

EFFECT OF WINTER GRAZING OF ALFALFA STANDS  
ON SURVIVAL AND PARASITIC ACTIVITY OF  
BATHYPLECTES CURCULIONIS (THOMSON)

By

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## CHAPTER I

### INTRODUCTION

The alfalfa weevil, Hypera postica (Gyllenhal), a major pest of alfalfa in both the larval and adult stages, significantly reduces crop quality and yield. It is found in all 48 contiguous states and parts of Canada. Two strains of the alfalfa weevil have entered Oklahoma, with the eastern strain reported by P. D. Currey (Econ. Ins. Surv. and Detection, USDA 1968) and the western strain by D. Arnold, Survey Entomologist, Oklahoma State University. The strains have merged in western Oklahoma (Berberet and Gibson 1976). Serious damage by the weevil is reported annually in all parts of the state (Berberet and Pinkston 1976).

One important means of control has been provided with the introduction of parasitism of the alfalfa weevil into this country. This was first undertaken in 1911 when Bathyplectes curculionis (Thomson), an endoparasite of weevil larvae, was introduced from Italy into Utah (Chamberlin 1926). This species has demonstrated a remarkable ability for dispersal (Chamberlin 1926, Puttler et al. 1961, Dysart and Puttler 1965) as it accompanies the weevil into previously uninfested areas. Chamberlin (1924) states that, in comparison with other weevil parasites, average parasitism over large areas has been highest for this species. Research data indicate that rates of parasitism are sufficiently high for the species to be an important factor in control

of the alfalfa weevil (Brunson and Coles 1968, Dysart and Day 1976, Berberet and Gibson 1976).

All B. curculionis complete at least one generation per year, and a percentage progress through a second generation. In the eastern states, the first brood emerges about one to 2 weeks before the peak abundance of alfalfa weevil larvae in fields, and the second brood parasitizes weevils one to 3 weeks after peak larval abundance (Dysart and Day 1976). A similar pattern of activity occurs in Oklahoma (Berberet et al. 1978). Hamlin et al. (1949) conclude that the percentage of weevil larvae parasitized increases with the length of time the larvae are exposed to B. curculionis adults.

B. curculionis may provide an immediate economic gain by decreasing the total food consumption by parasitized weevils (Armbrust et al. 1970, Duodu and Davis 1974a). Direct mortality of early weevil instars due to parasite oviposition may also occur (Duodu and Davis 1974b). Both Bathyplectes anurus (Thomson) and B. curculionis reduce the population of the next weevil generation after parasitism, but, unlike B. curculionis, parasitism by B. anurus does not result in a correspondingly significant reduction in weevil feeding (Morrison and Pass 1974). Gibson (1974) found a difference in timing of parasitism on the weevil population by B. anurus and B. curculionis which he felt would minimize interspecific competition between the 2 species of parasites in Oklahoma.

Use of insecticides to control weevil populations may be important for maintenance of yields and stands. Davis (1970) indicates that various insecticides cause initial reduction in numbers of B. curculionis adults, and that there was no indication any insecticide

showed a differential killing action between parasitized and unparasitized weevil larvae. He advocated use of carbofuran as the most promising insecticide for direct control of the alfalfa weevil in Utah. Surgeoner and Ellis (1976) report that, although carbofuran does not reduce the percentage parasitism by B. curculionis, it may reduce the number of parasites that develop per unit area. Miller et al. (1973), in comparison of treated (with Thimet) and untreated fields, believe the smaller larval population in the treated area would be exposed to a greater number of parasites and thus yield a higher parasitism than the untreated area.

Laboratory research has been done to compare insecticide penetration of cocoons containing diapausing and nondiapausing B. curculionis larvae (Bartell et al. 1976). Due perhaps to the thin-walled, partially transparent nature of the nondiapausing cocoons between first and second generations, various insecticides may cause significant mortality. Cocoons containing diapausing B. curculionis larvae were impervious to the chemicals tested. These results are supported by other researchers (Wilson and Hintz 1971, Cherry and Armbrust 1975). Wilson and Armbrust (1970) believe that properly timed use of insecticides appears to be compatible with survival of the parasite, B. curculionis, in the Midwest.

