

## *Gryllus pennsylvanicus* Burmeister

Fall Field Cricket

Figs 28–37, 45–50, 52, 53, 139, Table 1, 2

1838 *Gryllus pennsylvanicus* Burmeister. Handb. Ent., II, p.734. Lectotype male designated by Alexander, 1957, p. 586. “North America.” Burmeister’s original description (last paragraph under 13. Gr. Campestris) reads: “A similar species (Gr. pennsylvanicus\*) is found in North America; it is somewhat smaller, the tegmina shorter than the body, without yellow base, but with brown main longitudinal vein.” According to Michael Ohl (pers. comm. to DBW May, 2003) of the Museum of Natural History of Humboldt-University in Berlin (ZMB), entry #983 of the historic catalogue of the ZMB says (catalogue columns separated by slashes): “*Gryllus abbreviatus* Serv./ 4 [specimens; subsequently corrected to 3]/ Pennsylvan. Zimmerm./ Types of *Gryllus pennsylvanicus* Burm.\*” These 3 specimens are still in the collection and include the male lectotype labeled by R.D. Alexander and 2 females. Sigfrid Ingrisch (pers. comm. to DBW May, 2003) believes that although the “...original description reads only North America, ...one might guess from the name [and the catalogue entry] that it was from Pennsylvania.” Lectotype male and labels illustrated on OSF website (Cigliano *et al.* 2019).

1957 *Acheta pennsylvanica*. Alexander. Ann. Entomol. Soc. Amer. 50: 586.

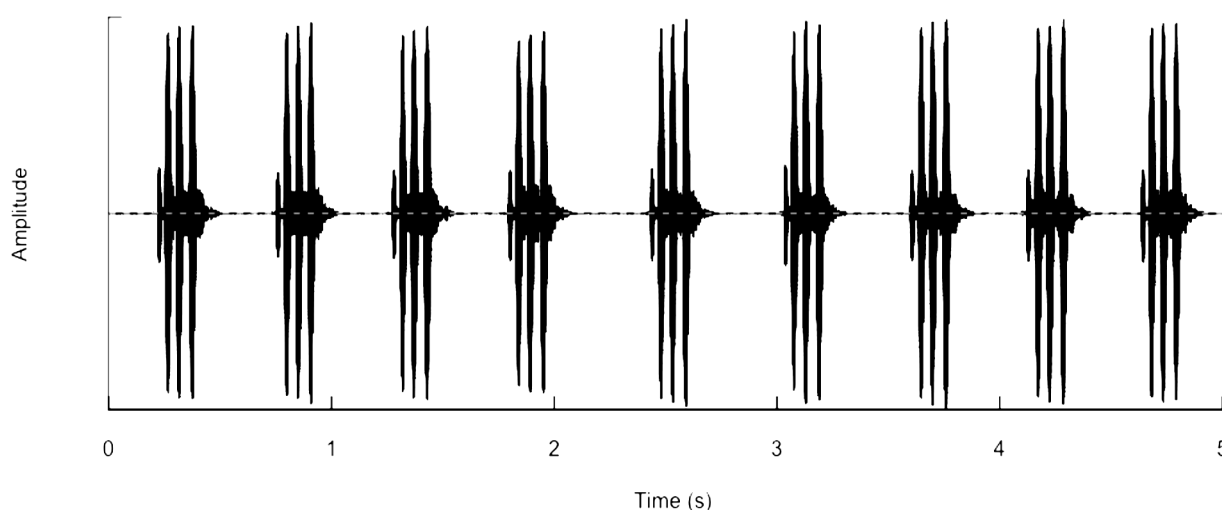
1964 *Gryllus pennsylvanicus*. Randell. Can. Entomol. 96: 1592.

‘G. eastern and western pennsylvanicus’, ‘G. hanksville’ and ‘G. near hanksville’ of DBW notebooks.

