Great Basin Naturalist

Volume 41 | Number 3 Article 4

9-30-1981

Bionomics and control of the walnut spanworm, *Phigalia plumogeraria* (Hulst), on bitterbrush in Utah

Malcolm M. Furniss
Intermountain Forest and Range Experiment Station, USDA Forest Service, Ogden, Utah

Gordon A. Van Epps
Utah State University

BIONOMICS AND CONTROL OF THE WALNUT SPANWORM, *PHIGALIA PLUMOGERARIA* (HULST), ON BITTERBRUSH IN UTAH

Malcolm M. Furniss[1] and Gordon A. Van Epps[2]

Abstract.— In 1979, the walnut spanworm defoliated a 1 ha bitterbrush seed orchard near Nephi, Utah. No seed was produced for two years thereafter due to feeding damage. Life stages were described and illustrated. The female is brachypterous and incapable of flight. First instar larvae readily drop on their silk threads and probably are dispersed by wind. The insect has one annual generation. Moths laid an average of 159 eggs per cluster in April; larvae began to appear in early May and matured by the first week of June. The pupal period extended from June until mid-April. The parasitic bombyliid, *Villa faustina* (Osten Sacken), was reared from pupae. In April 1980, shrubs contained an estimated average of 1044 eggs each. On 19 May, larvae averaged 1.9 per 7.5 cm of twig and were in the first and second instar. On 20 May the population was controlled by spraying with Sevimol-4. Other potential host plants, as determined from greenhouse tests, are rose, ceanothus, mountain mahogany, serviceberry, and willow.

The walnut spanworm, *Phigalia plumogeraria* (Hulst) was discovered defoliating bitterbrush (*Purshia tridentata* [Pursh] D.C.) in a seed orchard near Nephi, Utah, in June 1979. The larvae had been recorded previously (Rindge 1975) on *Juglans*, *Salix*, *Quercus*, *Malus*, *Prunus*, and *Acer* but not on bitterbrush. The moth is found in British Columbia and most western states. Because of the severity of defoliation and the importance of bitterbrush as big-game browse, we compiled the information reported here.

The best accounts of *P. plumogeraria* (=*Boarmia*) are those of Coquillett (1893, 1894, 1897) in California on English walnut. Rindge (1975) placed *plumogeraria* in the genus *Phigalia* with three other species, of which only the life history of *P. titea* (Cramer) seems to have been studied (Talerico 1968). Rindge's revision includes most of the significant information on *plumogeraria* except the description of the egg and five larval stages by Dyar (1903) and of all stages by McGuffin (1977). Although, as mentioned by Rindge (1975), Hulst evidently intended to name the species *plumigeraria*, we use *plumogeraria* in conformity with Fletcher's (1979) Catalog of Geometroidea.

Seed Orchard and Infestation

The infestation occurred 8 km south of Nephi, Juab County, Utah, at 1707 m elevation. Other known adult specimens from Utah were collected at Ogden 23 March 1977.[3] Rindge (1975) shows two Utah collections in the vicinity of that reported here.

The 1 ha bitterbrush seed orchard south of Nephi was seeded in 1966 in rows varying from 1.2 to 3.7 m apart. Source of seeds was Fountain Green Divide, approximately 17 km east of Nephi. Plants were thinned from 0.6 to 2.4 m apart within rows to determine optimum spacing. The plants averaged about 1.6 m tall in 1979. The seed orchard is surrounded by grain fields, and the nearest native bitterbrush is more than 3 km eastward.

The top 16 cm of soil consists of a friable reddish brown loam of moderately granular structure. It is mildly calcareous and mildly alkaline. The terrain has a 2 percent slope. Annual precipitation averages 32 cm, with an average of 2.2 cm monthly during June through November and 3.0 cm monthly thereafter. Prevailing winds are from the south or north.

On 17 May 1979, the bitterbrush appeared normal (Fig. 1A) although some small loopers

[1]Intermountain Forest and Range Experiment Station, USDA Forest Service, Ogden, Utah 84401. Present address: Intermountain Station's Forestry Sciences Laboratory, Moscow, Idaho 83843.
[2]Department of Range Science, Utah State University, Logan, Utah 84321. Present address: Snow Field Station, Ephraim, Utah 84627.
[3]Pers. comm. from Dr. D. C. Ferguson, USDA Systematic Entomology Lab., Washington, D.C., 4 February 1980.

