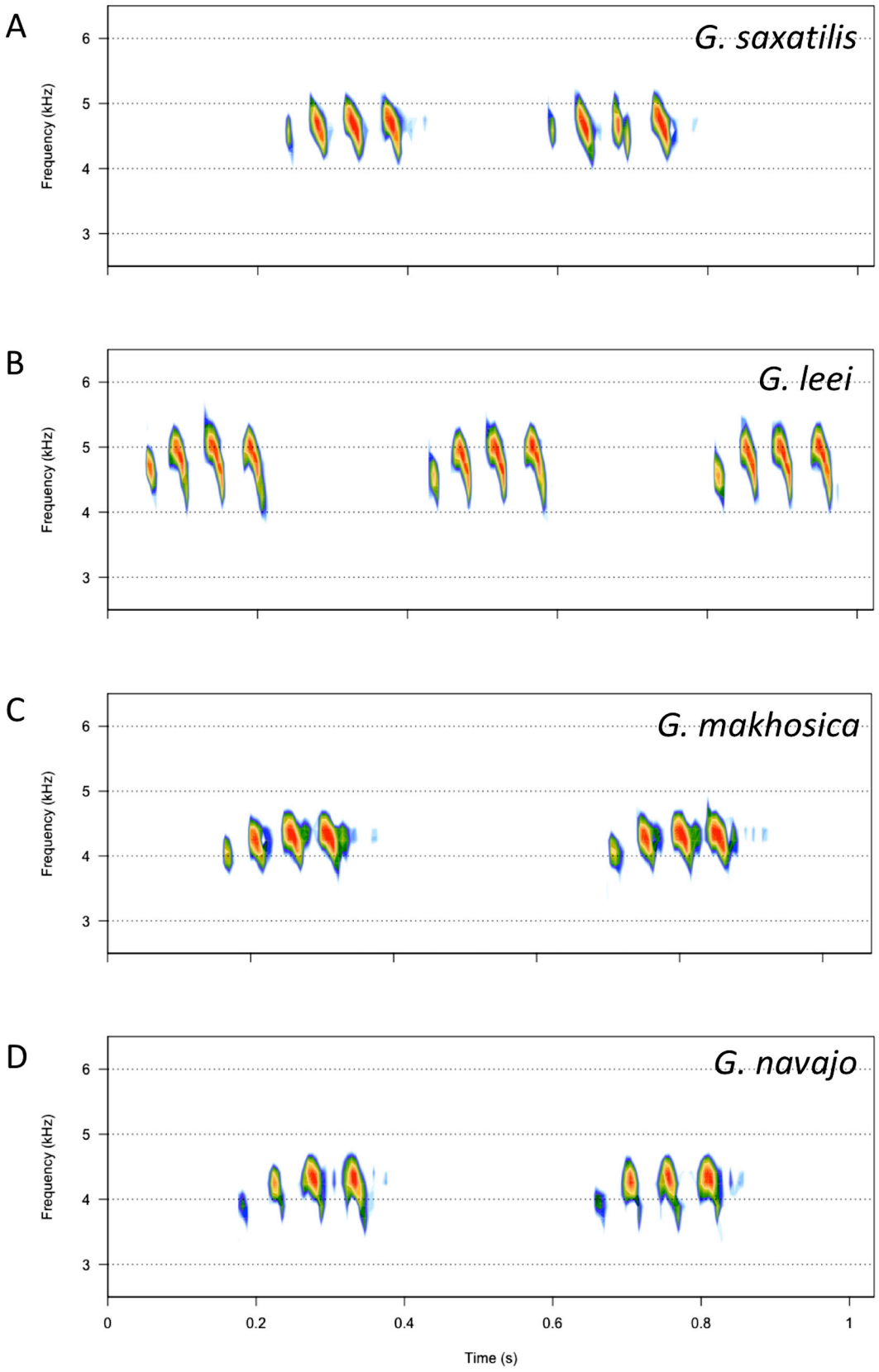

FIGURE 237. One second spectrograms of (A) *G. saxatilis*, (B) *G. leei*, (C) *G. makhosica*, and (D) *G. navajo*, same males as in Fig. 236.

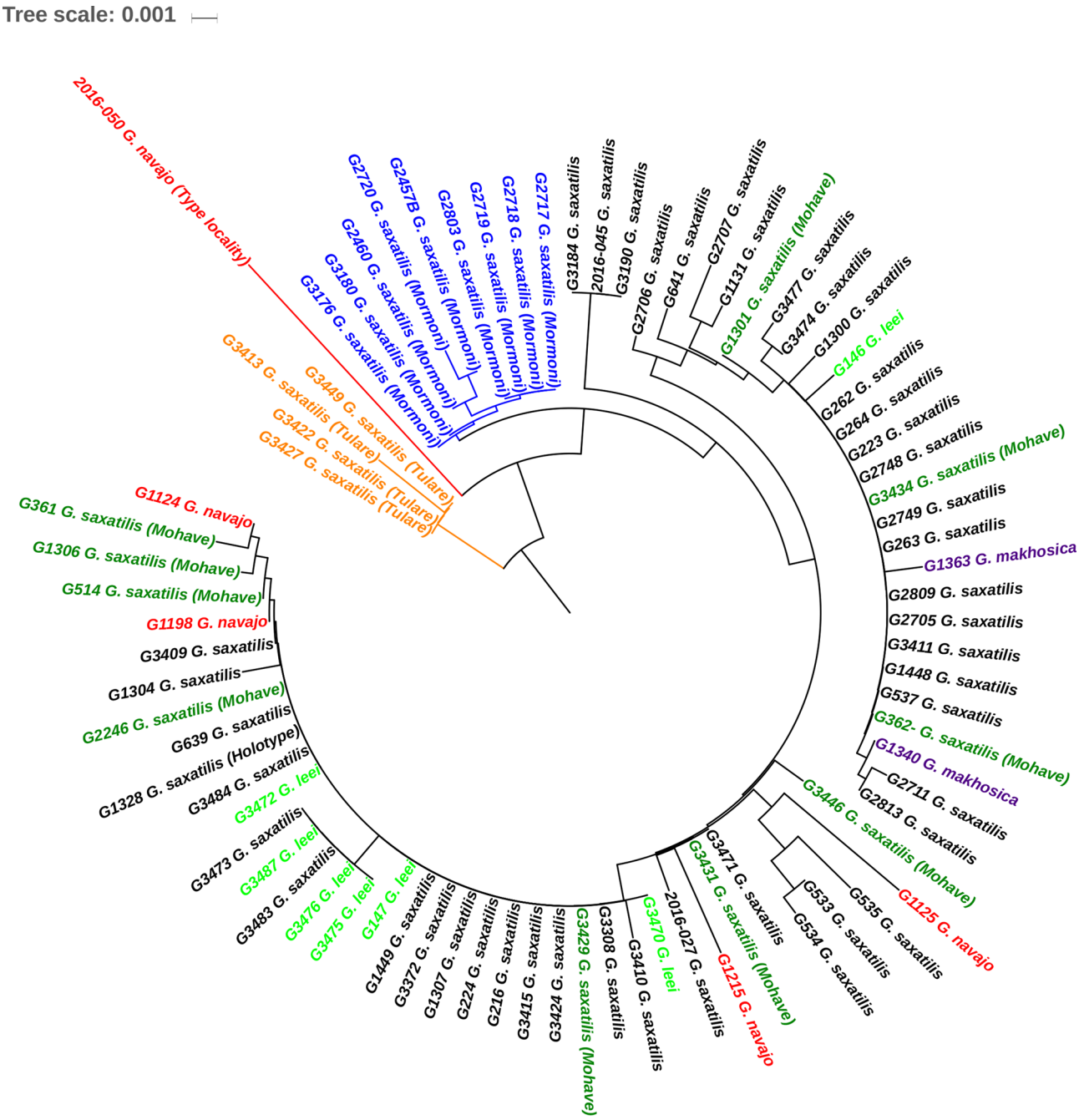

FIGURE 238. ITS2 gene tree, color coded to highlight species and potential cryptic species warranting further study. Collection stop numbers for ***G. saxatilis*** legs: S04-51 (G216); S04-62 (G223, G224); S04-74 (G262, G263, G264); S04-121 (G361, G362); S05-109 (G514); S06-5 (G535); S06-21 (G533, G534, G537); S06-105 (G639, G641); S07-64 (G1131); S09-22 (G1306); S09-28 (G1300); S09-29 (G1304, G1307); S09-32 (G1301); S09-43 (G1328); S09-131 (G1449); S09-141 (G1448); S12-34 (G2246); S13-10 (G2457B, G2460, G2717, G2718); S13-10A (G2719, G2720); S13-79 (G2705, G2706, G2707, G2711); S14-30 (G2748, G2749); S14-61 (G2809, G2813); S14-77 (G2803); S15-87 (G3176, G3180); S15-89 (G3184, G3190); S15-90 (2016-045); S15-93 (G3308); S15-96 (G3372); S16-17 (G3409, G3410, G3411, G3415); S16-18 (G3429, G3431); S16-21 (G3413, G3422, G3427, G3449); S16-23 (G3434, G3446); S16-33 (G3424); S17-7 (G3471, G3473, G3474, G3477, G3483, G3484); La Verkin overlook, Washington Co., UT (2016-027). Collection stop numbers for ***G. leei*** legs: S01-28 (G146, G147); S17-6 (G3470, G3472, G3475, G3476, G3487). Collection stop numbers for ***G. makhosica*** legs: S09-89 (G1340, G1363). Collection stop numbers for ***G. navajo*** legs: S07-56 (G1124, G1125, G1198, G1215); Goblin Valley, Emery Co., UT (2016-050).

