

**FIGURE 258.** Known distribution of *G. makhosica*.

*Paratypes.* (Total: 12♂ 6♀). **South Dakota.** Type locality, 29-viii-1989 (S89-75) 4♂ 1♀; 22-vi-1993 (S93-53) 4♂ 3♀; 30-vii-1997 (S97-90) 2♂; 3-vii-2009 (S09-89) 2♂ 2♀.

*Derivation of name.* “makhosica” is Lakota for “badlands” in reference to the cricket’s preferred habitat within Badlands National Park, an area inhabited by the Lakota people, and part of a confederation of seven related Sioux tribes.

*Geographic range.* (Fig. 258). Known only from Badlands National Park, South Dakota, where males sing from holes and crevices in clay badlands.

*Habitat.* Males sing from large cracks up to 10m above ground level on the face of badland clay cliffs and escarpments. Heard throughout Park in similar environments. Main canyon at Cedar Pass area with grasses, *Atriplex*, and *Sarcobatus*.

*Life cycle and seasonal occurrence.* One generation/year. Egg diapause not checked but probably absent since adults singing by late June, 1993. Adults known from 22-vi until 29-viii. One late instar male at S89-75, on 29-viii-1989.

*Variation.* **Hind femur:** vary in color from tan-orange to black.

*DNA.* Multilocus G1340 (S09-89). Sister species (Gray *et al.* 2019) are widespread *G. saxatilis*, Utah *G. leeii*, and Utah and Arizona *G. navajo*.

*Discussion.* Easy to approach. While *G. makhosica* occurs microsympatrically at the type locality with *G. personatus* (also in clay badlands) and *G. veletis* (in adjacent grassy areas), the latter two species are never found singing much above the canyon floor.

*G. makhosica* is found no closer than 850 km to the nearest population of *G. navajo* in Utah, and we know of no medium to long cerci, slow chirping similar cricket species, or population, between them. Thus, given morphological and habitat differences discussed above, it seems appropriate to treat them as separate species despite their similar multilocus DNA profiles.

### ***Gryllus navajo* Weissman & Gray, n. sp.**

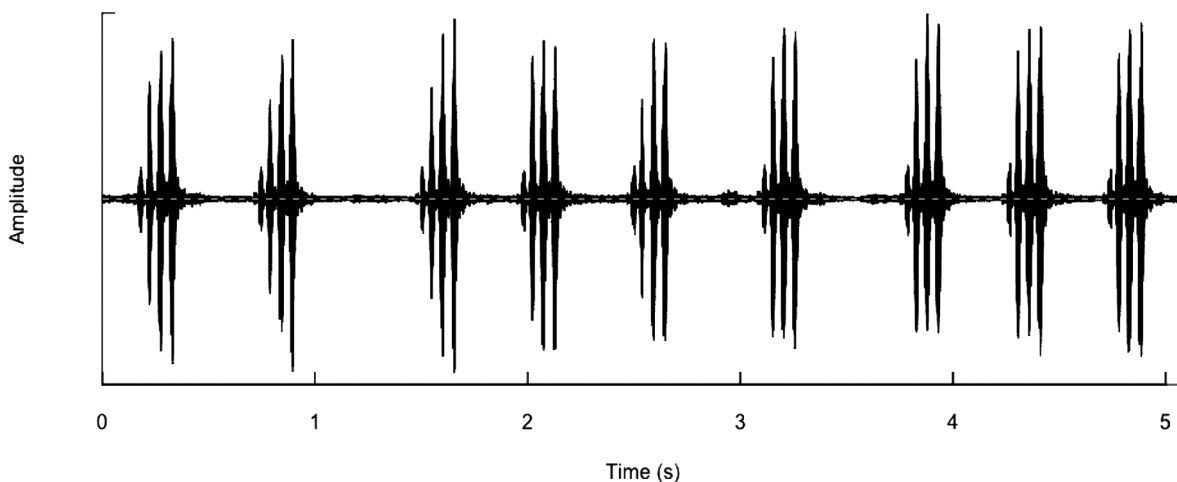
Painted Desert Field Cricket

Figs 236–238, 252–256, 259–262, Table 1

‘G. #39’ in DBW notebooks.

*Distribution.* Southeastern Utah and northern Arizona.