Fig. 1. Bitterbrush shrubs on 22 May 1979 before defoliation (A), and 6 June after defoliation (B) by walnut spanworm.

TABLE 1. Head widths of *Phigalia plumogeraria* larvae reared in greenhouse from eggs collected 10 April 1980.

Instar	No. of larvae	Head width (mm)	
		Average	Range
1	30	0.40 (0.39)[1]	0.37–0.43
2	30	0.70 (0.67)	0.68–0.78
3	30	1.15	1.09–1.21
4	30	1.78	1.69–189
5	30	2.62 (2.71)	2.54–2.87

[1]Figures in parentheses are averages from field populations; first and second instar larvae collected between 3–20 May 1980, fifth instar larvae collected 6 June 1979.

were present as recalled later. Plants had bloomed fully 22 May, with many more flowers than in previous years, and a good seed crop was expected.

During our next visit 6 June we found the orchard completely defoliated (Fig. 1B) and devoid of developing fruits, except on a few border plants. Mature larvae were collected and sent to the USDA Systematic Entomology Laboratory, Beltsville, Maryland, but could not be identified. We therefore set about rearing all life stages, taking photos, and developing information that would enable identifying and controlling the insect should it be encountered in the future.

LIFE STAGES

Egg

The 0.89 × 0.67 mm oval-shaped egg (Fig. 2) is slightly blunted at the micropyle end and is flattened on two sides. Coquillett (1893) described the color as dark grayish drab with a strong brassy tinge, although it reminds us of pewter. At low magnification, the chorion is slightly wrinkled transversely, except at the ends, which appear to have been dented with a ball peen hammer.

Larva

The larva is of the usual geometrid type (Fig. 3) and has five instars, during which it varies in body length from 2 or 3 mm to as much as 34 mm. Head widths of larvae are shown in Table 1. The crochets of mature larvae form a biordinal mesoseries.

FIRST INSTAR.— Length 2 to 3 mm, appearing blackish to the unaided eye, but under magnification the body is mottled dark brown with a broken white lateral line. The head is uniformly black and smoothly

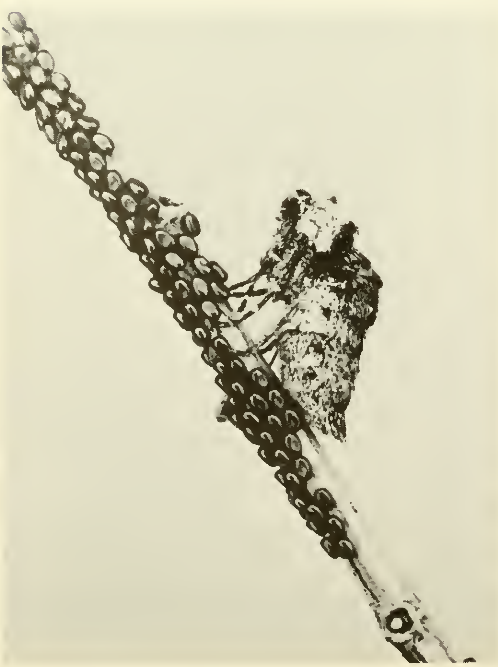

Fig. 2. Female moth and eggs on bitterbrush twig.

Fig. 3. Mature larva on bitterbrush.

rounded; the abdomen lacks prominent tubercles that are present in subsequent instars.

SECOND INSTAR.— Length 5 to 6 mm, appearing blackish brown to the unaided eye, but under magnification the body segments are blackish with lighter intersegmental areas. The head is mottled brownish and has fairly prominent, rounded epicranial lobes as in all subsequent instars. Primary setae are supported by prominent, darkly pigmented tubercles on several abdominal segments. Using Hinton's (1946) classification, the relative size of the most prominent dorsal tubercles is D2>D1 on the first four abdominal segments (A1–4), but D1>D2 on abdominal segment 8 (A8). The tubercle supporting seta L1 posterior of the spiracles is also prominent, particularly on A1–4. The relative size of the previously mentioned tubercles is A2 and A8>A1>A4.