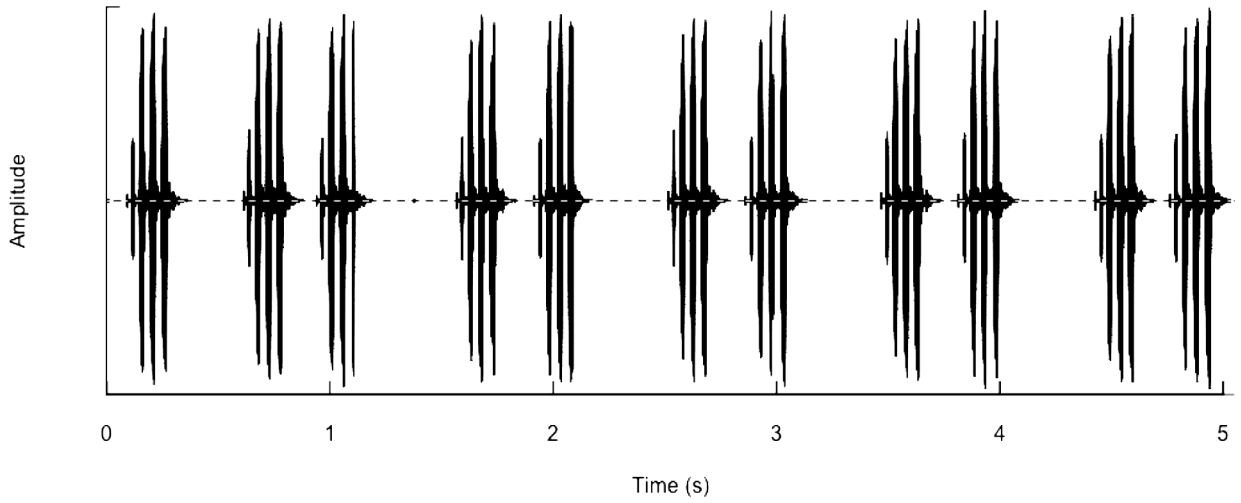

FIGURE 239. Calling song (R15-372) of *G. saxatilis* from type locality (S15-114), recorded at 25.5°C.

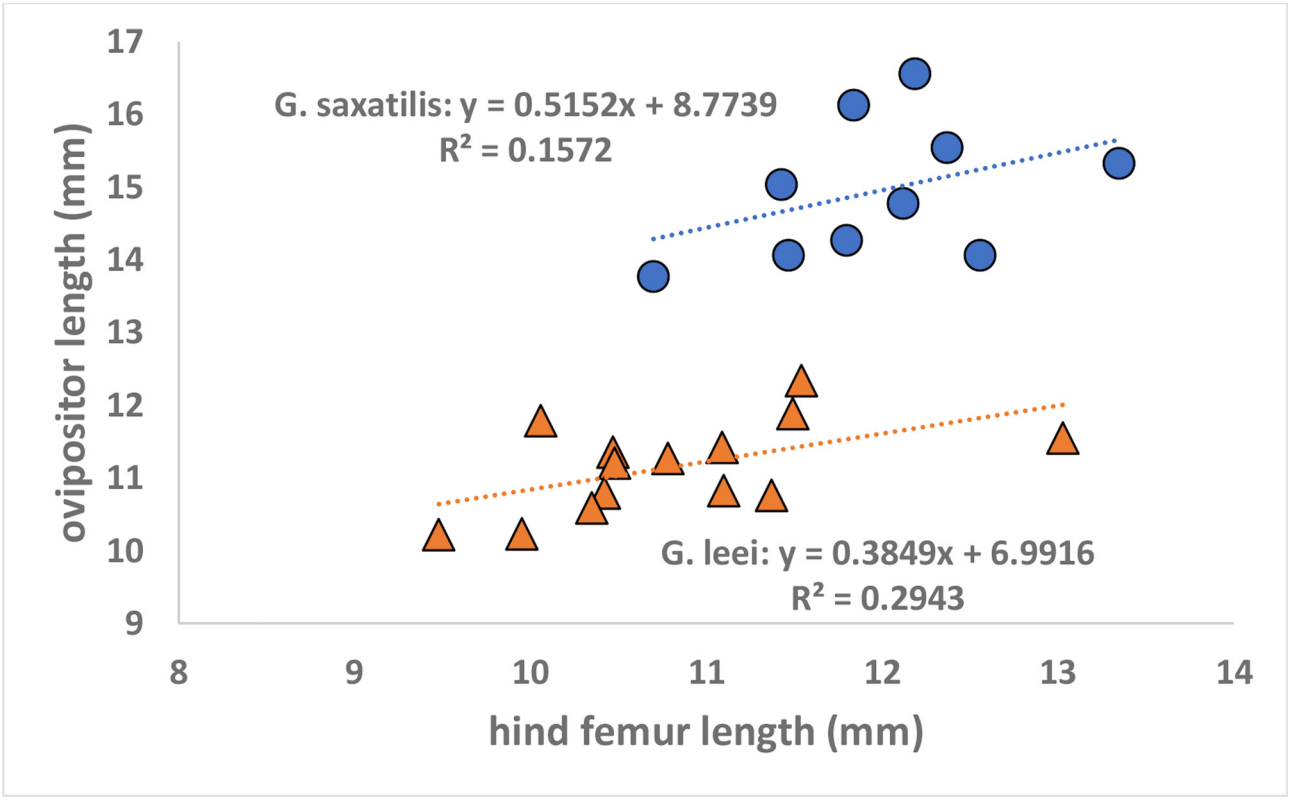

FIGURE 240. Regression of hind femur length vs. ovipositor length in *G. saxatilis* vs. *G. leei.*

under forest canopy and has different DNA. From *G. navajo* of red rock sandstone badlands in Utah and Arizona, the latter usually reddish in color with very long antennae in some populations reaching past tip of abdomen (e.g. Coconino Co., AZ, S07-56), cerci always longer than hind femur and, in certain populations, usually longer than ovipositor tip in situ. From Utah lava restricted *G. leei,* which are smaller crickets with shorter tegmina and longer cerci that always extend beyond the tip of the ovipositor, a rare situation in *G. saxatilis*. Ovipositor ~4–5 mm longer in *G. saxatilis* than in *G. leei* even when controlling for body size by regressing against hind femur length (Fig. 240; $F_{1,21}$ = 84.8. P<0.001; N = 14 *G. leei*; N = 10 *G. saxatilis*).

From South Dakota Badlands National Park *G. makhosica* which has long antennae extending well past tip of ovipositor and cerci longer than ovipositor in situ. The nearest population of *G. saxatilis* is ~580 km to the west near

Cody, WY, where the latter lives in rocky areas and seldom climbs more than a meter vs. the deep cracks in clay badlands, up to 10 m above the canyon floor, that *G. makhosica* frequently inhabits.

Holotype. Male (Fig. 241). California, Santa Clara Co., Mt. Hamilton, observatory area, 4040', 7-vi-2009, 37° 20.384' -121° 38.632', D.B. Weissman. S09-43, R09-46, G1328. 16S GenBank accession # MK446492; ITS2 GenBank accession # MK441923. BL 23.74, HF 13.45, LC 14.57. Right tegmen removed: 174 teeth, FL 4.5, TL 15.1, TW 5.7. Type deposited in CAS, Entomology type #19272.