Another factor affecting populations of B. curculionis is invertebrate predation by field crickets and various species of Carabidae (Cherry and Armbrust 1977). These authors (1975) believe this causes greater mortality to diapausing cocoons than the combined effects of weather, hyperparasites, and spraying. Their study showed that the summer cocoon population was reduced 65% by predation.



Several species of hyperparasites have been described which attack B. curculionis. The biotic potential of these insects is greater than that for B. curculionis, due to such factors as higher survival rates and multivoltinism (Puttler 1966, Pike and Burkhardt 1974). Survival rates over a two-year period averaged 25.9% for B. curculionis in comparison to 66% for secondary parasites in Wyoming (Pike and Burkhardt 1974).

An additional factor which may effect B. curculionis populations is winter grazing by livestock. Although some parasites may be crushed by the movements of the livestock, two benefits of grazing are evident. Weevil egg populations are reduced as much as 72% during the winter months (Berberet and Pinkston 1976) and cattle obtain essential nutrients from the alfalfa forage. During 1976-1978, field experiments were conducted to evaluate the use of winter grazing as it effects the viability of overwintering B. curculionis parasites.

## CHAPTER II

### MATERIALS AND METHODS

B. curculionis were reared from parasitized, field-collected weevils the summer previous to their being used in these studies and cocoons were held in a humidity chamber at  $23 \pm 5^{\circ}\text{C}$  and 60% R.H. A fence was constructed to separate grazed and ungrazed plots in an alfalfa field in Stephens County, Oklahoma. Sampling sites ( $0.18 \text{ m}^2 = 2\text{-square-feet}$ ) were located in a line at 1.5 m intervals through grazed and ungrazed plots and marked with flags or metal plates on the soil surface. Cocoons were placed around alfalfa crowns within each area in October to avoid hyperparasitism and predation, and still permit diapausing larvae to become acclimatized to cool autumn weather.

Samples of cocoons were removed from both plots from January through March. Cocoons which were visible on the ground surface were collected and loose soil and ground litter were taken from sampling sites to be sifted with screens to retrieve cocoons which had become embedded in debris or trampled into the soil. Numbers of intact, crushed, and empty cocoons were recorded. Cocoons which had a mutilated appearance with often only fragments remaining were recorded as being attacked by predators. Cocoons from which B. curculionis adults had emerged had a small, circular opening at one end. Intact cocoons were then dissected, and numbers of viable and inviable parasites were recorded, as well as the developmental stage of B. curculionis.

In February, 20 - 0.02 m<sup>2</sup> (0.25-square-foot) samples of plant material were removed at random from the grazed and ungrazed areas and processed to determine H. postica egg numbers (Pass and VanMeter 1966).

The t-test was used for comparison of means for percent recovery, total mortality, and crushed cocoons between grazed and ungrazed areas.

1977 Experiment. October 26, 1976, 50 sets of 35 viable (determined by dissection) cocoons were placed in the field, each set consisting of one group in grazed and one in ungrazed. Cattle grazed the alfalfa from December 29, 1976 to February 15, 1977. Samples were taken biweekly during January, and weekly during February and March. A minimum of 75 cocoons (grazed-ungrazed areas) was collected each sampling date with equal numbers of sets sampled each date. Alfalfa weevil egg samples were taken February 24.

1978 Experiment. Viability of diapausing larvae within the cocoons was determined by candling them using substage illumination. Dissection of a sample of candled cocoons indicated a 95% accuracy. October 13, 1977, 56 sets (grazed-ungrazed) of 75 cocoons were placed in the alfalfa field. Cattle grazed the alfalfa from December 10, 1977 to February 17, 1978. Samples were then taken at monthly intervals during December, January, and February, and weekly during March and April. Weekly sampling commenced one month later during this year of the study due to low temperatures during February, which prevented parasite development. Each sampling date, 4 sets (grazed-ungrazed) of cocoons were randomly chosen and sampled. Nine sampling dates and a total of 5400 cocoons were used in the experiment.

