

BIOLOGY AND IMMATURE STAGES OF *HEMILEUCA DIANA* AND *H. GROTEI* (SATURNIIDAE)

PAUL M. TUSKES

7900 Cambridge #111D, Houston, Texas 77054

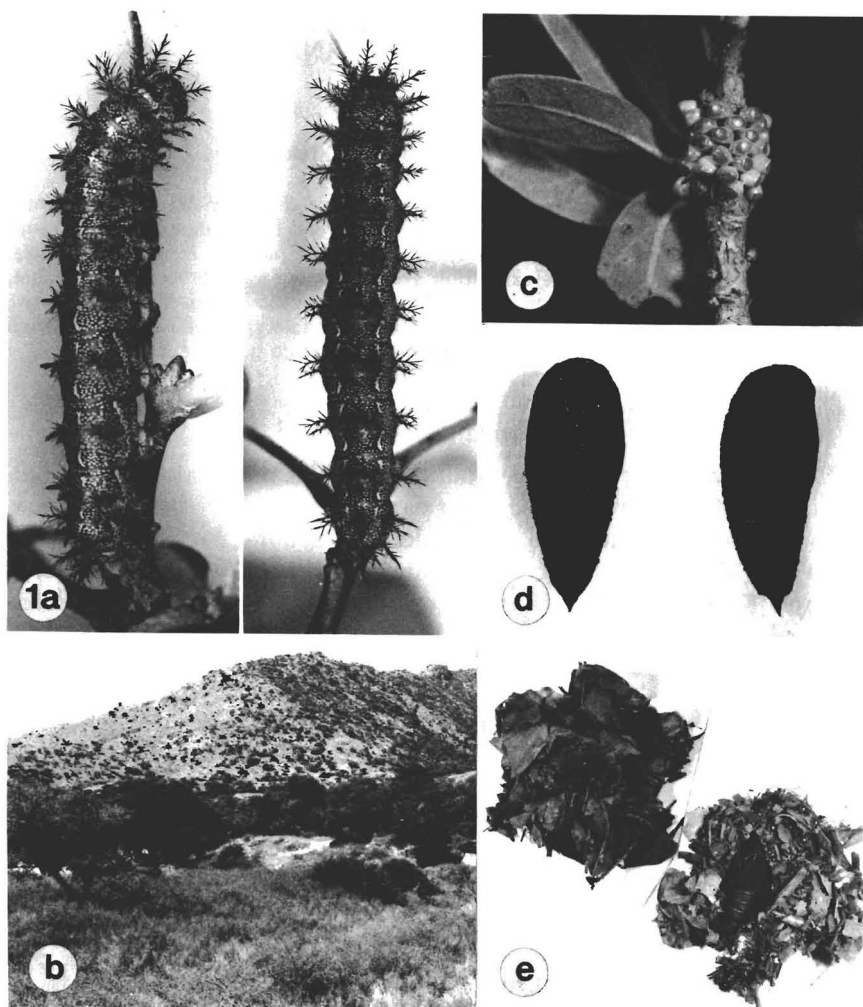
ABSTRACT. The primary host plant of *Hemileuca diana* in Arizona is *Quercus oblongifolia*, Mexican blue oak. Adult flight records extend from August to late November, but peak emergence is in October. The primary host plant of *H. grotei* in central Texas is *Quercus fusiformis*, live oak. Adult *grotei* fly from late October to December. Adult *Hemileuca grotei* from New Mexico are similar to those from Texas. Immature stages and adults of both species are illustrated, as is the holotype of *H. diana*. Although closely related, hybrid matings between these two species do not produce viable ova.

Hemileuca diana Packard

Hemileuca diana is locally abundant in the mountains of Arizona but frequently difficult to locate or capture. Presently *diana* is known from Arizona, New Mexico, Colorado, and Sonora, Mexico. Although there are two old Texas records, the data are incomplete and probably in error (Ferguson 1971). *Hemileuca diana* is associated with the montane oak habitat above 1,100 m (Fig. 1b) and is undoubtedly widespread from northern Mexico to Colorado. Because of its similarity to *H. grotei* Grote & Robinson, the two species have been confused in the literature, making it difficult to accurately determine the extent of either species distribution.