THIRD INSTAR.— Length 10 to 12 mm, color yellowish brown with contrasting black tubercles. Otherwise as described for second instar.

FOURTH INSTAR.— Length 14 to 21 mm, color variable: greyish cream, sometimes with a pinkish cast to body and head capsule.

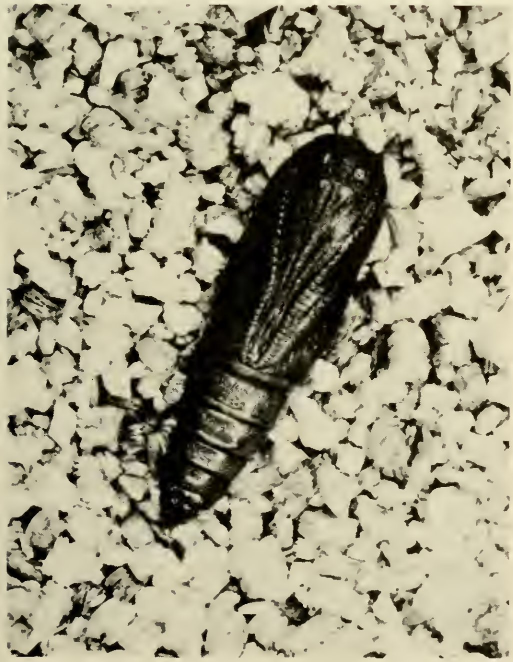

Fig. 4. Male pupa, ventral view.

Otherwise as described for previous two instars.

FIFTH INSTAR.— Length 18 to 35 mm, color greyish or greyish yellow in the field population, sometimes with a pinkish cast in reared larvae. Tubercles as described for instars 2 through 4 except their tips are orangish or yellowish brown, and the setae tend to be longer than their supporting tubercles rather than equal or shorter, as in earlier instars.

Pupa

The pupa (Fig. 4) is rather stout and shiny dark brown. It varies in length from 10 to 15 mm.

Females are generally wider and shorter than males:

	Female	*Male*
Length, mm	11.7	12.8
Width, mm	4.3	4.2
Ratio W/L	0.37	0.33

A two-spined cremaster is located at the tip of the abdomen. In some species a short projection occurs on each side at the base of the cremaster, but these are usually not of sufficient shape or length to be described as spines. Field-collected pupae often have tips of the cremaster spines broken.

As seems general in Lepidoptera, the genital opening of the female is located between abdominal segments 7 and 8, and that of the male spans segment 8. The impression of the antennae is similar in both sexes, but the edges are more elevated in the male. The best characteristics for separating the sexes of *plumogeraria* are the wings and side profile. The female's wings are vestigial, and she appears more hunchbacked than the male (Fig. 5).

Adult

The adult (Figs. 2 and 6) is described in detail by Rindge (1975). The characterization presented here will permit definitive separation of *P. plumogeraria* from other geometrids infesting bitterbrush. For example, the female of *Anacamptodes clivinaria profanata* (Barnes and McDunnough) is winged (Furniss and Barr 1967); wings of female *P. plumogeraria* are functionless minute pads. Likewise,

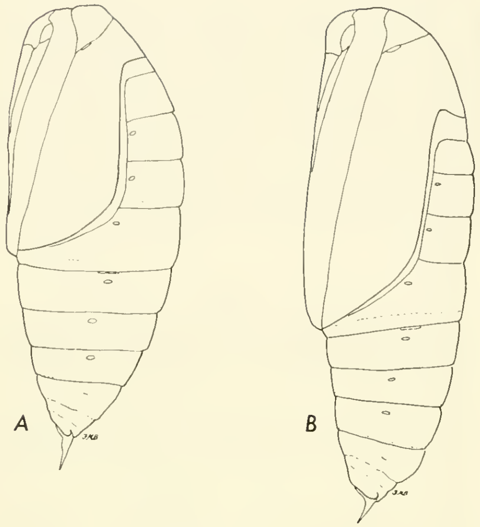

Fig. 5. Left side perspective of female (A) and male (B) pupa.

Fig. 6. Male moth on bitterbrush.

males are separable merely by the very broadly bipectinate antennae of *P. plumogeraria*.