Weevil egg samples were collected on February 24, March 9, and March 17. Larval samples were taken weekly after alfalfa growth began

(March 25). When larval populations exceeded the economic threshold (April 14), methyl parathion was applied at 0.6 kg/ha. Sweep samples were taken weekly beginning April 6 to collect weevil larvae (minimum of 100) to determine rates of parasitism by B. curculionis in the grazed and ungrazed areas. Larvae were placed in paper bags with fresh alfalfa foliage and transported to the laboratory for rearing. The top half of each bag was removed to allow ventilation and addition of fresh alfalfa. After pupation of host and parasite, the total number of insects was recorded, after which the percentage of each was calculated. The percent parasite cocoons multiplied by weevil larvae/0.09 m<sup>2</sup> gave the rate of parasitism/0.09 m<sup>2</sup> by B. curculionis.

### CHAPTER III

#### RESULTS AND DISCUSSION

Temperatures were much warmer during January and February of 1977 than the same months in 1978. As a result, pupation and adult development proceeded more rapidly during January and February of 1977. By contrast, March 1978 was much warmer than this month during the previous year, and by March 16, rates of pupation and adult emergence were similar for the two years.

Recovery rates in the grazed and ungrazed areas were similar ( $p = 0.05$ ) within each year of the study (Tables II, IV). The trampling of cocoons into the soil by the livestock did not effect recovery.

Total mortality between grazed and ungrazed areas was not significantly different ( $p = 0.05$ ) for 1977 (Table II). However, total mortality was significantly higher ( $p = 0.05$ ) in the grazed vs. ungrazed areas during 1978 (Table IV). Higher levels of mortality due to predators and hyperparasites were found in the grazed areas (Table IV). Dissection of the collected cocoons indicated a larger number of inviable cocoons in these areas. Possibly, cocoon inviability was due to exposure because protective plant cover had been removed by the livestock.

Crushing of cocoons by livestock is a significant mortality factor (Tables II, IV -  $p = 0.05$ ). The number of cocoons crushed varied considerably in the two-year study, both between years and between dates within the given year. Natural parasite populations may not be

as concentrated as they were in this study; thus, the number of cocoons destroyed could be lower than that indicated here. A 72% reduction (with clean grazing) in weevil egg populations (Berberet and Pinkston 1976) appears to outweigh the 3-12% reduction in parasite populations due to crushing. Another factor being researched at the present time which may effect the use of cattle in the alfalfa weevil management program is stand reduction due to increased incidence of diseases induced through the use of grazing.

H. postica larvae were present from early March until mid-May during each year of the study, the peak in 1978 occurring during the first half of April (Figure 1). Coincident with this, over 80% of the parasites had emerged and were available to parasitize host larvae (Table III). While synchronization of host and parasite is evident in both grazed and ungrazed areas of the field, parasitism was not sufficient to contain weevil populations which ranged from 125-150 larvae/0.09 m<sup>2</sup> (Figure 1). Insecticide application markedly decreased both host and parasite populations, after which nondiapausing second generation B. curculionis could effectively handle the remaining weevil larvae (Figure 1). Grazing does not appear to reduce parasitism rates (Figure 1), nor does it appear to limit percent emergence of B. curculionis (Tables I, III).

B. curculionis is becoming a more important component each year of a management program for the alfalfa weevil in Oklahoma (Berberet et al. 1978). Utilizing tolerant alfalfa varieties, winter grazing, and biological control, chemical insecticide usage can be reduced. From the standpoint of parasite survival, integration of winter grazing with biological control for H. postica appears feasible.

