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Life History of *Synalocha gutierreziae* Powell (Lepidoptera: Tortricidae) on Snakeweed (Asteraceae: *Gutierrezia* spp.)

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Abstract.—Larvae of the tortricid moth, *Synalocha gutierreziae* Powell, feed on the foliage of snakeweeds, *Gutierrezia* spp., which are among the most abundant and detrimental weeds in the southwest rangelands. In the laboratory, female moths deposited egg masses containing 15 to 429 eggs ($\bar{x}$ = 112). At 27°C the mean duration of the egg, larval, and pupal stages were 9.1, 47.2 and 9.0 days, respectively. The mean preoviposition period was 3.0 days. The total generation was ca. 68.3 days long. *Synalocha gutierreziae* has 3 or 4 overlapping generations each season, that each extend ca. 10 weeks. In the field, larvae were present from mid-March to late November. Several insect parasites and predators attack *S. gutierreziae* larvae, including Tachinidae, Braconidae, Ichneumonidae, Reduviidae, and Carabidae. Four spider species were also predaceous on larvae.

Snakeweeds, *Gutierrezia sarothrae* (Pursh) Britt. and Rusby, and *Gutierrezia microcephala* (DC.) Gray, are native to western North America (Correll and Johnston, 1970). Both species are important in range management because they are highly competitive with desirable perennial grasses (Ueckert, 1979; Gesink et al., 1973) and are toxic to most livestock (Kingsbury, 1964; Sperry et al., 1964). Platt (1959) reported 57.5 million ha (142 million acres) in the United States to be infested with these species.

The control of snakeweed with herbicides has been erratic and mostly unsuccessful (Sosebee et al., 1979, 1981). Prescribed burning can control snakeweed during certain periods of the year (Dwyer, 1967). Biological control may have potential as an effective, low cost method of control (DeLoach, 1978, 1980; Foster et al., 1981). Snakeweed is ranked as the best candidate for biological control out of 17 native weeds examined by DeLoach (1980).

A prerequisite to successful biological control is an understanding of a weed's insect associates (DeLoach, 1978, 1980; Andres, 1981). The first effort to determine the naturally occurring insects associated with snakeweed in western Texas and eastern New Mexico resulted in a list of 338 species from 86 families in 8 orders (Foster et al., 1981). The relationships of the most numerous and potentially destructive insects on snakeweed were described by Wangberg (1982). Several species of defoliating microlepidoptera were the most conspicuous insects on snakeweed. They included *Sarata incanella* (Hulst) (Pyralidae), *Synnoma lynosyrana* Walshingham and a species now called *Synalocha gutierreziae* Powell (Tortricidae: Sparganothini) (Wangberg, 1982). *Synalocha gutierreziae* has only recently been described (Powell, in press) and consequently nothing has been

published on its biology. Powell (in press) included a brief synopsis of the information reported in this paper. Due to *S. gutierreziae*'s similarity to *S. lynosyrana,* however, it is possible that some of the biological information for the two species has been confused in earlier literature. Therefore, the purpose of this research was to clarify the biology of *S. gutierreziae.*

The specific objectives of this research were (1) to describe the life history of *S. gutierreziae,* its life stages and behavior, (2) to determine its host plant(s), (3) to describe host plant damage and patterns of infestation, and (4) to identify natural enemies of *S. gutierreziae.*

Materials and Methods

This study was conducted from May 1981 to May 1983 in portions of western Texas and southeastern New Mexico, where heavy infestations of snakeweed exist. Observations of insects were made at nine locations in Lubbock, Winkler, Ward and Gaines Cos., Texas and in Lea Co., New Mexico. Intensive studies were completed 3.2 km (2 mi) east of Wink and 8.1 km (5 mi) south of Kermit, in Winkler County. A survey of flowering snakeweed plants was conducted in 10 counties throughout the Trans Pecos Area in addition to the above localities to establish geographical ranges of the insects. Additionally, searches were conducted at all of the beforementioned sites for *S. gutierreziae* and shelters of larval *S. gutierreziae* on other plants in the area.