The specimens of *diana* illustrated by Ferguson (1971) are typical in appearance but slightly smaller than average. The forewing length of males from southern Arizona ranges from 23 to 28 mm, $\bar{X} = 24.3$ mm ($N = 34$); females from 27.6 to 31.5 mm, $\bar{X} = 29.9$ mm ($N = 14$). The fore- and hindwing ground color of the female is black or dark brown. The forewing of the male varies from brown to dark brown, while the hindwing is dark brown. Both sexes have a cream-colored medial line which passes distal to the forewing discal spot (Figs. 2a, b, i, j). The genitalia of a male *diana* was illustrated by Ferguson (1971) but was accompanied with *grotei* locality data. Ferguson (pers. comm.) re-examined the specimen and confirmed its identity as *diana*.

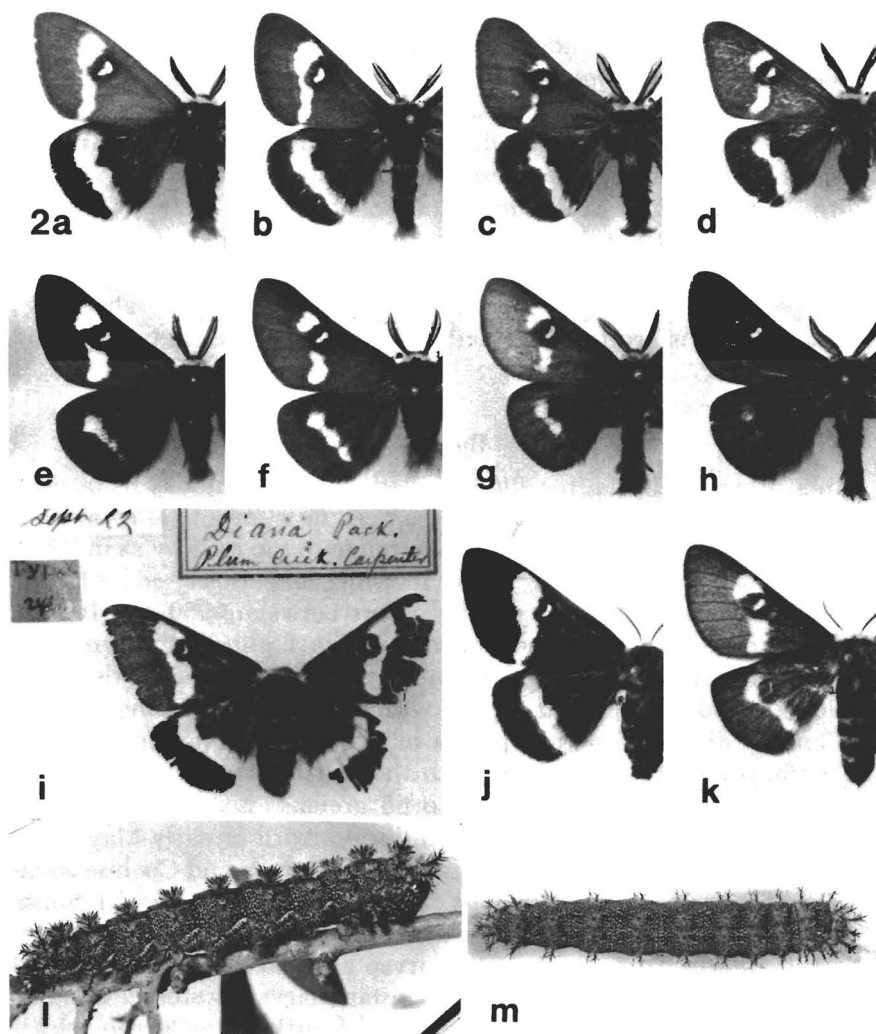
Minor geographical variation has been observed among the males in southern Arizona. This might be expected since many of the mountain ranges *diana* inhabits are isolated by distance and habitat. Males from the Huachuca Mts. in Santa Cruz and Cochise counties exhibit the most contrast between fore- and hindwing coloration (Fig. 2a). Specimens from the Santa Catalina Mts., Pima Co. (Fig. 2b), and Graham Mts., Graham Co., have forewings usually, but not always, darker than those from the Huachuca Mts. Specimens from the Chiricahua Mts.,



FIGS. 1a-e. Immature stages of *Hemileuca diana*. a, mature larvae, lateral and dorsal view; b, *H. diana* habitat, Pima Co., Arizona; c, egg ring on *Quercus oblongifolia*; d, ventral and lateral view of male pupa; e, pupal chamber.

