INTERACTION OF *BATHYPLECTES ANURUS* (THOMSON) AND *BATHYPLECTES CURCULIONIS* (THOMSON) FOR CONTROL OF THE ALFALFA WEEVIL, *HYPERA POSTICA* (GYLLENHAL), IN OKLAHOMA

By

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PREFACE

This investigation was designed to compare the rate of parasitism by *Bathyplectes anurus* (Thom.) and *Bathyplectes curculionis* (Thom.) in Oklahoma and to determine their effective parasitism of the alfalfa weevil, *Hypera postica* (Gyll.). *B. anurus* was introduced at several locations in Oklahoma to increase the parasite's distribution in the state. Hyperparasites of *B. curculionis* were reared from parasite cocoons and identified. Initial steps were undertaken to identify alfalfa weevil management practices which will encourage parasitism by *B. curculionis* and allow more extensive establishment of *B. anurus* in the state.

I wish to acknowledge and thank Dr. Richard Berberet, my major advisor, for his guidance and supervision during this study and in preparation of this manuscript. Financial support was provided through the Oklahoma Agricultural Experiment Station.

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I am especially grateful to those individuals who have instilled in me an inner confidence, from which I believe my academic success radiates; most notably, to my good friends John Zietlow and Dr. Galen Eiben, and to my parents, who have shared with me their beliefs, convictions and ambitions.

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CHAPTER I

INTRODUCTION

The alfalfa weevil, *Hypera postica* (Gyllenhal) is an introduced pest which causes millions of dollars damage to alfalfa each year in the United States. It was first detected in 1904 near Salt Lake City, Utah (Titus 1909). It has subsequently increased its range to include the western states east to Nebraska, the Dakotas, and Kansas (Hagan and Manglitz 1967). In the eastern states, the weevil was first collected in Maryland during 1951 (Poos and Bissell 1953) and it dispersed into 20 additional states by 1968 (Brunson and Coles 1968). The alfalfa weevil is presently found in the 48 contiguous states and portions of Canada. In many states drastic reductions in alfalfa acreage have taken place due to infestation by the alfalfa weevil (Cothran 1968).

Entry of the alfalfa weevil into Oklahoma was by two distinct strains (Berberet and Gibson 1976). The eastern strain entered the northeastern counties of the state from Arkansas and Missouri and the western strain was collected in the northwest corner of the state in 1969 after it entered from western Kansas and Colorado. The western strain is thought to have maintained a static distribution in the northwest corner of the state while the eastern strain migrated westward (Berberet and Gibson 1976). By 1973 weevils of the eastern strain and eastern-western hybrids primarily existed in Oklahoma because of the cross-mating between eastern and western weevils as the eastern strain moved westward.

The alfalfa weevil is recognized as a serious pest of alfalfa in Oklahoma and represents a serious threat to continued production of alfalfa forage and seed in the state (Berberet and Pinkston 1976). Use of insecticides is the primary means of controlling weevils in Oklahoma today, and at least one treatment prior to the first cutting is essential to prevent losses that exceed the cost of control.

In many areas of the United States the establishment of biological control agents is an important addition to other means of control. The importation from Europe of natural enemies of the alfalfa weevil was first undertaken in 1911 (Chamberlin 1926). One parasite, _Bathyplectes curculionis_ (Thomson), was established in Utah and had spread throughout the state by 1920. After its establishment in Utah, several other states imported this parasite, and through natural dispersal _B. curculionis_ increased its range to include all areas occupied by the western weevil. Chamberlin (1926) states that by 1919-1920 parasitism often exceeded 90% in the western states and in some areas it became difficult to collect alfalfa weevil larvae.

B. curculionis is an internal parasite of alfalfa weevil larvae. The female parasite oviposits primarily in first and second instars. Death of the host occurs after the weevil larva spins its cocoon. The parasite larva, which has fed inside the weevil larva, then spins its cocoon within that of the host (Brunson and Coles 1968).

According to Chamberlin (1924) most of the first generation *B. curculionis* larvae pupate and do not diapause, but give rise to adult parasites which produce a second generation. Second generation parasites and those remaining of the first generation diapause as larvae in cocoons until the following spring, when weevil larvae are available for hosts (Brunson and Coles 1968). Wilson and Armbrust (1970) found that in Illinois and Indiana 39% of the first generation larvae were non-diapausing. They believe that these individuals give rise to adults that produce a second generation of larvae about a month after the initial surge of parasitism in the spring. In Oklahoma, Gibson (1974) found only 5% of the first generation parasite larvae to be non-diapausing.

By 1957 the alfalfa weevil reached damaging populations in the eastern United States (App 1959). *B. curculionis* was introduced into Delaware, New Jersey, and Virginia in 1958 as part of a biological control program for the weevil (Puttler et al. 1961). Through natural dispersal and additional releases the parasite was established in most eastern states by 1968 (Brunson and Coles 1968). Similar programs were initiated to bring *B. curculionis* into the midwest where it now has an important role in management of the alfalfa weevil. Researchers in Illinois and Indiana believe that a reduction in weevil larva numbers from 1967 to 1968 was due largely to increased parasitism by *B. curculionis*. They say that properly timed chemical application for weevil control might be compatible with survival and effectiveness of this parasite (Wilson and Armbrust 1970). In some areas of Illinois and Indiana, mean parasitism exceeded 36% in 1968 with population levels of more than 96 weevil larvae per square foot and 74% parasitism in 1969 with 146 weevil larvae per square foot (Armbrust et al. 1970). The major effect of parasitism by *B. curculionis* may result from reduction in population density of the next weevil generation due to mortality of the weevil at the end of the larval development. *B. curculionis* may also cause an immediate economic gain to the grower by decreasing the total food consumption by parasitized weevils (Armbrust et al. 1970, Duodu and Davis 1974a) and by direct mortality of early weevil instars by parasite oviposition (Duodo and Davis 1974b).

B. curculionis entered Oklahoma through natural dispersal with the eastern and western strains of the alfalfa weevil. In 1972 the parasite was recovered from four counties in the northwestern and panhandle areas of Oklahoma and from three counties in the northeast (Berberet and Gibson 1976). Gibson (1974) monitored the distribution of

B. curculionis during 1972-1974 and collected preliminary data on the parasite's effectiveness as a control agent of the alfalfa weevil in Oklahoma. He found that the parasite rapidly increased its distribution in the state as well as its rate of parasitism.

