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Diapheromeridae: *Diapheromera*) from Holocene
Sandy Areas in Western Texas and New Mexico
(U.S.A.)**

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A NEW SPECIES OF STICK INSECT (PHASMATODEA: DIAPHEROMERIDAE: *DIAPHEROMERA*) FROM HOLOCENE SANDY AREAS IN WESTERN TEXAS AND NEW MEXICO (U.S.A.)¹

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ABSTRACT: A new species of stick insect, *Diapheromera arena* n.sp., from western Texas and New Mexico is the first new species of *Diapheromera* described from the United States in several decades. It lacks armature on the head of both sexes and has a unique apomorphy of a distinctly swollen third antennal segment that easily differentiates it from other species in that genus. Despite being broadly sympatric with *Diapheromera velii* Walsh, the occurrence of this new species only in areas of wind-blown sand and sand dunes appears to function as habitat separation between these two related stick insects at the local level. Despite the new species' relatively large geographic range, it is a rare taxon and much less common than *Diapheromera velii* in the same region. This new species is part of the specialized sandy environment ecosystem including endemic plants, other insects, and vertebrates in western Texas and New Mexico.

KEY WORDS: *Diapheromera*; new species; Texas; New Mexico; Holocene; Pleistocene; sand; stick insect; Phasmatodea

The stick insect genus *Diapheromera* Gray 1835 is the most diverse phasmatodid genus within the United States and includes the extensively studied species *Diapheromera velii* Walsh and *D. femorata* Say (e.g., Knauer and Giese, 1970; Capinera, 1985; Sivinski, 1978; Seely et al., 1991). The family level taxonomy of this genus changed after Zompro (2001) reassigned *Heteronemia* to the Suborder Areolatae, and then allocated all of the non-*Heteronemia* species formerly placed in Heteronemiidae into the Family Diapheromeridae. As one of the better-known genera of stick insects in the United States, no new species in *Diapheromera* have been described in the United States since 1934 when Hebard (1934) named the rare species *D. torquata* Hebard from the Chisos Mountains Basin in what is now Big Bend National Park in western Texas. However, new species continue to be described from Mexico (e.g., Vickery, 1997). Currently, several species of *Diapheromera* are known to occur in west Texas (*D. covilleae* [Rehn and Hebard], *D. femorata*, *D. velii*, *D. tamaulipensis* Rehn, and *D. torquata*), and most of these species (i.e., *D. velii*, *D. tamaulipensis*, and *D. covilleae*) have overlapping geographic ranges (Hebard, 1942; Stidham and Stidham, 2001a). Adding to that diversity, we have discovered a new species that also occurs in western Texas and southern New Mexico. While this new species' geographic range broadly overlaps that of *D. velii*, *D. covilleae*, and *D. tamaulipen-*

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sis, it occurs in a specific habitat type with a sandy substrate in western Texas and New Mexico in which the other geographically overlapping species of *Diapheromera* rarely occur. This new species is most commonly found on mesquite branches only in isolated sand dune areas or areas with sandy (rather than gravelly) substrates, such as those occurring in the areas around Monahans and El Paso, Texas, and Socorro, New Mexico (Fig. 1).

Institutional abbreviations: JASO - John Stidham Orthoptera registered collection with TAMU; TAMU - Museum of Entomology, Texas A&M University, College Station, Texas; TTUZ - Museum of Texas Tech University, Lubbock, Texas; and UMMZ - University of Michigan Museum of Zoology, Ann Arbor, Michigan.

SYSTEMATIC ENTOMOLOGY

Genus *Diapheromera* Gray 1835

Species *Diapheromera arena* n.sp.

(Figs. 2-3, Table 1, Appendix)

Type material. Holotype: Male specimen from Interstate Highway 10, Ft. Hancock, Hudspeth County, Texas locality (VI/30/2005) deposited in TAMU (see Appendix). Allotype: Female specimen collected with the holotype male (VI/30/2005) also placed in TAMU (see Appendix). Paratypes: Five males and three females from the Ft. Hancock locality (VI/30/2005) deposited in the JASO collection.

Referred specimens. There are over 40 known specimens from Texas and New Mexico housed in various collections listed in the Appendix (Fig. 1).

