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N. C. Elliott  
*Michigan State University*

G. A. Simmons  
*Michigan State University*

C. Chilcote  
*Michigan State University*

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**PARASITISM OF EARLY INSTAR JACK PINE BUDWORM  
(LEPIDOPTERA: TORTRICIDAE) BY APANTELES SPP.  
(HYMENOPTERA: BRACONIDAE) AND GLYPTA FUMIFERANAE  
(HYMENOPTERA: ICHNEUMONIDAE)<sup>1</sup>**

N. C. Elliott<sup>2,3</sup>, G. A. Simmons<sup>2</sup>, and C. Chilcote<sup>2</sup>

ABSTRACT

*Glypta fumiferanae* and two species of *Apanteles* parasitized 1st-4th instar jack pine budworm (*Choristoneura pinus*). Apparent parasitism of budworm in four Michigan populations ranged from 10.6 to 30.9% for *A. fumiferanae*, 4.3–16.4% for *A. morrisoni*, and 2.1–9.1% for *G. fumiferanae*. *A. morrisoni* probably parasitized 3rd-4th instar jack pine budworm. Based on the results obtained, it is suggested that sampling overwintering budworm larvae is appropriate for estimating apparent parasitism by *A. fumiferanae* and *G. fumiferanae*. Sampling budworm larvae at ca. 500 degree-days (base 8.9°C) is appropriate for estimating apparent parasitism by *A. morrisoni*.

Studies have been done to determine the factors responsible for fluctuations of populations of the jack pine budworm, *Choristoneura pinus* Freeman, (JPB) (Foltz et al. 1972, Batzer and Jennings 1980). However, none of the factors investigated were consistently associated with observed fluctuations in JPB populations. Predators and parasites were thought to be important at low JPB population densities and in populations declining following an outbreak. However, natural enemies were thought to be of limited importance in damping the release of populations to outbreak.

In studies of epidemic JPB populations, apparent parasitism rates of early instars (1st-4th instar) were high (Kulman and Hodson 1961, Allen et al. 1969, Batzer and Jennings 1980). *Apanteles fumiferanae* Viereck and *Glypta fumiferanae* (Viereck) accounted for a large proportion of the observed parasitism. Other species of *Apanteles* were present in the collections, but their contribution to total parasitism was not distinguished from that due to *A. fumiferanae*.

*A. fumiferanae* and *G. fumiferanae* are univoltine, monophagous, and well adapted to their host (Brown 1946a, 1946b). Both species emerge from 4th to 6th instar JPB in June and July and pupate on jack pine foliage for about 10 days. Adults emerge and parasitize 1st and 2nd instar JPB in July and August soon after JPB egg eclosion. Eggs of both parasite species overwinter in 2nd instar JPB and eclose in the spring, after 2nd instar JPB emerge from hibernaculæ and commence feeding (Brown 1946a, 1946b). The life histories of other species of *Apanteles* that parasitize JPB and also the spruce budworm (*C. fumiferana* Clemens) are not well known, but most are believed to have alternate or alternative hosts (Mason 1974).

Because the role of parasites and predators in the life system of JPB has not been satisfactorily elucidated, further studies of natural enemies of JPB are warranted. In this

<sup>1</sup>Michigan Agricultural Experiment Station Journal, Article No. 11626.

<sup>2</sup>Department of Entomology, Michigan State University, East Lansing, MI. 48824

<sup>3</sup>Present address: USDA, ARS, Northern Grain Insects Research Laboratory, Rural Route #3, Brookings, SD 57006.

study, we determined the species of *Apanteles* that parasitized early instar (1st-4th) JPB in several populations in Michigan and apparent parasitism of early instar JPB by *Apanteles* spp. and *G. fumiferanae*. Aspects of the life history of *A. morrиси* (Mason) were also elucidated. Based on the information obtained, we suggest appropriate times for sampling JPB to obtain estimates of apparent parasitism by these species.

#### MATERIALS AND METHODS

JPB collections were made at four locations [Grand Traverse Co. (GR), Wexford Co. (WE), Crawford Co. (CR), and Oscoda Co. (OS)] in Michigan's Lower Peninsula during the summers of 1983 and 1984. During the years this study was done, JPB populations at the locations were in the latter stages of an outbreak which began in 1979 (Battenfield 1982, 1983). Study plots were constructed in the following manner. At each location a random point was selected along a 0.5-km stretch of road passing through a mature jack pine (*Pinus banksiana* Lamb.) stand. From the selected point an azimuth was followed a random distance (between 60 and 160 m). The point reached by this method was established as the plot center and a plot of ca. 25-m radius was established around the center point. Samples were obtained by examining the terminal 46 cm of a single branch taken from the lower crown and mid-crown of each of 15 dominant or codominant jack pine trees selected randomly from within each plot. All larvae on each branch were removed and placed in plastic cottage-cheese containers (10–15 larvae per container) with 0.5-cm holes cut in the top. The holes were covered with fine cloth which permitted enough air flow to prevent excessive moisture from building-up within the containers. Freshly cut foliage was placed in each container daily. Parasites that had emerged from hosts and pupated were removed, placed in 1-dram glass vials, and reared for emergence of adults.