FIGURE 241. Holotype male (left) *G. saxatilis.* Female (right) also from type locality (S97-62)

Paratypes. (Total 776♂ 300♀) **CANADA. British Columbia,** Haynes Ecological Reserve Hwy 97 3 m N Osoyoos, 1200', 26-viii-2000 (S00-27) 5♂ 7♀; 19-vi-2004 (S04-62) 4♂ 8♀. **USA. Arizona.** *Coconino Co.,* Lees Ferry, 19-v-1987 (S87-35) 4♂. *Mohave Co.,* Kingman, 3700', 2-viii-1992 (S92-113) 9♂ 25♀. Hualapai Mt. Road 1.8 m NW Hualapai Mt. Rec. Area, 5850', 16-vi-2007 (S07-64) 1♂. Quartzsite, 1000', 26-vi-1980 (S80-46) 2♂ 1♀. **California.** *Calaveras Co.,* Hwy 26 3.3 m SW West Point, 14-v-2005, 740m (S05-51) 1♂. *Colusa Co.,* Hwy 20 at mile post 10.9, 547' 5-viii-2014 (S14-61) 2♂. *Contra Costa Co.,* Mt Diablo State Park, 3800', 13-vii-1982 (S82-37) 4♂; 13-viii-1994 (S94-96) 2♂; 17-viii-1996 (S96-78) 2♂. *Fresno Co.,* Jacalitos Canyon, 840-1020', 29-viii-1981 (S81-76) 1♂; 9-iii-1982 (S82-2) 1♂; 6-iii-1992 (S92-33) 1♂; 3-vi-1997 (S97-54) 6♂ 1♀; 29-viii-1998 (S98-83, 84, 85) 8♂ 1♀; 18-viii-2001 (S01-97, 98, 99, 100) 19♂ 2♀; 4-v-2003 (S03-31 & 32) 2♂. *Inyo Co.,* Alabama Hills W Lone Pine, 4240', 8-x-1995 (S95-110) 1♂. Big Pine, 4000', 8-x-1995 (S95-112) 3♂ 1♀; 27-vi-2017 (S16-18) 4♂ 4♀. Bishop, 4150', 16-iii-1996 (S96-13) 1♂; 28-viii-2005 (S05-99) 1♂ 7♀. Death Valley National Monument, Furnace Creek, -186', 5-vi-1983 (S83-60) 2♂; 25-vi-1992 (S92-61) 2♂. Stovepipe Wells, 5', 5-vi-1983 (S83-59) 1♂; 25-vi-1992 (S92-62) 2♀; 1.9 m W Wildrose Ranger Station, 3700', 23-vi-1980 (S80-27) 2♂; Hwy 178 3.5-7 m E west boundary of Monument, 4050-5000' (S80-29) 2♂. Lone Pine, 3400', 7-x-1995 (S95-107) 5♂ 2♀; 22-viii-1998 (S98-78) 1♂; 29-viii-2005 (S05-105) 6♀. Panamint Springs, 1920', 8-x-1995 (S95-108) 1♂. Shoshone, 25-vi-1992 (S92-60) 4♂ 3♀. White Mts., Westgard Pass, Hwy 168, 1.4 to 6.7 m W Summit, 5540-7271', 17-ix-1998

(S98-98 & 98-99) 4♂ 1♀; 27-vi-2017 (S16-17) 4♂. Whitney Portal Rd 8 m W Lone Pine, 6300', 29-viii-2005 (S05-104) 2♂; just below main campgrounds, 8200', 5-viii-1978 (S78-119) 1♂. Hwy 395 8-9 m N Bishop, 4400-4700', 4-vi-1983 (S83-55) 10♂; 26-vi-1992 (S92-64) 7♂ 1♀. Hwy 395 11.2-11.5 m N Bishop, 4600', 20-viii-2009 (S09-142) 9♂ 2♀. *Kern Co.,* Jawbone Canyon off Hwy 14, 3000', 16-iii-1980 (S80-1) 1♂. Hwy 14 30 m N Mojave, 3100', 18-viii-1982 (S82-68) 1♂. Mojave, 2756', 28-viii-1983 (S83-117) 3♂; 17-iii-1996 (S96-18) 1♂; 28-v-2009 (S09-32) 1♂. Tehachapi, 4147', 21-vii-2015 (S15-93) 2♂. Oakcreek Rd. 2.2 m E Tehachapi Willow Springs Rd., 28-v-2009 (S09-29) 7♂ 4♀. Hwy 58 26 m E Mojave, 2400', 27-viii-1982 (S82-108) 1♂. Short Canyon ~10 m NW Inyokern, 3800', 9-vi-1983 (S83-69) 5♂. Hwy 178 3.2 m NW Hwy 14, 3928', 21-vii-2015 (S15-94) 2♂. Hwy 178 19.4 m W Hwy 14, 3064', 21-vii-2015 (S15-95) 1♂. Hwy 178 8 m E Lake Isabella, 2720', 21-vii-2015 (S15-96) 3♂ 6♀. *Kings Co.,* Tar Canyon, 1040', 18-iv-2003 (S03-19) 3♂ 2♀. *Lake Co.,* Hwy 20 near mile post 40.72, 1402', 5-viii-2014 (S14-62) 4♂. *Lassen Co.,* Hwy 36 1 m W Susanville, 4429', 29-viii-2003 (S03-92) 3♂; 7-viii-2014 (S14-74) 3♂. *Los Angeles Co.,* San Gabriel Mts. Hwy N6 1.35 m NW Devil's Punchbowl, 4400', 8-vi-1983 (S83-67) 4♂; Henninger Flats, 2580', 25-ii-2001 (S01-9) 1♂ 1♀. Santa Catalina Island, Avalon, Hermit Gulch Campground, 500-900', 10-vii-2018 (S18-25) 3♂ 5♀; Middle Ranch, 7-viii-1972, 7♂; Mills Landing, 15-vi-1971, 4♂. Santa Monica Mts., Hwy 27 8 m N Hwy 1, 1000', 24-vi-1992 (S92-59) 2♂. Santa Clara River, dry river bed near Acton, 2710', 29-VI-2003 (S03-74) 2♂ 2♀. 21-viii-2006 (S06-84) 1♂ 3♀; 28-v-2009 (S09-26) 1♀. *Madera Co.,* Coarsegold, 2213', 20-vii-2015 (S15-89) 9♂. Hwy 41 3.2 m N Oakhurst, 3500', 27-viii-1982 (S82-111) 1♂. Hwy 41, mile post 16, 1169', 20-vii-2015 (S15-90) 1♂ 1♀. *Mendocino Co.,* Hwy 162 4 m E Longvale, 1000', 2-viii-1980 (S80-59) 3♂. *Modoc Co.,* Hwy 299 2 m W Cedarville, 5210', 30-viii-2003 (S03-97) 1♂. Hwy 299 3.9 m E Hwy 395, 5000', 30-viii-2003 (S03-95) 1♂. Hwy 299 12.8 m E Hwy 395, 5810', 30-viii-2003 (S03-96) 1♂. *Monterey Co.,* Hwy 198 27 m NW Hwy 33, 2180', 3-vi-1997 (S97-55) 1♂. *Riverside Co.,* Blythe, 400', 26-vi-1980 (S80-47) 3♂. Joshua Tree NM, Cottonwood Springs, 2975', 14-vi-1980 (S80-6) 3♂. Whitewater Canyon, 24-iv-1982 (S82-14) 1♂; 6-iv-1991 (S91-13) 6♂ 1♀. Hwy 74 3 m SW Palm Desert, 1740', 26-v-2009 (S09-20) 1♂. *San Benito Co.,* Pinnacles National Monument, Chalone Campground, 12-viii-1982 (S82-45) 1♂. *San Bernardino Co.,* Afton Canyon, 1-v-2005, 1400' (S05-50) 1♂. Baker, 1000', 4-viii-1991 (S91-72) 2♂ 2♀; 5-v-2003 (S03-38) 2♂; 30-viii-2005 (S05-110) 3♂. Barstow, 2420', 21-viii-1998 (S98-77) 1♂ 1♀. Havasu Lake, 6-vi-1983 (S83-62) 7♂. Halloran Springs Microwave Station, 4200', 4-viii-1991 (S91-69) 11♂ 10♀. First wash off I15 on road to Halloran Springs Microwave Station, 2900', 4-viii-1991 (S91-70) 2♀. Kokoweef area, 35° 24.917' -115° 30.166', 5010', 30-viii-2005 (S05-109) 1♂. Lake Arrowhead, 5100', 14-vii-1991 (S91-57) 2♂; 20-vii-1994 (S94-64) 3♂. Ludlow Exit off I40, 2060', 16-viii-1998 (S98-60) 5♂ 5♀. Mt. Pass, 4600", 4-viii-1991 (S91-71) 1♂; 22-vii-2016 (S16-23) 2♂ 1♀. Newberry Springs, 2160', 16-viii-1998 (S98-59) 1♂ 1♀. Yucca Valley, 3160' 26-v-2009 (S09-22) 3♂ 1♀. Truck stop, I40 exit at Goffs, 23-vii-2016 (S16-32) 4♂ 1♀. Hwy 18 near Cushenbury Mitsubishi Cement Plant, 4500' 27-v-2009 (S09-25) 6♂ 6♀. Hwy 95 14 m NW Vidal, wash area, 1200', 6-vi-1983 (S83-63) 4♂. *San Diego Co.,* Hwy 79 1.5 m S Hwy 8, 3220' 5-vi-1997 (S97-58) 2♂. *Santa Barbara Co.,* Anacapa Island, West Island, 23-vi-1971, 1♂. Santa Cruz Island, Field Station, 320', 11-vi-1970, 6♂ 1♀; 14-vi-1972, 6♂; 5-ix-1973, 2♀; 11-vii-2004 (S04-64) 2♂; Prisoner's Harbor, sea level, 11-vii-2004 (S04-65) 1♂. Santa Ynez Mts., Lake Cachuma, 2100', 4-vi-1997 (S97-56) 6♂. Santa Ynez Mts., Hwy 154, 1050-1300', 24-vii-1981 (S81-26) 2♂; 23-vi-1992 (S92-57) 4♂ 1♀. *Santa Clara Co.,* Mt. Hamilton, 4040', 10-iv-1982 (S82-7) 1♂; 9-vi-1982 (S82-22) 4♂; 7-vi-1997 (S97-62) 10♂ 6♀; 7-vi-2009 (S09-43) 3♂ (including holotype) 1♀; 27-viii-2015 (S15-114) 3♂. Mt. Umunhum, 3306' 5-vii-2018 (S18-20) 9♂ 6♀. *Shasta Co.,* Lake Shasta, Bridge Bay Rd yacht area, 4-viii-1980 (S80-67) 3♂. Shasta Dam Visitor's area, 4-viii-1980 (S80-66) 3♂. *Trinity Co.,* Hwy 299 3.5 m (S14-67) and 10.9 m (S14-68) E Humboldt Co. line, 626'-1390', 6-viii-2014, 6♂. Hwy 299 28.8 m E Humboldt Co. line, 1255', 6-viii-2014 (S14-70) 2♂. **Colorado.** *Moffat Co.,* Dinosaur National Monument, Lodore Canyon, Limestone River Campground, 5105', 5-viii-2012, 1♂. **Idaho.** *Elmore Co.,* Hwy 51 12 m S Mt. Home, 2400', 12-vi-2004 (S04-41) 3♂. Hwy 51 10.3 m S Hwy 67, 26-vi-2014 (S14-30) 4♂ 2♀. *Owyhee Co.,* Bruneau Dunes State Park, 2660', 7-vi-1996 (S96-39) 1♂. Hwy 51 1 m N Bruneau, 2900', 7-vi-1996 (S96-38) 3♂. Hwy 51 at mile post 49.6, 4540', 7-vi-1996 (S96-36) 9♂ 8♀. Hwy 51 13 m SE Mt. Home, 2780', 7-vi-1996 (S96-40) 4♂. *Washington Co.,* Weisel Dunes OHV Play Area, 27-vi-2014 (S14-34) 3♂. **Nevada.** *Churchill Co*., Fallon, 4000', 16-ix-1998 (S98-95) 2♂ 2♀. Fallon Range Training, 4133', 17-vii-2018, 38.918846° -118.196263° (S18-32) 1♂ 2♀, A. Abela. Fallon Range Training, 4974', 17-7-2018, 39.15550° -118.341317° (S18-33) 7♂ 2♀, A. Abela. Fallon Range Training, 5997', 20-vii-2018, 39.444553° -118.046063° (S18-36) 2♂, A. Abela. *Clark Co*., Cottonwood Cove, 750', 24-vi-1980 (S80-36) 6♂ 1♀. Henderson, 2000', 24-vi-1980 (S80-35) 2♂. Indian Springs, 4300', 3-viii-1992 (S92-114) 1♂. Las Vegas, 15-viii-1998 (S98-57) 5♂ 1♀.

