Potential and challenges for biocontrol of invasive wood borers: a case study involving the emerald ash borer

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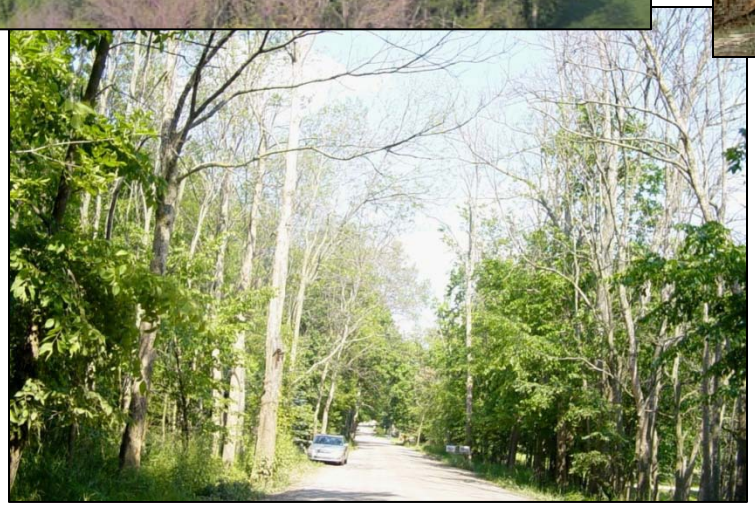
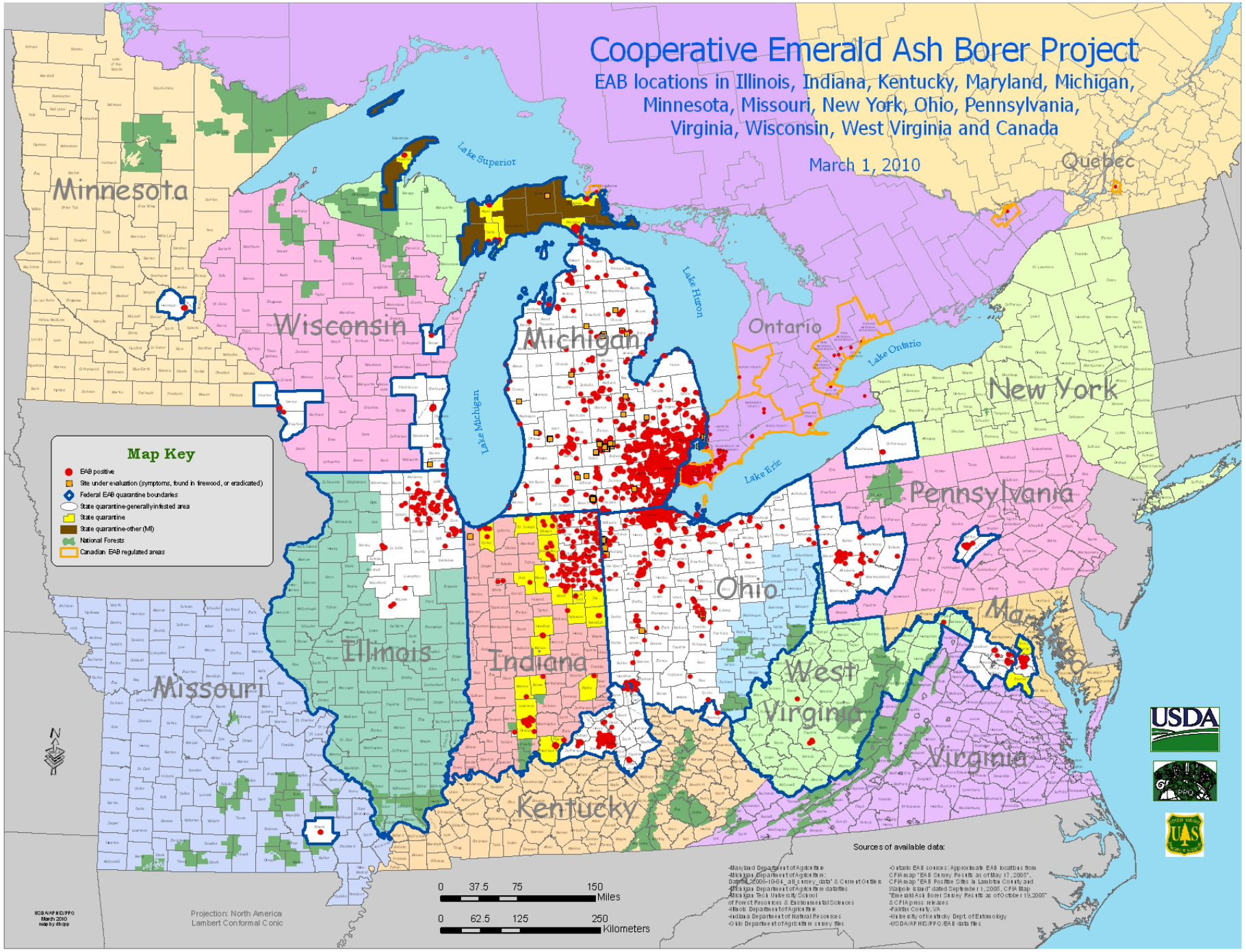
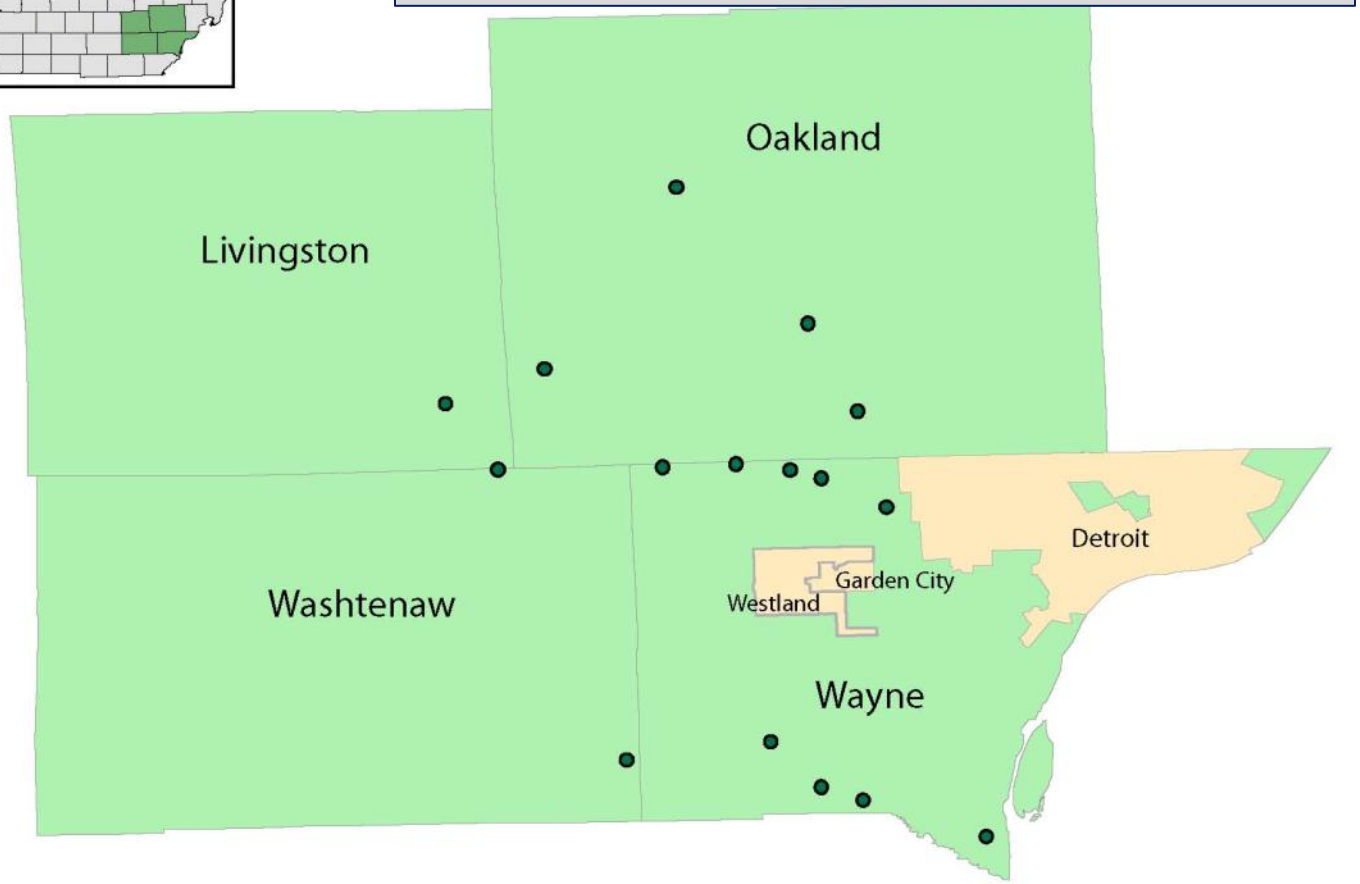
Agrilus planipennis, the emerald ash borer (EAB), was discovered in southeast Lower Michigan in 2002 after arriving from Asian in early 1990's