Male.— Body 10 to 11 mm long, brownish grey. Wings large, grey color; forewing 18 to 24 mm, sometimes weakly marked with two dark cross lines. Antennae bipectinate with long (0.5–2.8 mm) biciliate pectinations, from which the specific name aptly derives. Dorsum of abdomen reddish brown.

Female.— Body 7 to 11 mm; head, thorax, and appendages grey. Antennae simple. Dorsum of first abdominal segment covered by a dense mat of black spines and scales; remaining segments with reddish brown scales trailed by mixed black and white spines or scales; whitish underneath abdomen.

Seasonal History and Behavior

In California, moths were reported to emerge between early January and late March (Coquillett 1897). Larvae matured there in the latter part of April and pupated in soil during May. One generation occurred annually. In Utah, however, those events occurred later in the bitterbrush orchard, probably due to the colder climate.

Adult

In the orchard, moths were abundant 7 April 1980 and are presumed to have begun emerging several days earlier. (Time of emergence could be inferred also from five males caught in flight at Ogden, Utah, 23 March 1977.[4] Mating was not observed. The duration of adult presence was not determined, but females seemed to outlast males.

Egg

Eggs were first observed 7 April 1980, while bitterbrush was still dormant. Eggs were laid only on 1979 terminals, mainly in the upper crown, on their flat side in closely spaced masses of 23 to 345 eggs (average 159). Of egg masses sampled, 23 percent had been laid in 1979; 77 percent were laid in 1980, but we don't know if this represents the relative size of those generations.

Eggs were very abundant when collected for incubation 12 April. Hatching began in the field before 2 May and was virtually

[4]Ibid.

complete on 16 May. Eggs incubated at 22–24 C hatched in 10 days. Larvae emerged from the micropyle end. Examination of 22 incubated egg masses disclosed that 17 percent of the eggs were not viable.

Larva

Larvae were first observed 2 May. Newly hatched larvae dropped readily on silk threads after encountering the end of a twig or edge of a leaf. This behavior aided their dispersal by wind. Later instars dropped on threads only when touched or jarred.

Larvae were sampled in 1980 prior to application of insecticide on 20 May. The proportion of instars by date were:

Date	*Number*	*Instar I*	*Instar II*
		(Percent)	
8 May	48	100	
13 May	71	99	1
16 May	56	66	34
19 May	123	58	42
20 May	303	8	92

No further observations were possible because of elimination of larvae by treatment we will discuss later. In 1979, however, larvae had matured by 6 June. Such rapid development of the ravenous later instars accounts for the sudden defoliation in 1979 (no damage visible 22 May; completely defoliated before 6 June). Likewise, Coquillett (1893) quoted a Santa Barbara walnut grower who saw his orchard eaten up in the space of one week.

Larvae were reared at 21 C, 17 hr day. The duration of instars was as follows:

Instar	*Number*	*Duration (days)*	
		Average	*Range*
I	30	4.5	4–5
II	30	2.5	1–4
III	28	3	1–6
IV	23	4	2–6
V	17	11	9–13
Total		25	17–33

The duration of fifth instar larvae may have been prolonged by depletion of foliage periodically, due to their capacity to consume leaves. Four host plants were infested to compare their suitability to larval growth. Larvae grew fastest on wild rose (*Rosa sp.*) and redstem ceanothus (*Ceanothus sanguineus* Pursh.), followed by mountain mahogany (*Cercocarpus ledifolius* Nutt.), then bitterbrush. Possibly the reason for slower development on bitterbrush was that smaller leaves of that plant may have resulted in larvae intermittently running out of food before being transferred to other plants. In the greenhouse, some larvae wandered onto potted Scouler's willow (*Salix scouleriana* Barratt) and serviceberry (*Amelanchier alnifolia* Nutt.) and appeared to feed and develop normally.

Pupa

Date of pupation was not determined precisely but probably occurred in 1979 soon after 6 June, when all larvae were in their fifth instar and foliage had been eaten. Pupae are known to have been in the soil 10 July, but no observation was made between those dates. Diapause was present in pupae and was broken with only fair success by refrigeration for over 90 days at ca 2 C followed by rearing at room temperature.

In 1980, termination of the pupal stage in the field obviously began prior to 7 April, when adults and eggs were seen on plants. Some pupae were found in soil 12 April, but most moths are believed to have emerged by then. Pupae occurred in the upper 10 cm of soil and were more abundant closer to the base of the plant.