Spring Mts., Lee Canyon Rd, at intersection with Hwy 95, 3600', 15-viii-1998 (S98-56) 2♂. Lee Canyon Rd. at mile post 8.8, 6000', 2-viii-1991 (S91-60) 10♂ 8♀; 15-viii-1998 (S98-55) 1♀; 5-ix-2006 (S06-105) 3♂. Searchlight, 3540', 24-vi-1980 (S80-37) 1♂; 23-vii-2016 (S16-33) 3♂. *Humboldt Co.,* Hwy 95 4 m N Winnemucca, 4480', 9-vi-1996 (S96-45) 2♂; 17-iv-1998 (nymphs reared to adult) (S98-22) 3♂ 2♀; 2-iii-2005 (nymphs reared to adult) (S05-27) 2♂. Hwy 290 11-11.8 m N Paradise Valley, 6220-6460', 8-vi-1996 (S96-43) 12♂ 3♀. Hwy 140 ~12 m W Denio Junction, 4200', 28-vi-1992 (S92-70) 10♂ 4♀. *Lincoln Co.,* Panaca, 4900', 20-viii-1982 (S82-80) 1♂. 7 m E Panaca, 6000', 20-viii-1982 (S82-81) 3♂. Pioche, 6000' 20-viii-1982 (S82-79) 1♂. Hwy 319 4.1 m W Utah state line, 6140', 18-viii-2009 (S09-131) 1♂. Hwy 319 10.6 m W Utah state line, 6280', 18-viii-2009 (S09-132) 2♂ 1♀. *Mineral Co.,* Mina, 4360', 4-ix-1999 (S99-98) 2♂. Hwy 95 just S Mina, 4680', 18-iv-1998 (nymphs reared to adult) (S98-25) 2♂ 2♀. Hwy 395 5 m S Hawthorne, 5200', 26-vi-1992 (S92-65) 5♂ 2♀. *Nye Co.,* Beatty, 3300', 22-viii-1998 (S98-80) 5♂ 7♀. Currant Summit, 6999', 19-viii-2009 (S09-140) 5♂ 1♀. Tonopah, 6140', 10-x-1995 (S95-115) 5♂ 1♀; 4-ix-1999 (S99-99) 1♂; 19-viii-2009 (S09-141) 1♂. *Pershing Co.,* Rye Patch State Rec. Area, 4050', 27-vi-1992 (S92-67) 3♂. Rye Patch Dam road exit, 4000', 27-vi-1992 (S92-68) 9♂ 6♀. *Washoe Co.,* Reno, near intersection I80 and Stoker St., 5000', 23-viii-2002 (S02-63) 7♂ 2♀; 31-viii-2003 (S03-99) 6♂ 3♀; early May, 2004 (S04-31) 9♂ 2♀. Hwy 447 22.5 m S Gerlach, 4300', 3-vi-1983 (S83-50) 2♂. *White Pine Co.,* outskirts Baker, 5380', 9-vi-1996 (S96-49) 5♂ 3♀. Hwy 488 3.1 m W Baker. 6020', 9-vi-1996 (S96-48) 9♂ 5♀. Hwy 488 5 m W Baker, 6440', 9-vi-1996 (S96-47) 2♂. **Oregon.** *Harney Co.,* 10.7 m S Burns at mile post 10.7, 4100', 14-vi-2004 (S04-51) 5♂ 1♀. Hwy 205 16.6 m NW Fields, 4720', 2-vi-1997 (S97-52) 17♂ 6♀. *Josephine Co*., Store Gulch Campground, 900', 27-vi-1992 (S92-80) 1♂ 1♀. 2.6 m E Store Gulch Campground, 1300', 30-v-1983 (S83-36) 11♂ 7♀. 8 m W Selma, 800', 27-vii-1992 (S92-79) 1♂ 6♀. *Lake Co.,* Alkali Lake, 2-vi-1983 (S83-46) 3♂. Hwy 31 at mile post 62.7, 5200', 17-VI-2004 (S04-57) 2♂. *Sherman Co.,* John Day Dam, 24-vi-1983 (S83-100) 2♂. Hwy 97 0.7 m SE Biggs, 220', 31-v-1997 (S97-47) 5♂ 2♀. Hwy 97 14.8 m S Biggs, 1460', 31-v-1997 (S97-48) 3♂. *Wasco Co.,* Hwy 97 23 m N Madras, 2160', 31-v-1997 (S97-49) 2♂. **Utah.** *Box Elder Co.,* Hwy 30 1 m N Hwy 69, 4700', 20-vi-1987 (S87-50) 12♂ 8♀. *Grand Co.,* Moab, 25-iv-2006 (S06-21) 4♂. *Juab Co.,* Eureka, 23-v-2015 (S15-13) 1♂ 1♀. *Kane Co.,* 6.4 m up road to Zion Narrows, 6740', 9-viii-1991 (S91-93) 1♂ 1♀; 10-vi-1996 (S96-51) 7♂ 3♀. *Millard Co*., Copley's Trail ~8 m E Fillmore, 6300', 31-vii-1992 (S92-104) 2♂ 1♀. Fillmore, E Canyon Rd. 0.9 m E Business I15, 4920', 31-vii-1992 (S92-103) 4♂ 1♀; 18-v-2001 (S01-30) 3♂ 2♀; 20-v-2017 (S17-7) 14♂ 7♀. S. Canyon Rd. 1.8 m E Business I15, 5040', 18-v-2001 (S01-31) 1♂ 1♀. S. Canyon Rd. 8.1 m E Business I15, 5820', 18-v-2001 (S01-32) 2♂. Hwy. 6 at mile post 41, 39° 2' 9.8" -113° 20' 15.7", 5239' 23-v-2015 (S15-15) 6♂ 7♀. *San Juan Co.,* Hwy 191 4 m S Moab, 21-vi-1987 (S87-58) 2♂. Hwy 191 9 m N Monticello, 6200', 21-vi-1987 (S87-60) 2♂. *Tooele Co.,* Dugway Proving Grounds, Granite and Sapphire Mts., 1400m, 24-27-viii-2013 (S13-79) R. Delph, 7♂ 4♀. Johnson Pass, Hwy 199 between mile posts 11.6-15.2, ~6000', 20-vi-1987 (S87-52) 4♂; 30-vii-1992 (S92-92) 7♂; 9-ix-2004 (S04-105) 2♂. Stockton, 5390', 9-ix-2004 (S04-106) 2♂; 23-v-2015 (S15-11) 1♀. Tooele, 23-v-2015 (S15-10) 1♀. *Uintah Co.,* Hwy 149 0.5-1.4 m S Dinosaur National Monument, 5000', 10-ix-1999 (S99-128) 3♂. *Washington Co.,* Hurricane, 3420', 20-iv-1999 (S99-12) 5♂ 1♀. St. George, 3040', 19-v-1995 (S95-39) 11♂ 1♀. Zion National Park, 4440-5640', 10-vi-1996 (S96-52 & 53) 3♂. La Verkin, 3420', 11-ix-2004 (S04-121) 9♂ 5♀. Hwy 9 1-2 m NE La Verkin, 3700', 9-viii-1991 (S91-95) 1♂; 10-vi-1996 (S96-57) 5♂. **Washington.** *Grant Co.,* Ephrata, 1240', 30-v-1997 (S97-46) 9♂ 5♀. Wanapum Dam Reservoir, 750' 1-vi-1983 (S83-44) 6♂ 2♀; 1300' (S83-43) 2♂. Hwy 155 ~6 m S Grand Coulee, 1600', 30-v-1997 (S97-44) 2♂ 3♀. Hwy 17 2 m N Soap Lake, 1120', 27-viii-2000 (S00-32) 10♂. Hwy 17 14.1 m N Soap Lake, 1220', 27-viii-2000 (S00-31) 1♂. Hwy 155 6.5 m N Coulee City, 1660', 30-v-1997 (S97-45) 3♂. *Lincoln Co.,* Hwy 2 ~10 m W Davenport, 2260', 30-v-1997 (S97-40) 4♂. Hwy 174 4.5 m SE Grand Coulee, 1760', 30-v-1997 (S97-41) 3♂. **Wyoming.** *Fremont Co.,* Hwy 20 ~13 m N Shoshone, 4810', 18-vii-2011 (S11-70) 7♂ 4♀. *Park Co.,* 3.1 m W Cody, 5200', 2-viii-1997 (S97-104) 6♂ 2♀; 16-vii-2004 (S04-74) 4♂ 1♀.