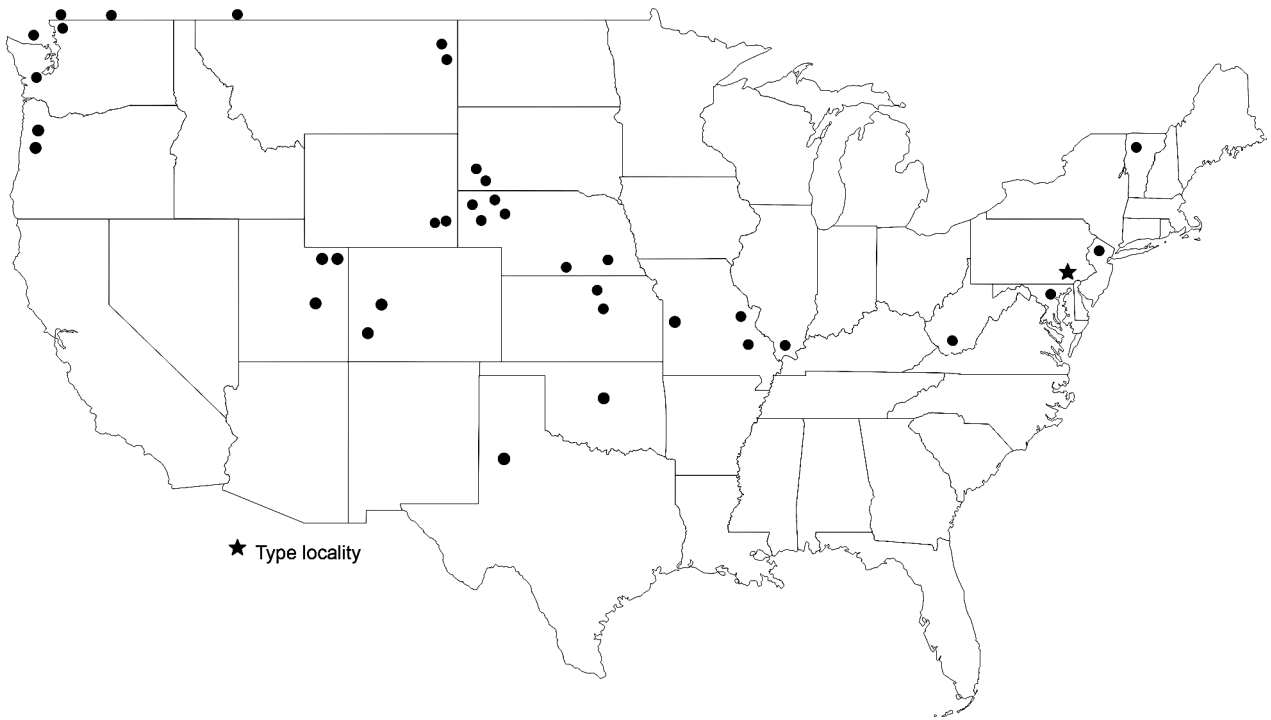
**Distribution.** Widespread across the US although absent from the Southwest and Southeast.

**Recognition characters and song.** We apply this name to any US *Gryllus* with the following constellation of characters: obligate (winter) egg diapause, one generation/year, adults first appearing mid to late summer (usually after August 1<sup>st</sup>), slow chirping (2–3 c/s; Fig. 31; R04-110), 3–5 p/c, black crickets with short cerci, a relatively long ovipositor and generally not living on sandy substrates. Morphologically most similar to *G. firmus* and we discuss elsewhere (see Hybrid Zones, p. 61) the problems associated with separating the two species. Must also be separated from *G. veletis* which occasionally overlaps in distribution and time of occurrence. Where *G. pennsylvanicus* and *G. veletis* are synchronic in Nebraska, South Dakota, Oklahoma, Missouri, and Kansas, clear field differences (see Table 2, p. 144) in pulse rate and tooth count, with *G. pennsylvanicus* having a lower pulse rate and higher tooth count, are apparent, although such song differences appear absent in Michigan (Alexander & Meral 1967). Also, *G. pennsylvanicus* overwinters in an egg diapause while *G. veletis* overwinters as a late instar since the eggs have no diapause. In northwestern Oregon, *G. pennsylvanicus* can be distinguished from morphologically similar looking, black, short cerci, non-egg diapausing spring and early summer adult *G. veletisoides* compared to the late summer adults of *G. pennsylvanicus* with different DNA. We suspect that the 2 taxa may be synchronic in northwestern Oregon in late July–early August but have no collections to document.

**Derivation of name.** Apparently in reference to the type series being collected in Pennsylvania (see discussion above).



