BIOLOGICAL CONTROL OF THE JAPANESE BEETLE

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Introduction

The Japanese beetle is one of the most damaging turf and landscape pests in Michigan, requiring expensive chemical management on high quality turf. Unfortunately, JB thrive under the same conditions that landscape managers are striving to create: pure stands of irrigated grass, on whose roots the larvae feed, and the trees and shrubs required for adult feeding. However, another factor that JB requires to support large populations might be the key to gaining inexpensive control. JB can only achieve high densities in the absence of effective natural enemies. Are there parasites, pathogens, and/or predators that might reduce JB to non-injurious levels? In this paper, we will describe the current and potential future role of natural enemies as tools for management of JB in Michigan.

The JB was introduced to the United States from Japan in about 1916, and quickly spread. Early researchers recognized that while the JB was becoming a pest in the US, it was insignificant in Asia where it was attacked by several natural enemies (King and Holloway, 1930).

> The Japanese beetle was accidentally introduced ... apparently free from all its insect enemies and true parasites. It has found a congenial land with food and favorable climate, and so has multiplied without check ... (King 1931)

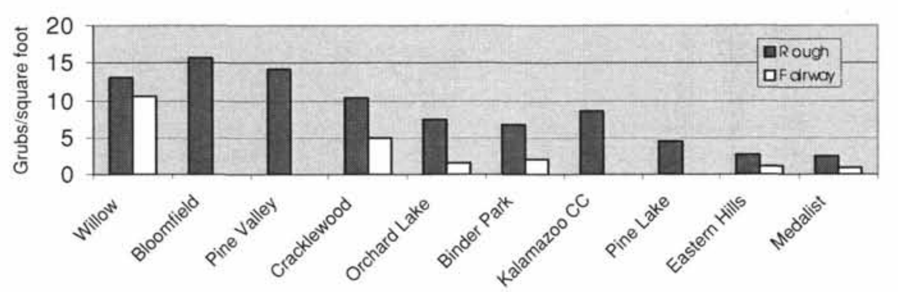
Several introductions were successfully made, so that JB has been reunited with some of its natural enemies in Eastern states. Perhaps as a consequence, it has been observed that JB populations often peak 5-10 years after introduction to a new area, followed by a decline over the next 10-15 years—consistent with the expected effect of growing populations of natural enemies. In our own study, we are seeking to evaluate JB natural enemies in Michigan with the following objectives:

1) Determine which JB natural enemies introduced to the US are established in MI.
2) Where absent, introduce pathogens and parasites that might suppress JB.
3) Monitor JB at introduction and control sites to determine natural enemy impact.

Survey of JB Natural Enemies in MI

We identified 12 sites with irrigated turf at golf courses located across southern Michigan. In order to assess the environment into which natural enemies would be introduced, we measured JB density. Grub density in untreated rough ranged from 2.5 to 16 grubs/ft² (Figure 1).

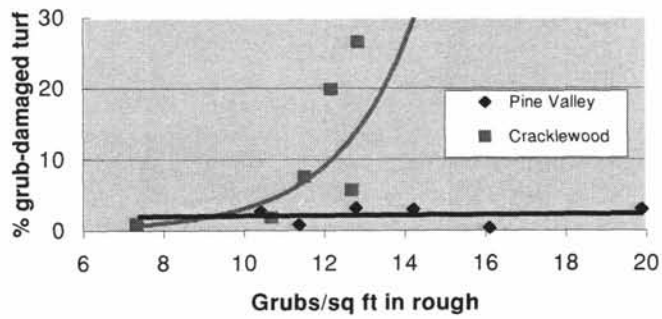
Figure 1. White Grub Density on Michigan Golf Courses, September 1999



Consistent with observations of many managers, the trend was for higher JB populations in the southeastern counties where JB has recently appeared in large numbers. If the densities observed this year are typical, JB are frequently near (in some cases below) the threshold where control is probably necessary. Thus a complex of biological controls that decrease JB by even 50% might reduce the need for broad preventive chemical treatment.

A note on control thresholds for JB:
At what population density do grubs begin to damage turf? Clearly the answer will vary depending on the variety, irrigation, and general health of the turf. We assessed grub density and turf damage on the rough for 6 holes at two golf courses in Macomb County (Figure 2). Cracklewood (high stress, low input conditions) showed significant grub damage when JB exceeded 10/ft^2; Pine Valley (lower stress, greater inputs) showed minimal damage at 20/ft^2.

Figure 2. Grub Density vs Turf Damage



Our investigation focused on parasites and pathogens, including:

Ø *Istocheta aldrichi.* A tachinid fly, introduced to the US from Japan in 1922. *Istocheta* deposits an egg on the pronotum of an adult beetle. A larva emerges into the beetle and feeds on the host's body killing it before it lays eggs. Long term studies in Connecticut found parasitism averaging 7-20% (McDonald 1999).