The effectiveness of *B. curculionis* in controlling the eastern strain of the weevil is reduced by encapsulation of parasite eggs by hemocytes of the weevil larvae (Puttler 1967). The hemocyte capsule apparently interferes with respiration and nutrition of the parasite embryo causing death of fully encapsulated eggs (Van den Bosch 1964). Gibson and Berberet (1974) studied histologically the encapsulation of *B. curculionis* eggs in weevil larvae which were collected in northwestern Oklahoma. They suggest that contact between eastern and western weevil strains may affect parasitism of the weevil by *B. curculionis* in the West, should the ability to encapsulate be transferred through crosses between the two strains. In a later publication they report that the effectiveness of *B. curculionis* is reduced in all regions of Oklahoma due to encapsulation of parasite eggs, indicating that the West is now occupied by eastern weevils and hybrids (Berberet and Gibson 1976). In solitary parasitized weevils up to 50-60% of all *B. curculionis* eggs are destroyed by encapsulation, but an increase in the parasite population in Oklahoma during future years may increase the effectiveness of *B.*

curculionis as a control agent through increased superparasitism (Gibson 1974, Berberet et al. 1976).

In Oklahoma, the larvae of B. curculionis that diapause do so in their cocoons from May or June until March of the following year. Because the cocoons are exposed for this extended period of time they are extremely susceptible to attack by hyperparasites.

Puttler (1966) collected four species of hyperparasites including the pteromalids Catalaccus aeneoviridis (Girault) and Eupteromalis viridescens (Walsh), the chalcid Spilochalcis albifrons (Walsh), and the ichneumonid Gelis sp., that attack B. curculionis in New Jersey and Delaware. These species occur as primary and secondary parasites on many insects throughout the United States (Meusebeck et al. 1951, Peck 1963). Puttler (1966) postulates that the multivoltine species of hyperparasites, which apparently do not diapause, could be especially detrimental to parasite populations but concludes that the low rate of parasitism in the presence of abundant host material in the laboratory leave some doubt as to their potential in reducing the parasite population. In Indiana Gelis sp. is apparently capable of seriously suppressing the impact of B. curculionis on the alfalfa weevil populations (Caldwell and Wilson 1975).

Day (1969) describes the biology of another hyperparasite of B. curculionis, Dibrachys cavus (Walker), which is a pteromalid recorded from about 100 different host species in North America. D. cavus is a multivoltine species, active during the summer and fall when B. curculionis cocoons are available in the field. Both E. viridescens and D. cavus are gregarious ectoparasites of B. curculionis larvae within cocoons. The emergence of a large number of hyperparasites from a single B. curculionis cocoon may ultimately affect the impact of B. curculionis on the alfalfa weevil population.

In Colorado eight species of hyperparasites that commonly attack cocoons of B. curculionis are identified (Cross and Simpson 1972). The pteromalid Sceptrothelys grandiclava (Walker) appears to be the most detrimental hyperparasite of diapausing B. curculionis cocoons. The ichneumonid Mesochorus agilis Cresson is the second most important hyperparasite and the pteromalid Eupteromalis americanis Gahan is also prevalent in their samples.

Seven species of hyperparasites of B. curculionis are reported in Wyoming, four of which are abundant and widely distributed in the state (Pike and Burkhart 1974). These species are extremely prolific and are presently decreasing the efficiency of their host for weevil control in Wyoming.

In 1972, a program was initiated to establish, through a series of releases, additional Hymenopterous parasites and predators to aid in control of the alfalfa weevil in Oklahoma (Gibson 1974). The agents were provided by the Insect Identification and Parasite Introduction Research Branch of the USDA at Moorestown, New Jersey. Gibson (1974) reports the establishment of the parasite Bathyplectes anurus

(Thomson) in Oklahoma at three locations as a result of adult releases and at an additional location using diapausing cocoons collected from primary adult release areas. He records the rate of parasitism by B. anurus at these sites during 1973-4. He proposes that the near synchronization between the peak seasonal population of B. anurus and the yearly peak of the weevil population may improve the parasite's potential as a control agent of the weevil in this state.

B. anurus is a univoltine parasite which oviposits in first and second instar alfalfa weevil larvae. Dysart and Day (1976) report its establishment in 17 eastern states and Ontario since its first introduction in 1960. B. anurus constructs its cocoon inside the cocoon of the weevil larva where it diapauses in the field during the summer. Pupation occurs in the fall and the parasite overwinters as an adult within the cocoon.

The larva of B. anurus is capable of flipping inside its cocoon which causes the cocoon to jump (Brunson and Coles 1968). The jumping behavior of B. anurus may increase survival of larvae in cocoons by enabling many to escape hyperparasites and unfavorable microclimates in alfalfa fields (Day 1970). This is particularly significant because many hyperparasites attacking B. curculionis are also found to attack B. anurus (Day 1969, 1970). Also favorable to alfalfa weevil control, B. anurus eggs are not encapsulated by H. postica larvae as in the case of B. curculionis

(Puttler 1967, Feuster[1]). 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 two species of parasites in Oklahoma. B. anurus has the same effect of reducing the population of the next weevil generation after parasitism as does B. curculionis, but there is not a corresponding significant reduction in weevil feeding (Morrison and Pass 1974).

In laboratory studies of post-diapausing B. curculionis prepupal and pupal stages, Caldwell et al. (1976) found a developmental threshold of 45°F for the parasite. About 312 accumulated heat units were necessary for development from pupation to adult emergence. This information may eventually provide a means of predicting spring parasite emergence if daily heat unit accumulation is recorded while parasite cocoons are overwintering.

Besides B. anurus, the eulophid parasite Tetrastichus incertus (Ratzeburg), the brachonid Microctonus aethiopoides (Nees), and the egg predator Peridesmia discus (Walker) (Pteromalidae) were released in Oklahoma during 1972-1973 (Gibson 1974). None of these biological control agents were recovered.

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[1]Personal Communication. 1976. R. W. Feuster, European Parasite Laboratory, 47, rue des Fontenelles, 92310 Sevres, France.

During 1975-1976, I conducted experiments to compare the rate of parasitism by B. anurus and B. curculionis in Oklahoma and to determine their effective parasitism of the alfalfa weevil. B. anurus was introduced at additional locations in Oklahoma to increase the parasite's distribution in the state. Hyperparasites of the two parasites were identified. Initial steps were undertaken to identify alfalfa weevil management practices which will encourage parasitism by B. curculionis and allow more extensive establishment of B. anurus in the state.