In 1983, two host collections were made at the GR site; one when JPB were primarily 2nd-3rd instars (4 June 1983) and later when primarily 4th-5th instars were present (23 June 1983). A single host collection was made at the WE site when 4th-5th instars were predominant in the population (22 June 1983).

In 1984, JPB were collected when 4th-5th instars predominated at the CR site (12 June 1984), and when 5th-6th instar JPB predominated at the OS site (20 June 1984).

Degree-day accumulations (DD) (Baskerville and Emin 1969), base 8.9°C, beginning 1 April of each year were obtained from records maintained by the Cooperative Crop Monitoring System (CCMS) from the nearest weather station to each of the sites.

The seasonal activity patterns of adult parasites were studied during 1983 using Malaise traps (Nyrop 1982) to measure the relative densities of adults of each species over time. A single trap was positioned against the bole in the upper half of the crown of each of 25 randomly selected dominant or codominant jack pine trees in the GR site. The traps were checked at 0800 h each day from 13 June through 20 August.

#### RESULTS AND DISCUSSION

*A. morrиси* was not reared from the sample of JPB collected at 194 DD (4 June) at the GR site (Table 1). At this time JPB were in the flower-mining stage and 3rd instars predominated. However, the species was reared from a sample taken at 475 DD (23 June) from the same site. Assuming that parasitism by *A. morrиси* followed a binomial distribution, the probability of obtaining no parasitized JPB in the early sample could be calculated (Hogg and Craig 1978). If the true proportion of JPB parasitized by *A. morrиси* was 0.061 (Table 1), the probability of obtaining no parasitized JPB in the early sample would be approximately 0.00002. In this simple calculation, we have used the estimated proportion in place of the parameter's actual value, but the low probability obtained indicates that it is unlikely that *A. morrиси* had parasitized a significant number of hosts before 194 DD. The two periods of seasonal activity of *A. morrиси* (at ca. 375 DD and later

Table 1. Parasitism of *C. pinus* larvae in samples from four collection sites.

	Collection site				
	GR	GR	WE	CR	OS
Degree days	194	475	455	525	659
No. hosts	176	244	141	110	55
Percent parasitism ( $\pm$ se)					
<i>A. fumiferanae</i>	20.5 $\pm$ 3.0	13.9 $\pm$ 2.2	10.6 $\pm$ 2.6	19.1 $\pm$ 3.7	30.9 $\pm$ 6.2
<i>A. morrisoni</i>	0	6.1 $\pm$ 1.5	4.3 $\pm$ 1.7	16.4 $\pm$ 3.5	14.5 $\pm$ 4.7
<i>G. fumiferanae</i>	2.8 $\pm$ 1.2	3.3 $\pm$ 1.1	2.1 $\pm$ 1.2	5.5 $\pm$ 2.2	9.1 $\pm$ 3.1

at ca. 800 DD) (Fig. 1) provided further evidence that *A. morrisoni* parasitized JPB in the spring (after ca. 200 DD), after JPB had emerged from overwintering hibernaculae and commenced feeding. The second activity period corresponded with the emergence of adults of the generation that parasitized JPB. The catch of females of all three parasite species increased as accumulated degree-days increased beyond 700 DD (Fig. 1). Peak emergence of adult *A. morrisoni* precedes emergence of *A. fumiferanae* which, in turn, precedes that of *G. fumiferanae* (Elliott 1985). Female *A. morrisoni* were caught in traps at the earliest date, followed by female *A. fumiferanae* and then female *G. fumiferanae*. The catch of *A. fumiferanae* and *G. fumiferanae* continued to increase to reach maxima between 1100 and 1200 DD (Fig. 1). Maximum catch per trap of *A. morrisoni* in the second period of activity was about 10% that obtained for *A. fumiferanae* or *G. fumiferanae* in spite of the fact that the parasitism rate and hence density of *A. morrisoni* adults was of the same order of magnitude as that of the other species. No *A. morrisoni* were caught after ca. 860 DD. The discrepancy in the numbers caught and temporal pattern of catch of *A. morrisoni* may have occurred because the species did not search jack pine for hosts after emerging from JPB, or at least did not search in the same microhabitats on jack pine as the other species. The first peak in activity of *A. morrisoni* was also low but a proportion of the total activity may have occurred before trapping began at ca. 325 DD.

Estimates of apparent parasitism ranged from 10.6 to 30.9, 4.3–16.4, and 2.1–9.1% for *A. fumiferanae*, *A. morrisoni*, and *G. fumiferanae*, respectively. No Microgasterinae other than *A. morrisoni* and *A. fumiferanae* were reared from early instar JPB.