Samples of *S. gutierreziae* were taken biweekly throughout the 2-year period and weekly during pupation and adult emergence. On each sample date, ca. 50 leaf "ties" (shelters constructed by *S. gutierreziae* larvae) were clipped at random from plants. Insects within each tie were removed and preserved in 75% ethanol. Frequency of larvae per tie was determined by examining one tie from each of 50 plants along a single line transect and recording the number of larvae found in each tie. *Synalocha gutierreziae* eggs, which are extremely difficult to observe in the field, were collected by microscopic examination of leaves and stems in the laboratory. The leaves and stems were collected from heavily infested plants to increase the probability of locating eggs. Plant damage was determined by measuring length and width of each tie, by counting the number of stems incorporated in the tie, and by recording the position on the plant where the tie was constructed. A total of 110 ties was examined for this purpose.

Additional collections were made for rearing and behavorial studies. Leaf ties containing larvae or pupae were removed from snakeweed, placed in plastic bags, and transported to the laboratory in an insulated container. Ties containing pupae were placed in a wide-mouth 3785 ml (one gallon) glass jar and covered with a piece of insect netting that allowed free air circulation. A 10% aqueous honey or sucrose solution was provided for emerging adults. Observations of insect behavior within the glass jar were possible with minimal disturbance to the insects. Following oviposition, the containers were placed in an incubator at 27°C and 80% R.H. Emerged females were allowed to oviposit until their death. Fresh snakeweed clippings were placed into the jars each day and the old clippings were removed and examined for eggs. Eggs deposited on the glass walls of the jar were circled with a waxed pencil and dated.

The number of instars was determined from laboratory rearing. On the day of eclosion, 20 neonates were placed in separate 50 × 9 mm petri dishes containing

fresh snakeweed clippings as a food source. Larvae were held at 27°C and 80% R.H. in a growth chamber. No free water was provided for the larvae. Snakeweed leaves were replaced with fresh leaves every 1 or 2 days until larvae pupated. Each larva was examined daily and the number of days between molts was recorded. The sex of pupae was recorded and moths were allowed to emerge. The pre-oviposition period of adults was recorded. Feeding behavior was observed in the field and laboratory.

Field collected larvae and pupae were reared individually in 50 × 9 mm petri dishes for parasites. Predators were field collected whenever observed attacking this species.

Results and Discussion

Host Plant and Host–Insect Interactions

Synalocha gutierreziae feeds on both *Gutierrezia sarothrae* and *G. microcephala* in western Texas and southeastern New Mexico (Fig. 1). It was not observed on any other plant. *Synalocha gutierreziae* consistently ties leaves at the terminals forming a small tube internally with a cone-shaped exterior. The mean external dimensions are 3.5 ± 1.3 cm long by 1.5 ± 0.6 cm wide (n = 110). A mean number of stems incorporated in the ties was 5.0 ± 4.5. The apices of the leaves are held tightly together with very little silk exposed to the outside. Larval and pupal life are spent within the ties. There are one to two larvae per tie ($\bar{x}$ = 1.1 ± 0.2, n = 50).

Life History

Egg.—The eggs are flat and scale-like in appearance. They are light green when deposited, identical to the color of new snakeweed leaves and become darker as they develop. The larval head capsule is black, and is visible through the chorion one to two days prior to eclosion. The chorion is transparent and has a rough and slightly reticulated surface. The eggs are deposited in elongated clusters, overlapping like shingles. In the laboratory, the number of eggs ranged from 15 to 429 per mass ($\bar{x}$ = 112 ± 120, n = 16). One mass of 42 eggs was found in the field on the upper leaf surface at the plant base. The eggs were in two rows slightly overlapping each other.

The duration of the egg stage ranged from 9 to 12 days. At 24°C, 1354 eggs in eight masses had a mean duration of 10.4 ± 0.7 days. At 27°C, 434 eggs in eight masses had a mean duration of 9.1 ± 0.3 days. All successful eclosions from one egg mass occur within 24 hours at these temperatures. Eclosion begins as a larva cuts a ragged slit through the chorion.