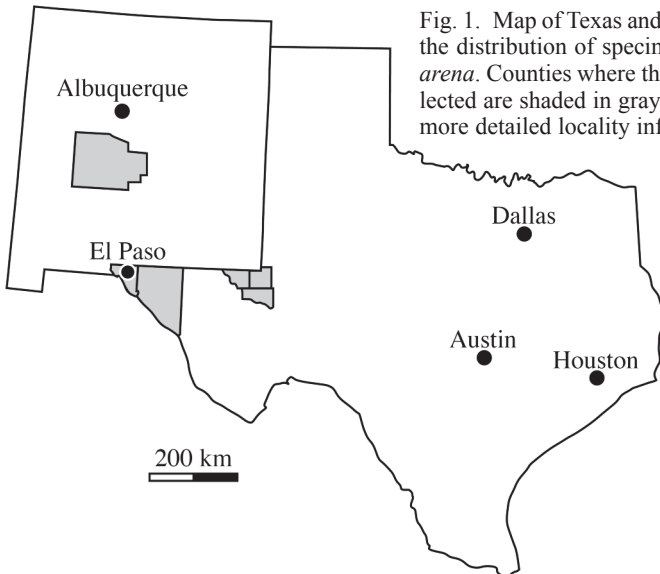


Fig. 1. Map of Texas and New Mexico showing the distribution of specimens of *Diapheromera arena*. Counties where the species has been collected are shaded in gray. See the Appendix for more detailed locality information.

Species etymology. The specific epithet is Latin for ‘sand’ and is used in reference to the windblown sands where this species occurs.

Diagnosis. This species differs uniquely from other known *Diapheromera* species in that its third antennal segment is distinctly swollen and enlarged relative to the adjacent more proximal and distal antennal segments (Fig. 2). This feature also is present in immature individuals of the new species. Its absence in other species of *Diapheromera* appears to indicate that this character is a unique autapomorphy of *Diapheromera arena*. On average, individuals of *D. arena* are larger than those of west Texas specimens of *D. velii* (Table 1). The poculum in *D. arena* is longer with a more distinct base, and the apical lip is broader with a straighter margin than that in *D. velii*. The egg of *D. velii* is slightly larger than that of *D. arena* (Fig. 3). The capitulum (cap) of *D. velii* is narrower and more elongate than that in *D. arena*. In *D. arena*, the collar is at a steeper angle to the longitudinal axis of the egg than the morphology in *D. velii*. The form of the egg of *D. velii* is longer and more spherical compared to the somewhat slender form of *D. arena* (Fig. 3). *Diapheromera arena* differs from *D. tamaulipensis* and *D. covilleae* in that it never possesses horns on the head (all specimens of both sexes), and the male poculum is never elongate. The consistent subequal lengths of the seventh, eighth, and ninth abdominal segments in *D. arena* differ from those in *D. persimilis*. Additionally, the presence of a lip on the poculum in *D. arena* contrasts with its absence in *D. persimilis*. Overall, individuals of *D. arena* are much more robust than those of the slender *D. torquata*.

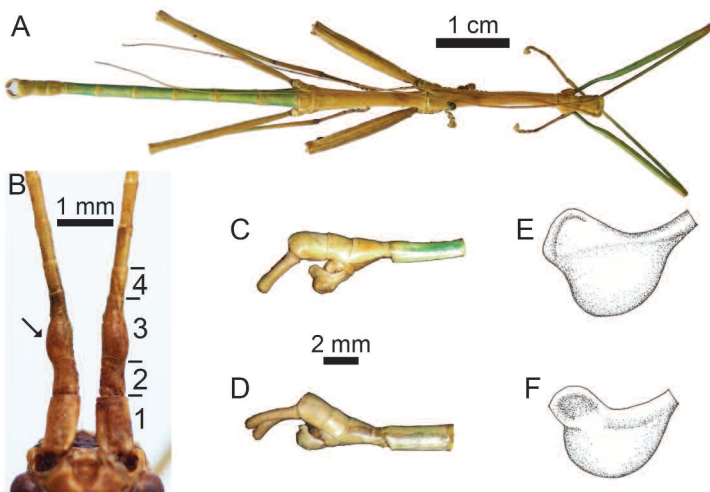


Fig. 2. Illustrations of *Diapheromera* species. A. Holotype male of *Diapheromera arena* in dorsal view. B. Close-up of the head and antennal bases of *D. arena*. Note the inflated third antennal segment (marked with an arrow). C. Male cerci and poculum of *D. arena* in lateral view. D. Male cerci and poculum of *D. velii* from west Texas in lateral view. E. Drawing of the poculum of *D. arena* in lateral view. F. Drawing of the poculum of *D. velii* in lateral view.