Cooperative Emerald Ash Borer Project
EAB locations in Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, Virginia, Wisconsin, West Virginia and Canada
March 1, 2010
Map Key
EAB positive
Site under evaluation (symptoms, found in firewood, or eradicated)
Federal EAB quarantine boundaries
State quarantine-generally infested area
State quarantine
State quarantine-other (MI)
National Forests
Canadian EAB regulated areas
Minnesota
Wisconsin
Michigan
Ontario
Quebec
New York
Pennsylvania
Ohio
Maryland
West Virginia
Virginia
Kentucky
Indiana
Illinois
Missouri
Lake Superior
Lake Huron
Lake Michigan
Lake Ontario
Lake Erie
N
0 37.5 75 150 Miles
0 62.5 125 250 Kilometers
Projection: North America Lambert Conformal Conic
USDA/APHIS/PPQ March 2010 map by dbapp
Sources of available data:
-Maryland Department of Agriculture
-Michigan Department of Agriculture; Digital_2005-10-04_all_survey_data" & Current Counties
-Michigan Department of Agriculture datafiles
-Michigan Tech University, School of Forest Resources & Environmental Sciences
-Illinois Department of Agriculture
-Indiana Department of Natural Resources
-Ohio Department of Agriculture survey files
-Ontario EAB sources: Approximate EAB locations from CFIA map "EAB Survey Results as of May 17, 2005", CFIA map "EAB Positive Sites in Lambton County and Walpole Island" dated September 1, 2005, CFIA Map "Emerald Ash Borer Survey Results as of October 19,2005" & CFIA press releases
-Fairfax County, VA
-University of Kentucky Dept. of Entomology
-USDA/APHIS/PPQ/EAB data files
USDA
PPQ

EAB natural enemy survey sites in southeast Michigan 2003-2004



Natural Enemy Survey of EAB Natural Enemies in SE Michigan: 2002-2004

<1% parasitism across all sites sampled

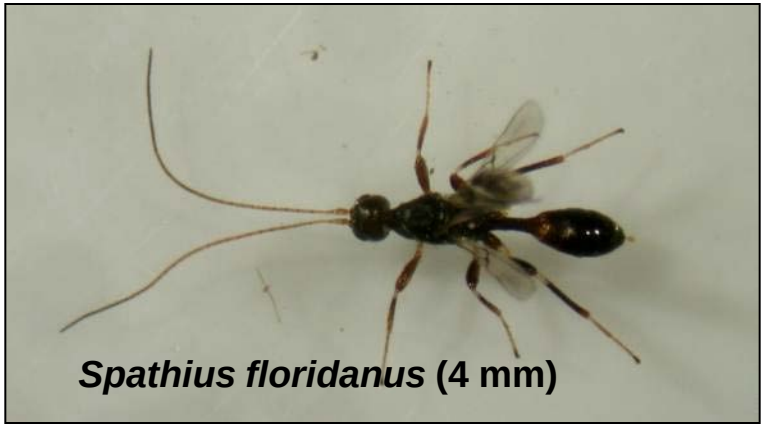
Phasgonophora sulcata (8 mm)

Chalcididae

Atanycolus spp. (12 mm)

Balcha indica (7-9 mm) (exotic)

Eupelmidae



Spathius floridanus (4 mm)

Braconidae

Provinces in China Surveyed for Ash, EAB, Natural Enemies: 2003-2005

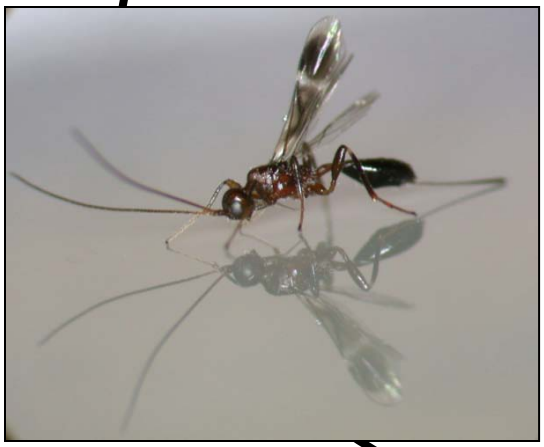



Life Cycle of *Oobius agrili* (Hymenoptera: Encyrtidae), a solitary & parthenogenic EAB egg parasitoid



Life cycle of *Tetrastichus planipennisi* (Hymenoptera: Eulophidae), a gregarious larval endoparasitoid of EAB

Life cycle of *Spathius agrili* (Hymenoptera: Braconidae), a gregarious larval ectoparasitoid of EAB