Larva.—Immediately after eclosion, the neonates begin to search for protected places and construct ties. Neonates lived up to 5 days without food or water. Laboratory reared larvae had seven instars. First and second instars have black heads with a yellowish-green body. Third instars have a light brown head. Fourth instars develop dark green longitudinal stripes. Fifth, sixth and seventh instars are similar, with the body slightly darker than preceding instars. The stadial length for each instar (Table 1) ranged from 5.0 ± 0.0 days to 7.6 ± 1.9 days except for seventh instar females that had a stadial length of 12.9 ± 3.9 days. The duration

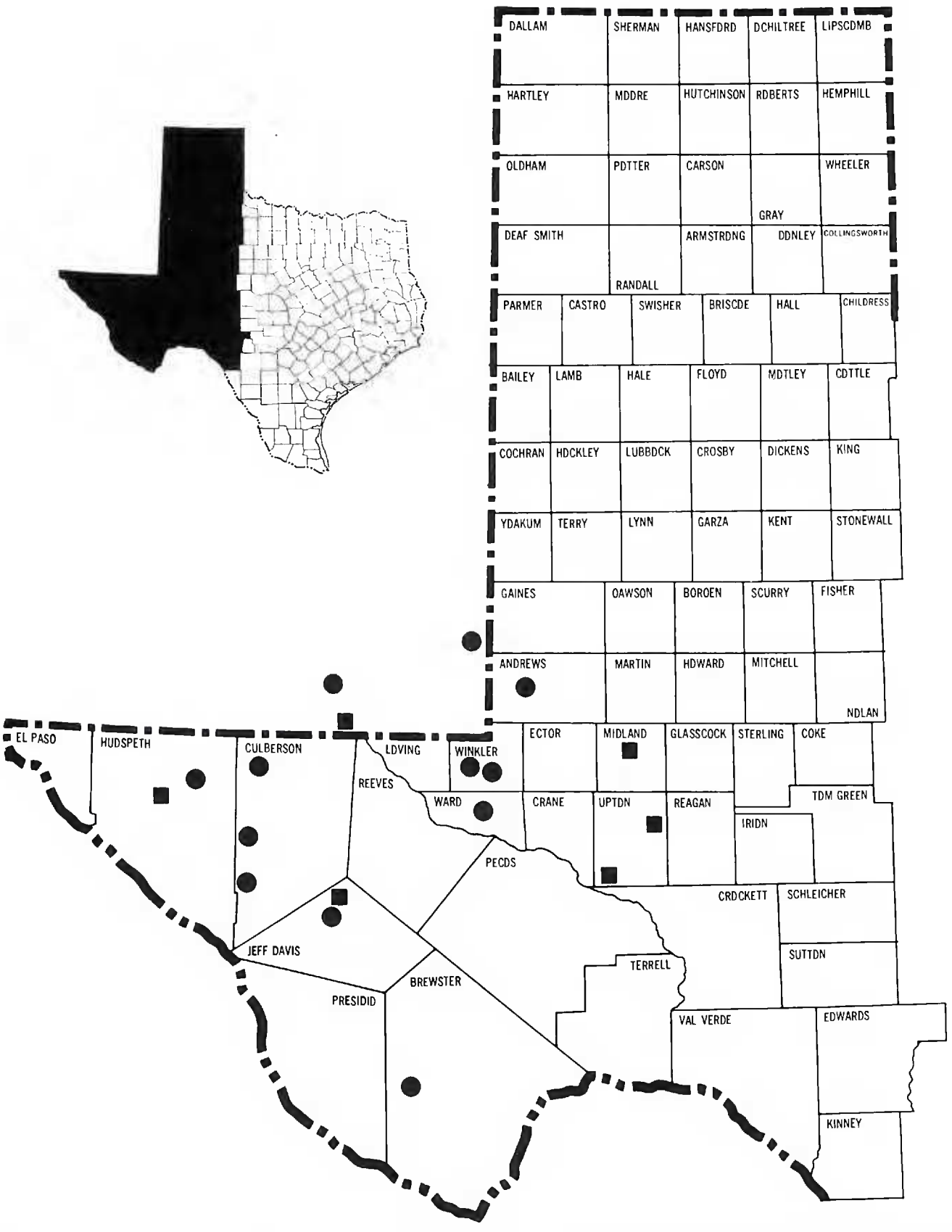

Figure 1. Collection sites of *Synalocha gutierreziae.* Circles represent collections of *Gutierrezia sarothrae.* Squares represent collections on *G. microcephala.*

