

BIOLOGICAL CONTROL OF WINTER MOTH

IN NORTHEASTERN NORTH AMERICA

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Booklet front cover image: An outbreak of winter moth larvae, *Operophtera brumata* (Photo: George Boettner, University of Massachusetts, Amherst)

KEY FINDINGS

THE GOAL OF THE WINTER MOTH BIOCONTROL PROGRAM IS TO PROTECT NATIVE FORESTS, CITYSCAPES, AGRICULTURAL LANDS, AND SENSITIVE ECOSYSTEMS

- The winter moth invaded North America prior to 1950, causing widespread defoliation of forest and shade trees.
- Two outbreaks in Nova Scotia and British Columbia were controlled with the biocontrol agent *Cyzenis albicans*, a tachinid fly.
- The winter moth invaded New England in the 1990s.
- A New England winter moth biocontrol program was initiated in 2005 with the collection and release of *C. albicans*.
- As of 2018, *C. albicans* has become established at 32 New England release sites.
- Winter moth populations have sharply declined in eastern New England, and additional *C. albicans* releases are recommended for other winter moth populations elsewhere in North America.



Adult male winter moth, *Operophtera brumata* (Photo: Olaf Leillinger)

BACKGROUND INFORMATION

Winter moth (*Operophtera brumata* L., Geometridae: Lepidoptera), a leaf-feeding inchworm caterpillar native to Europe, invaded eastern Massachusetts in the 1990s and started causing widespread defoliation of forest and shade trees throughout the region (**Fig. 1**). Winter moth larvae feed on many kinds of deciduous trees, and the moth has become a major pest of blueberries throughout NE North America.

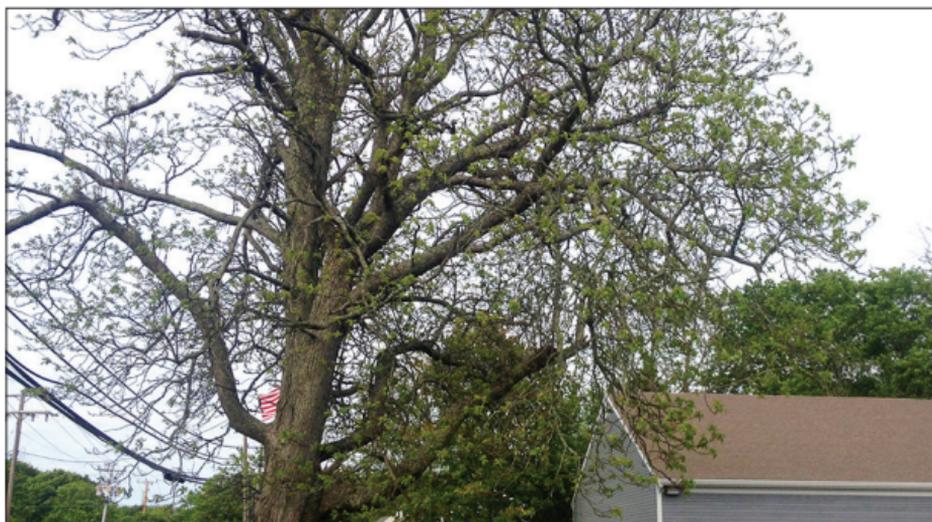


Fig. 1. Shade tree defoliated by winter moth larvae (Photo: Joe Elkinton, University of Massachusetts, Amherst)

Surveys from 2005-2007 revealed winter moths were established in coastal areas from Maine to SE Connecticut, as well as Nova Scotia (**Fig. 2**). Defoliation occurred at sites north and south of Boston in 2004 and spread west and south across Massachusetts and Rhode Island over the next decade (**Fig. 3**). Outbreak populations occurred in 2012 for the first time in SE Connecticut and coastal Maine. The coastal distribution of winter moth mirrors that of winter temperatures exemplified by the USDA cold-hardiness zones (**Fig 4**). Colder winter temperatures evidently prevent winter moths from invading interior regions of New England and Canada. The same map implies, however, that winter moths will readily occupy interior regions of the USA further south.