TABLE I

DEVELOPMENT OF OVERWINTERING BATHYPLECTES CURCULIONIS  
IN OKLAHOMA, 1977.

Date		Viable Parasites		
		% Larvae	% Pre-P & P	% Emerged
1/8	Grazed	100.0	0.0	----
	Ungrazed	92.3	7.7	----
1/19	G	100.0	0.0	----
	U	100.0	0.0	----
2/4	G	100.0	0.0	----
	U	100.0	0.0	----
2/17	G	93.0	7.0	----
	U	96.8	3.2	----
2/24	G	57.6	39.0	3.4
	U	59.6	40.4	0.0
3/3	G	21.7	69.6	8.7
	U	37.2	60.8	2.0
3/10	G	22.0	70.7	7.3
	U	27.4	70.6	2.0
3/16	G	11.1	77.8	11.1
	U	3.8	92.4	3.8

TABLE II  
MORTALITY OF BATHYPLECTES CURCULIONIS IN GRAZED VS. UNGRAZED  
ALFALFA IN OKLAHOMA, 1977.

Date		# Cocoons	% Predators	% Hyper- parasitized	% Crushed	% Total Mortality*
1/8	Grazed	66	0.0	----	4.5	33.3
	Ungrazed	21	25.0	----	----	38.1
1/19	G	80	5.0	----	5.0	25.3
	U	72	12.9	----	----	43.1
2/4	G	83	8.0	----	8.0	30.1
	U	89	15.4	----	----	28.9
2/17	G	80	8.3	----	12.5	29.6
	U	82	4.5	----	----	25.9
2/24	G	88	0.0	----	14.3	32.2
	U	84	0.0	----	----	38.1
3/3	G	82	0.0	----	16.7	43.9
	U	71	0.0	----	----	28.2
3/10	G	61	0.0	----	19.0	33.9
	U	79	0.0	----	----	36.3
3/16	G	53	0.0	0.0	17.6	32.1
	U	38	0.0	7.7	----	33.3
Means	G	74			12.2**	32.6
	U	67 NS			----	34.0 NS

\*Includes inviable parasites found in cocoons

\*\*Mean significantly different at 0.05 (t-test)



TABLE III

DEVELOPMENT OF OVERWINTERING BATHYPLECTES CURCULIONIS  
IN OKLAHOMA, 1978.

Date		Viable Parasites		
		% Larvae	% Pre-P & P	% Emerged
12/15	Grazed	100.0	0.0	----
	Ungrazed	99.4	0.6	----
1/5	G	98.8	1.2	----
	U	95.2	4.8	----
2/25	G	92.4	7.6	----
	U	83.7	16.3	----
3/4	G	83.2	16.0	0.8
	U	80.9	17.9	1.2
3/9	G	68.8	28.8	2.4
	U	79.4	18.4	2.2
3/17	G	18.4	69.5	12.1
	U	35.7	50.5	13.8
3/25	G	4.4	76.6	19.0
	U	1.4	74.1	24.5
3/31	G	2.0	58.4	39.6
	U	0.7	69.4	29.9
4/8	G	0.0	16.7	83.3
	U	1.0	18.6	80.4