*Recognition characters and song.* A slender, medium sized cricket always with short hind wings, frequently with both reddish tegmina and entire hind femur (Fig. 260), very long antennae in some populations (e.g. S07-56) reaching past tip of abdomen in situ. Cerci always longer than hind femur and in certain populations, usually longer than ovipositor tip in situ. *Song* (Fig. 259, R07-61) with 4–5 p/c (range 3–6), 75–180 c/m, PR 16–25. One of morphologically similar, never sympatric western US *Gryllus* spp. including *G. makhosica*, *G. saxatilis*, and *G. leei*. Distinguished from DNA similar but allopatric sister species *G. makhosica* from South Dakota by the following (and see Discussion, and comparative regressions, under *G. makhosica*, p. 251): general body color, especially hind femurs, more reddish in *G. navajo* vs. dark in *G. makhosica*, pronotum shinier in *G. navajo*; *G. navajo* lives in sandstone badlands vs. clay badlands for *G. makhosica*. Chirps in *G. makhosica* average 3–4 p/c vs. 4–5 in *G. navajo*. Elsewhere, under *G. makhosica*, we make several physical comparisons, employing regression analysis, between file teeth number, length of file, teeth/mm, tegmina length, hind femur length, and ovipositor length. While there is overlap in all of these metrics for these two species, their nearest populations are separated by some 850 km. Distinguished from sister species *G. saxatilis* whose cerci almost never longer than ovipositor and rarely (except at Checkerboard Mesa, Zion National Park) in open sandstone habitats and usually associated with rocks. Distinguished from Utah sister species *G. leei* which inhabits lava flows, has a shorter ovipositor and is separated by the Pahvant Mt. Range and Sevier Plateau of central Utah from *G. navajo*. Distinguished (Table 1, p. 18) from *G. longicercus* by *G. navajo* having fewer teeth in file, shorter cerci length, higher pulse rate, and different DNA (Gray *et al.* 2019).



**FIGURE 259.** Calling song (R07-61) of *G. navajo* from Coconino Co., AZ (S07-56), recorded at 25°C.

*Holotype.* Male (Fig. 260). USA, **Utah.** *Emery Co.*, 6.5 m W of Hwy 24 and 1.3 m W turnoff for Goblin Valley State Park, 5400', S92-108, R92-180, BL 17.67, HF 10.3, LC 10.2. Right tegmen removed, 154 teeth, FL 3.4, TL 10.2, TW 4.3. Type deposited in CAS, Entomology Type #19268.

*Paratypes.* (Total: 43♂ 35♀). **Arizona.** *Coconino Co.*, 49 m E Flagstaff on Hwy 99 ~6.85 road m NW I40, mile post 59.5, 4838', 35° 08.548' -110° 53.535', 8-viii-1991, (S91-89) 8♂ 11♀; 12-vi-1996 (S96-64) 2♂ 1♀; 14-vi-2007 (S07-56) 13♂ 13♀. Moenkopi Dune area on Hwy 264 3.1 m SE Tuba City, 4680', 6-viii-1991 (S91-82) 7♂ 1♀; 7-ix-1999 (S99-111) 1♂. **Utah.** Type locality, 1-viii-1992 (S92-108) 7♂; 11-vi-1996 (S96-58) 3♂ 9♀. *Wayne Co.*, Hwy 24 3 m NE Hanksville, 11-vi-1996 (S96-60) 2♂.

*Other collections, not counted as paratypes.* **Utah.** *Emery Co.*, Goblin Valley State Park, campground, 5000', 18-v-2016, 10♂ 19♀. Black Dragon Canyon, 4350', 24-v-2017, 32♂ 8♀. *San Juan Co.*, Oljato-Monument Valley, Douglas Mesa Rd. (County Road 419) 6 m N Utah—Arizona border, 5575', 26-v-2017, 10♂ 3♀.

*Derivation of name.* Named for the Native Americans (Diné) of the Navajo Nation who inhabit this area.