Cochise Co., are slightly smaller and have the least contrast between fore- and hindwings. Even though subtle differences are noted, overlapping phenotypic variation among these populations makes the application of subspecific names unwarranted.

Adults from central Arizona (Figs. 2c, d) appear intermediate to *diana* and *grotei*. The cream colored medial forewing line is thin and disrupted by the discal spot, as in *grotei* (Figs. 2e, f, g), but the hind-



FIGS. 2a-m. Adults of *Hemileuca diana*, *H. grotei*, and immature stages. **a**, *H. diana* ♂, Huachuca Mts., Cochise Co., Az; **b**, *H. diana* ♂, Santa Catalina Mts., Pima Co., Az; **c**, *Hemileuca* sp. ♂, Oak Creek Canyon, Coconino Co., Az; **d**, *Hemileuca* sp.? ♂, Sunflower, Maricopa Co., Az; **e-h**, *H. grotei* ♂♂, Burnet Co., Tx; **i**, Holotype ♀, *H. diana*; **j**, *H. diana* ♀, Santa Catalina Mts., Pima Co., Az; **k**, *H. grotei* ♀, Burnet Co., Tx; **l**, mature *H. grotei* larvae, lateral view; **m**, mature *H. grotei* larvae, dorsal view (larvae from Burnet Co., Tx).

wing medial line is well developed, and continues to the anal wing margin, as in *diana* (Figs. 2a, b). The forewing length of the six males examined ranged from 21 to 24 mm. The genitalia are variable but have distinct characteristics. I reared one larva collected on scrub oak

in Oak Creek Canyon, Coconino Co., Arizona. The mature larva was grayish, the intersegmental area was brown, and appeared distinct when compared to *diana* larvae from southern Arizona, and more similar to *grotei* larvae from Texas. Females from this population have not been available for examination. The material from central Arizona appears distinct and may represent an undescribed taxon.

An examination of the *diana* holotype from Plum Creek, Colorado (Fig. 2i) confirms that there is no obvious difference between the type and females from southern Arizona (Fig. 2j). Ferguson also noted that the type agreed well with material from southern Arizona. Therefore, if a new name is proposed it should be applied to the central Arizona phenotype.

Biology

In southern Arizona, the flight period of *diana* extends from mid-September to late November, with the peak near mid- to late October, but this may vary from one mountain range to the next by as much as three weeks. Adults emerge in the morning and usually mate before 1200 h. Male flight activity usually occurs between 0930 and 1630 h. Females oviposit during the afternoon. The flight of the female is slower, more straight, and higher among the oaks than that of the male, which is rapid, erratic, and usually within 3 m of the ground.

Females deposited 80 to 140 ova in two to four separate egg rings near the tips of the branch close to the leaf clusters (Fig. 1c). Field collected egg rings contained 25 to 65 greenish-gray ova. The eggs overwinter, and larvae usually hatch during April or early May.

The larval hostplant in Pima, Santa Cruz, Graham and Cochise counties, is Mexican blue oak, *Quercus oblongifolia* Torr. Michael J. Smith (pers. comm.) indicates that larvae are occasionally found on Emory oak, *Q. emoryi* Torr. Early instar larvae are black and feed gregariously. During the first two or three instars, larvae prefer developing flower buds and new leaves. If disturbed fourth instar larvae release their grip, fall to the ground, and disperse.

Mature larvae feed singly and do not drop to the ground when disturbed. Some larvae have six rather than five instars but are identical in appearance to those with one less. The mature larva is gray with a distinctly dark gray dorsal area, and purple intersegmental areas (Figs. 1a, b). Larvae from the Santa Catalina and Huachuca Mts. were reared on five different occasions and mature larvae from the Graham Mts. were examined. Within these three populations, the larval phenotype is uniform. Pupation usually occurs in early June but James S. McElfresh (pers. comm.) has found mature larvae during early September.

Larvae pupate under leaf litter, where they construct a small chamber of debris tied together with silk (Fig. 1e).

