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BIOLOGICAL CONTROL OF *FENUSA PUSILLA* (HYMENOPTERA: TENTHREDINIDAE) IN THE NORTHEASTERN UNITED STATES: A THIRTY-FOUR YEAR PERSPECTIVE ON EFFICACY

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ABSTRACT

Parasitoid releases against the birch leafminer *Fenusa pusilla* (Lepeletier) (Hymenoptera: Tenthredinidae) in eastern North America began in 1974, with releases in eastern Canada, followed by others in the Middle Atlantic States and New England. Of 4 parasitoids released, only 1, the ichneumonid *Lathrolestes nigricollis* (Thompson), established and spread widely. Studies of its preliminary impacts were made in several locations in the 1980s and 1990s, but full impact of the parasitoid on host density was not yet achieved in that period. Here we report results of surveys in 7 states (MA, CT, RI, NY, PA, NJ, DE) in 2007 documenting the current birch leaf miner levels (as % of leaves mined in spring) and parasitism. Survey results show that the pest has declined dramatically to barely detectable levels in 5 states (MA, CT, RI, NY, PA) but that in southern NJ, the pest remains abundant (ca 50% leaves mined) despite significant parasitism levels. Survey results, in context with previous evaluations made when populations were still declining, show that the project has been completely successful in much of the northeastern USA, but that there is a southern limit to efficacy in mid-New Jersey. Possible reasons for lack of control in this area, in contrast to high levels of control elsewhere, are discussed.

Key Words: *Fenusa pusilla*, *Lathrolestes nigricollis*, birch leafminer, *Betula* spp. biological control, evaluation, efficacy

RESUMEN

La liberación de parasitoides usados contra el minador de abedul, *Fenusa pusilla* (Lepeletier) (Hymenoptera: Tenthredinidae), en el este de Norte America empezó en 1974, con liberaciones en el este de Canadá, seguidas por otras en los estados del Medio-Atlántico y Nueva Inglaterra. De los 4 parasitoides liberados, solo 1, el ichneumonídeo *Lathrolestes nigricollis* (Thompson), se estableció y se esparció ampliamente. Se realizaron estudios sobre su impacto preeliminar en varias localidades en los años de la década de los 1980 y 1990, pero el impacto completo del parasitoides no fue realizado en este periodo. Aquí reportamos los resultados de los sondeos en 7 estados (MA, CT, RI, NY, PA, NJ, DE) en 2007 documentando los niveles actuales de el minador de abedul (como un % de las hojas minadas en la primavera) y el parasitismo. Los resultados del sondeo muestran que esta plaga ha disminuido dramáticamente a niveles apenas detectables en 5 estados (MA, CT, RI, NY, PA) pero en el sur de NJ, la plaga sigue abundante (ca. 50% de las hojas minadas) a pesar de niveles de parasitismo significativos. Los resultados del sondeo, en contexto con evaluaciones previas hechas cuando las poblaciones todavía estuvieron disminuyendo, muestran que el proyecto ha sido exitoso en mucho del noreste de los Estados Unidos, pero hay un límite sureño para su eficacia en el medio de New Jersey. Se discuten las razones posibles para la falta de control en esta área en contraste con los niveles altos de control en otros lugares.

Birch leafminer (*Fenusa pusilla* [Lepeletier]) (= *pumila* Klug) (Hymenoptera: Tenthredinidae), an invasive Palearctic leaf mining sawfly attacking several species of *Betula*, has been present in North America for at least 85 years, and was first recorded in Connecticut (Friend 1933). When high proportions of tree leaves are mined, browning

makes ornamental birches unsightly, although damage does not normally cause tree death. Investigations on natural sources of mortality associated with the pest in Connecticut (Friend 1933) and Quebec (Cheng & LeRoux 1965, 1969, 1970) showed that parasitism of larvae was insignificant (<5%) compared to the situation in the its na-

tive range in central Europe, where parasitism was much higher (38-47%) (Eichhorn & Pschorn-Walcher 1973). This difference prompted the initiation of classical biological control programs in both Canada and the USA, leading to the release of 4 parasitoids: the ichneumonids *Lathrolestes nigricollis* (Thompson) and *Grypocentrus albipes* Ruthe, the braconid *Phanomeris* sp., and the eulophid *Chrysocharis nitetis* (Walker). The ichneumonids were released in Canada (Quebec and Newfoundland) from 1974-75 (Raske & Jones 1975; Guèvremont & Quednau 1977), and all 4 species were released in NJ, DE, MD, and PA between 1976 and 1982 (Fuester et al. 1984). Later, releases of just the 2 ichneumonids were made in MA (1979-1980), in MA and RI (1989-1991) (Van Driesche et al. 1997), and western Canada in the 1990s (Langor et al. 2000).