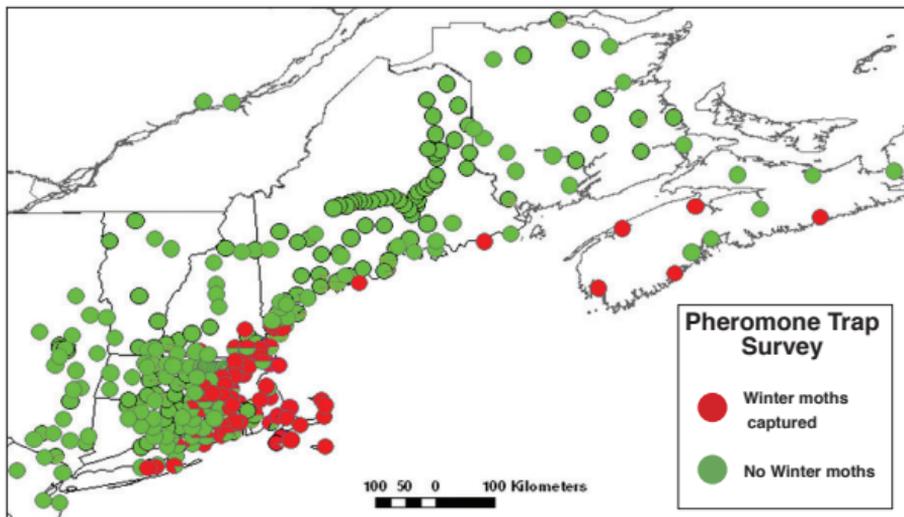


Fig. 2. Winter moth establishment in NE North America from 2005-2007 surveys (Elkinton et al. 2010. *Ann. Ent. Soc. Amer.* 103:135-145)

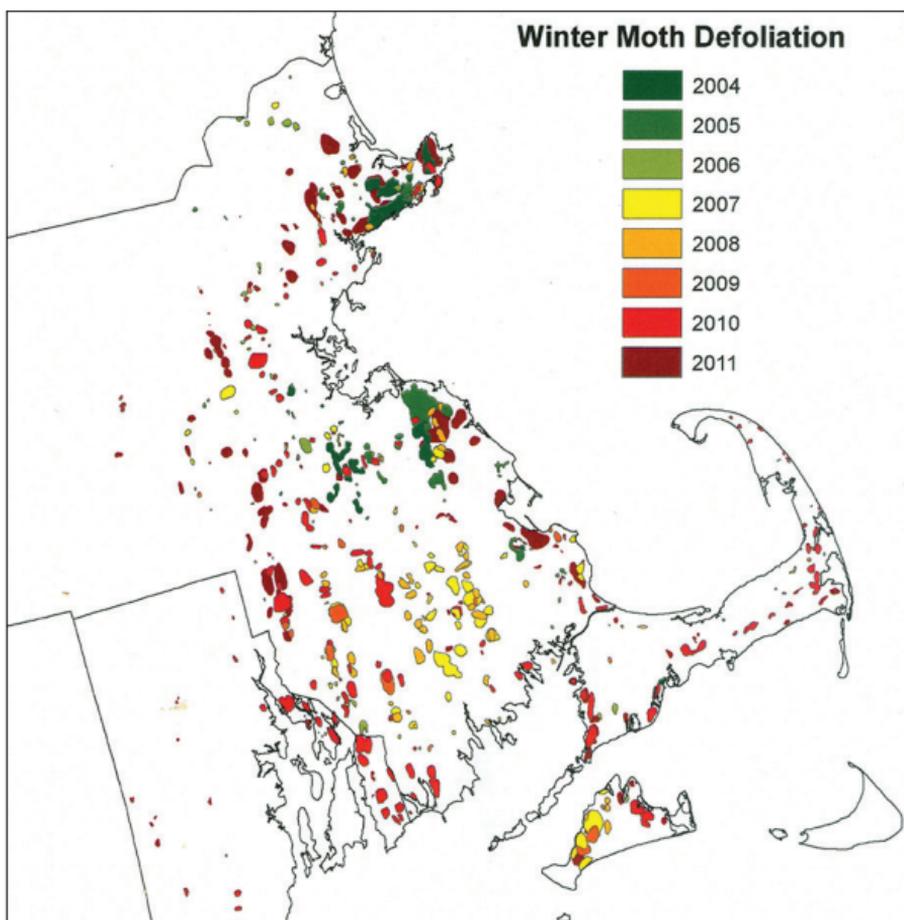


Fig. 3. Spread of winter moth around Boston 2004-2011 (compiled from annual aerial surveys, Elkinton et al. 2014 *Biol. Invasions* 16:2263-2272)