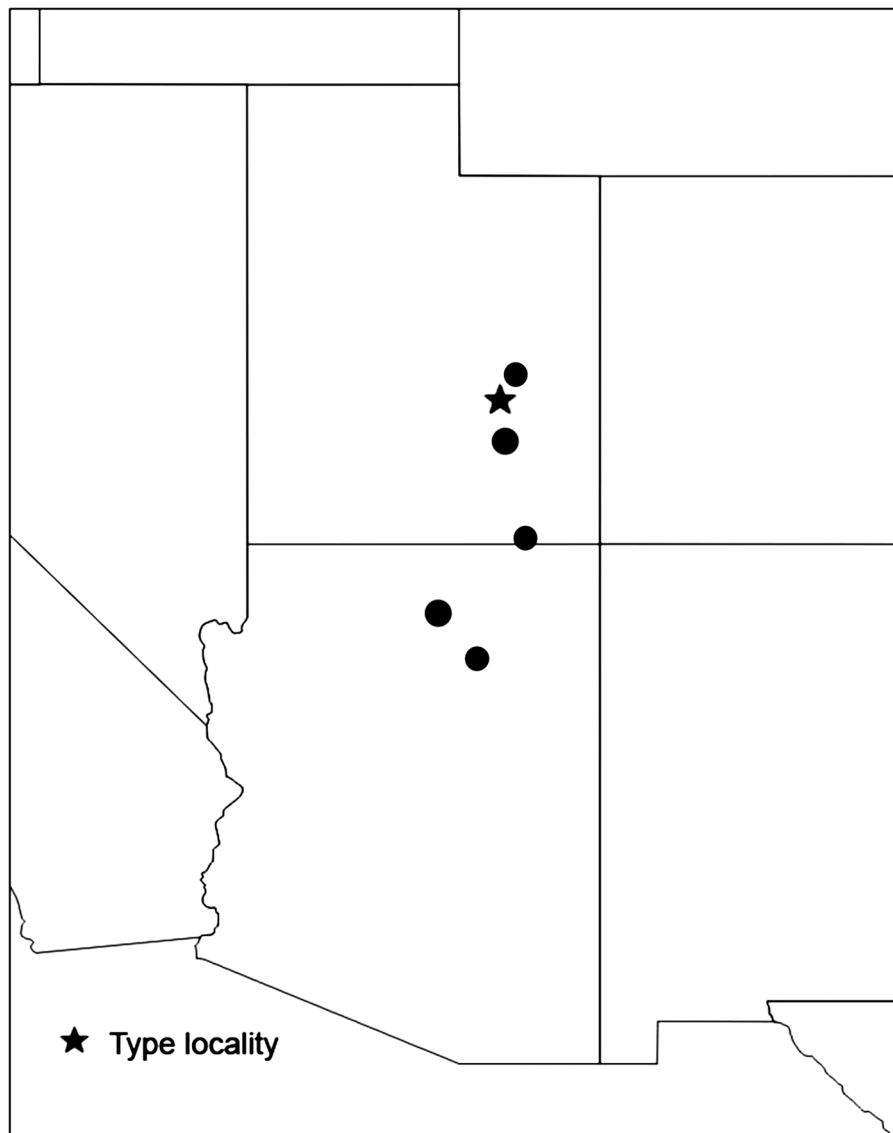
*Geographic range.* (Fig. 261) Southeastern Utah and northern Arizona, associated with Painted Desert red sandstone outcrops and escarpments and occasionally rocky outcrop areas, as at type locality.

*Habitat.* Singing from cracks in sandstone cliffs at Moenkopi Dunes (S91-82), near Hanksville (S96-60), and at 79 km E Flagstaff (S07-56) and occasionally in valley floors. Many more males walking around at Goblin Val-

ley (S96-58) and 79 km E Flagstaff (S07-56) than singing: at S07-56, for every male heard singing, we collected 5 males (and many females) at a long oatmeal trail laid in the open, vegetated, sandy valley floor away from the sandstone escarpments. At Goblin Valley, it appears that the crickets live within cracks in the mudstone/sandstone escarpments during the day, and then descend to forage on the valley floor at night; adult males call both from cracks in the escarpments and from the valley floor (often from under the meager plant cover), whereas females and nymphs more likely encountered on the valley floor (DAG observations 14-vi-1999, 9-viii-2005, 18-v-2016, 25-v-2017, 20-22-v-2018).