Derivation of name. "saxatilis" is Latin for "found among rocks," in reference to this species' most typical habitat.

Geographic range. Fig. 242. Also into northern Baja California, Mexico. Only known populations east of the Continental Divide are those in Wyoming.

Habitat. Tolerant of widely varying ecological conditions from elevations between -57m (Furnace Creek, Death Valley National Monument, CA S83-60) to over 2200m (Inyo Co., Westgard Pass, S98-98 & S16-17) up to around 2500m at Whitney Portal campgrounds (S78-119), but almost always associated with rocks. Occasionally in cracks of buildings (Halloran Springs Microwave, S91-69) or debris piles in dry river bed bottoms (Jacalitos Canyon, S01-

100). Rarely climbs >1-2m in vegetation, but one male singing from palm tree 10m above ground at Furnace Creek (S83-60). Does climb within rocks along cliff faces (e.g. Long Canyon, Burr Trail, Boulder Co., Utah; Checkerboard Mesa, Zion National Park, Kane Co., Utah); also in rocks supporting railroad tracks in Mojave, CA (S83-117).

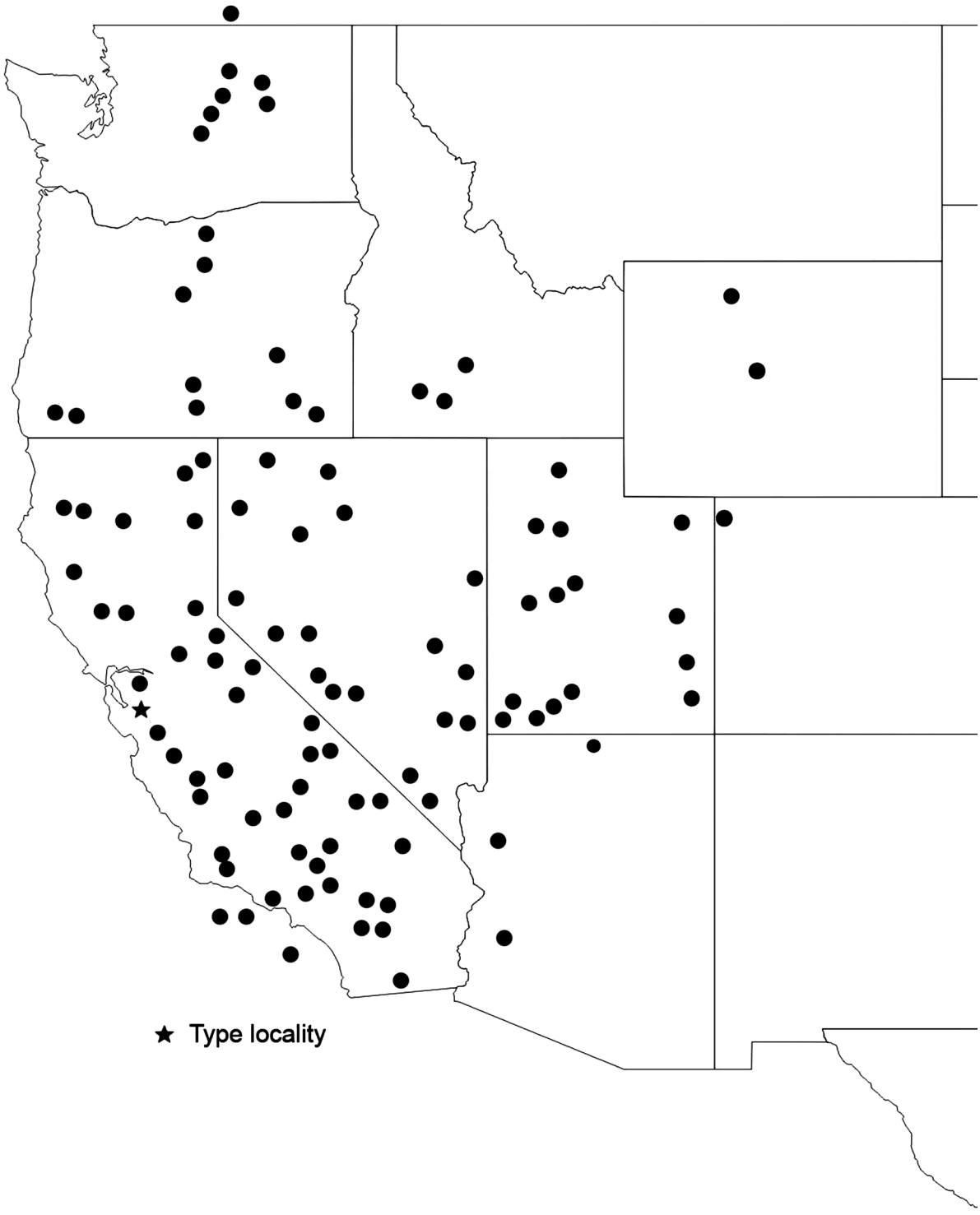

FIGURE 242. Known US distribution of *G. saxatilis*.