TABLE IV

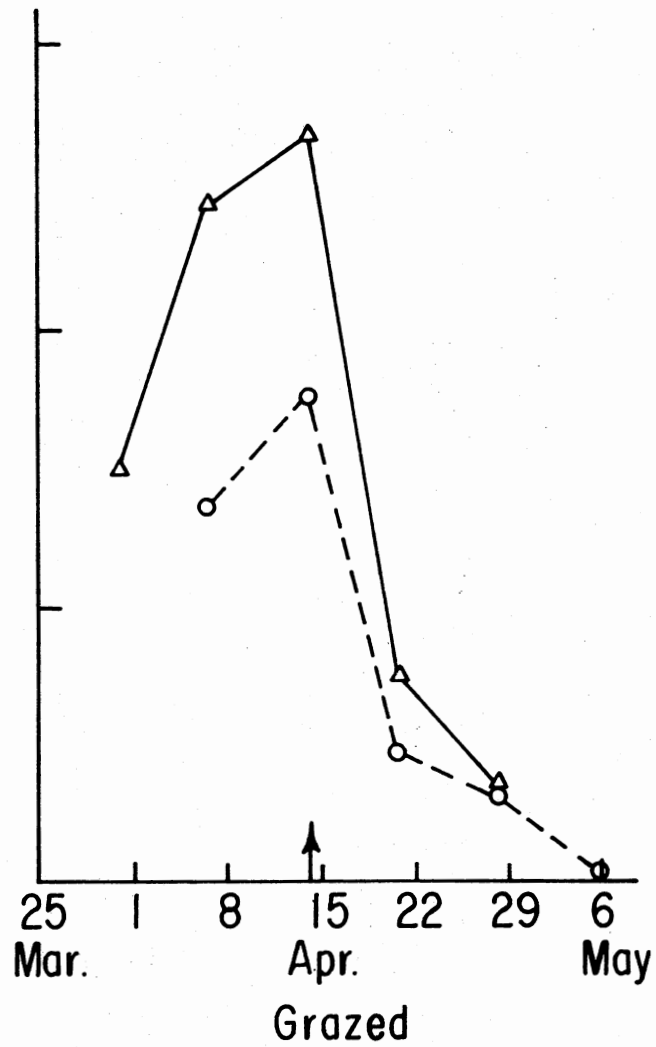
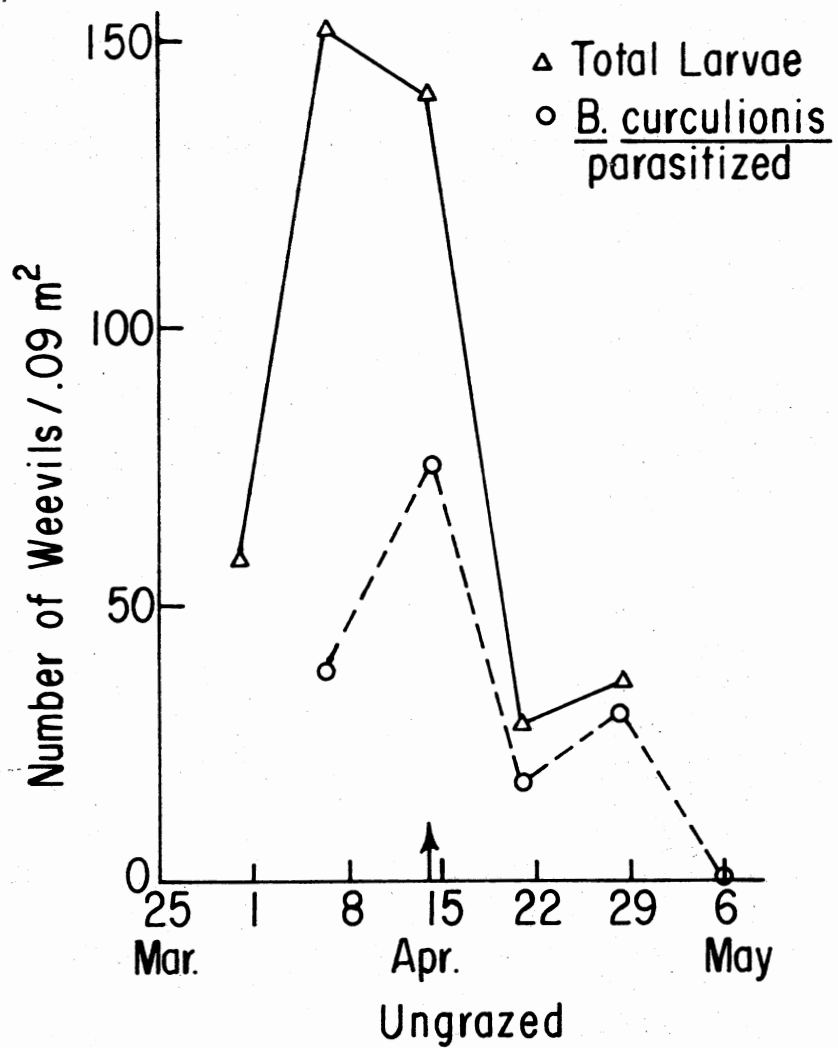
MORTALITY OF BATHYPLECTES CURCULIONIS IN GRAZED VS. UNGRAZED  
ALFALFA IN OKLAHOMA, 1978.