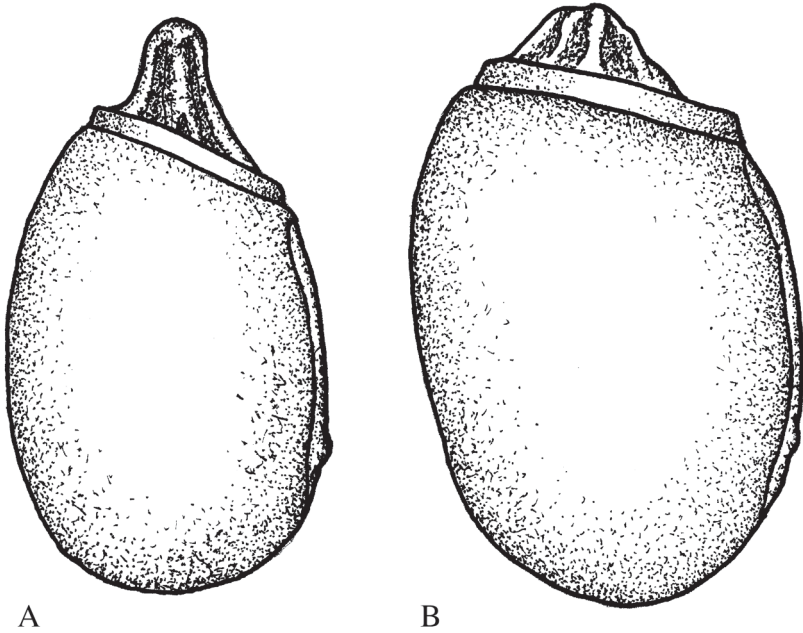


Fig. 3. Variation in *Diapheromera* eggs. Eggs of: A. *Diapheromera arena* and B. *D. velii*.

Table 1. Comparison of *Diapheromera* Body Lengths. All *D. velii* measurements from Western Texas specimens, and *D. arena* measurements are from Texas and New Mexico specimens.

Species	Sex	# Specimens	Average	Range
<i>D. velii</i>	M	34	75 mm	64 – 87 mm
<i>D. velii</i>	F	10	82.9 mm	74 – 85 mm
<i>D. arena</i>	M	25	83.7 mm	68 – 89 mm
<i>D. arena</i>	F	12	90 mm	78 – 95 mm

Distribution. This species has been collected at sandy substrate localities in El Paso County, Hudspeth County, Loving County, Ward County, and Winkler County in western Texas, and Socorro County, New Mexico (Fig. 1, Appendix). We have found this species as adults from the middle of June through early October (see Appendix for individual dates).

Description. Male - Ft. Hancock holotype specimen.

Head – Antennae thin, very elongate, extending (when bent backwards) to the sixth abdominal tergite. Third antennal segment approximately 50% longer than second segment, its inner surface noticeably swollen (Fig. 2). Eyes small, hemispherical. Head quadrate to rectangulate in dorsal aspect, cylindrical in cross section. Head without horns or other armature.

Pronotum – Dorsally slightly smaller than area of head, with a narrow, shallow median sulcus. Dorsal surface smooth, lacking tubercles or nodules.

Mesonotum – Elongate, slender, cylindrical, widening over the insertion of mesocoxae.

Metanotum – Similar to mesonotum in form except slightly shorter than the mesonotum. Widens posteriorly over metacoxal insertion.

Abdomen – Elongate, slender. First segment slightly shorter than segments 2 – 4. Segments 5 – 6 approximately same length as first segment. Segments 7 – 9 short and roughly equal in length.