CHAPTER II

INTERACTION OF *B*. *ANURUS* AND *B*. *CURCULIONIS* IN OKLAHOMA

Materials and Methods

Two untreated fields (Duncan-Stephens County and Stillwater-Payne County) in which Gibson (1974) reports establishment of *B*. *anurus* and *B*. *curculionis* were used as primary sampling areas during 1975-1976. Each week, five one-square-foot samples of alfalfa foliage were removed at random from the primary sampling areas and processed in berlese funnels to determine host population density (larvae/square foot). Sweep samples were taken twice weekly to collect weevil larvae (up to 500-1000 when possible) for parasite retrieval. Larvae were reared on fresh alfalfa foliage in short, open-topped paper bags until weevil pupation when the parasite cocoons and weevil pupae were counted. The ratio of *B*. *anurus* to *B*. *curculionis* in parasitized weevils was computed from data collected from rearing.

To calculate total percent parasitism, 100 weevil larvae were collected weekly from the primary sampling areas and refrigerated at 4°C until dissection. Weevil larvae were dissected under water in glass dishes using a stereomicroscope to detect parasite eggs and larvae. The number of encapsulated eggs and larvae vs. those that were healthy was used to calculate actual parasitism (% weevils parasitized), effective parasitism (% weevils containing healthy parasites), and the rate of encapsulation. The number of effectively parasitized weevil larvae per square foot was calculated using host population density and percent effective parasitism. Percent reduction in parasitism due to encapsulation and percent superparasitism was calculated. The percent of non-diapausing cocoons was recorded for each sampling date.

Heat unit accumulation was calculated for locations in close proximity to the release sites from January 1 to May 10 of 1975 and 1976 using climatological data from the United States Department of Commerce, Environmental Data Service. The threshold developmental temperature for *B. curculionis*, 45°F, was used as the base temperature for the calculations. The threshold temperature was subtracted from the daily maximum and minimum temperatures and their differences were averaged to find daily heat unit accumulation. The sum of all daily heat unit accumulations from January first until a given day gave the total heat unit accumulation to that day. An attempt was made to correlate heat unit accumulation with host and parasite activity at the untreated sampling areas during 1975-1976.

Results and Discussion

Intermittent cold weather during February and March is likely to be a major limiting factor on early season parasite populations in Oklahoma. Heat unit accumulation during the alfalfa weevil season in 1975 was far behind that for the same calendar dates in 1976 (Figures 1-4) and the delayed emergence and activity by weevil parasites in 1975 was a result. The intermittent cold and wet weather in Oklahoma probably destroys a portion of early emerging adult parasites whereas weevil eggs and larvae are protected by the alfalfa stems and terminals respectively. When the early spring weather is mild (1976) parasitism by _B. anurus_ and _B. curculionis_ reaches its first peak while the weevil larva population is still increasing (Figures 3, 4). Under these conditions a second peak in parasitism by _B. curculionis_, corresponding to second generation parasite emergence, occurs near the time of peak host populations in the field. The long period of parasite-host interaction and synchrony of parasite attack with host population buildup is encouraging but these mild weather conditions are unfortunately not the rule in Oklahoma and 1975 conditions (Figures 1, 2) more closely approximate average conditions. Parasitism by _B. anurus_ in Oklahoma remains relatively synchronized with peak weevil populations under both mild and harsh spring weather conditions. Percent non-diapausing _B. curculionis_ larvae at the two sites in 1975-1976 (Tables

I-IV) was considerably higher during the first week of parasite retrieval (21-100%) than in the last weeks of retrieval, as would be expected for a second generation parasite emergence. Non-diapausing B. curculionis cocoons in late season indicate that the parasite may produce a partial third generation in Oklahoma if weevils are still available on their emergence.

During the time when B. anurus is parasitizing weevils in Oklahoma, percent multiple parasitism (Table I-IV, shown as superparasitism) is not notably high, except when the weevil population is low (Duncan, 1976), even though the population of B. curculionis may also be high at this time. This indicates that there is little competition for hosts at peak season when the host population is at normal levels. In late season when the weevil population is declining, superparasitism by B. curculionis increases, indicating the inability of the parasite to find unparasitized hosts.

Maximum early season reduction in parasitism due to encapsulation ranged from 50-80% (Table I-IV). Encapsulation of early season parasite eggs prevents the destruction of parasitized hosts and reduces the buildup of the second generation parasite population. Late season reduction in parasitism due to encapsulation was notably lower, ranging from 1-17%. These lower rates probably result from increased superparasitism and the inability of the weevil to encapsulate supernumerary eggs.

TABLE I

PARASITISM BY B. ANURUS AND B. CURCULIONIS
AT THE RELEASE FIELD IN PAYNE COUNTY,
OKLAHOMA, 1975

	H. POSTICA	B. ANURUS		B. CURCULIONIS						
				Actual		Effective				
Date	Larvae/ ft^2	%	ft^2	%	ft^2	%	ft^2	% Reduction	% Non-diapause	% Super-parasitism
4/12	500	3.2	16.0	0.8	4.0	0.8	4.0	0	100	0
4/19	447	1.0	4.5	2.0	8.9	1.0	4.5	50	25	0
4/24	269	1.0	2.7	0.0	0.0	0.0	0.0	0	0	0
5/1	209	0.3	0.6	1.7	3.6	0.7	1.5	59	14	0
5/8	50	0.8	0.4	30.0	15.0	25.0	12.5	17	0	19
5/15	10	0.0	0.0	48.0	4.8	40.0	4.0	17	0	33

TABLE II

PARASITISM BY B. ANURUS AND B. CURCULIONIS AT THE RELEASE FIELD IN STEPHENS COUNTY, OKLAHOMA, 1975

	H. POSTICA	B. ANURUS		B. CURCULIONIS						
				Actual		Effective				
Date	Larvae/ ft^2	%	ft^2	%	ft^2	%	ft^2	% Reduction	% Non-diapause	% Super-parasitism
4/14	105	0.0	0.0	2.0	2.1	1.0	1.1	50	0.0	50
4/21	85	0.7	0.6	4.3	3.7	3.3	2.8	23	26.3	0
4/28	55	0.0	0.0	10.0	5.5	8.0	4.4	20	10.7	0
5/6	10	0.0	0.0	45.0	4.5	40.0	4.0	11	3.8	31
5/12	2	0.0	0.0	89.0	1.8	84.0	1.7	6	4.3	47