**FIGURE 31.** Five second calling song of *G. pennsylvanicus* (R04-110) Whatcom Co., WA (S04-91), at 25°C.



**FIGURE 32.** Populations of *G. pennsylvanicus* studied by us.



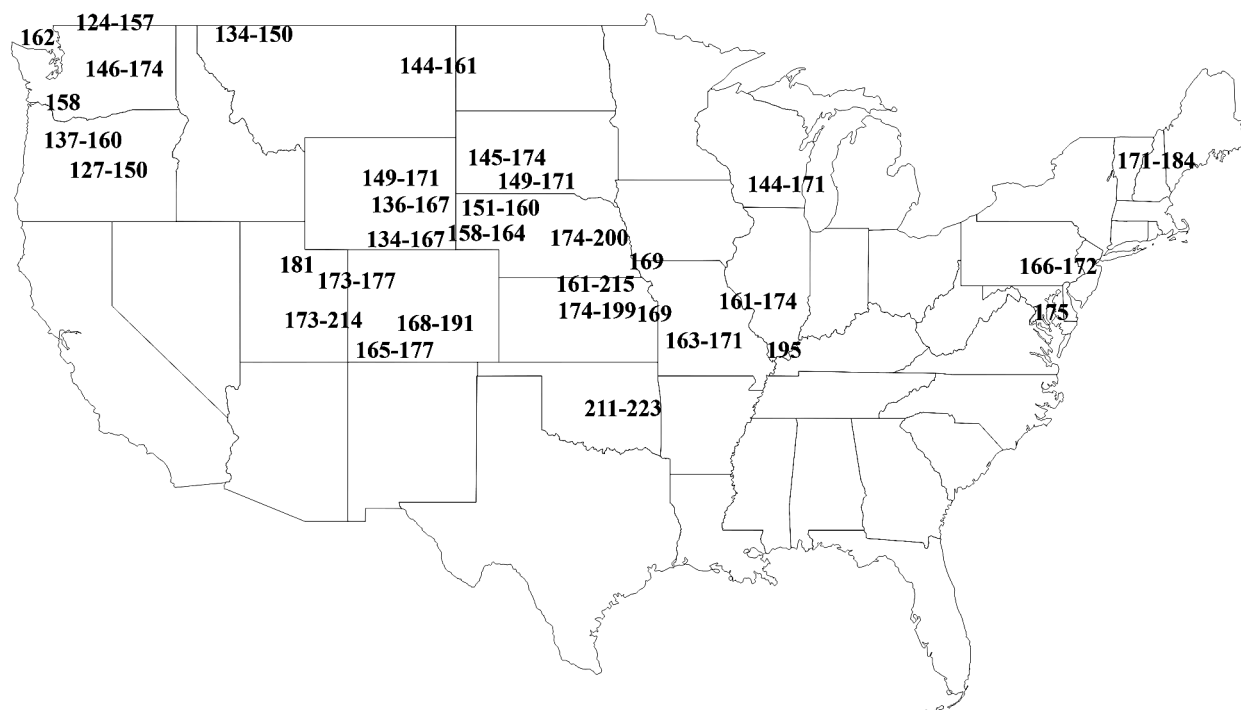
**FIGURE 33.** Size differences, in *G. pennsylvanicus*, between northern (right) from Berrien Co., Michigan, and southern (left) from Saline Co., KS [S02-49]).

**Geographic range.** Fig. 32. More eastern localities are presented in Walker (2019) and Capinera *et al.* (2004). An egg-diapausing cricket in Cuatrociénegas, Mexico may also be *G. pennsylvanicus*, and will be addressed in our Mexico *Gryllus* paper. California localities listed in Weissman *et al.* (1980) are actually *G. saxatilis*. We believe that a fall (18-ix-2013), long ovipositor (18.42 mm) adult female collected in the Texas Panhandle, in Lubbock (S13-80), is *G. pennsylvanicus*, despite no associated song, tooth count or egg diapause data, given the elevation of 990 m and 33° N latitude. This female (G2708) mapped in the multilocus tree (Gray *et al.* 2019) with other individuals of *G. pennsylvanicus* and *G. firmus*, without clearly resolving which. If indeed *G. pennsylvanicus*, this would represent the most southerly range limit (excepting the unconfirmed Cuatrociénegas samples).