Foreleg – Coxae short, cylindrical. Trochanter tiny. Femora slender with two shallow dorsal, two lateral, and one ventral slightly serrate carinae. Femora narrower and curving outward in basal quarter. Tibiae slender, cylindrical in cross section with five shallow, faintly serrate longitudinal carinae (two attingent dorsal, two lateral, and one median ventral). Lateral and ventral tibial carinae with minute setae increasing in density in apical quarter of length. Tarsi composed of five segments, each with apical pulvilli. First tarsal segment with a dorsal median pair of attingent low carinae; apices ventrally bilobate. First tarsal segment length roughly equal to that of segments 2 – 5 combined. Tarsal segments 2 – 3 with dorsal median rounded carina. Tarsal segments 1 – 4 with dense setae on ventrum. Tarsal segments 2 – 4 ventrally bilobate. Apical tarsal segment with two short curving claws and a broad pad between the claws.

Midleg – Coxa present as short ring. Trochanter minute. Femora straight, cylindrical but swollen in appearance with its length slightly shorter than mesonotum. Femora with five low longitudinal carinae having low serrations, with an inner, ventral subapical spine. Tibiae straight, slender, slightly longer than femora, possessing five low serrate carinae as on forelegs. Lateral and ventral tibial carinae with setae as with fore tibiae. Tarsi similar to fore tarsi.

Hind Leg – Coxae present as short ring. Trochanter minute. Femora straight, cylindrical with five longitudinal shallow carinae. Ventral and lateral femoral carinae strong. Femora approximately same length as foreleg femora. All femoral carinae with serrations along their length. Femora with a large inner, ventral subapical pointed spine directed apically. Tibiae similar to mesotibiae, roughly one-sixth longer than hind femora. Tarsi similar to but slightly longer than mesotarsi.

Poculum – With distinct short, narrow base. Cup deeply convex, and border of apex relatively straight with a short median notch.

Cerci – Cylindrical, curving inward along length. Approximately same length as last abdominal segment. With flattened inner surface in apical one-third of length. Covered with minute setae. Possessing a short, straight, inner basal spine. Coloration – Overall, specimens are light tan except for basal three-quarters of foreleg femora and two-thirds of fore tibiae that are green. Abdomen green overall. However, first six abdominal segments have tan rear borders, and lateral borders of tergites also tan. Basal one-half to one-third of meso- and metatibiae green.

Description. Female, Ft. Hancock allotype specimen.

Head – Antennae elongate, thin extending back to end of third abdominal segment. Third antennal segment with inner surface swollen, enlarged relative to second segment. Second segment swollen on ventral surface. Head cylindrical, dorsal surface slightly convex. Eyes round, hemispherical.

Pronotum – Slightly shorter than head, possessing shallow median sulcus and cross sulcus across its midlength. Dorsal outline quadrate. Dorsal surface lacking tubercles.

Mesonotum – Elongate, cylindrical, widening gradually from front to rear. Surface smooth with a few scattered tiny nodules. Some reticulation laterally at rear margin, faint median carina present.

Metanotum – Elongate, cylindrical, shorter than mesonotum. Surface smooth with a few tiny nodules. Slight median carina present. Cross sulcus present just forward of metacoxal insertion.

Abdomen – Elongate with nine smooth segments that uniformly decrease in diameter toward apex. Tiny supra-anal plate possessing oblique-angulate apex and tent-like form. Cerci approximately one-half of length of last abdominal segment; slender, cylindrical, slightly concave inner surface, covered with tiny scattered setae. Segments 1 – 6 roughly equal in length. Segments 7 – 8 are each about one-half the length of sixth segment. Segment 9 shorter than segment 6. Subgenital plate as long as total length of the segments 7 – 8, with apex obtuse-angulate with a round tip. Subgenital plate with short apical median carina.

Foreleg – Coxa tiny, thin sliver. Trochanter, short cylindrical. Femora approximately same length as mesonotum. Femur basal quarter narrower, widening distally with thin, strongly elevated dorsal and ventral carinae. Femora with two lateral carinae. All carinae lack serrations. Tibiae length 2 – 3 mm longer than femora. Tibiae with five longitudinal carinae: two attingent dorsal, two lateral and one ventral. Tarsi five segmented, all setose on ventrum. First tarsal segment equal in length to segments 2 – 5 combined. Apical tarsal segment with two short curving claws and a broad pad between claws. Pulvilli present on apices of segments 1 – 5.