TABLE III

PARASITISM BY B. ANURUS AND B. CURCULIONIS
AT THE RELEASE FIELD IN PAYNE COUNTY,
OKLAHOMA, 1976

	H. postica	*B. anurus*		*B. curculionis*						
				Actual		Effective				
Date	Larvae/ft^2	%	ft^2	%	ft^2	%	ft^2	% Reduction	% Non-diapause	% Super-parasitism
3/9	99.7	0.0	0.0	1.0	1.0	1.0	1.0	0	0	0.0
3/15	128.4	0.0	0.0	3.0	3.9	2.0	2.6	33	11	0.0
3/22	111.1	1.1	1.2	5.9	6.6	1.9	2.1	68	75	0.0
3/28	113.0	1.9	2.1	6.1	6.9	1.1	1.2	82	22	25.0
4/5	147.4	5.9	8.7	4.1	6.0	3.1	4.6	14	17	0.0
4/15	45.0	1.0	0.5	6.0	2.7	5.0	2.3	17	0	14.3
4/19	9.8	2.2	0.2	14.8	1.5	13.8	1.4	7	0	5.9
4/29	2.0	1.1	0.1	43.9	0.9	39.9	0.8	9	3	13.3
5/3	1.0	0.0	0.0	49.0	0.5	41.0	0.4	16	0	16.3
5/6	0.5	0.0	0.0	93.0	0.5	92.0	0.5	1	0	34.4

TABLE IV

PARASITISM BY *B. ANURUS* AND *B. CURCULIONIS*
AT THE RELEASE FIELD IN STEPHENS COUNTY,
OKLAHOMA, 1976

	H. POSTICA	*B. ANURUS*		*B. CURCULIONIS*						
				Actual		Effective				
Date	Larvae/ ft^2	%	ft^2	%	ft^2	%	ft^2	% Reduction	% Non-diapause	% Super-parasitism
3/10	28.8	0.0	0.0	39.0	11.2	25.3	7.3	35	0	12.1
3/16	30.8	1.5	0.5	45.2	13.9	22.3	6.9	51	0	34.5
3/23	62.7	8.0	5.0	48.0	30.1	40.0	25.1	17	22	28.6
3/30	97.7	1.4	1.4	8.4	8.2	6.4	6.3	24	14	0.0
4/6	102.9	1.8	1.9	24.2	24.9	19.2	19.8	21	34	3.8
4/14	52.2	0.3	0.2	24.7	12.9	22.7	11.8	8	4	8.0
4/21	13.0	0.0	0.0	31.4	4.1	21.6	2.8	31	2	9.4
4/27	6.0	0.0	0.0	35.0	2.1	33.0	2.0	6	8	8.6
5/7	1.0	0.0	0.0	69.0	0.7	65.0	0.7	6	3	16.9

Figure 1. Rate of Parasitism by *B. anurus* and *B. curculionis*, and Host Population Level of *H. postica* in Payne County Release Field, 1975