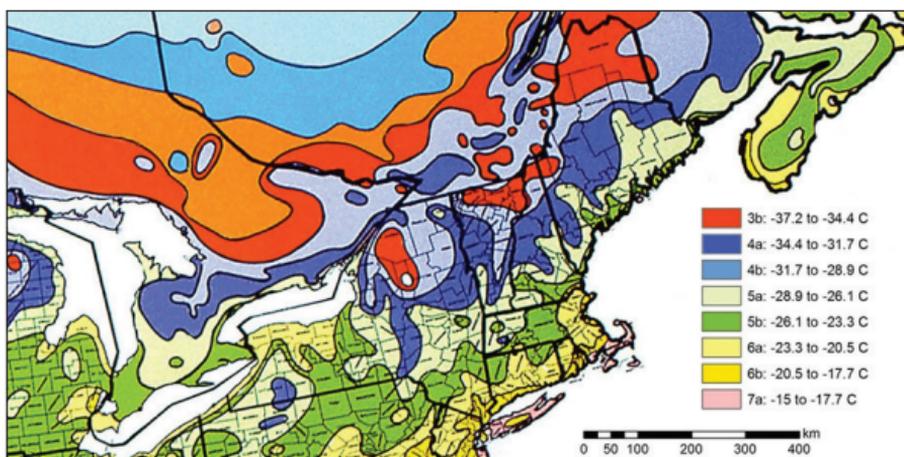


Fig. 4. Plant cold hardiness zone map for NE North America through 1990. Note: Zone 6a, which occurred in E Massachusetts and Nova Scotia, has now moved northward and inland encompassing coastal Maine and New Hampshire. (Source: USDA ARS)



WINTER MOTH BIOLOGY

Winter moths are so-named because adults emerge in late November and the males (**Fig. 5c**) are observed flying throughout December, whenever temperatures are above freezing. The females are wingless (**Fig. 5d**), and after mating they lay eggs on the stems of trees. The eggs hatch in late April and larvae bore in the expanding buds of their host trees. Much of the leaf damage occurs before the leaves fully expand. Winter moth larvae are green and typical inchworms (**Fig. 5a**) in that they lack appendages in the middle of their body, resulting in their characteristic looping or inching gait. They complete development in late May and drop out of the tree canopies to burrow into the soil and leaf litter beneath the trees where they spin earthen cocoons in which they form pupae (**Fig. 5b**). They remain in these cocoons until late November, when the adults emerge and the cycle begins again.