On four different occasions a total of seven *diana* females from Arizona attracted and mated with wild male *grotei* in Texas. Collectively, the *diana* females deposited nearly 900 ova, but none hatched. Dissection of the hybrid ova about one month after pure *diana* and *grotei* ova hatched revealed that only a few contained dead, partially developed embryos; most ova appeared to be infertile. The high degree of genetic incompatibility between these two taxa leaves no doubt that they are distinct species. Females of both *H. juno* (Packard) and *H. electra* (Hwy. Edwds.) can be used to attract *H. diana* males (Tuskes 1984). A cross between an *electra* female and a male *diana* produced fertile ova, but upon hatching the larvae refused to feed on host plants of either species. Females of *electra* will also attract and mate with male *H. eglanterina* (Boisduval) but only infertile ova are produced (Collins & Tuskes 1979).

Larval Description

The larval description is based on 26 larvae reared to maturity from ova collected in 1982 by Mike Smith and the author, at Molino Basin, Santa Catalina Mts., Pima Co., Arizona. Preserved larvae are in the author's collection.

First instar. **Head:** Black, diameter 0.7 mm. **Body:** Length 6 mm, width 1.4 mm. Ground color black. Dorsal area black, lateral and ventral surfaces dark brown to black. Dorsal and dorsolateral scoli forked near apex, one seta on each fork. All scoli black. True legs and prolegs black.

Second instar. **Head:** Black, diameter 1.5 mm. **Body:** Length 10–11 mm, width 2.0–2.2 mm. Similar to first instar except for a small red dot between the dorsolateral and lateral scoli on abdominal (A) segments A1 and A7.

Third instar. **Head:** Black, diameter 2.1–2.3 mm. **Body:** Length 19–20 mm, width 4.0–4.2 mm. Ground color black. All scoli black and branched. Lateral surface with traces of 3 incomplete lines extending length of larva. Line 1 incomplete, undulating, and white, touching lateral scoli and extending length of larva. Line 2 thin, white dash just anterior of dorsolateral scoli on each abdominal segment. Line 3 thin, white, and broken by black segmental area, passing just ventral to dorsal scoli. Spiracles, prolegs, and true legs black.

Fourth instar. **Head:** Black with short white secondary setae; diameter 3.5–3.9 mm. **Body:** Length 32–37 mm, width 9.5–11 mm. Ground color black. Three broken white lateral lines extend length of larva. Line 1 passes between lateral scoli and is well defined only on posterior portion of each segment. Line 2 passes between dorsolateral scoli; prominent on posterior of each segment. Line 3 passes mid-way between dorsolateral and dorsal scoli; broken by intersegmental area. Area between line 1 and ventral surface gray; between lines 1 and 2 (spiracular area) black; between lines 2 and 3, dark gray. Dorsal and mid-dorsal area black. All scoli black with white or hyaline colored spines. Short white secondary setae extend from white or light gray pinacula on lateral and dorsal surfaces. Prominent red-orange dot occurs between lateral and dorsolateral scoli on A1; similar but smaller dot on A7. Spiracles black. All shields black. Inner portion of proleg and ventral surface brown. True legs black.

Fifth instar. Head: Dark brown with numerous white secondary setae; diameter 5.1–5.4 mm. **Body:** Ground color dark gray. Length 47–58 mm, width 7.5–10 mm. Dorsolateral, lateral and sublateral scoli with black shafts and black and gray spines; base of shaft ringed with gray. Dorsal metathoracic scoli to A8 rosette type with black tips and dark gray base. Pro- and mesothoracic dorsal scoli enlarged. Two prominent light gray lateral lines extend length of larva and divide dorsal and lateral areas. Line 1 undulating, and passes between lateral scoli. Line 2 passes just ventral to dorsolateral scoli and is interrupted by maroon intersegmental area. Lateral segmental area between lines 1 and 2 gray with numerous light gray pinacula which may contain short white secondary setae. Dorsal area black with fewer light gray pinacula than lateral segmental area. Intersegmental area between lateral and dorsolateral scoli black or dark gray. Dorsal intersegmental area maroon. Ventral surface light brown to flesh with light gray pinacula in intersegmental area. Prominent shiny orange spot occurs posterior and near to spiracles on A1 and A7. Thoracic shields black. True legs dark brown. Prolegs gray with dark gray shields. Spiracles orange.

Hemileuca grotei Grote & Robinson

Until recently, little information was available on the biology of *Hemileuca grotei*. Ferguson (1971) illustrated both *grotei* and *diana*, and pointed out major differences in adult morphology, wing pattern, and distribution. Kendall and Peigler (1981) provided additional information on the distribution and flight period of *grotei* in Texas. No mention has been made of the extreme phenotypic variation found in the adults, and only a partial description of the immature stages has been published.