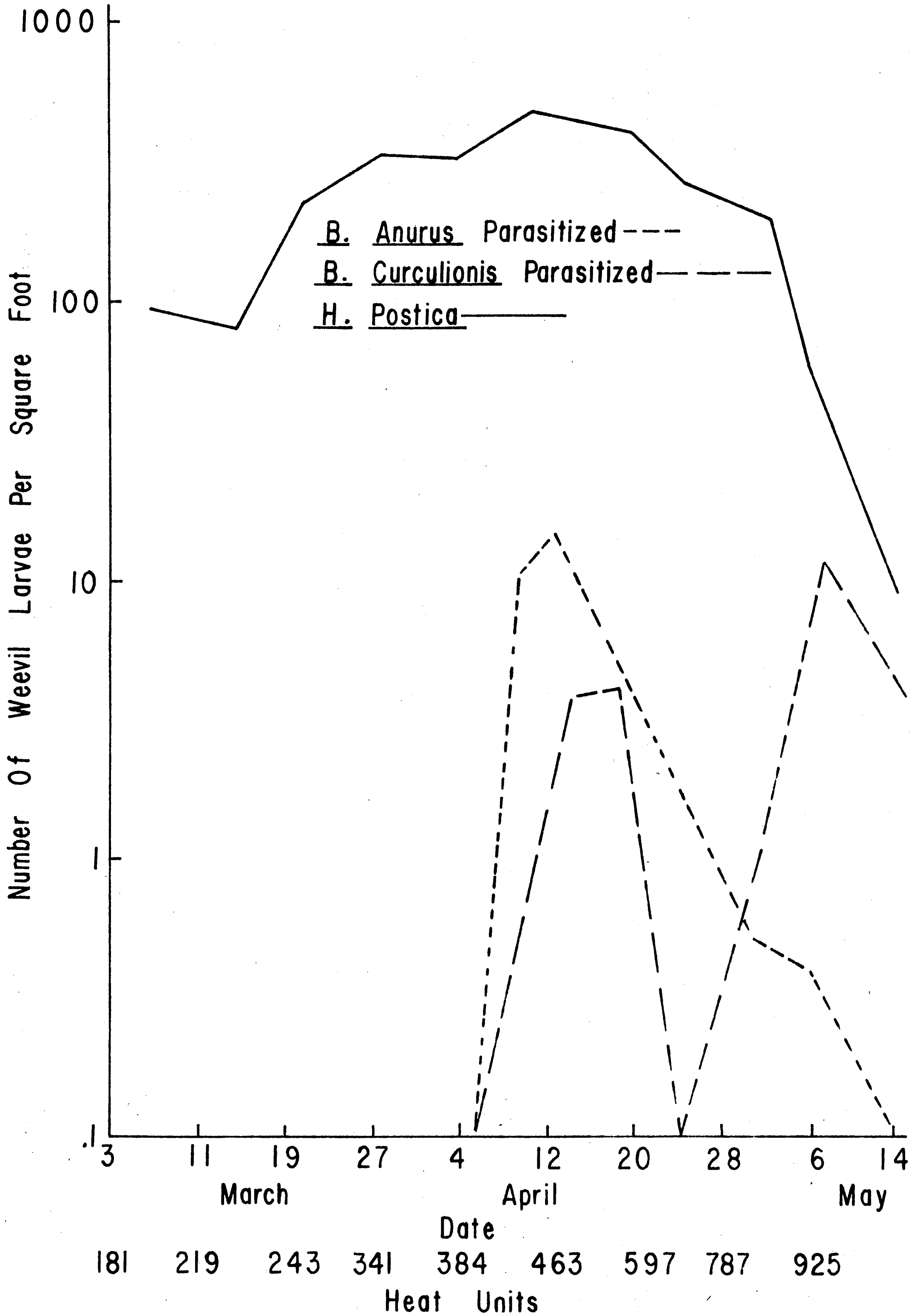
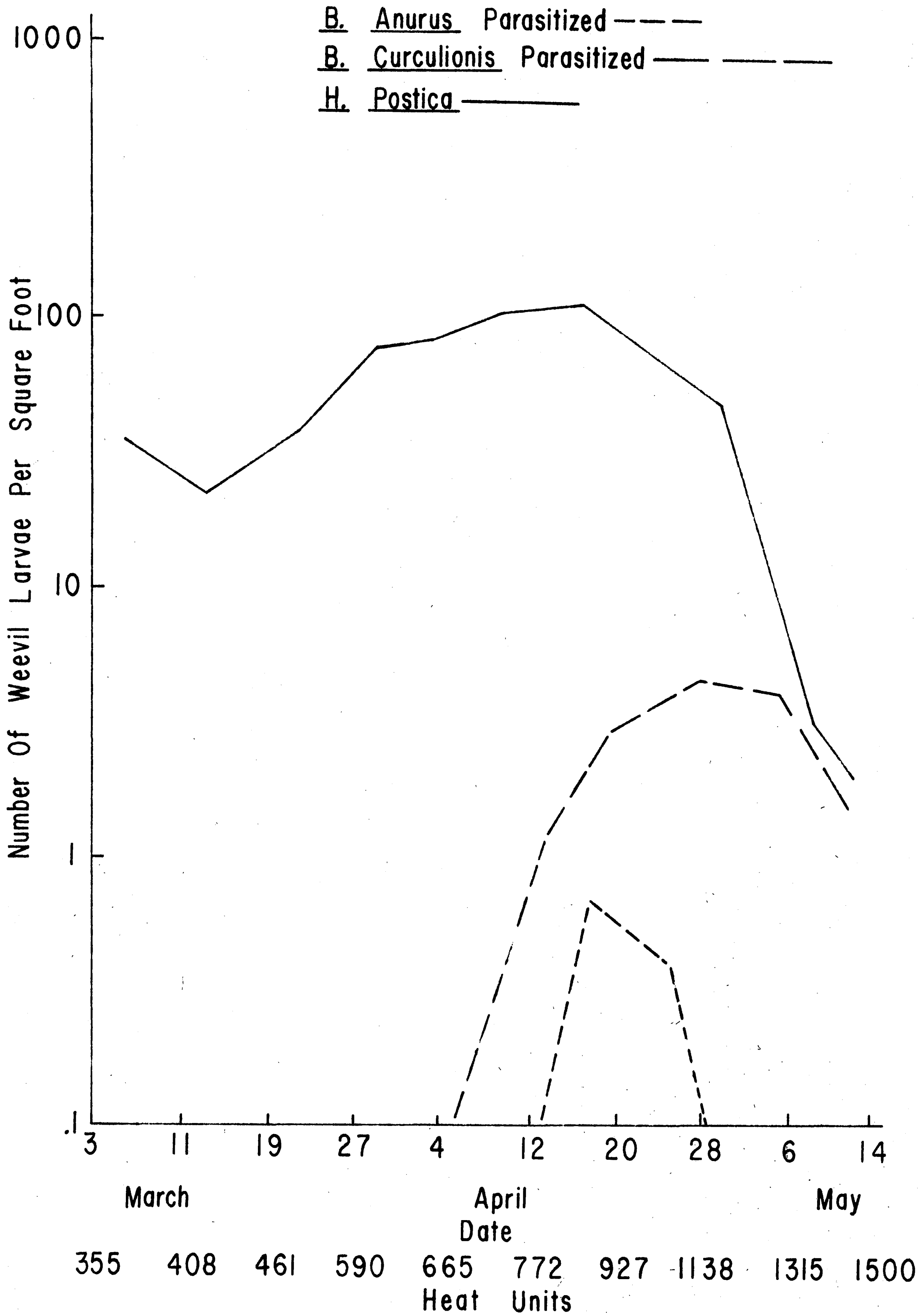
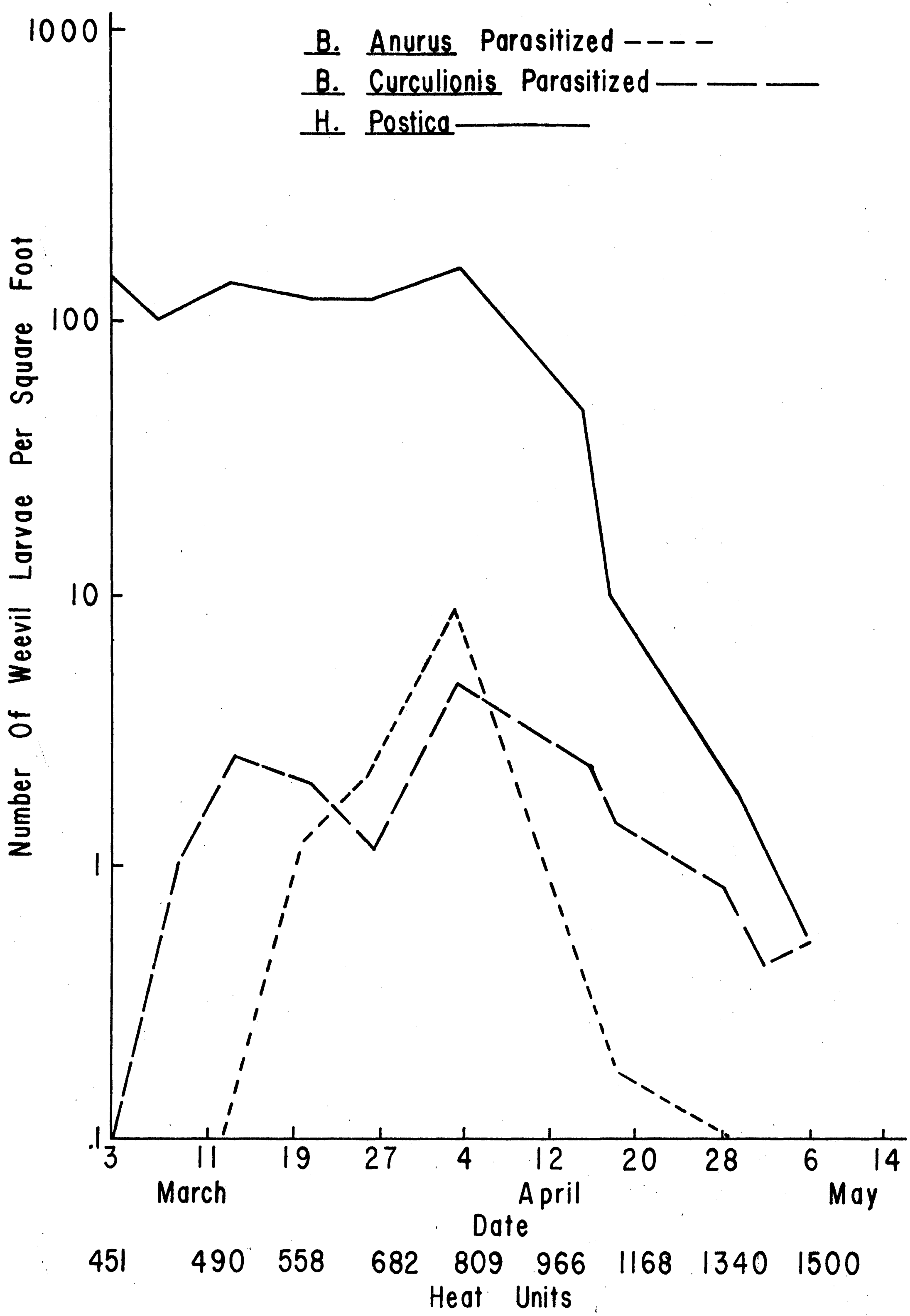