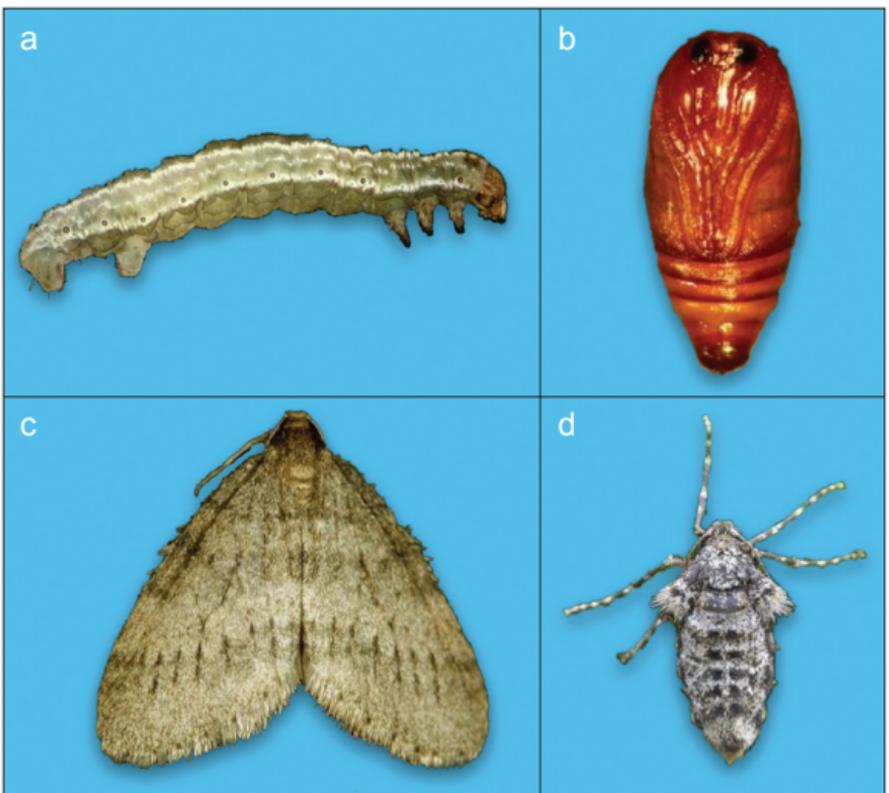


Fig. 5. Winter moth life stages: (a) larva, (b) pupa, (c) adult male, (d) adult female (Modified from photos by D. Wagner, reprinted from Elkinton et al. 2015, FHTET-2014-07)



HISTORICAL BIOLOGICAL CONTROL OF THE WINTER MOTH

Prior to the current invasion by winter moth to Massachusetts, there were two previous invasions to Canada—Nova Scotia prior to 1950 and British Columbia in the 1970s. Both prior invasions had been suppressed by the introduction of parasitic insects attacking winter moth in Europe, in particular the tachinid fly *Cyzenis albicans* (**Fig. 6a**). The immature fly develops and forms a puparium inside the infected winter moth pupa (**Fig. 6b**), killing the moth in the process.

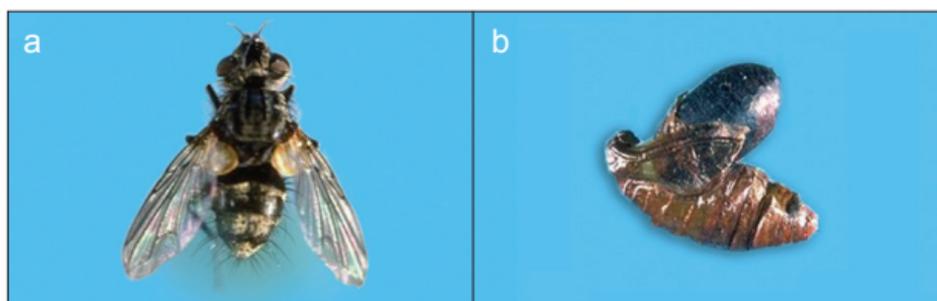


Fig. 6. *Cyzenis albicans* (a) adult, (b) puparium inside winter moth pupa (Photos: Nicholas Condor)

Cyzenis albicans was first released in Nova Scotia in 1954. Initial recoveries of the flies occurred in 1957, and parasitization of winter moth larvae increased from 10% in 1959 to 60% in 1962, whereupon winter moth populations at the release site collapsed. Winter moth densities have remained at low levels in Nova Scotia (**Fig. 7**) and British Columbia ever since, similar to levels in most of Europe.