Most males and females have a well defined white medial band on the forewing interrupted by the dark discal spot. On the male hindwing, the white medial line is usually widest between M1 and M2, then narrows and terminates between Cu1 and 2A (Figs. 2e, f, g). In females, the medial hindwing line is more developed, seldom strongly tapering, and extends beyond 2A to the anal margin of the wing (Fig. 2k).

Some adults are almost entirely black, with only the white bar in the center of the forewing discal spot present. Others have only a trace of the hindwing medial line (Fig. 2h). Of approximately 400 males examined, 3 to 7% represent the dark phenotype. The occurrence of a dark phenotype is not uncommon in many *Hemileuca* species (Tuskes 1984). Normally, the ground color of the male is dark brown to nearly black. Sometimes the base of the forewing is dark gray, and the medial and distal portions are light gray (Fig. 2g). The ground color of the female is dark brown to black. Forewing length of males from Inks Lake, Burnet Co., Texas, ranged from 22.0 to 25.3 mm, \bar{X} = 24.2 mm (N = 30); females varied from 26.0 to 29.4 mm, \bar{X} = 28.1 mm (N = 30).

In addition to Texas, *Hemileuca grotei* occurs in New Mexico. Richard Holland collected a series at Dome Lookout (Sandoval Co., X-11-

84, elev. 2,460 m), and in the northwestern corner of the state at Fort Windgate (McKinley Co., IX-30-1975). The average forewing length of the Dome Lookout males is identical to that of central Texas populations. There are subtle differences in coloration and the frequency of various phenotypes between central Texas and New Mexico material examined. In 38% of New Mexico males ($N = 18$), the white medial hindwing line is absent; thus the wing is solid black. Further, there does not appear to be a relationship between the presence or absence of the medial hindwing line and the development of the forewing medial line. In Texas populations, if the hindwing line is reduced or absent, the forewing line also tends to be reduced. One specimen exhibits the same grayish scaling on the forewing as illustrated in Figure 2g. The only female examined was identical to those from central Texas.

Biology

Both males and females are active day flyers. The flight season in central Texas extends from October to early December, but peak emergence is near mid- to late November. Local climatic conditions significantly influence duration and extent of daily adult flight. In late November 1982, 26 males were collected during a one-day trip. The high temperature for the day was 14.4 C, with light rain, strong gusty winds, and 85% cloud cover. The first males were observed at 1020 and the last at 1430 h. During a trip in 1983, conditions at the same location were clear with a high of 25 C and light winds. At that time males were very abundant, and in flight from 0910 to 1800 h. Females were observed and captured in flight from about 1200 to 1800 h.

Newly emerged larvae are black and feed gregariously. The dark coloration may aid thermoregulation and increase activity during the early spring. Like those of *H. diana*, fourth instar *grotei* larvae tend to drop from the branch if disturbed. During the late fourth and fifth instars, larvae exhibited almost equal preference for flowers or leaves. The natural larval hostplant is *Quercus fusiformis* Small. Kendall and Peigler (1981) reported that *Q. havardii* Rydberg \times *Q. stellata* Wangerheim, *Q. texana* Buckley, and *Q. marilandica* Muenchhausen are also utilized, but to a lesser extent. Mature larvae measure 39 to 48 mm in length, and have a gray ground color. The dorsal surface is darker than the lateral surface and the intersegmental area is reddish brown (Fig. 2l, m).

Before pupation the larva appears to darken, shrink in size, and the intersegmental color becomes less prominent and the light yellow pinacula become light gray. Larvae wander from one to three days before constructing a loosely woven cocoon in the leaf litter. Seventy-

seven larvae were reared from ova to maturity; 43 were males and 34 were females. All appeared to have five larval instars, and exhibited little variation. As with *H. diana*, most *grotei* pupae produce adults the same year, but both species have the ability to spend two years in the pupal stage.

Larval Description

The description is based on 77 larvae reared to maturity from ova deposited by a female collected by the author at Inks Lake State Park, Burnet Co., Texas.

First instar. **Head:** Black, diameter 0.8 mm. **Body:** Length 6 mm, width 1.2 mm. Ground color black to dark brown. Dorsal pro- and mesothoracic scoli forked at tip. Metathoracic scoli forked or spiked, remaining scoli spikelike. All scoli black with light colored setae extending from apex of each shaft. Ventral surface dark brown to black. True legs and prolegs black.