Midleg – Coxa a short ring. Trochanter small, roughly one-half length of coxa. Femora slightly shorter than fore femora, with five carinae; bearing low serrations on ventral carinae and with a short, ventral subapical spine. Femora only slightly swollen. Tibiae with five carinae as on fore tibiae, length slightly longer than femora. Tarsi similar to fore tarsi.

Hind Leg – Coxa a short ring. Trochanter small, approximately one-third length of coxa. Femora slightly shorter than fore femora, rectangular in cross section with five longitudinal carinae as on mid femora and with a short inner subapical spine. Ventral femora carinae slightly serrate. Tibiae rectangulate in cross section, with low setose serrations. Hind tarsi similar to other legs.

Coloration – Coloration of dried specimens approaches that of living specimens when adequately dried. Overall, color usually light green with yellow dor-

sal, longitudinal areas on thorax and yellow on lower side of head. Legs have green femora. Tibiae are green at their bases with more distal portions light brown. Apices of mid- and hind femora have black edges. Inner base of mid- and hind femora have a dark brown to black mark. Ventrums of body yellow. There are a few specimens that exhibit a grey-tan general coloration instead of green.

Egg – The egg is the normal ovoid form found in species of *Diapheromera* (Fig. 3). The size of the eggs is approximately 1.4 mm long and 2.2 mm wide (measurements follow Clark, 1976). Those of *D. velii* specimens from western Texas are 1.6 mm long and 2.5 mm wide.

DISCUSSION

While the inflated antennal segment readily distinguishes *D. arena* from other currently recognized species of *Diapheromera*, Scudder (1901) described *D. mesillana* from New Mexico, a species that Hebard (1942) later synonymized with *D. velii*. Examination of specimens that previously were identified by Scudder (housed in the Academy of Natural Sciences, Philadelphia; ANSP) as *D. mesillana* from eastern New Mexico demonstrates that they do not have the antennal character, and otherwise do not differ from *D. velii*. In addition, the specimens that comprise the *D. mesillana* type series (ANSP) are immature individuals, and their antennae do not exhibit a swelling of the third segment. In contrast, all immatures of *D. arena* that we have collected display (as in the adults) the character of having swollen third antennal segments. This additional morphological feature further supports that *D. mesillana* is a synonym of *D. velii*, and that it is not simply a series of immatures of *D. arena*. Thus, we agree with the synonymy of *D. mesillana* and *D. velii*. Additionally, the localities where *D. mesillana* has been reported, in large part, do not match the habitat for that of *D. arena*.

The geographic overlap, absence of horns, and other morphological similarities shared with *Diapheromera velii* are suggestive of a close relationship between *D. velii* and *D. arena*. Overall, the morphology of these two species is very similar and even though we had specimens of this new species for over 30 years, its morphological similarity to *D. velii* and its rarity obscured its identification as a different species for much of that time. It was only with the large sample we collected in 2005, including females with eggs and mating pairs (such as the holotype male and allotype female), that we were finally able to distinguish *D. arena* as a distinct species. Even though both *D. velii* and *D. arena* occur on mesquite (*Prosopis glandulosa*) and taller species of bunch grasses in western Texas, it would appear that some aspect of the substrate/soil (or the geologic history underlying the formation of that substrate) played a role in the divergence of *D. arena* from other species of *Diapheromera*.

The localities in western Texas where we have collected *D. arena* are all mapped as Pleistocene and Holocene windblown sands (Eifler and Barnes, 1976; Dietrich et al., 1983) and thus are all in a geologically relatively new, and constantly shifting habitat. Although the sands in the Monahans area have their ori-