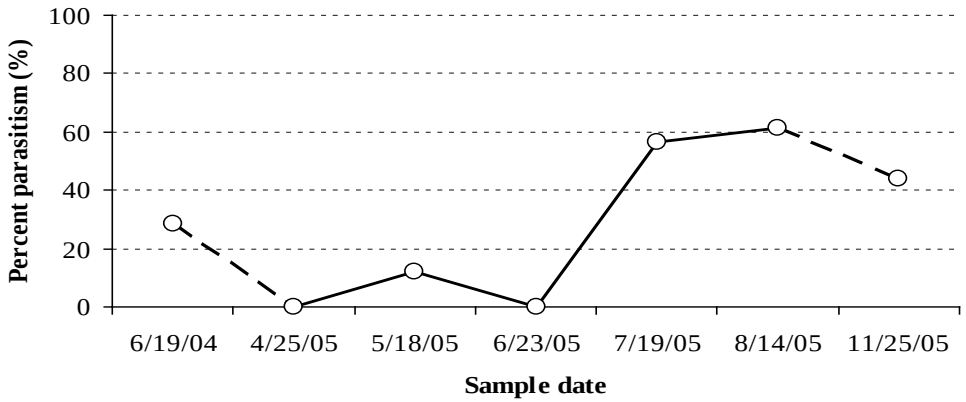
Fraxinus pennsylvanica (green ash) planted in China

~74% EAB-population reduction by combined effect of *Oobius agrili* and *Tetrastichus planipennisi**

EAB egg parasite:

***O. agrili* –**

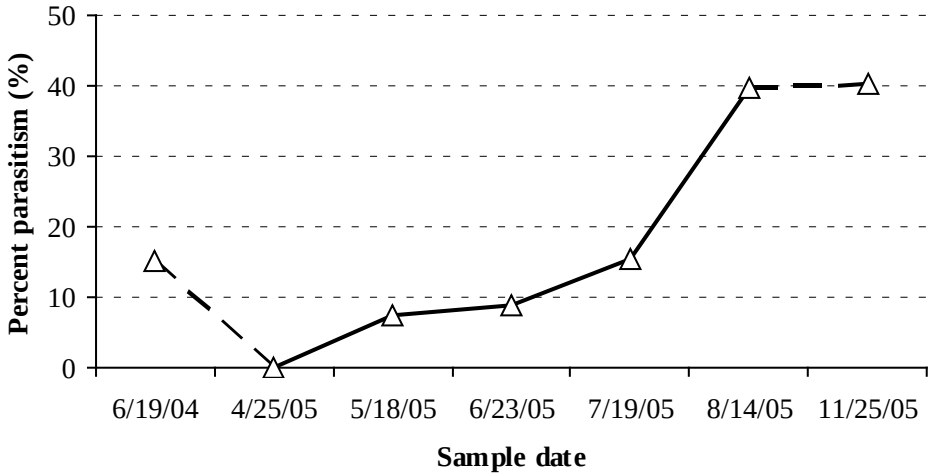
average 36.5% parasitism



EAB larval parasite:

***T. planipennisi* –**

average 22.4% parasitism



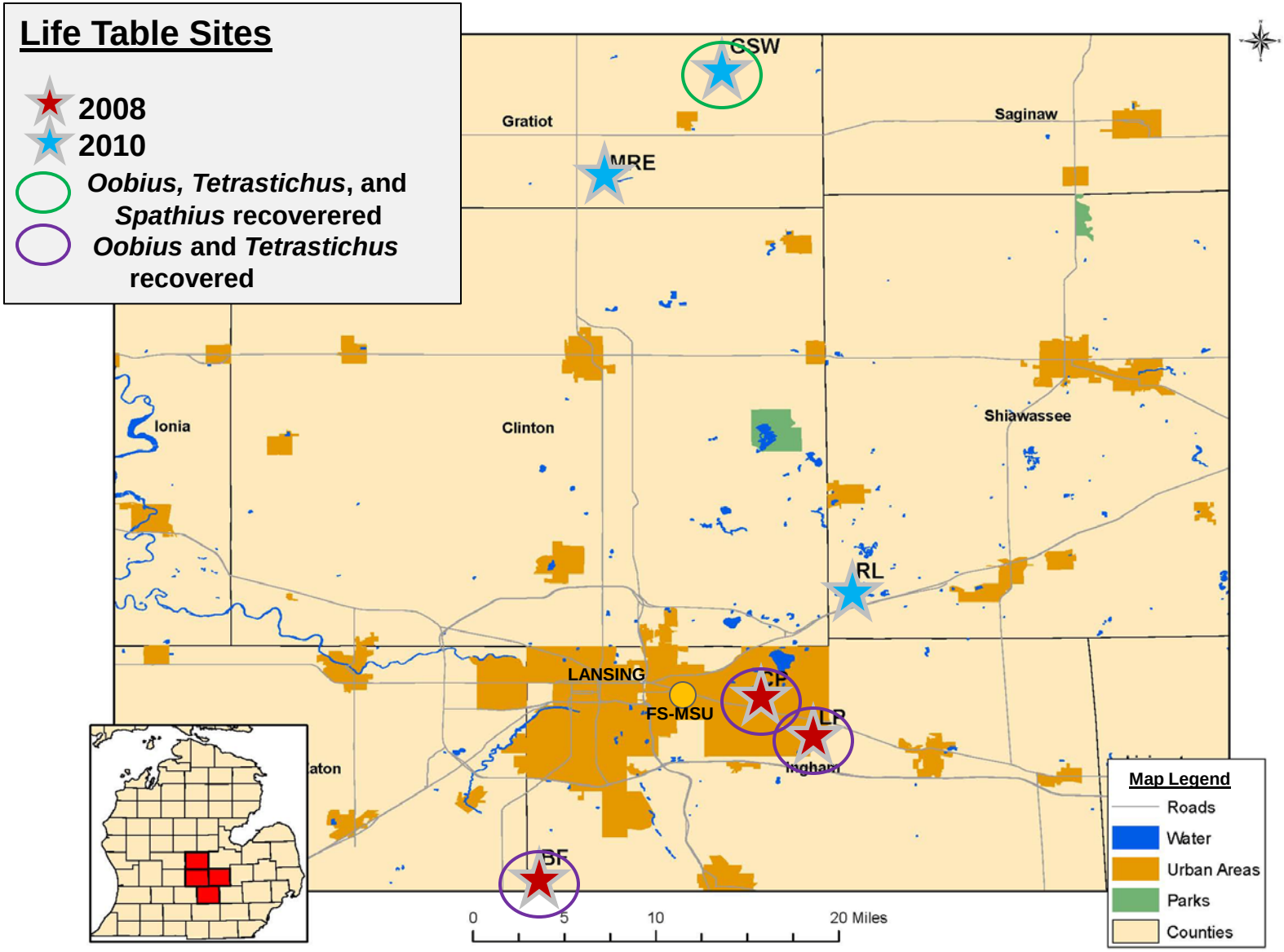
*Liu & Bauer. 2007. Biological Control. 42: 61-71