Population Sampling

On 10 and 11 April 1980, we collected one egg mass from 1979 terminals of three shrubs from every other row. The sample shrubs were located near the ends and middle of each row. The egg mass chosen was the third one encountered from an arbitrary beginning point. A total of 33 egg masses were obtained; 26 had current-year eggs and 7 had empty 1979 eggs. The 1980 egg masses had an average of 159 eggs (SD = 71.8). Examination of the 33 sample shrubs disclosed 261 egg masses (average/shrub = 7.91, SD = 5.35).

The 1980 population of eggs in the entire orchard is estimated to have been: 407 shrubs × 7.91 egg masses × 159 eggs = 511,880. If 83 percent were viable, as indicated by incubation of a sample lot, the orchard contained 424,860 first instar larvae, or 1,044 larvae per shrub. On 20 May, after insecticide was applied, 500 second instar larvae were collected on a sheet beneath one shrub; thus, allowing for dispersal and natural mortality, the estimate of initial larval population may be accurate.

On 19 May, a 7.5 cm twig was taken from the north and south sides of each of the same 33 shrubs from which eggs had been sampled 10 and 11 April. As noted earlier, 58 percent of the larvae were first instar; 42 percent wre second instar. Results were:

	North	*South*	*Both*
Total larvae	53	73	126
Aver. no./7.5 cm	1.61	2.21	1.91
SD	1.46	1.60	1.55

Only 10 of the 66 twigs had no larvae; range was 0 to 7 larvae.

Control

Natural Control

Coquillett (1897) reported two larval parasites: an unidentified tachinid and an undetermined species of *Apanteles* (Ichneumonidae). Our search of parasite records has disclosed no additional information, although *P. titea*, which occurs generally more eastward, has six parasites (Talerico 1968).

We discovered one parasite, a bombyliid fly, *Villa faustina* (Osten Sacken), which emerged in early June from *P. plumogeraria* pupae collected from soil in early April 1980. It was not abundant enough to be a significant control factor. We also commonly found wings of males in early April that we think resulted from predation by birds. Coquillett (1897) noted that blackbirds preyed on larvae in California.

Soil characteristics and the inability of females to fly also affect abundance of *P. plumogeraria*. Soil that is friable is well suited for larvae to enter and pupate. Compact soil is less suited to pupation because its density presents a physical barrier and is more apt to heat to a temperature harmful to larvae seeking to pupate.

The inability of female moths to fly limits their dispersal. Probably adult females and immature stages are occasionally transported accidentally by man's conveyances. But, judging from observations of larval behavior, dispersal apparently occurs mainly by wind after eclosion of larvae.

Applied Control

Prior to April, sticky barriers could be applied to stems to prevent female moths from climbing the plants to oviposit. This method may be feasible in a seed orchard but not over an extensive area.

Larvae in the first and second instars were controlled effectively by treatment 20 May 1980, with a spray consisting of 2.93 ml Sevimol-4[5] per liter of water. Sevimol-4 contains 40 percent carbaryl. The spray was applied in calm air at the rate of 593 l/ha with a modified John Deere garden sprayer[6] pulled behind a 14 hp John Deere garden tractor. A broad jet with adjustable nozzles was mounted on a pipe approximately 1.8 m behind the sprayer. The jets were adjusted to deliver spray outward. The tractor was driven up every other row. Whereas the prespray population (19 May) was 1.91 larvae per 7.5 cm of twig, only 5 live larvae were found on 30 plants 22 May.

Discussion

Occurrence of this outbreak on bitterbrush carries some lessons. Even a well-studied shrub may be seriously damaged by native insects not previously known on that shrub. Examples of similar geometrids killing mountain mahogany for the first known time are *Anacamptodes clivinaria profanata* (Barnes and McDunnough) in southwestern Idaho (Furniss and Barr 1967) and *Stamnodes animata* (Pearsall) in northwestern Nevada (Furniss et al. in preparation). Both of those insects were unstudied and difficult to identify. Information such as host plants, biology, and immature stages was lacking until the insects' sudden destructiveness attracted study. Along with potential damage by such native insects,

[5]Although this paper reports research involving a pesticide, it does not contain recommendations for its use nor does it imply that the use discussed has been registered. All uses of pesticides must be registered by appropriate state and/or federal agencies before they can be recommended.