1000
100
10
1
.1
Number Of Weevil Larvae Per Square Foot
B. Anurus Parasitized
B. Curculionis Parasitized
H. Postica
3
11
19
27
4
12
20
28
6
14
March
April
May
Date
181
219
243
341
384
463
597
787
925
Heat Units

Figure 2. Rate of Parasitism by *B. anurus* and *B. curculionis*, and Host Population Level of *H. postica* in Stephens County Release Field, 1975



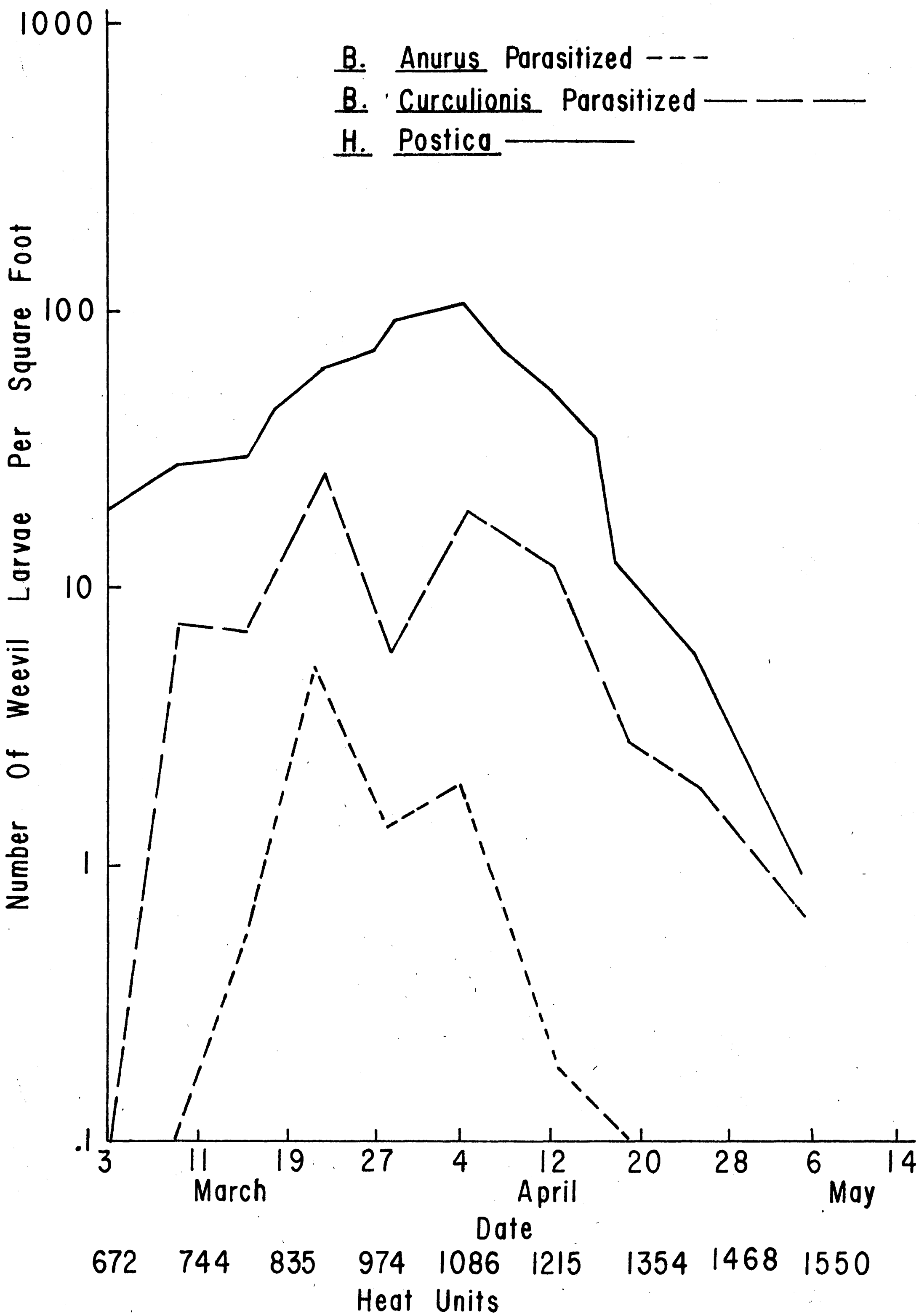
B. Anurus Parasitized
B. Curculionis Parasitized
H. Postica
Number Of Weevil Larvae Per Square Foot
1000
100
10
1
.1
3
11
19
27
4
12
20
28
6
14
March
April
May
Date
355
408
461
590
665
772
927
1138
1315
1500
Heat Units

Figure 3. Rate of Parasitism by *B. anurus* and *B. curculionis*, and Host Population Level of *H. postica* in Payne County Release Field, 1976



B. Anurus Parasitized
B. Curculionis Parasitized
H. Postica
Number Of Weevil Larvae Per Square Foot
1000
100
10
1
.1
3
11
19
27
4
12
20
28
6
14
March
April
May
Date
451
490
558
682
809
966
1168
1340
1500
Heat Units

Figure 4. Rate of Parasitism by *B. anurus* and *B. curculionis*, and Host Population Level of *H. postica* in Stephens County Release Field, 1976


B. Anurus Parasitized
B. Curculionis Parasitized
H. Postica
Number Of Weevil Larvae Per Square Foot
1000
100
10
1
.1
3
11
19
27
4
12
20
28
6
14
March
April
May
Date
672
744
835
974
1086
1215
1354
1468
1550
Heat Units

CHAPTER III

ESTABLISHMENT OF *B. ANURUS* AT ADDITIONAL SITES IN OKLAHOMA

Materials and Methods

During 1974 and 1975 additional releases of *B. anurus* were made at several locations in western Oklahoma. Two hundred forty-three diapausing *B. anurus* cocoons, obtained by rearing parasitized weevils collected from primary parasite release areas in Oklahoma in the spring of 1974, were placed in an untreated alfalfa field (designated Grady County subrelease area) near Chickasha, Oklahoma on September 20, 1974. The cocoons were carefully placed on the soil surface in alfalfa crowns and allowed to overwinter.