Summary of Host Specificity Studies

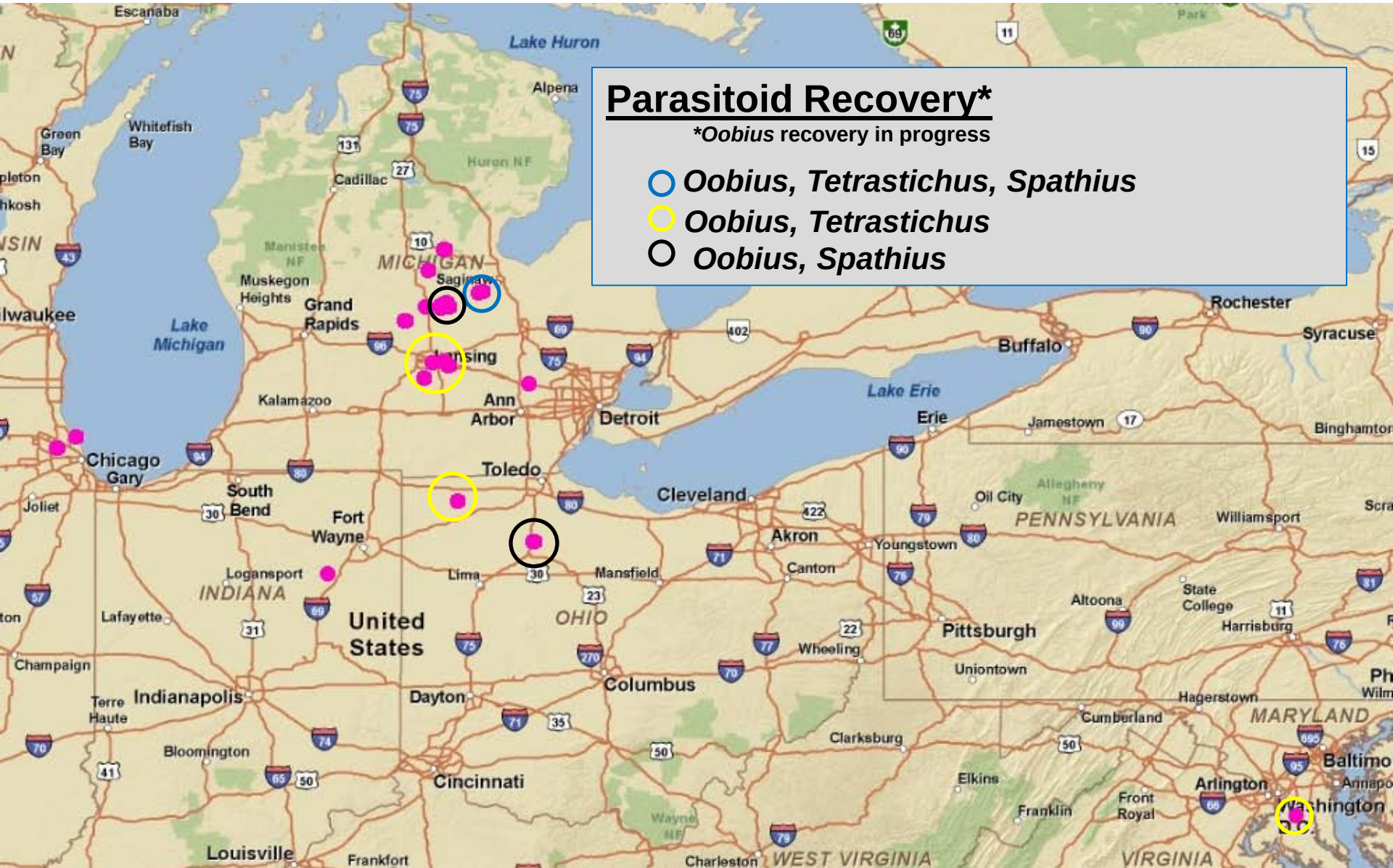
Parasitoid Species	No-choice Assays (family or genus)	Species (n)	Host Accept (n)	Choice Assays (n spp.)	Olfacto-metry	Survey in China
Oobius	***Agrilus***	6	3	3	No	No
	Cerambycidae	2	-	-		
	Lepidoptera	4	-	-		
	Total	12				
Tetrastichus	***Agrilus***	5	-	No	No	Yes
	Chrysobothris	3	-			
	Cerambycidae	5	-			
	Tenebrio	1	-			
	Lepidoptera	2	-			
	Hymenoptera	1	-			
	Total	17				
Spathius	***Agrilus***	9	4	No	Yes	Yes
	Cerambycidae	3	-			
	Lepidoptera	6	-			
	Curculionidae	1	-			
	Total	19				

2007: First EAB Biocontrol Research Sites*

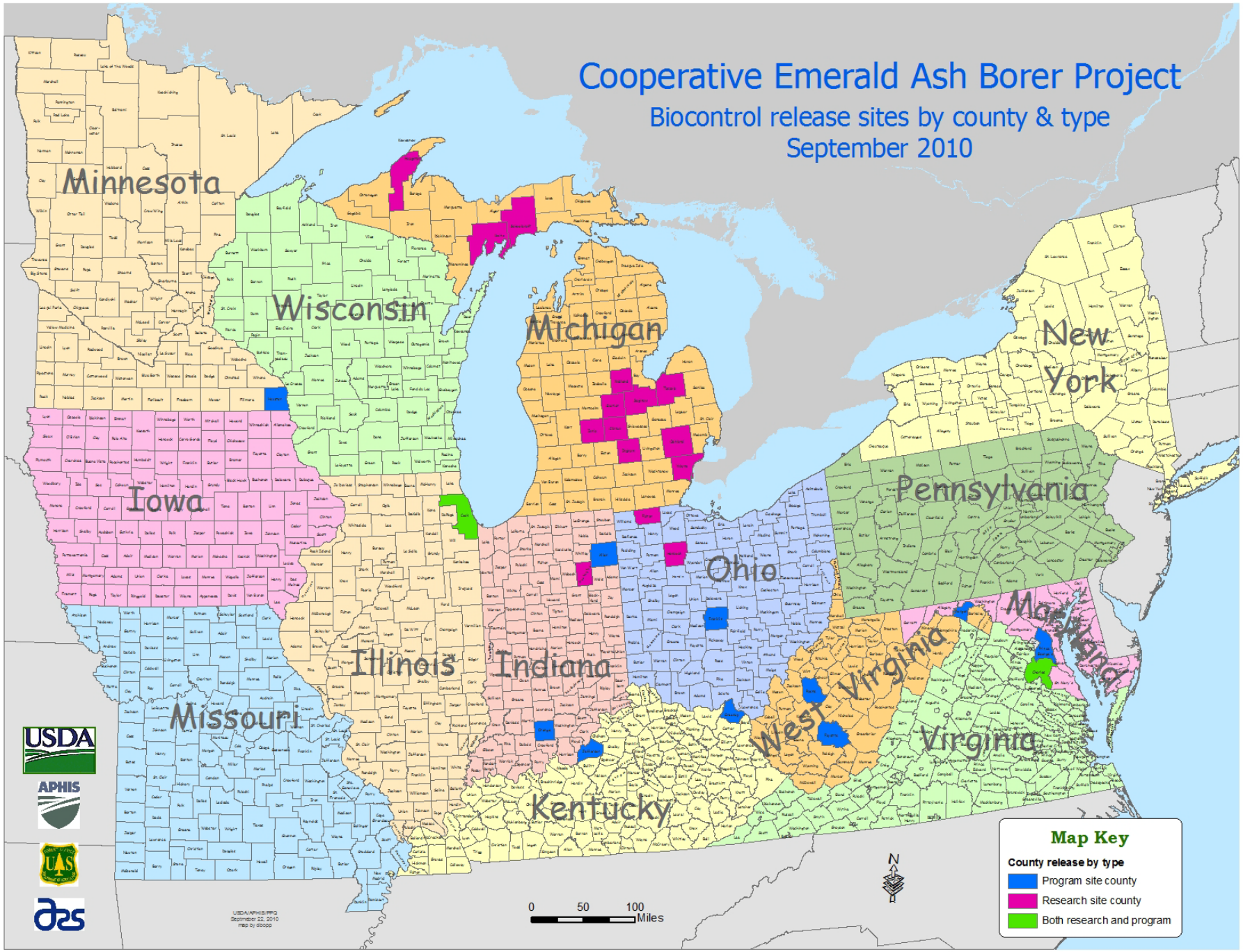
Location of EAB Biological Control Life Table Sites: Central Lower Michigan