Second instar. **Head:** Black, diameter 1.4 mm. **Body:** Length 10 mm, width 1.8 mm. Similar to first instar with one exception: A small orange patch occurs between the dorsolateral and lateral scoli of A1.

Third instar. **Head:** Black, diameter 1.8–2 mm. **Body:** Length 18–19 mm, width 3.4 mm. Ground color black. Pro- and metathoracic scoli enlarged; shaft black, spines yellow and black. Dorsal abdominal scoli black; spines yellow with black tips, rosette pattern developing. Dorsolateral, lateral and sublateral scoli black with black spines. Trace of 3 incomplete light yellow lines extend length of larva, lines variable. Line 1 undulating, subspiracular, extending from A1 to A9, and touching base of each lateral scoli. Line 2 broken, consisting of dots passing along base of dorsolateral scoli. Line 3 often well developed, extending from T2 to A8, passing just ventral of dorsal scoli, often disrupted by intersegmental area. Orange dot on A1 and smaller dot on A7, both set between dorsolateral and lateral scoli. True legs, prolegs, and spiracles black. Small yellow pinacula occur on all segmental areas, including ventral surface.

Fourth instar. **Head:** Black, diameter 3.0–3.4 mm. **Body:** Length 31–33 mm, width 5 mm. Ground color black. Dorsal thoracic scoli T1 and T2 elongated, with black shafts and gold spines. Dorsal abdominal scoli rosette type with black base and gold spines, and light brown to black tips. Dorsolateral, lateral and sublateral scoli with black shaft and gold spines. Three incomplete light yellow lines extend length of larva, some may be poorly developed. Line 1 undulating, subspiracular, connecting base of all abdominal lateral scoli. Line 2 lightly marked, sometimes absent, in line with dorsolateral scoli on segmental area. Line 3 passes just ventral to base of dorsal scoli; interrupted by black intersegmental area. Body covered with small light yellow pinacula with a short hyaline setae extending from each. Mid-ventral surface dull orange-brown. Spiracles orange. Prominent orange dot occurs between lateral and dorsolateral scoli of A1; smaller dot similar in color and location on A7. True legs and prolegs black.

Fifth instar. **Head:** Black with short white secondary setae, diameter 4.6–5.0 mm. **Body:** Length 39–48 mm, width 7.0–8.5 mm. Ground color gray. Dorsal prothoracic scoli (T1) elongated; shaft black with black and light yellow to cream colored spines. Dorsal metathoracic scoli similar to dorsal T1 scoli but with light yellow to yellow-gray rosette spines at base. Dorsal abdominal and T3 scoli rosette type with yellow to yellow-gray spines and black tips. Dorsolateral, lateral, and sublateral scoli with black shaft and light yellow to white spines. Two to three incomplete light yellow to light gray lateral lines extend length of larva; the two dorsalmost may be poorly developed. Line 1 well developed, undulating, subspiracular, extending from A2 to A9, and touching base of each lateral scoli. Line 2 lightly marked, sometimes absent, in line with dorsolateral scoli on segmental area. Line 3 passes just ventral to base of dorsal scoli; interrupted by intersegmental area. Lateral surfaces gray, dorsal area dark grayish-black. Body covered

with small light yellow to cream or light gray pinacula with a short hyaline seta extending from each. Lateral intersegmental are brown to rust. Spiracles light orange. Prominent brown dot occurs between lateral and dorsolateral scoli on A1 and A7. Ventral surface light brown. Thoracic shield black. True legs and prolegs dark brown to near black.

Kendall and Peigler (1981) published a partial description of a mature *groeti* larva but did not give the source of their material. Comparison of their larval description with larvae from Burnet Co. indicates a number of differences. Larvae from Burnet Co. have a shiny black head; reddish brown intersegmental area; scoli of three different configurations and size; and brownish orange spiracles. Kendall and Peigler described *groeti* larvae as having a rusty brown head with mottled black patches; maroon intersegmental area; almost equally developed scoli; cream colored spiracles; and concluded they were most similar to larvae of *H. burnsi* (Watson). The larval description of *burnsi* by Comstock (1937), together with my observations suggest there is little similarity between these two species. In coloration and morphology, *groeti* larvae from Burnet Co., Texas are most similar to *diana* and *diana*-like larvae from central Arizona.

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