Adult parasites for release in Oklahoma were provided by the Insect Identification and Parasite Introduction Research Branch, ARS, USDA at Moorestown, New Jersey. A release of 458 *B. anurus* adults was made on May 4, 1974 near Guymon, Oklahoma (Texas County). At Cordell (Washita County) 173 parasites were released on April 18, 1975. Near Chickasha (Grady County) 352 adults were released on April 19 and near Hobart (Kiowa County) 195 adults were released on April 24, 1975.

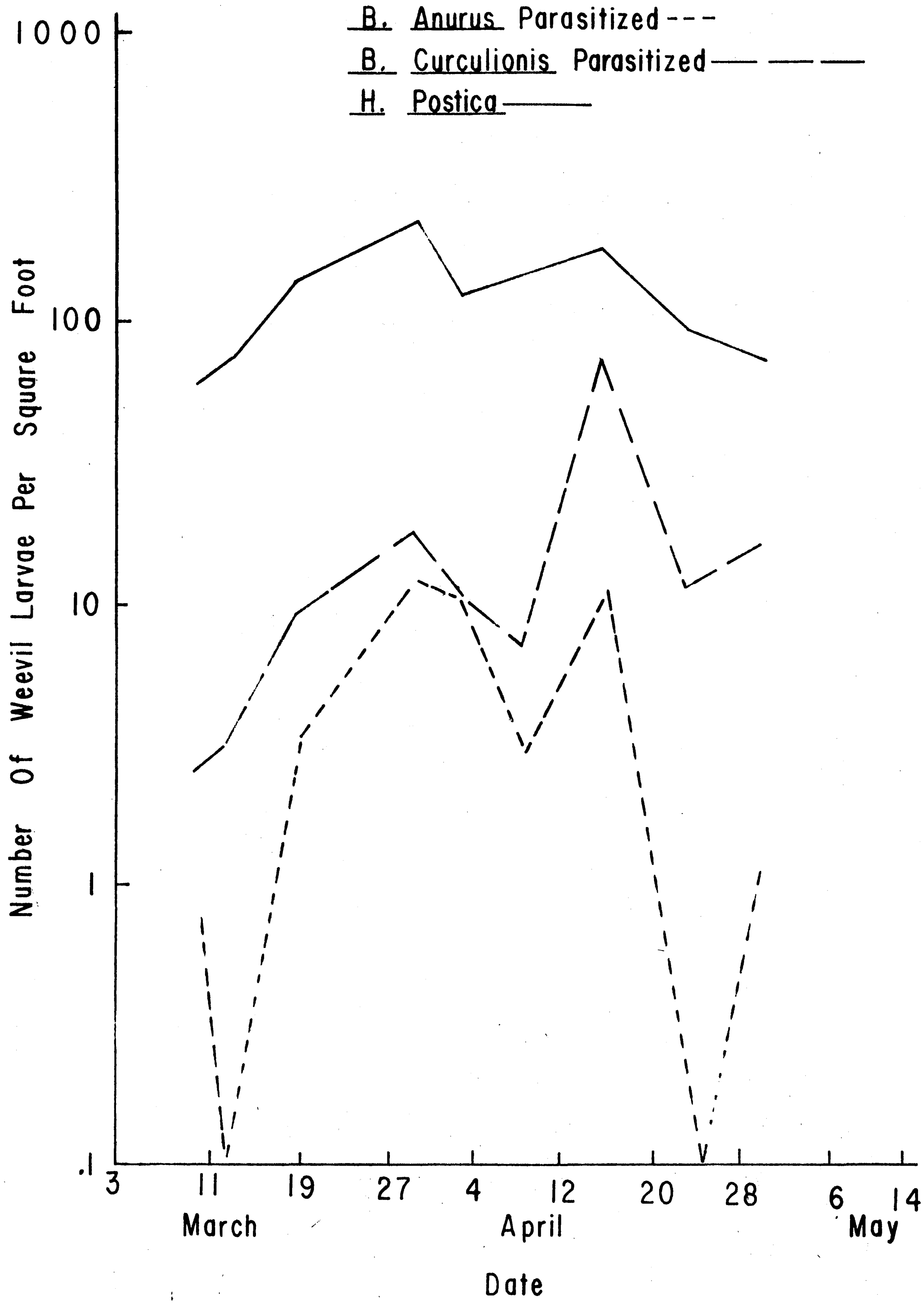
To confirm establishment of *B. anurus* in each of these release areas, a substantial number of weevil larvae (500-1000 if possible) was collected at approximately two-week intervals during March and April the year following release. The weevils were reared on alfalfa foliage until parasite emergence or weevil pupation. Establishment was confirmed if parasite cocoons were recovered the year following release at each location.

Results and Discussion

At the Chickasha subrelease area a total of six parasites were reared from 1785 weevil larvae collected during 1975. In 1976, 330 *B. anurus* were reared from 9618 weevil larvae at the Chickasha subrelease area. Levels of parasitism by both species at the Chickasha subrelease area (Figure 5) are very encouraging for biological control of the weevil. It is apparent that establishment of *B. anurus* in other areas could be accomplished using diapausing cocoons provided that the use of insecticides is restricted.

As a result of adult parasite releases near Chickasha and Cordell, establishment of *B. anurus* was confirmed in two additional locations in Oklahoma during 1976. No *B. anurus* were recovered from either the Guymon or the Hobart release areas.

Figure 5. Rate of Parasitism by *B. anurus* and *B. curculionis*, and Host Population Level of *H. postica* in Grady County Subrelease Field, 1976


B. Anurus Parasitized
B. Curculionis Parasitized
H. Postica
1000
100
10
1
.1
Number Of Weevil Larvae Per Square Foot
3
11
19
27
4
12
20
28
6
14
March
April
May
Date

CHAPTER IV

RECOVERY OF HYPERPARASITES FROM ALFALFA WEEVIL PARASITES IN OKLAHOMA

Materials and Methods

To investigate the impact of hyperparasitism on the population of diapausing parasite larvae, cocoons of *B. anurus* and *B. curculionis* were collected from alfalfa fields in 1975 and 1976 and dissected or held for hyperparasite emergence. A special effort was made to collect a large number of parasite cocoons from the panhandle region of Oklahoma where *B. curculionis* has interacted with the western strain of the weevil as well as the more recently established eastern strain.