Life cycle and seasonal occurrence. No egg diapause: UT, Box Elder Co. (S87-50); CA, Halloran Springs Microwave (S91-69); Reno, NV (S02-63, S03-99); British Columbia (S04-62); NV, Current Summit (S09-140); UT, Dugway Proving Grounds (S13-79); UT, Millard Co., Fillmore (S17-7). Probably one generation/year in Southern and Central California as adults present in May but almost none heard singing by August, which is when a sec-

ond generation, if present, would be maturing. On the other hand, there appears to be 2 generations/year in Reno, Washoe Co., NV. In early May, 2004 (S04-31), singing males were heard throughout town. We collected 9♂ 1♀ and 1 last instar ♀ that soon molted to adult. On 23-viii-2002 (S02-63) we collected 7♂ 2♀ along with 2 mid-late instars, but singing males were geographically restricted. Eggs from those 2 adult females had no diapause. On 31-viii-2003 (S03-99) we collected 6♂ 2♀ and 3 mid-late nymphs. Eggs from those females also had no diapause. One collected female nymph was a last instar 3-xi-2003 and an adult 1-v-2004 (in a laboratory minimally heated during the winter). Further work over several years with more sampling, and variable rainfall, is needed to interpret this pattern.

Variation. **Body color:** Generally dark (Fig. 243) but reddish individuals known (Fig. 243, CA, Jacalitos Canyon, S01-97). **Hind wing length:** see "Discussion" below. **Number file teeth:** Varies from 122-190 (Fig. 244), a greater range than typically seen in a *Gryllus* species with a more limited distribution. **Tegminal bars** present in certain populations**:** 2 of 7 field collected adult females from UT, Millard Co., Fillmore (S17-7); in both sexes from CA, Kern Co., Tehachapi (S09-29).

FIGURE 243. Color variation in *G. saxatilis*, moving left to right: left long hind winged 'G. mohave' (Baker, CA, S03-38); middle long hind winged 'G. mohave' (Kingman, AZ, S92-113); right *G. saxatilis* (Fresno Co., CA, S01-97).

DNA. G. saxatilis falls within a clade of closely related western chirping species that we recognize here as *G. saxatilis, G. leei, G. makhosica,* and *G. navajo.* Multilocus G3310 Mt. Hamilton, CA (S15-114—type locality for *G. saxatilis*); G3484 Fillmore, UT (S17-7—locality of *G. saxatilis* nearest [14 km east] to type locality of *G. leei*); G3431 Big Pine, CA (S16-18—'G. mojave', where all 12 collected individuals had long hind wings); and G1131 Kingman, AZ (S07-64—'G. mojave') all map (Gray *et al.* 2019) in a group of rock chirpers along with Utah *G. leei,* South Dakota *G. makhosica*, Arizona and Utah *G. navajo,* and California 'G. tulare' and 'G. mormoni'. Individuals of *G. saxatilis* from Mt. Pass, CA, (S16-23), near Goffs, CA (S16-32), and Searchlight, NV (S16-33) all have the same 16S sequence that we found in 'G. tulare'. ITS2 (Fig. 238, p. 236) does a poor job resolving within the *S*axatilis Group, specifically *G. makhosica*, *G. leei*, and *G. navajo* ITS2 sequences are intermingled with *G. saxatilis*. Ironically, the 'tulare' and 'mormoni' forms, which we do not recognize here as distinct species, are better resolved by ITS2 than the taxa we do recognize. Further work is clearly warranted; analysis of SNP data from rad-seq on a large series of *G. saxatilis* and *G. navajo* is already underway (Collosi *et al*., in prep.), see discussion under *G. navajo*, p. 258.

Discussion. This species was initially split into several groups, mostly for convenience, based on geography and some physical differences. All populations in California, Oregon, and Washington west of the Sierras and Cascades were called 'G. #2'. Those populations in California, Oregon, and Washington east of the Sierras and Cascades, and

those collected in southern Idaho and Nevada were designated 'G. #11'. Populations from Utah, northern Arizona, and Wyoming were labeled 'G. #22'. And lastly, those individuals not always associated with rocky habitats but with human habitation, and with long hind wings and small heads, from the Great Basin and Mojave Desert areas of California, southern Nevada and adjacent Arizona, were called 'G. #38' or 'G. mojave'. While we suspect that cryptic species may exist within this geographically diverse assemblage, we are not able to separate them either morphologically or with DNA profiles. All have similar songs and have been included as paratypes under *G. saxatilis*.

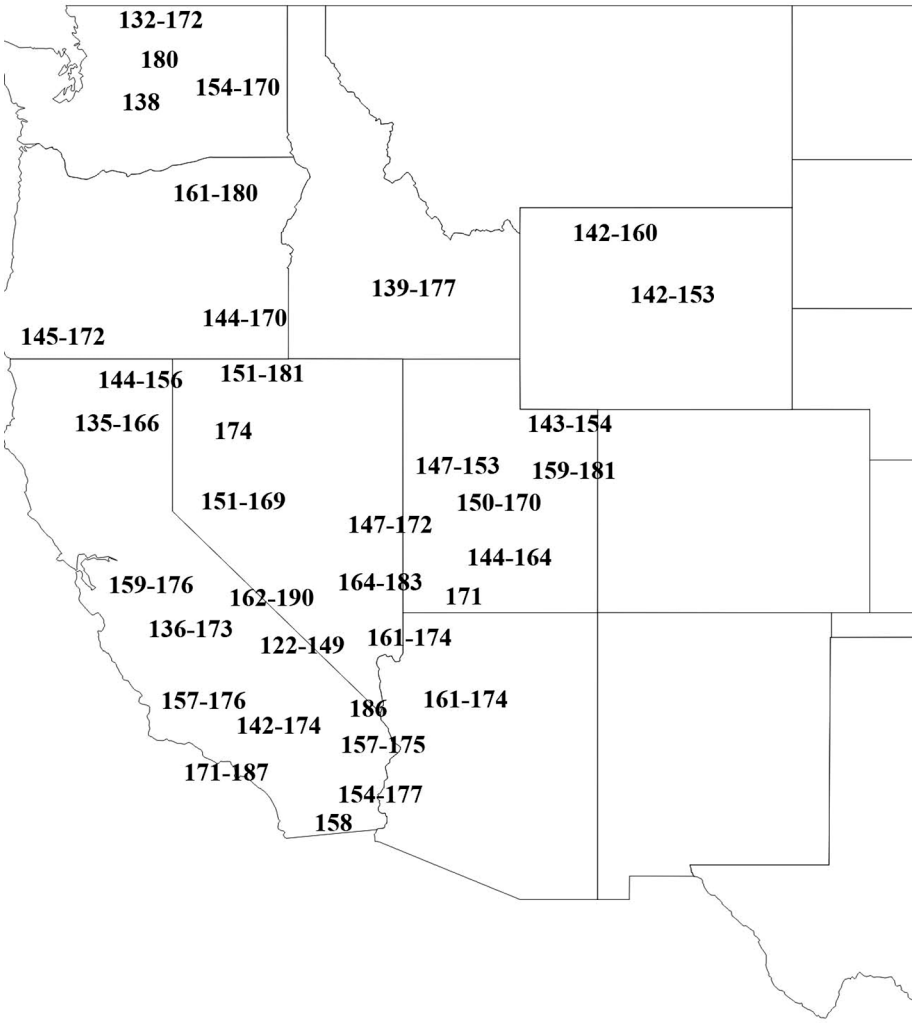

FIGURE 244. Distribution map of file tooth number in *G. saxatilis*. Counts vary from 122 (Tulare Co., CA, S03-28) to 190 (Big Pine, CA, S16-18).

Still, the most likely cryptic taxon are those individuals considered to be *'*G. mojave' based on the common, but not universal, reduced head width and almost universal presence (Fig. 243) of long hind wings (e.g. all 9 males and 25 females from Kingman, AZ (S92-113); all 11 males and 10 females from Halloran Springs (S91-69) and, in total, 97 of 120 males [81%] and 84 of 85 females [99%] from the Great Basin and Mojave Desert, where we considered all collected *G. saxatilis* to be *'*G. mojave'. Most of these just discussed, long hind-winged individuals were from areas of human influence, either adjacent to or within town boundaries or outside towns but associated with human structures. In contrast, a nice series of 14 individuals of *G. saxatilis*, collected by A. Abela in undisturbed Great Basin Desert habitat, Churchill Co., NV (S18-32, 33, 36), all had short hind wings. Also, only one of 8 males and the only female from another undisturbed, (high elevation—2216m) locality, Westgard Pass, CA, on the western edge

of the Great Basin, had long hind wings. And away from the Great Basin and Mohave Deserts, only 6 of 530 adults (~1%) had long hind wings. It thus appears that a combination of living with human influence within and near the Great Basin and Mojave Deserts, favors adults with long hind wings.