**Habitat.** In towns in cracks, under objects, in grassy vegetated areas and also in clay badlands in Alberta, Canada (S05-72, 73) and Nebraska (S97-83).

**Life cycle and seasonal occurrence.** One generation/year. Obligate egg diapause present: Vancouver, Canada (S00-54), Scottsbluff, Nebraska (S99-144), Sidney, Montana (S97-95), Guernsey, Wyoming (S97-78, S99-138 & 99-139), Concordia, Kansas (S02-50), Corvallis, Oregon (S83-39), Hanksville, Utah (S04-128). Overwinter as eggs in diapause (Rakshpal 1962) with first adults appearing in late July–early August. Field collections in early August typically yield a few adults with most of the population late instars. In early summer, it is not unusual to find adult *G. veletis* microsympatric with early-mid instar *G. pennsylvanicus*; while in August, it is not unusual to find adult *G. pennsylvanicus* microsympatric with early to mid-instars of *G. veletis*.

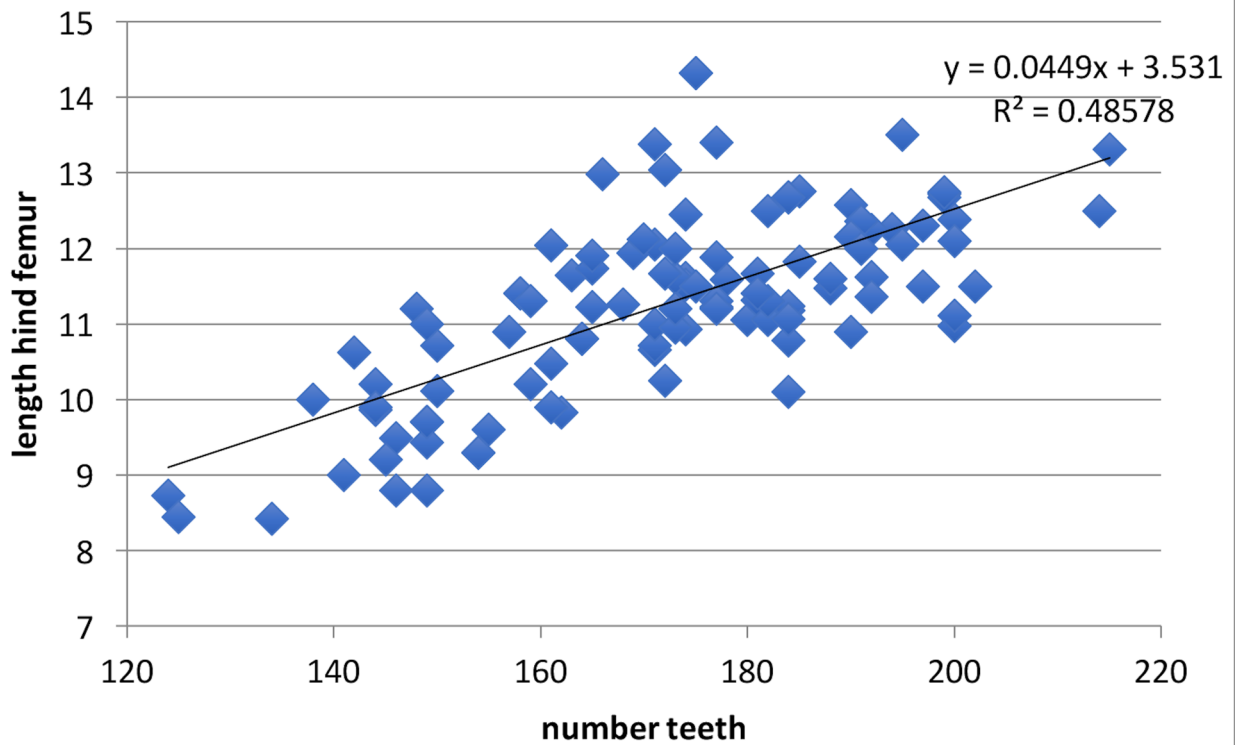
**Variation. Body length:** Northern specimens (Michigan) considerably smaller than those from Kansas (Fig. 33). **Hind wing length:** Rare adults of both sexes with long hind wings, including two of five females from Lincoln, NB (S02-52). **Number of file teeth** (see Fig. 34): Range from 124–223 with more northern and smaller males having shorter files and fewer total teeth. Teeth/mm also higher where tooth number highest in Nebraska, Colorado, Kansas, Missouri, and Oklahoma. In 13 males from Salina, Kansas (S02-49), teeth ranged from 161–215, or a 54-tooth range. This parameter usually varies by <30 teeth over an entire species' range (Weissman, unpublished). **Ovipositor length:** Range from 10.43 to 22.29 mm (Lincoln, Nebraska, S02-52) with larger females having longer ovipositors (for example, Fig. 35, S02-49). **Pulse rate:** Varies from 10.4–25.0, with males with higher number of teeth having lower pulse rates (see Fig. 52 in Hybrid Zones, p. 68).