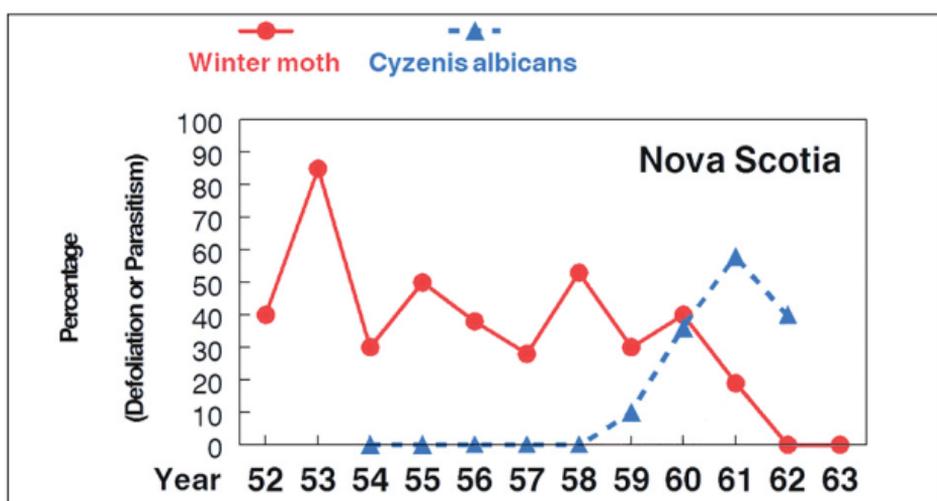


Fig. 7. Defoliation by winter moth and percentage of parasitism by *Cyzenis albicans* in Nova Scotia in the 1950s (adapted from Embree 1965 and Elkinton et al. 2015, FHTET-2014-07)



BIOLOGICAL CONTROL OF THE WINTER MOTH IN NEW ENGLAND

- Researchers at the University of Massachusetts, Amherst initiated a winter moth biocontrol program in New England in 2005. Over the next decade, they obtained the tachinid fly, *C. albicans*, by collecting winter moth caterpillars infested with immature flies from Vancouver Island, where both the fly and its winter moth hosts were introduced in the 1970s.
- The tachinid flies were reared over the winter and released the following spring at sites across New England (**Fig. 8**).
- Monitoring efforts in subsequent years indicated that this fly successfully established in New England.
- As of 2018, the fly had been released at 44 sites and had established at 32 (**Fig. 8**).
- Furthermore, at six widely spaced sites, long-term studies showed that as of 2017, parasitism of winter moth by *C. albicans* had increased coincident with a sharp decline of winter moth densities (**Fig. 9**).
- Winter moth defoliation has now largely disappeared in New England. It thus appears that *C. albicans* has converted winter moth to a non-pest status that seems likely to persist indefinitely, much as it did in Nova Scotia in the 1950s.



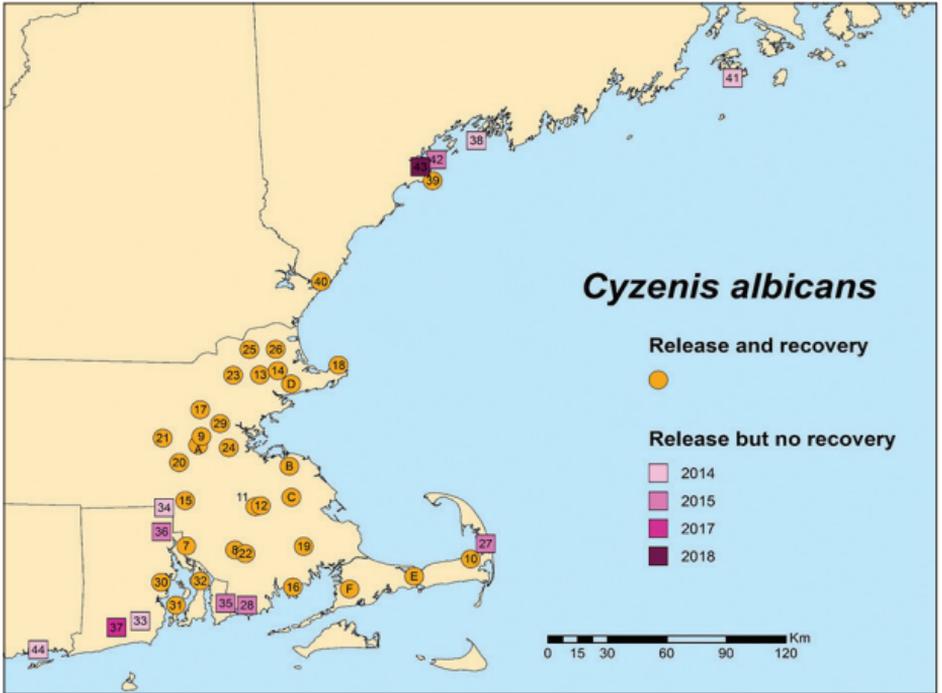


Fig. 8. *Cyzenis albicans* release and recovery sites in New England 2005-2018 (Drawn by G. Luzader and A. Liebhold)