Spring 2010: sites where introduced EAB parasitoids were recovered



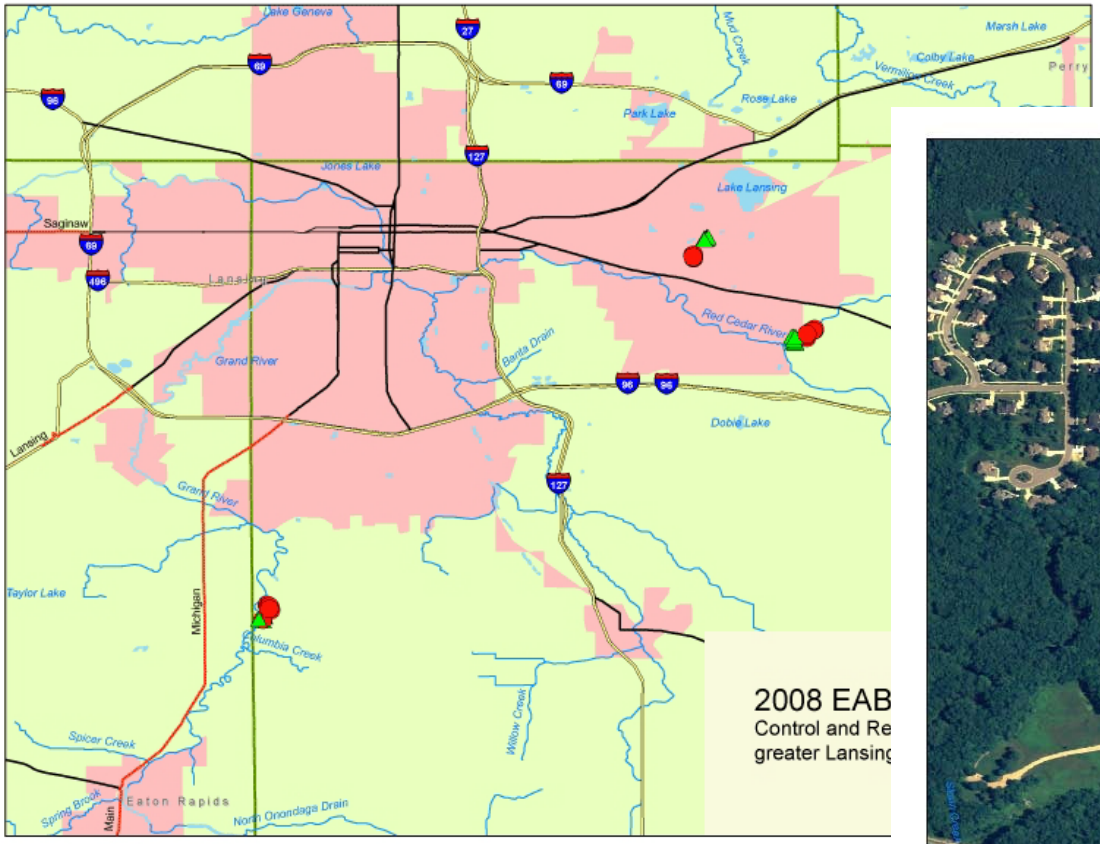
USDA APHIS EAB Parasitoid Rearing Facility – Brighton, MI

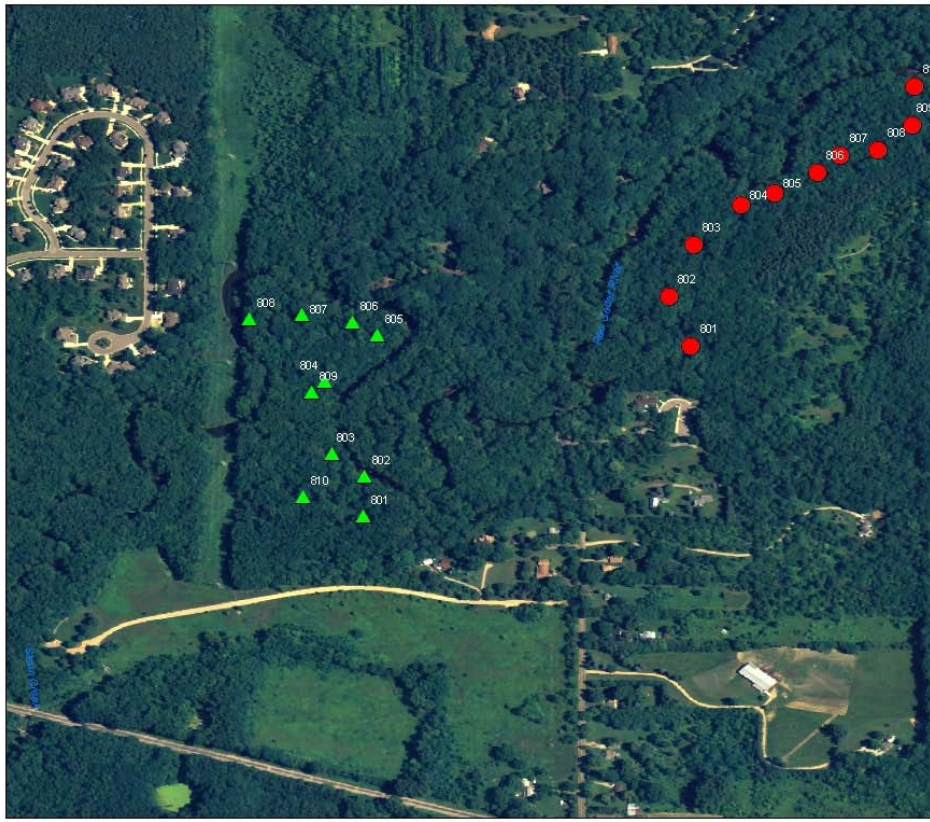

Cooperative Emerald Ash Borer Project
Biocontrol release sites by county & type
September 2010
Minnesota
Wisconsin
Michigan
New York
Iowa
Pennsylvania
Ohio
Illinois
Indiana
Missouri
West Virginia
Virginia
Kentucky
Maryland
USDA
APHIS
0 50 100 Miles
N
Map Key
County release by type
Program site county
Research site county
Both research and program

Evaluation of Introduced Parasitoids for Biocontrol of EAB in MI

- Monitor the establishment
- Quantify the impact or contribution to EAB mortality