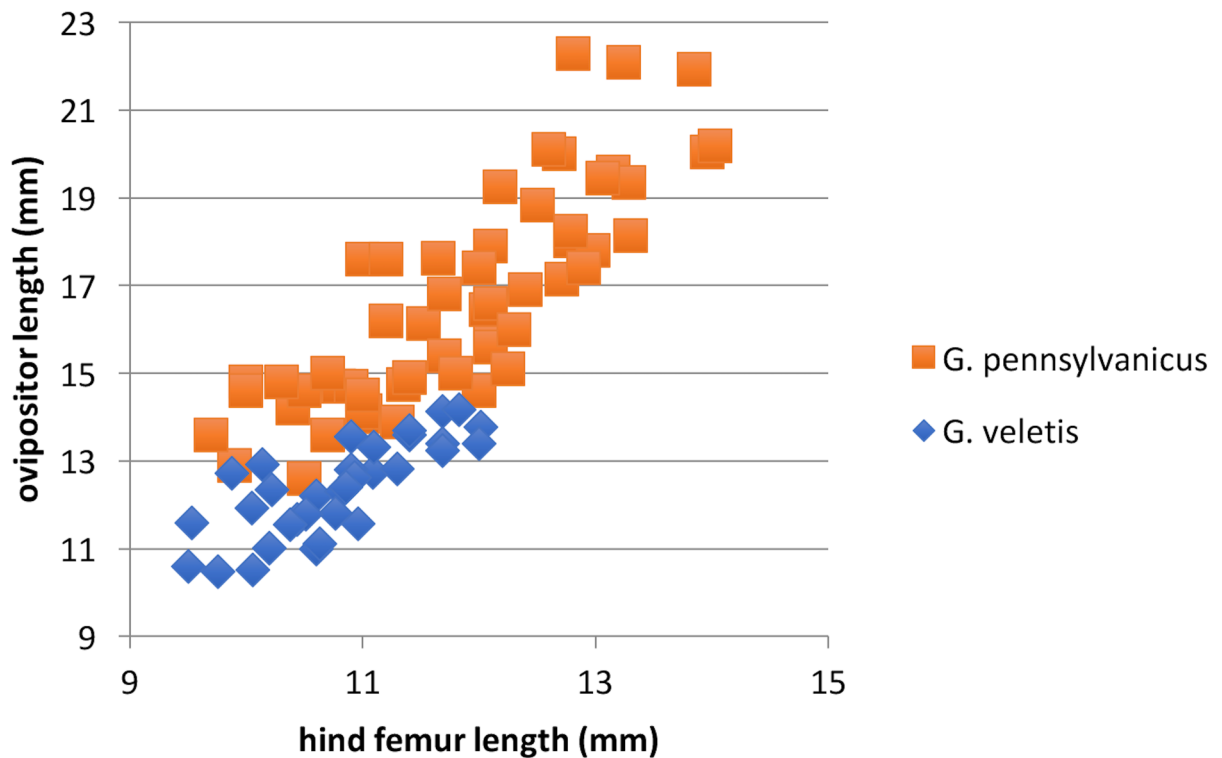
**FIGURE 34.** Map of *G. pennsylvanicus* showing variation in file tooth number across the United States. File teeth range from 124 (Vancouver, S00-54) to 223 (Oklahoma City, S02-48).