of sixth and seventh instars in females was significantly ($P < 0.05$) longer than in males. The larval stage was completed in 47.2 ± 4.9 days when held at 27°C and 80% R.H.

The larvae conceal themselves by tying leaves together. Shelters constructed by first instars consist of three to four leaves. The larvae oscillate their heads from one leaf to another, attaching silken strands to trichomes on the leaf surface. As the leaves are drawn closer together, the larvae attach more strands and continue this behavior until the leaves come together forming a tube. It has been suggested, and documented in some cases, that there is a shrinking property of silk that aids

Table 1. Mean stadial lengths of (±SE) *Synalocha gutierreziae* reared in the laboratory at 27°C and 80% R.H.

Instar	Male	Female
First	5.0 ± 0.0	5.0 ± 0.0
Second	5.8 ± 0.5	5.9 ± 0.4
Third	7.0 ± 1.1	6.9 ± 1.4
Fourth	6.0 ± 1.1	6.6 ± 1.1
Fifth	5.5 ± 0.5	5.6 ± 0.9
Sixth[1]	6.0 ± 0.5	7.4 ± 1.3
Seventh[1]	7.6 ± 1.9	12.9 ± 3.9

[1] Significantly longer for female using a *t*-test (R. G. D. Steel and J. H. Torrie, Principles and procedures of statistics, New York, McGraw-Hill Book Company, 1960) with 95% confidence limits.

the larva in bending the leaves (Knaggs, 1867; Atkins et al., 1957). As the larvae grow, new leaves from developing terminals are incorporated into the shelter.

Early instars skeletonize young leaves throughout the plant. As larvae develop, they begin to consume entire leaves. Larvae usually feed on the underside of leaves incorporated in the tie. Occasionally larvae are observed feeding on leaves near the ends of the shelters during the day, with only the anterior portion of the body exposed. In some instances larvae constructed silken semi-circular tunnels to nearby stems and fed away from the leaf tie. Larvae chew through the leaf bases and retreat into their ties before consuming the leaves. Feeding was not observed at night, but frass accumulation overnight was noted.

Synalocha gutierreziae defecates by backing to the lower opening of the tie, exposing and wiggling the posterior portion of the body. This motion propels the fecal pellet away from the shelter.

Pupa.—The 7th instars tie additional leaves to their shelter just prior to spinning a silken cocoon. The cocoon is a thin sheet of silk inside the tie that lines the pupation chamber. After completing the cocoon, the body of the larva shortens, and the insect is quiescent unless disturbed. In the laboratory, the pre-pupal period ranges from one to two days. The obtect pupae are greenish-yellow at first, then darken to brown by the second day. Abdominal segments 7 and 8 differ between sexes. In the male segments 7 and 8 are completely separated by an intersegmental membrane ventrally that is lacking in the female (Fig. 2). The duration of the pupal stage was 9.0 ± 1.0 (n = 32) days, when held at 27°C and 80% R.H. The duration of the pupal stage in females and males was not significantly ($P < 0.05$) different between sexes.

Rows of short, stout spines are present dorsally on the abdominal segments (Fig. 2). They may aid the pupae in moving upward inside the pupal chamber just prior to emergence. Adult emergence occurs after the anterior portion of the pupa has wiggled free of the tie and the cremaster has anchored to the silk lining of the tie. Exuviae are commonly found attached to the shelters months after adult emergence.