Study Site and Sampling Tree Maps





Parasitoid Releases

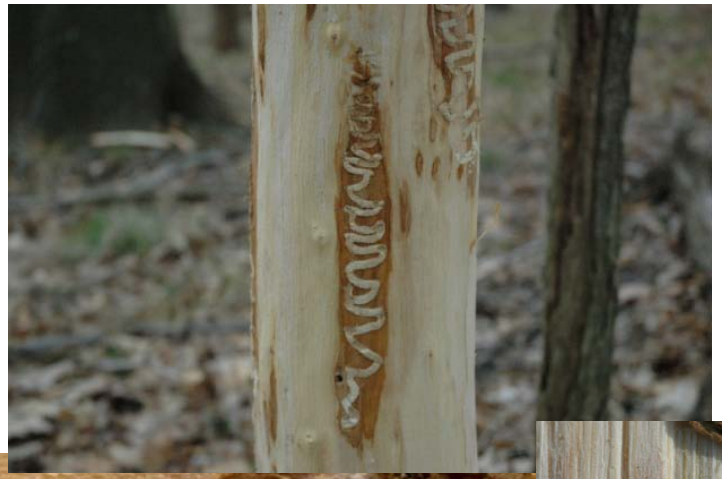
Species	2008 – Per Site	2009 – Per Site
O. agrili (F) 	100 – one release: June-July	**300** - one release: June-July
S. agrili (F) 	80 –One release: late Sept.	**600** – two releases: July - August
T. planipennisi (F) 	100 – One release: late Sept.	**3200** - 41 releases: June - September

Sampling Approaches

- Collecting EAB eggs, larvae, and associated parasitoids by destructively sampling EAB infested trees
- Using the **real cohort or cohort populations established over a course of time**
  - measure parasitism and its contribution on EAB population dynamics

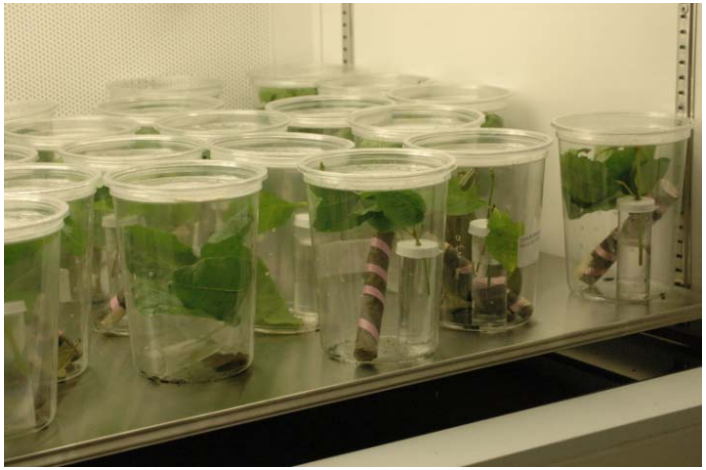
Challenges in Sampling EAB and Its Parasitoids

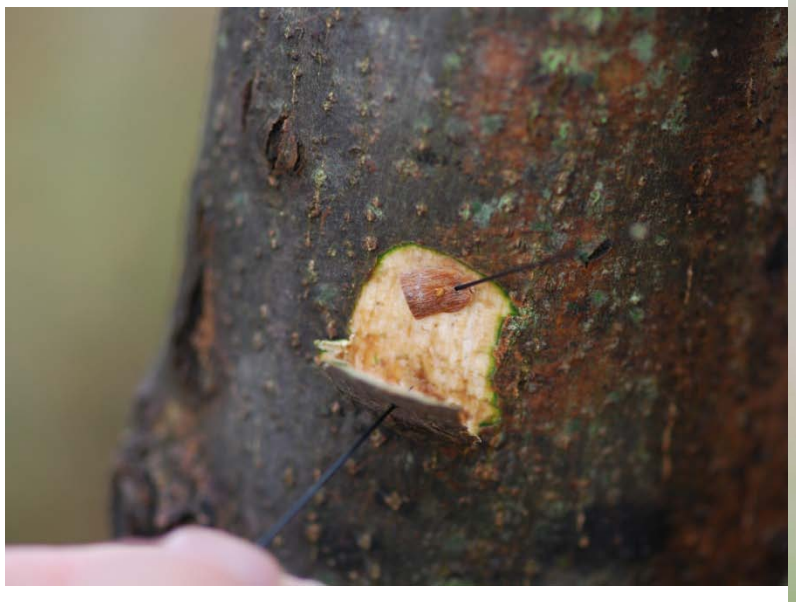
- Immature stages living in concealed habitat
- One to two years/generation



Survey for naturally occurring EAB eggs to evaluate egg parasitoid

Lab-reared EAB eggs placed in the cut crevice of the tree trunk





Egg/larval cohorts from caged adults

Sampling EAB larvae and associated Parasitoids

- Trunks (0 – 2.5 m above the ground) completely debarked
- Fate/Stage of EAB larvae and associated parasitoids were determined

Impact of the Egg Parasitoid – *Oobius agrili* (Encyrtidae)

Parasitism by *Oobius agrili:*
- naturally-occurring eggs

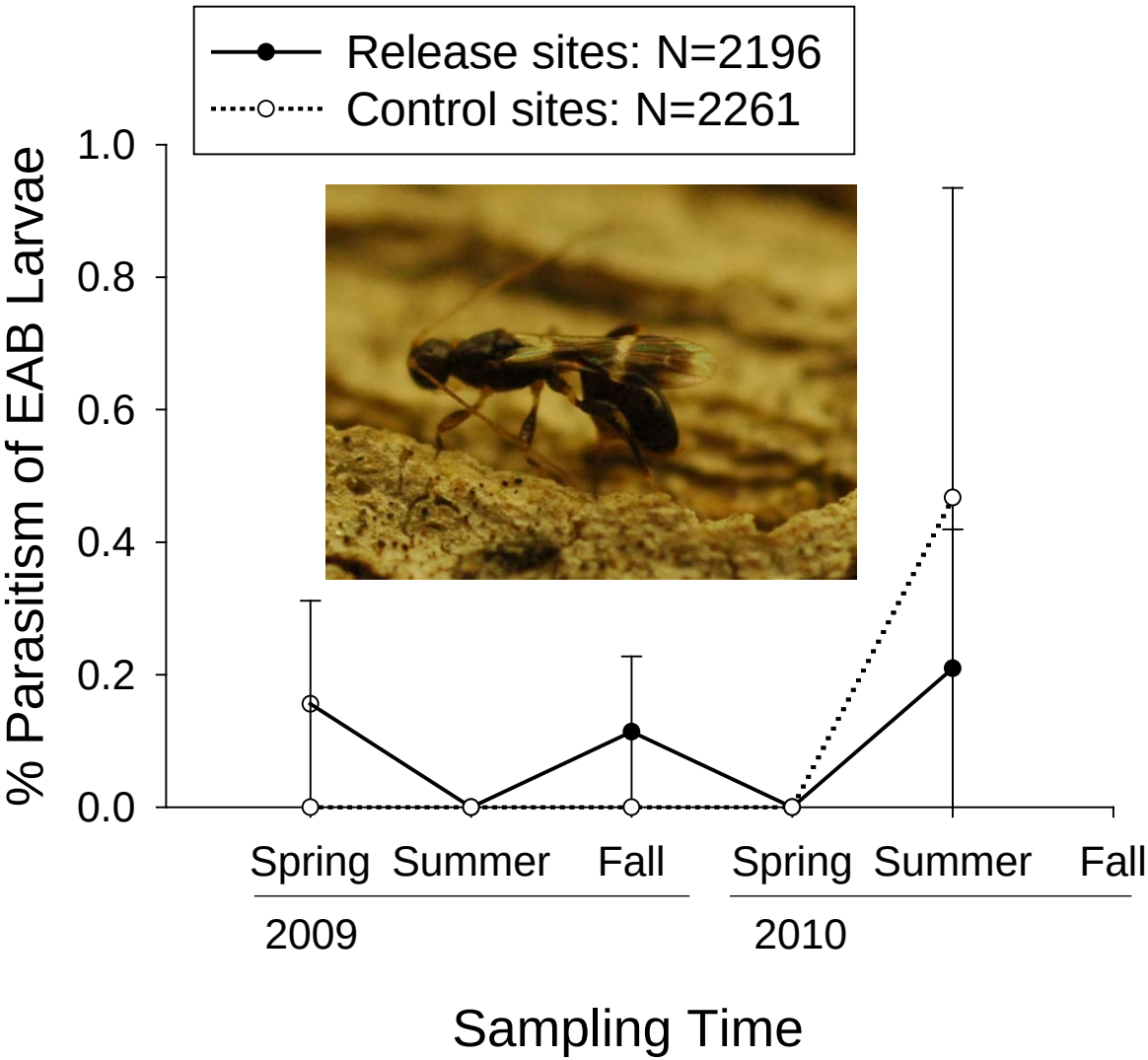
TRT	**2008 (P/N)**	**2009 (P/N)**
Release	2 /175 (1.1%)	11 /261 (4.2%)
Control	0 /123	0 /420