**FIGURE 260.** Holotype male of *G. navajo*.



**FIGURE 261.** Known distribution of *G. navajo*.

*Life cycle and seasonal occurrence.* No egg diapause Moenkopi Dunes (S91-82); Goblin Valley (May collections, 2016-2018); capable of multiple generations per year under lab conditions, but situation in the field less clear. Adults known from mid-May through early September with nymphs also collected during June through August visits. For instance, collections in May at Goblin Valley were mostly of adults: (18-v-2016) 9 adult males, 19 adult females, 1 nymph male; (26-v-2017) 54 adult males, 36 adult females, 1 nymph female and 1 nymph male, whereas collections in August (1-viii-1992 and 9-viii-2005), only many early to mid-instars seen. It is not clear to us if these August nymphs represent what will become a second generation, or if those nymphs will be the ones that overwinter until spring. Given that the average high/low temperature in September and October is 30.6/10.0°C and 22.2/2.8°C, respectively (<https://weather.com/weather/monthly/1/Goblin+Valley+State+Park+UT+USUT0091:1:US>), we suspect that these August nymphs overwinter rather than become an adult second generation.

*Variation.* **Color:** Individuals vary from solid red (Fig. 262, Moenkopi Dunes, S91-82) to almost solid black except for the hind femurs, which are usually reddish. Most females with tegminal bars. **Head:** varies from red to black, many times with a black face and a reddish top of head. **Cerci length:** 17 of 24 females from the 3 collection dates at 79 km E Flagstaff have their cerci longer than the ovipositor tip in situ. In all other collections, the female cerci in situ are slightly shorter than the ovipositor tip.

*DNA.* Multilocus 2016-040 (type locality, Goblin Valley State Park, campground) and G1067 (79 km E Flagstaff, S07-56) sister species (Gray *et al.* 2019) with widespread *G. saxatilis*, Utah lava *G. leei*, and South Dakota Badlands *G. makhosica*.





**FIGURE 262.** Color variation in *G. navajo*. Viewing left to right: holotype male from Goblin Valley, UT (S92-108); male from Coconino Co., AZ (S07-56); female (with spermatophore) from Coconino Co., AZ (S91-89); and red male from Moenkopi Dunes, AZ (S91-82).

*Discussion.* The question arises if *G. navajo* could just be an edaphic color form of some *Gryllus*, especially *G. saxatilis* or *G. makhsosica*, that is darker when living away from red sandstone? We think not, especially when one considers the unique behavior displayed by this species at the type locality and E Flagstaff (S07-56)—their high density and the tendency of both sexes to walk around away from cover is unusual in *Gryllus* and certainly unknown for any similar western taxon discussed under “Recognition characters” (but note *G. lightfooti* does this in some dense populations, e.g. Maricopa Co., AZ, 33.97995, -111.87249, 8-viii-2016). Lab cultures continue to produce variably reddish individuals and do not simply result in dark *G. saxatilis*-like coloration. Genetic structure of cricket populations in and around the Colorado Plateau is being examined by E. Collosi *et al.* using RAD-seq SNP data, and should help clarify the situation with respect to *G. navajo* and *G. saxatilis*.

*G. navajo* were poor singers in the field E Flagstaff (S07-56), and we have found that in some other *Gryllus* species, when at high densities, males do not need to sing much to attract females since both sexes are mobile and would easily find each other with random walkabouts (and maybe assisted by their long antennae?). Once back in the laboratory, these males sang well. In contrast, male *G. navajo* singing well in the field at Moenkopi Dunes (S91-82) and Goblin Valley (S96-58), sang poorly once in the laboratory: of 7 males collected 6-viii-1991 at Moenkopi, the first male was recorded 31-viii; for the 3 Goblin Valley males collected 11-vi-1996, the first male was recorded 5-vii. On the other hand, adult males collected in May, 2017, were relatively easy to record (N=112 males from several localities). Such variable, taciturn behavior may also reflect past, high tachinid parasitism, although despite our multiple collecting trips, we have never collected a single tachinid-parasitized *G. navajo*!

Lots of red mites on both sexes E Flagstaff (S91-89 and S07-56) on two visits.

### Species/topics that need further investigations

1. How many generations a year do *Gryllus* living in the Southwestern US have? What is the influence of rain-fall on this potential generation number and for how long are eggs viable after being laid in dry substrate?
2. How precise is female song recognition/preference in *Gryllus* species with very variable calling songs, e.g. *G. staccato* (with variable pulses/chirp) and *G. coхни* (with variable pulses/trill)? If females are relatively indiscriminate given the within-species variation in male song, does that increase the likelihood of mistaken female phonotaxis to non-conspecific song?