Wire screen mounted on a wooden frame was used to separate cocoons from litter in alfalfa fields of Beaver, Payne, and Texas Counties during the summer of 1975 to retrieve parasite cocoons. The cocoons were held in groups of 20 in one-ounce, plastic cups for hyperparasite emergence in a chamber regulated to 65% relative humidity and 23°C. After about five months, one-half of the diapausing parasite cocoons were dissected and the remainder were put into cold storage for three months to break diapause. Then cocoons were returned to the rearing chamber until emergence of either the parasite or hyperparasites.

Due to the difficulty experienced in field collecting large numbers of parasite cocoons, the technique for detecting hyperparasites was modified in 1976. *B. curculionis* cocoons were accumulated by rearing large numbers of parasitized weevil larvae early in the year. Three release fields were chosen, one each in Stephens, Payne, and Texas Counties. Cocoons were placed in alfalfa crowns in groups of 20, 50, or 100. Each group was marked with a tin plate secured by a wire stake. Markers were distributed in the fields on linear transects and separated by 30 feet to insure easy relocation of the cocoons. After two to six weeks, cocoons were recovered with an aspirator and placed in a rearing chamber of hyperparasite emergence.

Results and Discussion

On July 7, 1975, a total of 163 diapausing *B. curculionis* cocoons were collected from the Beaver County alfalfa field. No hyperparasites emerged in the rearing chamber but when a portion of the cocoons were dissected on January 1, 1976, one cocoon contained four small dead larvae which presumably were hyperparasites of *B. curculionis*. No other hyperparasites emerged after cold storage.

At the Texas County sampling area on July 14, 1975, 30 *B. curculionis* cocoons were collected. No hyperparasites emerged nor were any dissected from the parasite cocoons.

A total of 20 *B. anurus* and nine *B. curculionis* cocoons were collected on July 23, 1975, at the Stillwater primary sampling area (Payne County). No evidence of hyperparasitism was found.

Of 300 *B. curculionis* cocoons placed in the Texas County field on April 23, 1976, 80 were recovered on May 24. Eleven hyperparasites emerged from four of these cocoons. The hyperparasites were sent to the United States National Museum for identification. Gordon Gordh identified 10 of the parasites as the pteromalid *Eupteromalus tachinae* (Gahan) and reported its recent collected from Illinois where it attacks *B. curculionis*. *E. tachinae* has been collected from other hosts in Tennessee and Louisiana including the armyworm, *Psuedoletia unipuncta* (Haw.). One encyrtid wasp (Encyrtinae) also emerged from the *B. curculionis* cocoons but was not identified to species.

An additional 1500 *B. curculionis* cocoons placed in the same field in Texas County on June 14 and retrieved on June 27 did not yield hyperparasites. Two thousand cocoons placed in a Stephens County field and 1000 cocoons placed in a Payne County field during June and July also failed to yield hyperparasites. It may be that cocoons placed in the fields earlier in the season at the Payne and Stephens County sites would have yielded hyperparasites, as was the case in Texas County. The relatively short time that *B. curculionis* has been present in Payne and Stephens Counties may also account for the lack of hyperparasitism.

CHAPTER V

MAXIMIZING PARASITE POPULATIONS IN OKLAHOMA

In order to achieve the greatest benefit from parasitic species in Oklahoma, alfalfa weevil management practices must be identified which will encourage parasitism by _B. curculionis_ and allow more extensive establishment of _B. anurus_. Prudent chemical insecticide usage would be a major concern of such a management system, but additional methods should be utilized.

Research to isolate varieties of alfalfa resistant to the alfalfa weevil has been underway since the early 1930's (Barnes et al. 1973). Several varieties including 'Team' and 'Arc' have been released and have proven thus far to be effective in reducing losses due to weevil feeding (Gallaway 1973); however, weevil populations in Oklahoma since 1971 have caused damage exceeding the ability of these tolerant varieties to prevent economic loss (Berberet and Pinkston 1976).

Winter grazing of alfalfa by livestock has been utilized in Oklahoma to reduce the number of overwintering weevil eggs in the field. Berberet and Pinkston (1976) report a 72% reduction in egg numbers and a reduction in larval populations before chemical application in the spring due to grazing; however, the impact of grazing on overwintering B. anurus and B. curculionis cocoons has not been evaluated.

Probably the most discouraging factor influencing parasitism by B. anurus is the inability of the parasite to disperse from release areas. Parasite retrieval data from Oklahoma release sites indicate that B. anurus will scarcely disperse one-fourth mile across a field in four years and only infrequently has the parasite been collected in fields adjoining the release fields.

The potential of B. anurus for any given year is a factor of the success of adults emerging during a few weeks at peak weevil larval populations. Host finding will present no problems to B. anurus, but intermittent cold or rainy weather is likely at the time of adult emergence and parasitism is reduced by these factors. Because peak weevil season coincides with adult parasite emergence, chemical application also reduces the effectiveness of this parasite in Oklahoma. Experience with B. anurus to this point leaves little hope that this parasite will soon become a significant part of an alfalfa weevil management program in Oklahoma.

The role of B. curculionis for alfalfa weevil control in Oklahoma has a practical value to alfalfa growers in this state now and perhaps to a greater extent in the future. Under favorable spring weather conditions parasitism starts early allowing second generation parasitism to reach its peak at the time of peak weevil season. With each larva effectively parasitized by *B. curculionis*, the number of adult weevils entering diapause is decreased. Benefit to the grower comes with every weevil larva parasitized due to the reduction in weevil feeding. Chemical application is often made in early season without preventing late season buildup of the parasite population. In Oklahoma, the extremely high levels of parasitism found in the relatively low host population densities in late weevil season have dual benefit, reducing the need for a chemical application before or after first cutting and building the diapausing parasite population to a level which may contribute to early season parasitism the following year.

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Thesis: INTERACTION OF BATHYPLECTES ANURUS (THOMSON) AND BATHYPLECTES CURCULIONIS (THOMSON) FOR CONTROL OF THE ALFALFA WEEVIL, HYPERA POSTICA (GYLLENHAL), IN OKLAHOMA

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