Here we present information on the efficacy of these releases in the northeastern United States. A preliminary evaluation (Van Driesche et al. 1997) of the status of the pest in MA and RI conducted from 1990-1995, showed that the pest had declined locally around the principal MA release site in Amherst from 54% of leaves mined in spring to just 3%. Furthermore, by 1995 a difference had developed between Amherst, MA (at various non-release sites within 4 km of the 1980 release site) versus a similar town (Northampton) located 15-20 km from the release point. In the Northampton area, where the parasitoid would have arrived later, 33% of spring birch leaves were still being mined and only 14% of the larvae were parasitized by *L. nigricollis*. In contrast, in Amherst, closer to the original release site, only 6% of spring leaves were mined and 28% of the larvae were parasitized (Van Driesche et al. 1997). This suggests that at that point in time, there was a zone, centered on the original release area, where the pest was controlled, while further away control was still developing.

Preliminary data published previously, while suggesting the existence by the 1990s of local areas of pest suppression, do not reflect the full extent of area-wide pest control caused by this classical biological control project. Here, we present results of a set of state-level surveys carried out in spring of 2007 by the authors to determine the current abundance of *F. pusilla* mines on birch species in the northeast USA. Surveys were run in RI and CT (Casagrande), Massachusetts (Van Driesche), New Jersey (Mayer), Pennsylvania and Delaware (Fuester) and Long Island, New York (Gilrein).

MATERIALS AND METHODS

Sampling in Rhode Island (1990-2008)

Beginning in 1990, the second year of releases of *L. nigricollis* in RI, Casagrande and colleagues sampled for parasitism at a release site in Ryan

Park in North Kingstown. Samples consisted of 100 leaves, haphazardly selected from a stand of small (ca. 2-4 m) grey birch, *Betula populifolia* Marshall, on the edge of large block of deciduous forest. Individual leaves were plucked (without looking at them) from branches distributed throughout the site from leaves accessible from the ground and were then returned to the laboratory where larvae were removed and dissected. Samples were timed to closely precede larval drop from the leaves for pupation. We did not measure leaf damage until 1996, as until then it appeared that all leaves in the stand were damaged. Beginning in 1996, we noted whether there was any birch leafminer damage to the leaves collected for parasitism measurements. The site was sampled from 1990 to 2008 except for 1992-93 and 2001-03. Leaf damage for 1990 was determined by examining photographs of the sample site taken in late May of that year.

State Surveys in 2007

Surveys were done in 7 states (MA, RI, CT, NY [Long Island only], PA, NJ, DE) (Fig. 1) in May and Jun of 2007 (Table 1). The survey was conducted along roadsides in urban, suburban, or rural residential areas where grey or white (*Betula papyrifera* Marshall) birch trees were present in landscapes or naturally occurring along roadsides. Following haphazard routes in such areas, birch trees were examined when encountered. From each tree, 100 leaves were plucked without looking at them and then examined to determine the number of leaves bearing distinctive *F. pusilla* mines. Leaves with leafminer larvae (from these samples and supplemental samples) were taken to the laboratory and dissected to detect eggs or larvae of *L. nigricollis*. State summaries were

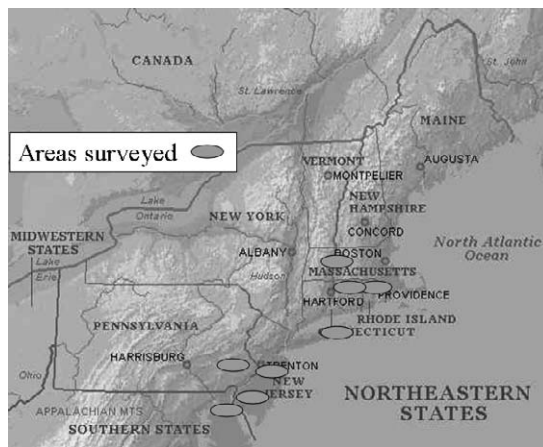


Fig. 1. Areas (ellipses) surveyed for birch leafminer (*Fenusa pusilla*) and its parasitoid *Lathrolestes nigricollis* in 2007.