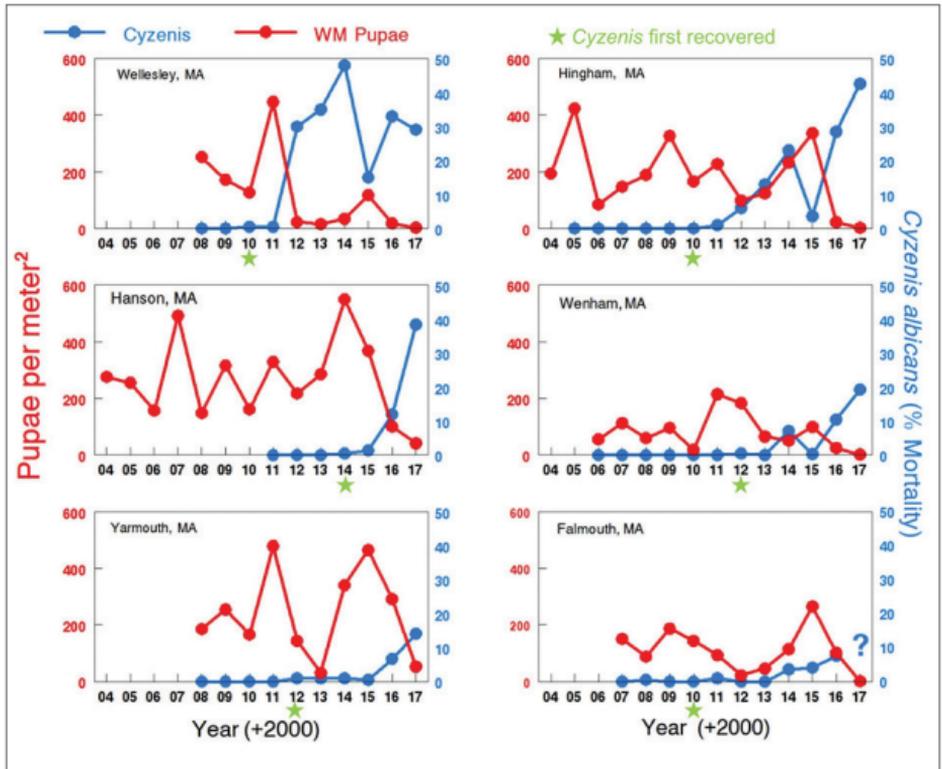


Fig. 9. Density of winter moth pupae (red) and percent parasitism by *Cyzenis albicans* (blue) at six widely spaced sites in Massachusetts indicated by the symbols with capital letters in **Fig. 8**. The blue symbols begin the year of first release. Green stars indicate years *C. albicans* was first recovered at each site (Elkinton et al. unpublished data)



WHAT YOU CAN DO

■ Look for evidence of the winter moth

- Although winter moth attacks a wide variety of plants, it is especially problematic on oak, maple, birch, apple, and blueberry
- Look for heavy defoliation (**Fig. 10**) accompanied by high densities of winter moth larvae (green inchworms, see brochure cover and **Fig. 5**) in May
- Look for large numbers of small brown moths (wingspan ~1 inch) flying in late November or December. Adults of most other common moth species are not active at that time



Fig. 10. Tree defoliated by an outbreak of winter moth larvae (Photo: Hannah Broadley, University of Massachusetts, Amherst)

■ If you live in coastal and eastern New England and have high densities of winter moth, do nothing. *Cyzenis albicans* will catch up and reduce winter moth populations

■ If you live in western New England or further south and west and encounter high populations of what appears to be winter moth, proper identification is warranted. Contact Joseph Elkinton at the University of Massachusetts, Amherst for more information (elkinton@umass.edu). DNA-based identification is readily available. USDA permits are required to make new releases of *Cyzenis albicans*.



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Booklet back cover images: Winter moth larvae (top) and defoliation damage (middle and bottom) (Photos: Hannah Broadley, University of Massachusetts, Amherst)