Date		# Cocoons	% Predators	% Hyper- parasitized	% Crushed	% Total Mortality*
12/15	Grazed	150	10.7	0.0	2.7	24.0
	Ungrazed	183	3.3	0.0	---	9.3
1/5	G	209	7.2	1.4	3.3	21.5
	U	198	2.0	0.0	---	6.1
2/25	G	159	10.7	0.0	0.0	25.2
	U	115	8.7	6.1	---	20.0
3/4	G	160	6.3	6.3	1.3	21.9
	U	182	3.3	0.0	---	11.0
3/9	G	168	9.5	3.0	2.4	25.6
	U	212	4.2	0.0	---	12.7
3/17	G	232	1.3	6.9	2.6	25.0
	U	237	2.5	0.4	---	11.4
3/25	G	197	6.6	2.5	3.6	30.5
	U	166	1.8	0.0	---	11.4
3/31	G	203	8.9	0.5	4.4	26.6
	U	166	11.4	0.6	---	17.5
4/8	G	134	7.5	10.4	2.2	41.8
	U	123	3.3	0.0	---	17.1
Means	G	179			2.7**	26.9**
	U	176 NS			---	12.9**

\*Includes inviable parasites found in cocoons

\*\*Mean significantly different at 0.05 (t-test)

Figure 1. Rates of Parasitism by Bathyplectes curculionis in  
Grazed vs. Ungrazed Alfalfa in Oklahoma, 1978.  
(Arrow indicates date of parathion application.)



#### REFERENCES CITED

- Armbrust, E. J., S. J. Roberts, and C. E. White. 1970. Feeding behavior of alfalfa weevil larvae parasitized by B. curculionis. J. Econ. Entomol. 63: 1689-1690.
- Bartell, D. P., J. R. Sanborn, and K. A. Wood. 1976. Insecticide penetration of cocoons containing diapausing and nondiapausing Bathyplectes curculionis, an endoparasite of the alfalfa weevil. Environ. Entomol. 5(4): 659-661.
- Berberet, R. C., and W. P. Gibson. 1976. Bathyplectes curculionis in Oklahoma: distribution and effective parasitism of the alfalfa weevil. Ann. Entomol. Soc. Am. 69: 205-208.
- Berberet, R. C., K. E. Nuss, and W. P. Gibson. 1978. Parasitism of the alfalfa weevil in the Southern Plains by Bathyplectes spp., 1973-78. J. Econ. Entomol. (In press).
- Berberet, R. C., and K. N. Pinkston. 1976. Control of the alfalfa weevil in Oklahoma. OSU Extension Facts. No. 7166. 4 pp.
- Brunson, M. H., and L. W. Coles. 1968. The introduction, release, and recovery of parasites of the alfalfa weevil in the eastern United States. USDA Prod. Res. Rep. 101. 12 pp.
- Chamberlin, T. R. 1924. Introduction of parasites of the alfalfa weevil into the United States. USDA Circ. 301. 9 pp.
- Chamberlin, T. R. 1926. The introduction and establishment of the alfalfa weevil parasite Bathyplectes curculionis (Thomson) in the United States. J. Econ. Entomol. 19(2): 302-310.
- Cherry, R. H., and E. J. Armbrust. 1975. Field survival of diapausing Bathyplectes curculionis, a parasite of alfalfa weevil. Environ. Entomol. 4(6): 931-934.
- Cherry, R. H., and E. J. Armbrust. 1977. Predators of Bathyplectes curculionis (Hymenoptera: Icheumonidae), a parasite of Hypera postica (Coleoptera: Curculionidae). Entomophaga. 22(3): 323-329.
- Davis, D. W. 1970. Insecticidal control of the alfalfa weevil in northern Utah and some resulting effects on the weevil parasite Bathyplectes curculionis. J. Econ. Entomol. 63(1): 119-125.