Impact of Larval parasitoids

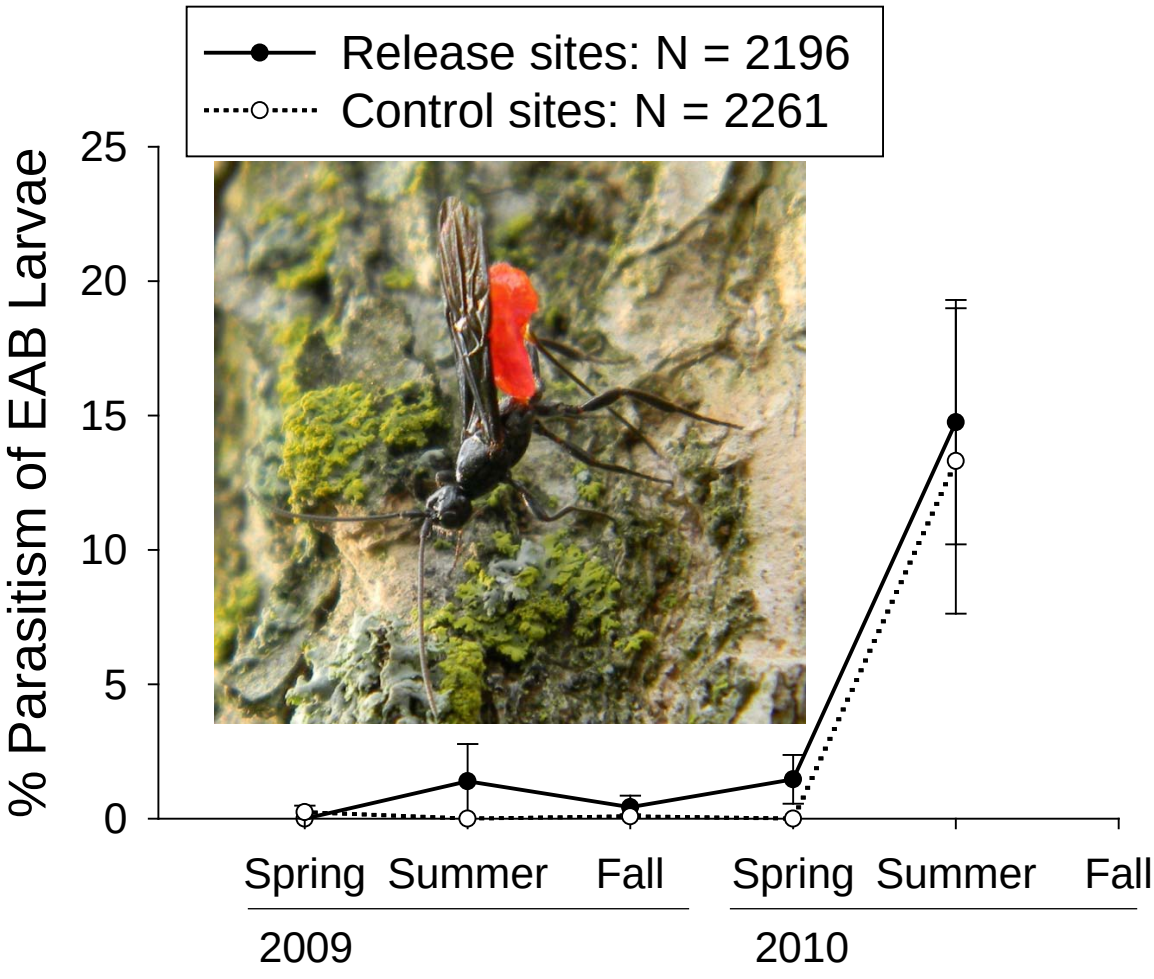
- *Tetrastichus planipennisi & Spathius agrili*