Adult.—For a brief time after emergence, the wings hang ventrocaudally. After hardening they fold roof-like over the dorsum. Forewings are tan with brown mottling and have upraised scale tufts. The hindwings of the male are dark grey with a silvery fringe. Hindwings of the females are light brown with a silvery

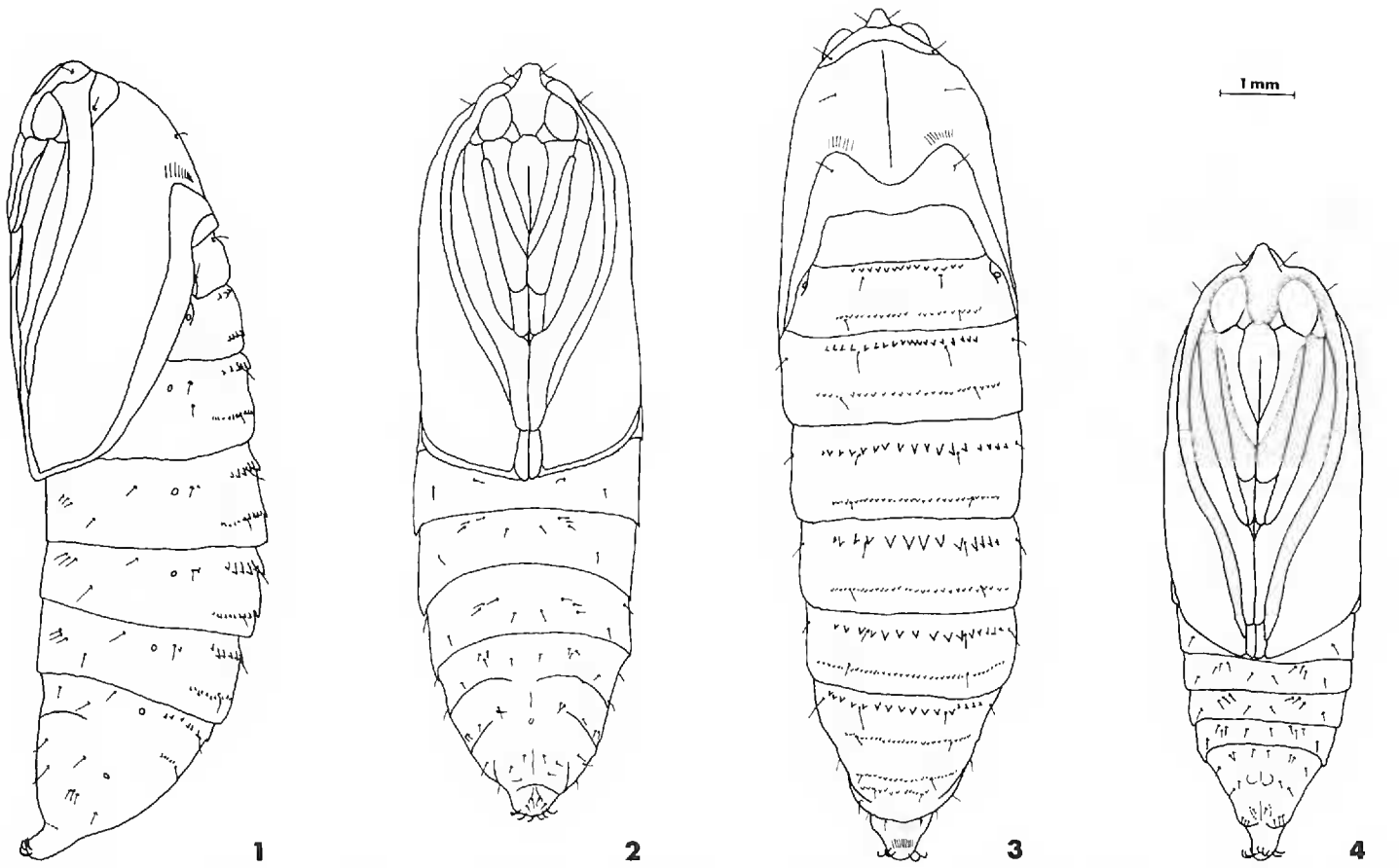

Figure 2. External pupal morphology of *Synalocha gutierreziae*: (1) lateral view of female; (2) ventral view of female; (3) dorsal view of female; (4) ventral view of male.

fringe. The adults are cryptic and usually remain hidden among the snakeweed foliage.