On the 21-km-long road between Hualapai Mt. Rec. Area and Kingman, Arizona, going from 2042m to 1128m, there are 4 species of medium sized, medium-long length cerci, slow chirping *Gryllus* species. *G. montis* is highest in the pine-oak forest, but extends into the higher elevation interior chaparral as low as 1585m. Once out of the forest driving almost due west through interior chaparral, faster chirping *G. lightfooti* is heard starting at 1738m and heard into Kingman. *G. longicercus* starts at 1646m, drops out at 1433m, and is then heard again in Kingman. *G. saxatilis* was first heard in 1992 (S92-113), on the outskirts of Kingman, at 1128m, in large numbers (9 males and 25 females, all with long hind wings. In 2007 (S07-64), only one male *G. saxatilis*, with long hind wings, heard and collected at 1783m. Three species (*G. montis, G. longicercus,* and *G. saxatilis*) heard microsympatric, in both 1990 (S90-56) and 1991 (S91-65), at 14 km SE Kingman at 1646m.

Five tachinid *Ormia ochracea* emerged from 1 male near Palm Desert, CA (S09-20); one *O. ochracea* emerged from a male from Corn Springs, Riverside Co., CA (33.625, -115.333) collected 10-iv-2015—seasonally among the earliest *O. ochracea* we have encountered. One, two, and three tachinid *Exoristoides johnsoni* emerged from three males from Fallon, NV (S98-95). One tachinid *E. johnsoni* emerged from each male, both collected as nymphs, from 6.4 km N Winnemucca, NV (S98-22). For such a widespread species, this is a surprisingly low parasitism rate. Perhaps this rate is reduced by having only 1 early-season generation/year, before the tachinid fly numbers become significant.

One female *G. saxatilis*, Oregon, Josephine Co., 13 km W Selma (S92-79) with horsehair worm. One male, California, Tulare Co. (S03-27) with mermithid worms (see Poinar & Weissman 2004).

Occasional males continue to sing while turning over rocks attempting a capture—a behavior also seen in *G. longicercus*.

Two geographically restricted areas of *G. saxatilis* give us pause, based primarily upon DNA results. We gave individuals from these two areas tentative names, and we now discuss them: 'G. mormoni' is from the area around Folsom Lake, CA, and 'G. tulare*'* is from Tulare Co., CA. They both have 16S, ITS2, and multilocus DNA sequences distinctive from other *G. saxatilis* and from each other. Since neither can be morphologically or ecologically separated from typical *G. saxatilis*, and in the absence of any vicariant physical barrier, we tentatively place them together with the nominate species and discuss them below, but do not consider them paratypes. Comparing 'G. mormoni' vs. 'G. tulare', they can be separated by DNA (Fig. 238), almost non-overlapping teeth/mm (Table 1, p. 18), non-overlapping file teeth vs. tegmina width (Fig. 245), and little overlap between hind femur length vs. ovipositor length (Fig. 246), although the latter could be the simple result of larger body size in 'G. tulare'.

'G. mormoni' Known only from around Folsom and Placerville, in California's Sacramento Valley, that portion of the California Central Valley that lies to the north of the Sacramento-San Joaquin River Delta. Medium sized, generally black, narrow pronotum, medium length cerci and always short hind wings. Song a slow chirp (1.5-2.5 C/S), 4-5 P/C, PR 17-21 at 25°C. Separated from nominate *G. saxatilis* by DNA (Fig. 238) and the narrower tegmina in 'G. mormoni' (Table 1, p. 18). Additionally, paratype *G. saxatilis* not known from the Central Valley floor proper but only in foothills of adjacent mountain ranges to the west (e.g. Jacalitos Canyon near Coalinga, Fresno Co.; Tar Canyon near Kettleman City, King Co.); to the north (e.g. Lake Shasta, Shasta Co.); and east (West Point, Calaveras Co.).

Specimens studied. (23♂ 18♀). **California.** *El Dorado Co.,* 4.7 air miles NE Placerville, Mosquito Rd near mile post 5.64, 8-viii-2014, 519m, 38° 46' 34.76" -120° 45' 08.57' (S14-77) 4♂ 1♀. *Sacramento Co*., Folsom, intersection of Folsom Blvd. and Hwy 50, 174', 19-vii-2015 (S15-87) 6♂ 2♀; Folsom, intersection of Folsom Blvd. and Blue Ravine Rd., 19-vii-2015 (S15-88) 5♂ 7♀. Folsom Lake SRA, Beal's Point area near Folsom Dam, 463', 6-v-2013, 38° 43' 06.61" -121° 10' 10.18", 29-iii-2005 (S05-38) 2♂, collected as mid instars; 6-v-2013 (S13-10A) 6♂ 8♀.

Derivation of name. Named for Mormon Island, a California mining community that developed, starting in 1848, after gold was discovered on the south fork of the American River. The community was subsequently razed and covered with water from Folsom Lake, which formed in 1955, after the construction of Folsom Dam. Due to California's record drought from 2012-2017, parts of Folsom Lake were exposed, where we collected a nice series in 2015. Mormon Island is designated as California Historical Landmark #569.

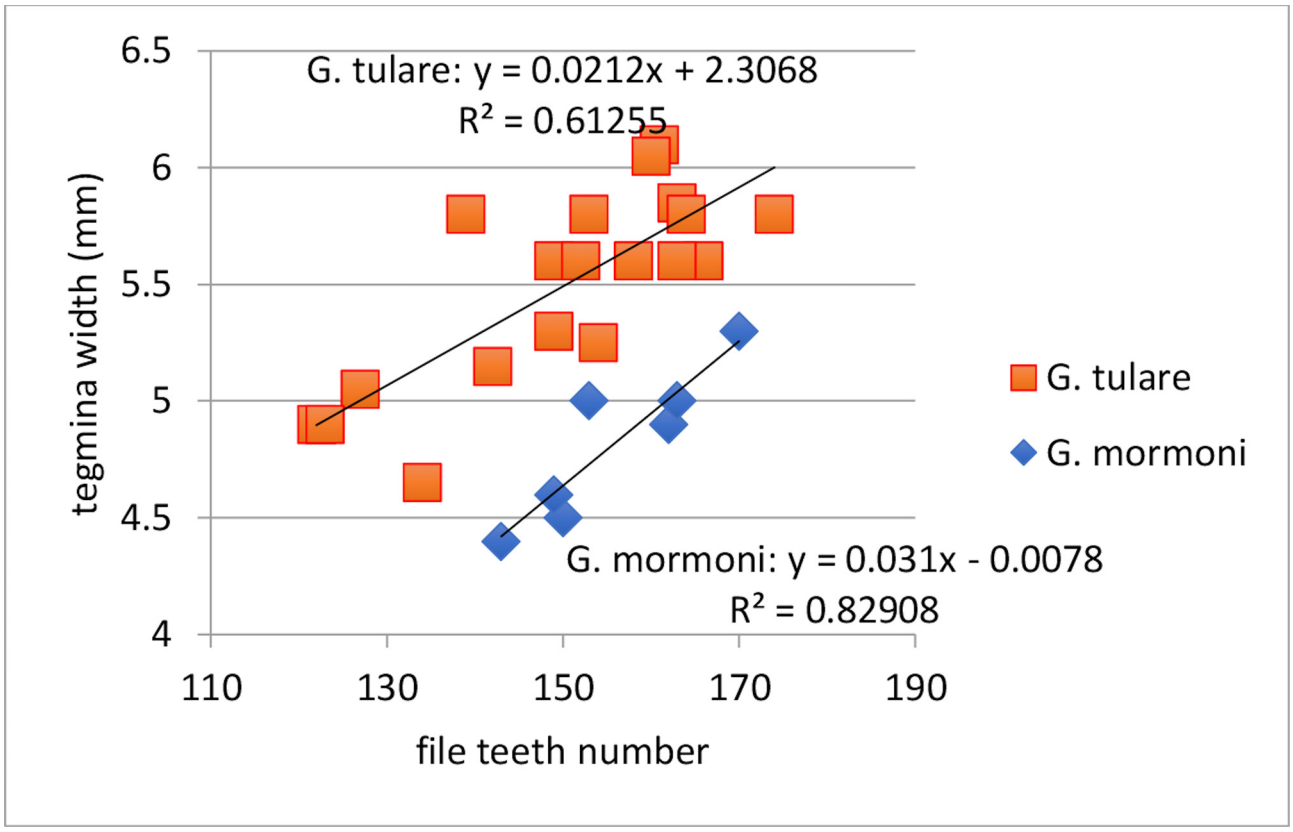

FIGURE 245. Regression of file teeth number vs. tegmina width in 'G. tulare' vs. 'G. mormoni' showing absence of overlap.