Ø *Tiphia vernalis.* A wasp introduced from Korea in 1925, and established in 15 states by 1953. In late spring, *Tiphia* stings and paralyzes JB grubs, then deposits an egg. The larva attaches externally and consumes the grub. Parasitization rates increase with JB density and have reached 60% at 6 grubs/ft^2 (Fleming, 1976). USDA is currently looking for more consistently effective biotypes in China (McDonald 1999).

Ø *Ovavesicula popilliae.* A protozoan pathogen discovered in 1985 (Andreadis and Hanula, 1987). *Ovavesicula* infects the malphigian tubules of JB. Its effects on JB are unclear. Only one research team has investigated this pathogen, finding: 1) infected JB at 70% of sites; 2) infection rates average 25% but reach 90% at some sites; 3) 50% reduction of fecundity for heavily infected beetles.

Ø Nematodes. Parasitic nematodes are very effective biocontrols for grubs, providing mortality comparable to chemical treatments when applied at high (expensive) rates (Georgis and Gaugler, 1991). However reasonable economy might be possible if we can determine the conditions in which a single low-dose application can persist for more than one season. A second promising approach is the use of nematodes as a synergist for imidicloprid (Merit): A recent study found that a low dose of nematodes significantly enhanced the effect of imidicloprid applied at an otherwise ineffective rate (Koppenhsfer and Kaya, 1998).

Ø Bacillus popilliae. *B. Popilliae* (milky spore disease) has long been available commercially, and has an unreliable record when applied as a control (Redmond and Potter, 1995). However when established naturally, it may be valuable as a minor mortality factor and as a stressor increasing grub susceptibility to chemical and biocontrols (Thurston et al., 1994).

In our Michigan survey, adult beetles and grubs were collected throughout the 1999 growing season, and examined for natural enemies. The two parasite species were absent from all sites; *B. Popilliae* and entomopathogenic nematodes (*Steinernema* and *Heterorhabditis sp.*) were present but rare at three of 13 sites, and Ovavesicula was found at just a single site (Table 1).

Table 1. Survey of natural enemies of the Japanese beetle in Michigan

Natural Enemy	JB examined	# of sites Observed	Infection Rate in MI	Infection Rate at other sites
Parasites:				
Istocheta aldrichi (fly)	12,000	0	0	7-20% (CT)
Tiphia vernalis (wasp)		—0	0	10-60%
Pathogens:				
Bacillus popilliae (bacteria)	1300	3/13	3	1-70% (NJ, MD)
Nematodes	700	3/13	1	3-60%*
Ovavesicula (protozoa)	1300	1/13	<1	24% (CT)

**Mortality up to 4 mos after application*

Collectively, the pathogens and parasites reviewed here are of virtually no benefit for JB control in Michigan.

Natural Enemy Introductions

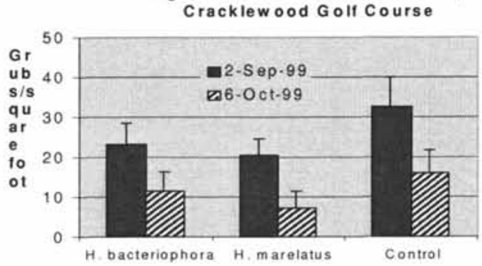
In 1999, we introduced two natural enemies imported from natural populations in the Eastern US: the parasite *Istocheta aldrichi*, and the pathogen *Ovavesicula popilliae* (Table 2). In 2000, we will survey for establishment and add additional release sites. The wasp parasite *Tiphia vernalis* will be introduced in the Spring of 2000.

Table 2. Introduction of natural enemies of the Japanese beetle in Michigan, 1999-2000

Natural Enemy		Release Date	# of sites	Source	Result
Parasites:	*Istocheta aldrichi (fly)*	Aug 1999	3MA	?	
	Tiphia popilliavora (wasp)	May 2000	5	TN	?
Pathogens:	Bacillus popilliae (bacteria)	Jul 1999	1	US, Korea?	?
	Nematodes	Sept 1999	5	US	30 d survival
	Ovavesicula (protozoa)	Sept 1999	5	MA	?

Two other pathogens were obtained from commercial sources. *B. Popilliae* was applied to a series of replicated plots at a site with high JB density (where *B. popilliae* is generally most effective). Heterorhabditid nematodes were applied to 5 sites. The low application rate did not provide measurable control (e.g., Figure 3); however nematodes were causing mortality after 30 days. Grub counts on these sites in 2000 will reveal whether nematodes provide useful suppression in the long term.

Figure 3. Nematode Treatments, Cracklewood Golf Course



Conclusion

Several of the JB natural enemies most significant in Connecticut are rare or absent in Michigan. If they can be effectively established here, our minimum expectation is for some reduction in Japanese beetle populations, with little or no yearly expenditure. Other possibilities include 1) severe reduction of JB if new species or biotypes can be identified from Asia; 2) enhanced activity of chemical treatments via stress-inducing pathogens; 3) new ideas for the implementation of commercial biological controls (*B. Popilliae,* Nematodes).

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