[6]The use of trade, firm, or corporation names in this report is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

there is an ever-present possibility of introduction of new insects as well as diseases (Furniss and Krebill 1972).

Results of our study will alert others to the potential of this geometrid to infest shrubs of several species. Besides feeding on bitterbrush in the field, in the greenhouse the larvae fed and matured on rose, redstem ceanothus, curlleaf mountain mahogany, saskatoon serviceberry, and scouler's willow.

Should other infestations occur, the insect can now be readily identified in all its stages. Information needed for control is available, including seasonal history, behavior, criteria for determining instars, and a method of treatment of high value shrubs such as in a seed orchard. We regret, however, that we couldn't observe an unaltered outbreak to determine long-term effects. Only then could we determine whether or when an outbreak in a natural shrub stand would require control or how to control it.

Acknowledgments

Moths were identified by Dr. Douglas C. Ferguson, Lepidoptera Section, USDA Systematic Entomology Laboratory, Washington, D.C. The bombyliid was identified by Dr. Jack Hall, Division of Biological Control, University of California, Riverside. We were assisted in the field by Eric Christensen, Utah State University, and Blaine Moore, Snow College, Ephraim, Utah. Charles R. Hepner, Jeffrey Littlefield, and Frances M. Bales, USDA Forest Service, Moscow, Idaho, assisted with rearing and measuring specimens. Frances also drew Figure 5. The manuscript was reviewed by Dr. William F. Barr, Department of Entomology, University of Idaho; Dr. Arthur R. Tiedemann, USDA Forest Service, Provo, Utah; and Charles F. Tiernan, USDA Forest Service, Missoula, Montana.

Literature Cited

COQUILLETT, D. W. 1893. Pages 26–29 *in* Report on some of the beneficial and injurious insects of California. USDA Div. Entomol. Bull. No. 30.

———. 1894. Pages 22, 23 *in* Report on some of the injurious insects of California. USDA Div. Entomol. Bull. No. 32.

———. 1897. Pages 64–66 *in* The walnut spanworm (*Boarmia plumigeraria* Hulst.). USDA Div. Entomol., New Ser., No. 7.

DYAR, H. G. 1903. Life histories of North American Geometridae-XLII. Psyche 10:168–169.

FLETCHER, D. S. 1979. Vol. 3 Geometriodea. *In* Nye, I.W. B., ed. The generic names of moths of the world. British Museum (Nat. Hist.), London. 243 pp.

FURNISS, M. M., AND W. F. BARR. 1967. Bionomics of *Anacamptodes clivinaria profanata* (Lepidoptera: Geometridae) on mountain mahogany in Idaho. Univ. Idaho Agric. Expt. Sta. Res. Bull. No. 73. 24 pp.

FURNISS, M. M., AND R. G. KREBILL. 1972. Insects and diseases of shrubs on western big game ranges. Pages 218–226 *in* C. M. McKell, J. P. Blaisdell, and J. R. Goodin, eds. Wildland shrubs—their biology and utilization. USDA For. Serv. Gen. Tech. Rep. INT-1, 494 pp.

FURNISS, M. M., D. C. FERGUSON, K. W. VOGET, J. W. BURKHARDT, AND A. R. TIEDEMANN. Bionomics and ecology of the geometrid *Stamnodes animata* (Pearsall) on curlleaf mountain-mahogany in Nevada. In preparation.

HINTON, H. E. 1946. On the homology and nomenclature of the setae of lepidopterous larvae with some notes on the phylogeny of Lepidoptera. Trans. Royal Entomol. Soc. London 97:1–37.

MCGUFFIN, W. C. 1977. Guide to the Geometridae of Canada (Lepidoptera). II. Subfamily Ennominae. 2. Mem. Entomol. Soc. Can. No. 101, 191 pp.

RINDGE, F. H. 1975. A revision on the New World Bistonini (Lepidoptera: Geometridae). Am. Mus. Nat. Hist. 156(2):129–130.

TALERICO, R. L. 1968. Life history of the looper *Phigalia titea* in Virginia. Ann. Entomol. Soc. Am. 61:557–561.