- Duodu, Y. A., and D. W. Davis. 1974a. A comparison of growth, food consumption, and food utilization between unparasitized alfalfa weevil larvae and those parasitized by Bathyplectes curculionis (Thoms.). *Environ. Entomol.* 705-710.
- Duodu, Y. A., and D. W. Davis. 1974b. Selection of alfalfa weevil larval instars by and mortality due to the parasite Bathyplectes curculionis (Thoms.). *Environ. Entomol.* 3: 549-552.
- Dysart, R. J., and B. Puttler. 1965. The alfalfa weevil parasite Bathyplectes curculionis in Illinois and notes on its dispersal. *J. Econ. Entomol.* 58(6): 1154-1155.
- Dysart, R. J., and W. H. Day. 1976. Release and recovery of introduced parasites of the alfalfa weevil in eastern North America. USDA Prod. Res. Rep. 167 61 pp.
- Economic Insect Survey and Detection, USDA. 1968. (First Report of H. postica in Oklahoma). *Coop. Econ. Ins. Report.* 18(25): 545.
- Gibson, W. P. 1974. Studies on control of the alfalfa weevil, Hypera postica (Gyll.), in Oklahoma with hymenopterous parasitoids. M.S. Thesis. Oklahoma State University, Stillwater, Oklahoma 64 pp.
- Hamlin, J. C., F. V. Lieberman, W. C. McDuffie, R. C. Newton, and L. J. Jones. 1949. Field studies on the alfalfa weevil in its environment. USDA Tech. Bull. 975. 84 pp.
- Miller, M. C., R. White, and J. Ashley. 1973. Effect of granular applications of Thimet® on larvae and parasites of the alfalfa weevil in north Georgia. *J. Georgia Entomol. Soc.* 8(3): 213-216.
- Morrison, W. P., and B. C. Pass. 1974. Food consumption of larvae of the alfalfa weevil parasitized by Bathyplectes anurus. *J. Econ. Entomol.* 67: 141-142.
- Pass, B. C., and C. L. VanMeter. 1966. A method for extracting eggs of the alfalfa weevil from stems of alfalfa. *J. Econ. Entomol.* 59(5): 1294.
- Pike, K. S., and C. C. Burkhardt. 1974. Hyperparasites of Bathyplectes curculionis in Wyoming. *Environ. Entomol.* 3(6): 953-956.
- Puttler, B. 1966. Biological notes on some hyperparasites of Bathyplectes curculionis (Thoms.). *J. Econ. Entomol.* 59:483-484.
- Puttler, B., D. W. Jones, and L. W. Coles. 1961. The introduction, colonization, and establishment of Bathyplectes curculionis, a parasite of the alfalfa weevil, in the eastern United States. *J. Econ. Entomol.* 54: 878-880.
- Surgeoner, G. A., and C. R. Ellis. 1976. Effect of field applications of carbofuran on Hypera postica (Coleoptera: Curculionidae) and its parasitoids. *Can. Entomol.* 180: 649-654.

Wilson, M. C., and E. J. Armbrust. 1970. Approach to integrated control of the alfalfa weevil. *J. Econ. Entomol.* 63(2): 554-557.

Wilson, M. C., and T. R. Hintz. 1971. An integrated approach to alfalfa weevil management. *Proc. 1st Annu. Alfalfa Symp.* pp. 10-21.

VITA - 2

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