TABLE 1. PERCENTAGE OF GREY OR PAPER BIRCH LEAVES MINED BY *FENUSA PUSILLA* AND PERCENTAGE OF LEAF MINER LARVAE PARASITIZED BY THE ICHNEUMONID *LATHROLESTES NIGRICOLLIS* IN SEVEN NORTHEASTERN STATES IN 2007.

State	No. sites examined	Sample dates	% leaves mined (# mined leaves/total)	% parasitism (# parasitized/ no. dissected)
MA	40	May 25-28	0.2 (8/4200)	NA (no larvae recovered ¹)
RI	23	May 30-Jun 5	0.5 (7/2300)	NA (1 unparasitized larva recovered)
CT	2	May 31	0.0 (0/200)	NA (no mines)
NY	70	May 20-Jun 20	0.0 (0/7000)	NA (no mines)
PA	5	May 17-Jun 9	0.2 (6/3700)	0% (0/12)
NJ-north ²	14	May 25-29	24.9 (348/1400)	57.9% (114/197)
NJ-south ²	10	May 25-30	84.8 (848/1000)	27.5% (25/91)
DE	5	May 12-21	10.4 (114/1100)	1.2% (5/408)
Total	183		6.4% (1331/20,900)	NA

¹No larvae were recovered to dissect for parasitism because larvae had already emerged from those few mines found.

²Northern NJ defined as 40°NL or above; southern NJ being below 40°NL. The northern third of NJ was not surveyed.

computed as the percentage of leaves with *F. pusilla* mines (summed over all sites) and the percentage of birch leafminer larvae parasitized (summed over all larvae from all sites). One exception to this process was that data from NJ were kept separate by location because strong differences occurred between sites in northern versus southern NJ. For comparison, the state was split into northern (40°NL or above) and southern (below 40°NL) parts.

RESULTS

Birch leafminer populations have come under complete biological control in all areas surveyed above 40°NL (mid-New Jersey). Mined leaves were extremely difficult to find in MA, CT, RI, PA, and NY (Long Island) (Table 1). In these areas, birch leafminer larvae could not be recovered in large enough numbers to estimate rates of parasitism. In New Jersey, density of the pest has been suppressed at most sites north of 40°NL, but south of this latitude, pest densities remain high (Fig. 2). Parasitism in sites above 40°NL (57.9%, 114/197) was approximately double the 27.5% (25/91) rate found in southern NJ. Infestations of birch leafminer at Newark, DE, were highly variable, with the incidence of mined leaves ranging from 0 to 57% on different trees and averaging 10.4%, intermediate between New Jersey and the other states. Parasitism was low (1.2%), but samples were taken when most of the mines were small. Because *Lathrolestes nigricollis* females prefer to attack semi-mature and mature larvae (Eichhorn & Pschorn-Walcher 1993), sample timing may have caused parasitism to be underestimated.

Some insight into the development of control over several decades is available from the repeated sampling of one site in RI, where annual

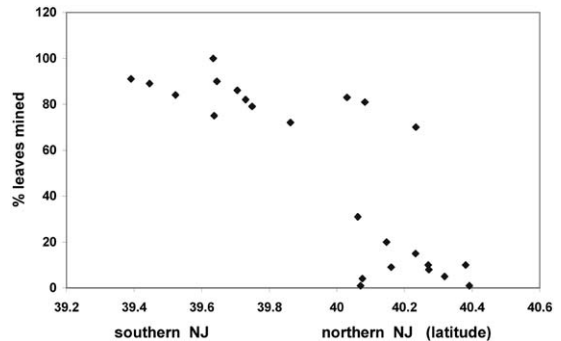


Fig. 2. Percentage of birch leaves mined in 2007 by birch leafminer versus latitude in New Jersey, showing lack of control in southern New Jersey (left) versus much greater pest suppression in northern New Jersey (right).