gin in the Pleistocene, much of the windblown sand and dune formation is relatively recent (late Holocene) in that area (Eifler, 1970; Holliday, 2001). In contrast, the sands in the Hueco Bolson (Ft. Hancock and El Paso localities) are late Pleistocene to Holocene in age, underlain by several older Pleistocene gravel beds (Gustavson, 1991). In combination with the overall similarity to *D. velii*, *D. arena* might be a relatively young species (i.e., Holocene origin) since the localities where it occurs are geologically young. The older gravelly substrate is where *Diapheromera velii* occurs in the Hueco Bolson. The older age of the windblown sand units in the Hueco Bolson versus the younger (late Holocene) sand dunes in the Monahans area potentially supports a hypothesis where species differentiation might have begun in the western part of *Diapheromera arena*'s geographic range with that species' later expansion to the East (Monahans area). Furthermore, the Hueco Bolson localities with *Diapheromera arena* appear to be disjunct (separated by the Apache, Sierra Diablo, Quitman, and other mountains) relative to the population in the Monahans area, and other montane regions separate the Hueco Bolson from the more northerly Socorro, New Mexico locality. This new species may be more widespread across the region in other areas of windblown sand, and surveying efforts in the future should include phasmatodid identification. Continued study of the populations of this species likely will find distinct genetic divergences among these populations unless the Monahans population (at the eastern edge of the known geographic range) is a recently founded population (sourced from a more western population). It is also possible that this species occurs in adjacent areas of northern Mexico where similar habitats occur.

These sandy areas in western Texas and New Mexico are home to many other unique and endemic species of plants (e.g., shinnery oak *Quercus havardii*), insects (e.g., *Stenopelmatus monahansensis* in Texas and *S. mescaleroensis* in New Mexico), and vertebrates (the dunes sagebrush lizard, *Sceloporus arenicolus*) (Stidham and Stidham, 2001b; Chan et al., 2009). While most of the conservation efforts in that region have focused on the lizard, many other endemic species with similar habitat requirements and limited geographic ranges would be aided by wider protection of these sensitive areas. Conversely, recognition of the potential effects of habitat degradation on the equally endemic insects might broaden support for conservation efforts (for the lizard) since they would not be based on a single species, but an ecosystem (plants, insects, vertebrates, and the sandy substrate). Some of these sandy areas are relicts from Pleistocene times (Eifler, 1970; Holliday, 2001), and their current status is under threat (e.g., Chan et al., 2009). The only area of this particular substrate that is temporarily protected in Texas is Monahans Sandhills State Park (~1550 ha, 6 mi²). We previously have described a Jerusalem cricket (*Stenopelmatus monahansensis*) from the same habitat as this new stick insect (Stidham and Stidham, 2001b), and suspect that additional unrecognized or undescribed species of insects await discovery in the remaining dunes in the region.

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APPENDIX

All known *Diapheromera arena* specimens, their locality data, and museum collection location:

TAMU specimens (collected by the authors and forms part of the JASO registered collection):

Interstate Highway 10, 25 miles west of Sierra Blanca, Hudspeth County, Texas, X/9/1983; 3 males, 1 female.

Interstate Highway 10, 20 miles east of El Paso, El Paso County, Texas, VII/19/1987; 1 male.

Interstate Highway 10, El Paso, El Paso County, Texas, VIII/09/1993; 1 male.

Interstate Highway 10, 40 miles east of El Paso, El Paso County, Texas, VI/25/1983; 4 males, 3 females.

Interstate Highway 10, Fabens, El Paso County, Texas, VI/25/1983; 1 male.

Interstate Highway 10, Ft. Hancock, Hudspeth County, Texas, VI/30/2005; 6 males, 4 females.

Interstate Highway 10, 4 miles east of Ft. Hancock, Hudspeth County, Texas. VI/18/2017; 1 male, 2 immature males (3-4 instar), 2 immature females (3-4 instar).

Interstate Highway 20, 2 miles East of Monahans, Ward County, Texas, VI/29/2005; 2 males, 1 female.

Interstate Highway 20, West of Monahans, Ward County, Texas, IX/29/1995; 1 male.

Interstate Highway 25, 15 miles North of Socorro, Socorro County, New Mexico, VIII/03/2001; 4 males, 2 females.

Route 60, 10 miles West of Socorro, Socorro County, New Mexico, VIII/05/2001; 1 male.

TTUZ specimens

28 miles North of Mentone, Loving County, Texas, VIII/8/1979; 6 males, 3 females.

UMMZ specimens

Winkler County, Texas, September.