Females usually rest at the terminal ends of the plant twigs throughout the day. This behavior is identical to the "calling" position of *S. lynosyrana* (Powell, 1976). Any disturbance of the plant caused the females to drop to the ground. Females were never observed in flight. Wellington and Henson (1947) reported that female *Choristoneura fumiferana* (Clemens) are unable to fly until after the first egg mass is deposited. Males have been observed flying throughout the day, usually fluttering just above snakeweed plants. Moths were not observed to fly at night.

Adults survived 6 to 20 days ($\bar{x} = 11.5 \pm 4.1$; $n = 18$) in the breeding jars. There were no significant differences in longevity between sexes (t-test, $P < 0.01$). No adult feeding was observed in the field or in the laboratory.

Mating was observed in the field only four times, and was during daylight. Pairs *in copulo* were motionless, usually resting vertically in a tail-to-tail position with the distal parts of the wings overlapping. One mating pair, on 7 November 1981, at 1045 CST, remained attached for 56 minutes after they were first observed.

Oviposition was only observed in the laboratory during the day under normal room lighting. However, eggs were usually deposited between 1800 and 1900 CST. *Synalocha gutierreziae* females used the apex of their ovipositor to tap the surface of the container for one to four minutes before depositing eggs. Selection of oviposition sites by tortricine moths is principally by tactile stimulation (Powell, 1964). After a row of eggs was deposited, females turned and deposited the next row in the opposite direction. The eggs of the second row were placed in the interstices of the first row.

Synalocha gutierreziae secretes a thin cloudy film along with each egg, that may act as an adherent. Powell (1964) reports a similar opaque covering for many

Sparganothini. *Platynota stultana* (Walsingham) covers its egg masses with a "clear cement" secreted by abdominal glands (Nelson, 1936).

At the end of oviposition, two clusters of scales were deposited at the lower end of the elongate egg mass. This behavior was observed numerous times in the laboratory. However, not all egg masses had these scale tufts present. No scale tufts were found on the one egg mass collected in the field. Eggs were always deposited on the glass walls of the jar, rather than on the host plant clippings.

Virgin females began depositing sterile eggs on the third day after emergence. The longest oviposition period was three days. Seventy-one percent of the eggs were deposited the first day of oviposition.

Synalocha gutierreziae has multiple, overlapping generations each season, which extend approximately 10 weeks each. Larvae were collected from 17 March to 26 November 1982 in Winkler County, Texas. Based on this 37-week interval, *S. gutierreziae* may have three or four generations each year. The average life span, from oviposition to death, is 76.4 $\pm$ 4.9 (n = 16) days when held at 27°C and 80% R.H. The life span was not significantly different ($P < 0.05$) between the sexes. Development appears to continue as long as environmental conditions remain favorable. Powell (1964) stated there is no pattern of life cycle in multivoltine tortricid species. Collection dates suggest more than one generation per year.

Natural Enemies

Several parasites and predators attack the larvae of *S. gutierreziae.* Among the parasites three species of tachinid flies, *Erynnia tortricis* (Coquillett), *Nemorilla pyste* (Walker) and *Voria ruralis* (Fallen) are occasionally reared from pupae. *Macrocentrus* sp. (Hymenoptera: Braconidae) and three undetermined species of Ichneumonidae were the principal groups involved. Over 55% of the observed parasitism was due to one of the ichneumonid species.

Two insect predators, *Sinea diadema* (F.) (Reduviidae), and *Philophuga viridis* Dejean (Carabidae) were observed preying on *S. gutierreziae* larvae one and six times, respectively. Four spider species, *Misumenops* sp. (Thomisidae), *Sassacus papenhoei* Peckham and Peckham, *Phidippus audax* (Hentz), and *Metaphidippus* sp. (Salticidae) frequently attacked larvae. Many spider species were collected living in close association with *S. gutierreziae* larvae, any of which were potential predators.

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