samples were taken in most years from 1990 to 2008 (Fig. 3), and at this location, it is clear that the percentage of leaves mined fell from about 87% (avg. for 1990, 1996, 1997, 1998) to about 2.6% (average for 2004, 2005, 2006, 2007, and 2008). During this same period, the rate of larval parasitism by *L. nigricollis* rose steadily from an average of 5.5% (1990, 1991, 1992, 1995, and 1996) to a high of 38% in 2004. Thereafter, too few mines were present to obtain larvae to examine for parasitism.

DISCUSSION

Fenusa pusilla, which remained a high-density pest in the northeastern United States throughout the 20th century, has now come under complete biological control in MA, CT, RI, NY (Long Island), PA, and northern NJ due to the intro-

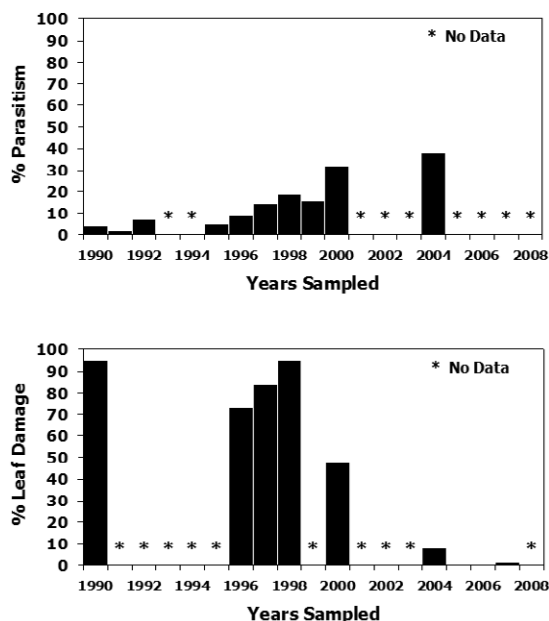


Fig. 3. Percentage of grey birch leaves mined by first generation *Fenusa pusilla* and percentage of larvae parasitized by *Lathrolestes nigricollis* at Ryan Park in North Kingston, RI, between 1990 and 2008. (Years with no bars prior to 2004 are missing data. After 2005, larvae, and hence parasitism, were undetectable).

duced parasitoid *L. nigricollis*. In southern NJ, the pest remains abundant despite relatively high levels of parasitism. In DE, populations of the pest are variable but lower than in southern NJ. However parasitism rates observed in our DE samples were also low. Why the pest has not been suppressed in southern NJ or DE is unknown. In terms of time, these areas have been colonized for a longer period than the more northerly regions where the pest has declined, so it seems unlikely to be merely a transitional phase moving toward control. Poor control by the parasitoid in southern NJ may relate to poor photoperiodic match between the region from which the parasitoid was originally collected (Austria, at 47-48°NL) and our sample areas in southern NJ (<40°NL), or may be due to southern NJ's higher summer temperatures. Mismatch of photoperiod can limit parasitoid impact if adult emergence is not well timed to the availability of the correct host stage, or if the percentages of the parasitoid population that enter diapause in the first and second generations differ from the diapause rates of the pest in the corresponding generations (Nealis 1985; Van Driesche et al. 1997). In DE, scarcity of suitable birch species also may be important. Only 2 species of birch (*Betula lenta* L. and *Betula nigra* L.) occur naturally in Delaware (Taber 1995) and of these, *B. nigra* is not a preferred host for *F. pu-*

silla. Preferred species such as gray birch or European species exist only as planted landscaping trees, and these are often in stressed condition due to climate. Further research is needed in NJ and DE to clarify the importance of these factors.

The results of our surveys illustrate the importance of continued monitoring of a classical biological control project for a very extended period, here 34 years since the first releases. Evaluations on short time scales (3-6 years), typical of many research projects, may be premature and underestimate ultimate impacts of new biocontrol agents.

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