Based on the observed bimodal seasonal pattern of adult female *A. morrisoni* activity it is likely that oviposition was complete by 450–500 DD. At the GR site in 1983, the JPB population was near peak 4th instar at 450–500 DD. If *A. morrisoni* parasitizes 3rd-4th instar JPB and there is no differential mortality among parasitized larvae and those not parasitized from the time parasitization takes place and host collections are made, 500 DD would be an appropriate time to sample to estimate apparent parasitism by *A. morrisoni*. If sampling is done earlier, some parasites would still be ovipositing, and if sampling is done later, some parasites would have emerged from hosts.

Lewis (1960) found that spruce budworm larvae parasitized by *A. fumiferanae* and *G. fumiferanae* suffered proportionally fewer dispersal losses than unparasitized larvae. However, McLeod (1977) observed no differential losses among parasitized and unparasitized larvae. Pupation of *A. fumiferanae* and *G. fumiferanae* does not occur until after 550 DD (Elliott 1985); hence, sampling JPB larvae to determine parasitism rates by the two species may be done at any point up to 550 DD. Until more is known regarding the existence of differential mortality of unparasitized and parasitized larvae, the dissection of overwintering larvae as described by Kemp and Simmons (1976) would be the most reliable method for estimating apparent parasitism by *A. fumiferanae* and *G. fumiferanae*.

Life table studies (Foltz et al. 1972, Batzer and Jennings 1980) indicate that unidentified sources of mortality operating on 3rd-6th instars are significantly correlated

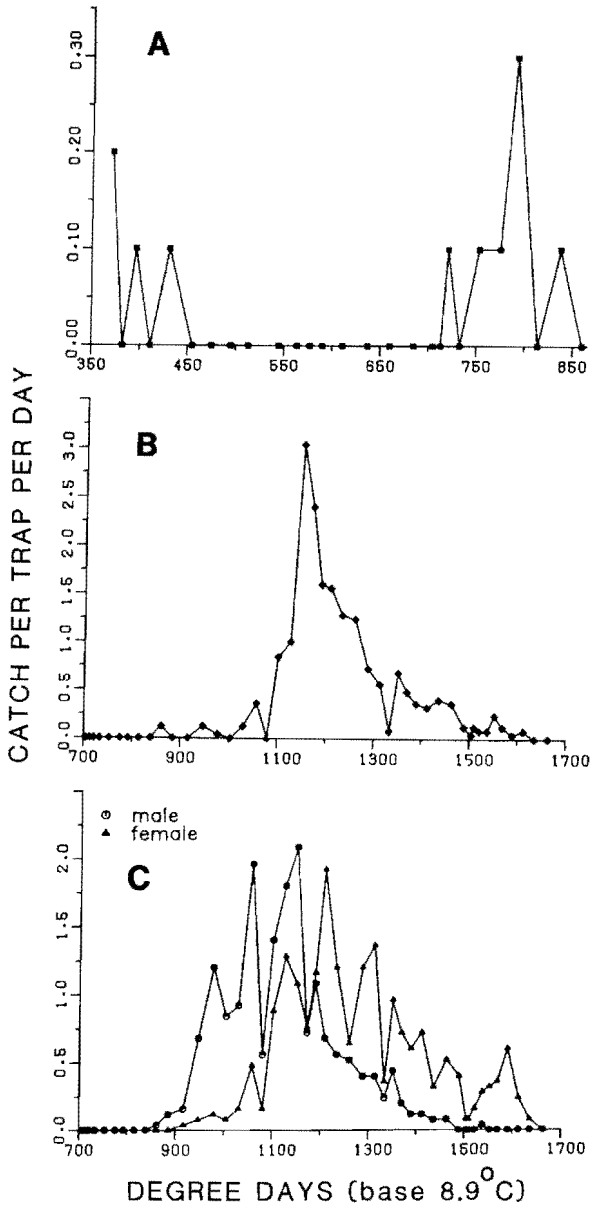


Fig. 1. Malaise-trap catch of adult parasites in relation to accumulated degree days (base 8.9°C); (A) female *Apanteles morrissi*, (B) female *Apanteles fumiferanae*, (C) male and female *Glypta fumiferanae*.

with total generation survival. Parasitism by *A. morrissi* may have been responsible for a portion of this unidentified mortality since in both studies the sampling intervals were constructed in such a way that impact due to this parasite could go partially undetected. Oviposition, larval development, and subsequent emergence from hosts could have occurred in the time span between consecutive samples. Miller and Renault (1976) studied parasitism in endemic populations of the spruce budworm and found that parasitism by *Apanteles* species other than *A. fumiferanae* was generally low and sporadic. They concluded that this was influenced by the abundance of alternate or alternative hosts which, in part, determined the abundance of the parasites. The ubiquity of *A. morrissi* in the JPB populations surveyed in this study indicates that parasitism by this species may be an important source of mortality in outbreak and declining populations of JPB.

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