**FIGURE 35.** Long ovipositor *G. pennsylvanicus* from Saline Co., KS (S02-49).



**FIGURE 36.** Regression *G. pennsylvanicus* showing a weak correlation between number of file teeth and hind femur length, the latter a proxy for body size.



**FIGURE 37.** Regression *G. pennsylvanicus* vs. *G. veletis* demonstrating longer ovipositors in the former taxa. Specimens from only the 6 localities discussed in text.



*Specimens examined.* **CANADA. Alberta:** Drumheller Municipal Airport, 2470', 15-viii-2005, 51° 29.028' -112° 43.235' (S05-73). Horseshoe Canyon 14km W Drumheller, 15-viii-2005, 51° 25.128' -112° 52' (S05-72). **British Columbia:** 3 m N Osoyoos, Haynes Ecological Reserve, 1200', 26-viii-2000 (S00-27). Vancouver, 15-viii-1983 (S83-125) S. Tanaka; 22-ix-2000 (S00-54). Vancouver Island, near Butterfly Zoo in Saanich, 16-ix-2007 (S07-90). **USA. Colorado:** *Garfield Co.*, Rifle, 5140', 15-viii-2009 (S09-109). *Mesa Co.*, Fruita, 4420', 16-viii-2009 (S09-114). **Illinois:** *Madison Co.*, 10-viii-2002 (S02-60). **Kansas:** *Cloud Co.*, Concordia, 1100', 7-viii-2002 (S02-50). *Saline Co.*, Salina, 1100', 7-viii-2002 (S02-49). **Maryland:** *Prince George Co.*, College Park, 500' 30-v-2004 (adult molt 6-viii-2004) S04-35. **Missouri:** *Cape Girardeau Co.*, Millersville, 9-viii-2002 (S02-58). *Jackson Co.*, Kansas City, 8-viii-2002 (S02-54). *St. Louis Co.*, St. Louis, 10-viii-2002 (S02-61). **Montana:** *Richland Co.*, Sidney, 1840', 31-vii-1997 (adults and late instars) (S97-95). Hwy 23 5 m SE Sidney, 1920', 31-vii-1997 (adults and late instars) (S97-94). **Nebraska:** *Dawes Co.*, Hwy 385 ~4 m S Hwy 20. 3680' 13-ix-1999 (S99-143). 3 m W and 13 m S Chadron near Coffee Grinder Butte, 3680', 28-vii-1997 (S97-84). 4 m W and 4 m S Chadron, 3100', 28-vii-1997 (S97-83). *Fillmore Co.*, Geneva, 1420', 7-viii-2002 (S02-51). *Lancaster Co.*, Lincoln, 940' 7-viii-2002 (S02-52). *Scotts Bluff Co.*, Scottsbluff, 3960', 13-ix-1999 (S99-144). *Sioux Co.*, Agate Beds National Monument, 4500', 13-ix-1999 (S99-141). **New Jersey:** *Morris Co.*, Pequannock, 13-ix-1987 (S87-100). **Oklahoma:** *Oklahoma Co.*, Oklahoma City, 1000', 6-viii-2002 (S02-48). **Oregon:** *Benton Co.*, Corvallis, 15-viii-1983 (S83-122), S. Tanaka. *Lane Co.*, Eugene, 14-x-2006 (S06-128). **Pennsylvania:** *Chester Co.*, New London, 406', August, 2011, 39.767099° -75.897706° (S11-107), D.H. Funk. **South Dakota:** *Jackson Co.*, Badlands National Park, 2200-2400', 30-vii-1997 (S97-90). Kadoka, 2200' 30-vii-1997 (S97-87). **Texas:** *Lubbock Co.*, Lubbock, 18-ix-2013 (S13-80). **Utah:** *Uintah Co.*, Jensen, 4740', 10-ix-1999 (S99-127). Naples, 5200', 10-ix-1999 (S99-126). *Wayne Co.*, Hanks-ville, 4500', 1-viii-1992 (S92-109); 11-ix-1998 (S98-88); 9-ix-1999 (S99-119); 12-ix-2004 (S04-128). **Vermont:** *Addison Co.*, Middlebury, 6-x-2006 (S06-117); 5-x-2008 (S08-74). **Washington:** *Mason Co.*, Shelton, 16-viii-1983 (S83-123) S. Tanaka. *Skamania Co.*, Mt St Helens, 3800', 16-ix-2015, 46° 15' 59" -122° 04' 50", pit fall trap, D.C. Lightfoot. *Whatcom Co.*, Birch Bay State Park, 5', 17-viii-2004, 48.54407° -122.45758° (S04-91). **West Virginia:** *Mercer Co.*, Camp Creek State Park, 2025', 19-vii-2011 (adult molt 9-ix-2011), 37.504477° -81.134305° (S11-108), D.H. Funk. **Wyoming:** *Platte Co.*, Guernsey, 4300', 12-ix-1999 (S99-138). Road 270 3.9 m N Hwy 26, 4300', 28-vii-1997 (mid-instars) (S97-82); 12-ix-1999 (S99-139).