Tetrastichus planipennisi

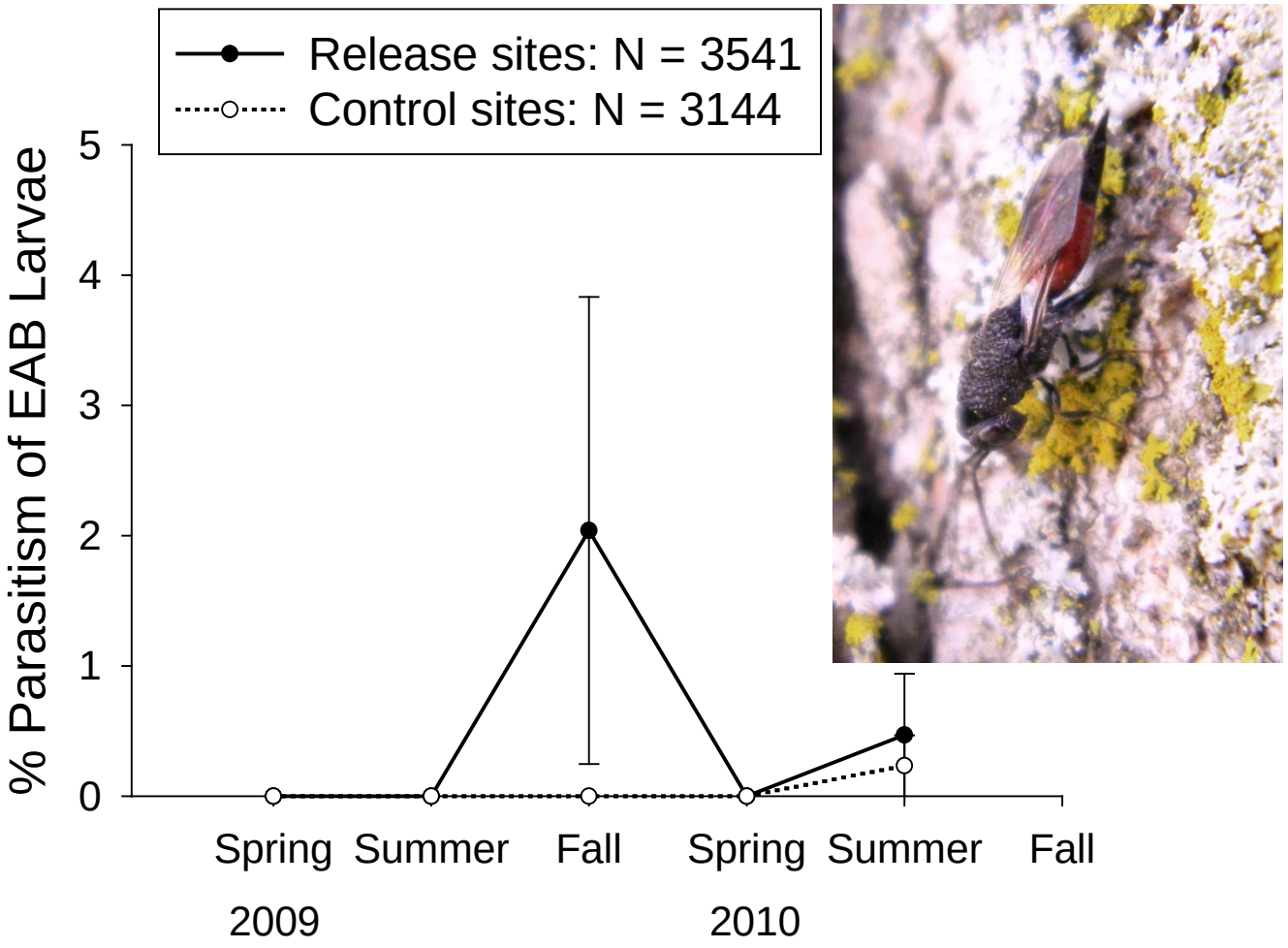
Spathius spp.



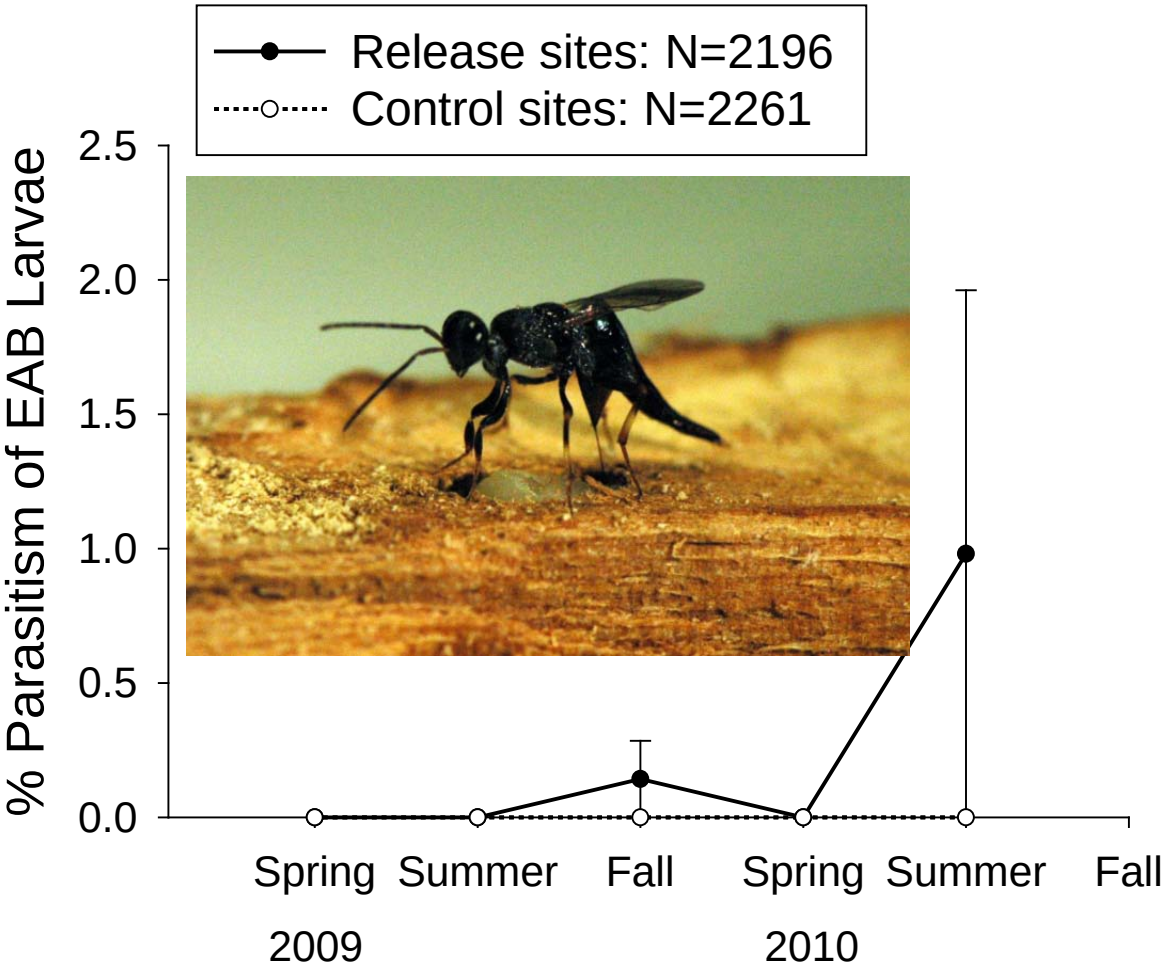
Atanycolus spp.



Phasgnophora sulcata



Balcha indica



Duan et al. 2010 – Environ. Entomol (*in press*)

Will We Succeed in Biocontrol of EAB: Potential & Challenges

- Why EAB becomes a serious pest killing North American ash trees:
  - **Parasitoid lost:**
    - Parasitism in its native range is high:

      >74% in China (Liu et al 2007; Wang et al. 2010)

      >80% in the Russian far east (Duan unpublished)
    - Parasitism in North America has been low: <15%

Challenges in Successful EAB Biocontrol

- EAB population does have “Outbreaks” on North American ash species *Fraxinus pennsylvanica* in Asia

Host Plant Resistance May Play a Key Role in Reducing Ash Tree Mortality

>80% larval parasitism by *Spathius* sp & *Atanycolus* sp

Perspective of EAB Biocontrol

- Ecological basis is partly supported by data
- Biocontrol can be important tool in reducing the EAB population. It will be challenging to apply as a remedial measure to prevent tree mortality.

Recommendations for Implementation of EAB Biocontrol

- Continue field releases/evaluations at the selected sites
- Explore for new guilds of natural enemies in native range
- Understand EAB population dynamics in both its native range (Asia) and new home (North America)

Acknowledgement

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