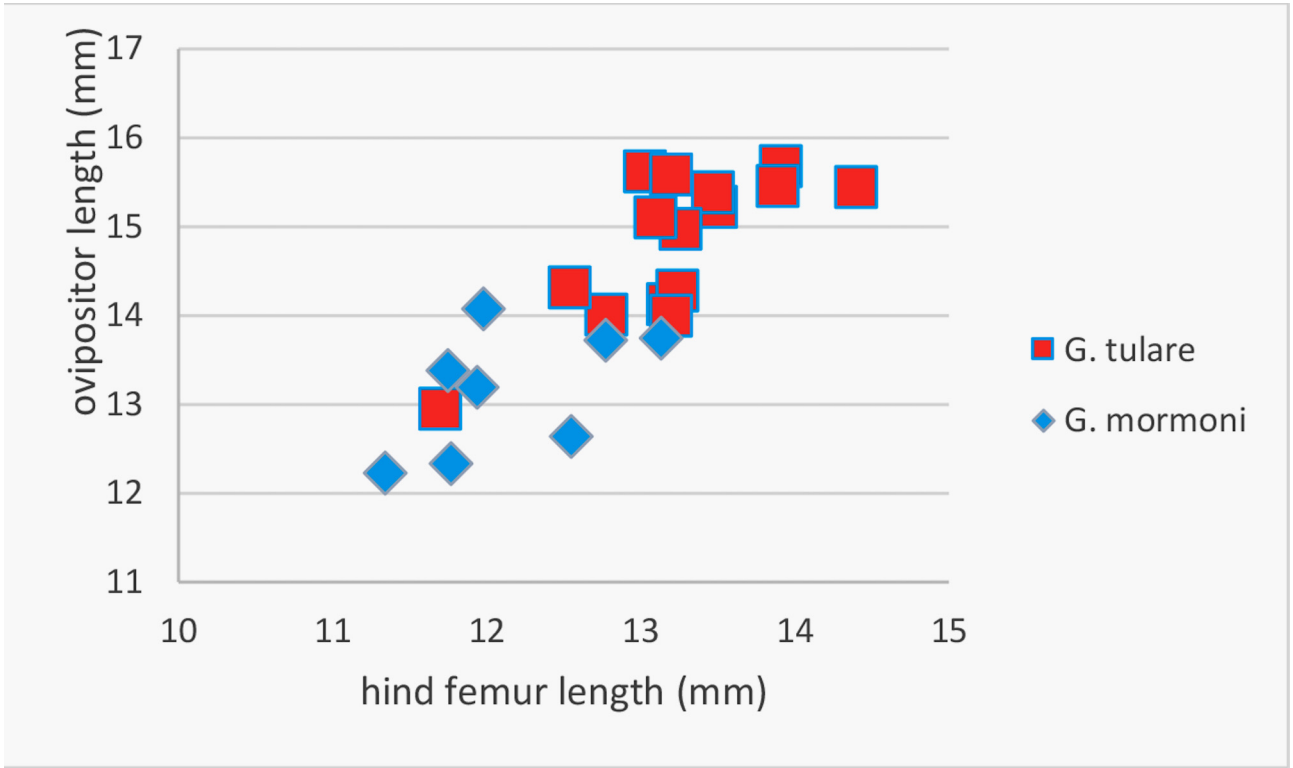

FIGURE 246. Regression of hind femur length vs. ovipositor length in 'G. tulare' vs. 'G. mormoni' showing minimum overlap.

Habitat. The Folsom Lake locality is open, short grassland, with rocks, lying in the completely dry, exposed part of "Folsom Lake", which may have been submerged in 2019 after an above-average rainfall year. A few males also singing from under adjacent rocks at the base of Folsom Dam. Similar sounding males also singing within oak-woodland of Folsom Lake SRA but none collected and species identity not confirmed as similar sounding *G. veletisoides* also occurs in the area. The two localities within Folsom city limits (S15-87, S15-88) were open areas with dirt and few rocks, the latter adjacent to the railroad tracks. Mosquito Road is 37 air km from the first locality and more typical habitat of *G. saxatilis* comprised of oak woodland with dirt road banks but few rocks. Crickets were heard for some 3 km along Mosquito Rd. between 511m and 684m elevation.

Life cycle and seasonal occurrence. No egg diapause (S14-77). One generation/year with nymphs overwintering as mid-late instars since late-instars present in late March and adults present and singing in early May. F_1 nymphs, from laboratory laid eggs, started molting to adults, in May, one year after they were laid.

'G. tulare' Only known from Tulare Co., California, always with short hind wings. Song a slow chirp (3) 4 (5) p/c, 90-225c/m, PR 15.2-23.8 at 25°C. Separated from nominate *G. saxatilis* by DNA (Fig. 238).

Specimens studied. (31♂ 17♀). **California.** *Tulare Co.,* Hwy 190 3.2 m E Springville, 1620', 20-viii-2006 (S06-81) 1♂. Hwy 190 6.5-10 m E Springville, 2320-3460', 29-v-2009 (S09-34, 35) 17♂ 13♀. Hwy 190 0.5 m W Pierpoint Springs, 4700', 4-v-2003 (S03-27) 2♂ 2♀. Hwy 190 5.4 m W Pierpoint Springs, 3700', 4-v-2003 S03-28) 5♂. Hwy 198 4.4 m E Lemon Cove, 725', 28-vi-2016 (S16-21) 6♂ 2♀.

Habitat. From 221-1433m elevation. Habitat typical for *G. saxatilis*: oak-woodland borders, chaparral, road cuts always associated with rocks.

Life cycle and seasonal occurrence. One generation/year, egg diapause not checked but undoubtedly absent as adults present in late spring. Mid-late instars seen early May (S03-27 & 28) and a last instar female seen late May (S09-35) when most of population adult.

Variation. **Cerci length:** Longer than ovipositor in situ in only one female (S09-34). **Color:** Hind femur normally varies from small reddish area medially where attaches to body to entire femur reddish with rest of hind leg black. Two males (S03-27 and S06-81) with entire hind legs reddish. **File teeth:** Vary from 122–174. All of these males have medium length cerci and DNA consistent with 'G. tulare.' The three *G. saxatilis* males with the fewest teeth (122–149, see Fig. 244, p. __) are in this 'G. tulare' group (S03-28, W Pierpoint Springs), collected on 4-v-2003, and raised through the last few instars in the laboratory.

***Gryllus leei* Weissman & Gray, n. sp.**
Utah Lava Field Cricket
Figs 231, 236–238, 240, 247–250, Table 1

Distribution. Known only from lava flows in the Black Rock Desert of west-central Utah.

Recognition characters and song. A small-medium, always short hind winged, generally black, shiny pronotum, small headed, short ovipositor, cerci always longer than ovipositor in situ *Gryllus* (Fig. 249). *Song* a chirp (Fig. 247, R17-7) of usually 4 (range 3–5) p/c, PR 17.5–22, CR 105–200 (range 98–225). Most importantly, because multilocus *G. leei* maps close to multilocus *G. saxatilis,* we can separate the two even though they are found only ~14 air km from each other, as follows: *G. leei* is smaller (S01-28, S17-6), with the longest body-length individual being shorter than the smallest individual of *G. saxatilis* (S01-30, S17-7), with good sample sizes from both populations. If the same species, it then logically follows that *G. leei* might have (see Table 1, p. 18) fewer file teeth, shorter files and shorter tegmina, and (non-overlapping) shorter ovipositors than nearby *G. saxatilis.* What doesn't necessarily follow is that *G. leei* has proportionally longer cerci, almost non-overlapping teeth/mm, and a different dominant frequency calling song. For the latter, 24 males from the type locality (S17-6) had a dominant frequency from 4017–5211 Hz while 15 males *G. saxatilis* from nearby (S17-7) had a dominant frequency of 3593–4097 Hz. Most male *G. leei* (20 of 22–91%) with 3–4 (rarely 5) harp veins while 12 of 13 (92%) nearby *G. saxatilis* have 4–5 (rarely 3) harp veins. Additionally, the cerci are longer, in situ, than the tip of the ovipositor in all 14 type locality females of *G. leei* while shorter than the tip in all 10 females of nearby (S17-7) *G. saxatilis.* This trend is confirmed when we regress ovipositor length on hind femur length (as an indicator of body size) (Fig. 248; hind femur: $F_{1,20} = 87.72$, $p < 0.0001$, species: $F_{1, 20} = 81.16$, $p < 0.0001$, species*hind femur $F_{1,20} = 0.10$, $p = 0.748$).