*DNA.* Multilocus G710 Middlebury, Vermont (S08-74); G368 Hanksville, Utah (S04-128); and G2708 Lubbock, Texas (S13-80) map (Gray *et al.* 2019) closest to Florida G62 Gainesville (S03-85), and Texas G1915 Bastrop State Park (S10-67); G1917 Schulenburg (S10-65); G1920 Brackettville (S10-63); G2029 Sea Rim State Park (S11-29); and G2715 Matagorda Island (S13-59) *G. firmus*.

*Discussion.* We initially considered western US *G. pennsylvanicus* to be several species given the range of file tooth counts and the geographic isolation of some populations. Because further collecting has not made the situation any clearer, combined with the multilocus DNA tree indicating close relatedness between these populations, we treat them as one species, although we believe further investigation is indicated.

Only *G. veletis* has a more widespread US distribution than *G. pennsylvanicus*. It thus seems prudent to compare the two taxa over their ranges since both may represent groups composed of several sister species. Fig. 34 suggests a clear north to south cline in increasing tooth count in files of *G. pennsylvanicus*. Northern males from Vancouver may have as few as 124 teeth while a male in Oklahoma had 223 teeth, a difference of 99 teeth. Regressing number teeth vs. hind femur length (Fig. 36) (the latter a good measurement of overall body size—see p. 17) we demonstrate that this cline in number of teeth is weakly related to body size ( $R^2=0.486$ ). In contrast, while males of *G. veletis* similarly double in size over their north to south distribution, number of teeth only increase from 116 to 175 (a difference of 59) in going south (Fig. 141, p. 140).

Where *G. pennsylvanicus* is sympatric and synchronic with *G. veletis*, as at Kadoka, South Dakota (S97-87); Jensen, Utah (S99-127); Concordia, Kansas (S02-50); Kansas City, Missouri (S02-54); and Geneva (S02-51) and Lincoln, Nebraska (S02-52), then ovipositor length in *G. veletis* considerably shorter than *G. pennsylvanicus* (Fig. 37).

As an example, the two collected female *G. pennsylvanicus* from Kadoka, SD (S97-87), both had ovipositors of 17.6 mm and hind femurs of 11.0 and 11.2 mm. A single female *G. veletis*, from the same locality, had an ovipositor of 11.7 mm and a hind femur of 10.6 mm. Both species sang from deep grass where individuals were difficult to collect. When synchronic and at the same temperature, field differences in PR between the two taxa are also easily appreciated as pulses in *G. pennsylvanicus*, at 20–25°C, are countable (as also seen in *G. longicercus* and *G. firmus*)

especially when males have more than 170 file teeth. Pulses in *G. veletis* are not countable by ear at 20–25°C and the chirp rate is noticeably faster. For instance, we could hear a PR difference in Lincoln, Nebraska (S02-52) when a *G. veletis* male, with 148 teeth, was singing at 5 AM adjacent to a *G. pennsylvanicus* male with 169 teeth. We wonder if these two species, in such areas of synchronicity, may display character displacement in pulse rate as evidenced by some of the highest numbers of file teeth seen in any *G. pennsylvanicus* males? In other words, having more teeth in the file could result in a slower pulse rate since more teeth are being struck. We suspect that synchronicity between these two taxa is also more common than we document (also see Alexander & Meral 1967) because most of our field collecting was done in early summer since that is when most other *Gryllus* species are adult.

*G. pennsylvanicus* has been used for studies on pest potential (Carmona *et al.* 1999), calling and courtship (Zuk 1987, Harrison *et al.* 2013) and behavior (French & Cade 1987, 1989), as well as an extensive study of Hybrid Zones done in the R. Harrison lab—see discussion starting on p. 61.

Mermithids (Poinar & Weissman 2004) present in one male from Sidney, MT (S97-95).

## ***Gryllus firmus* Scudder**

Sand Field Cricket

Figs 28–30, 38–51, 53, Table 1

1902 *Gryllus firmus* Scudder. Psyche 9:295.

1957 *Acheta firma* (Scudder). Alexander 1957. Ann. Entomol. Soc. Amer. 50:586. Lectotype male designated, “Pungo” Bluff, North Carolina. Three labels as follows: 1. Dingo Bluff, N. C. Nov. 15, 1876 Parker Maynard. 2. *Gr. firmus* Scudder’s type, 1901. 3. Red type label 14064. File with 175 teeth (per D. Otte, pers. comm. to DBW by J. Weintraub, 5/10/2018). Type in ANSP (see Fig. 38). Despite Scudder (1902) clearly stating Dingo Bluff, Rehn & Hebard (1915, p. 295) listed the locality as Pungo Bluff, without explanation. This change was repeated by Alexander (1957). Checking various geography name sources, we find no official place names of Dingo Bluff or Pungo Bluff but we do find, in North Carolina, a Pungo River, Pungo Creek, Pungo Swamp, and Pungo Lake as well as a coastal town of Pungo. A Google search for both ‘Dingo Bluff’ and ‘Pungo Bluff’ yielded both of these collection localities assigned to many other North Carolina insect specimens.

1964 *Gryllus firmus*. Randell, 1964 Canadian Entomologist 96: 1592.

‘*Gryllus* #19’, ‘near #19, #35, #45’ of DBW notebooks; Thompson *et al.* (2012) used ‘G. #45’ in their paper.

**Distribution.** From south coastal Texas (near Brownsville) east to the Atlantic coast and inland for variable distances. In Texas (Fig. 39), found a maximum of 350 km inland (Brackettville).

**Recognition characters and song.** A small to large cricket usually with black head, pronotum and tegmina, short hind wings, long ovipositor, >160 file teeth, and frequently associated with sandy substrate. *Song* a slow chirp (2–3 c/s) with 4p/c (range 2–5), and pulse rate usually <15 at 25°C (Fig. 40; R03-255). One generation/year (except along the southeastern US seaboard and continuous coastal areas along the Gulf of Mexico) because of an egg diapause, late summer maturing adults (although present year around in Florida [Capinera *et al.* 2004]). Generally light colored tegmina and individuals can have longitudinal head stripes (Fig. 41) when living on coastal beach or lowland sandy substrate habitats. Both dark (Fig. 41) and light-colored specimens from coastal and southern areas of Texas, whose eggs have no or variable egg diapause, such as from Brackettville or Schulenburg, are placed here. Those in coastal dunes also frequently with lighter colored body (as all 3♂ and 6♀ from Boca Chica State Park [S91-37]) and legs. Nickle & Walker (1975) note that, in Florida, the lateral portion of the tegmina is diagnostically dark with many distinctive cross veins there, a condition also typical of Texas *G. firmus* specimens but not diagnostic there because several other Texas taxa also have this character. Within our study area, *G. firmus* must only be distinguished from the closely-DNA related *G. pennsylvanicus*, with which it forms a long hybrid zone (Larson *et al.* 2013) along the eastern slopes of the Appalachian and Blue Ridge Mountains. We discuss this complex situation elsewhere in this paper (see Hybrid Zones, p. 61). But, for now, we consider any population in central and SE Texas with a high tooth count, low pulse rate and no egg or a variable egg diapause to be *G. firmus*. If *G. pennsylvanicus* occurs in this area, then all their eggs should have a diapause. We realize the cumbersomeness of this distinction but, at present, without further investigations, we cannot separate the two taxa except based on geography (compare maps p. 49 vs. p. 56). *G. longicercus* from western Texas also has >160 file teeth and a slow pulse rate but is distinguished from *G. firmus* in having longer cerci, associated with rocks, and different DNA.

**Derivation of name.** “firmus” is Latin for strong, stout, and durable perhaps in reference to its being the largest known US *Gryllus* when it was described in 1902.