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Introduction, establishment, and impact of *Lathrolestes thomsoni* (Hymenoptera: Ichneumonidae) for biological control of the ambermarked birch leafminer, *Profenusa thomsoni* (Hymenoptera: Tenthredinidae), in Alaska

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HIGHLIGHTS

- A biological control program was established to control the ambermarked birch leafminer (*Profenusa thomsoni*) in Alaska, USA.
- *Lathrolestes thomsoni* was determined to be an effective parasitoid and was mass reared and shipped from Canada to Alaska.
- From 2004 to 2009, a total of 3636 *L. thomsoni* parasitoids were released in Alaska.
- *Lathrolestes thomsoni* wasps were recovered at all nine release sites, suggesting establishment of the parasitoid.

GRAPHICAL ABSTRACT

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ABSTRACT

The ambermarked birch leafminer, *Profenusa thomsoni* Konow (Hymenoptera: Tenthredinidae), was first discovered in Alaska in 1991 but was not correctly identified until 1996 when it invaded Anchorage and became a widespread and damaging pest to forest and urban birches. In 2003, the parasitoid wasp, *Lathrolestes thomsoni* Reshchikov (Hymenoptera: Ichneumonidae), was selected as a candidate for a classical biological control program against *P. thomsoni*. Parasitized leafminer larvae were collected from the Northwest Territories and Alberta, Canada, where it was previously introduced and causing injury to *Betula* spp., and transferred to Alaska in soil as pre-pupae for emergence. From 2004 to 2008, 3636 adult *L. thomsoni* adults were released in birch stands in Alaska. Parasitoids were later recovered at all six release sites in Anchorage and the Kenai Peninsula. While percent leaves mined declined by 30–40% at parasitoid release sites over the period of this study, a similar decline was also observed at paired, non-release long-term monitoring sites. Therefore, the decline in the pest density cannot be ascribed entirely to *L. thomsoni*.

1. Introduction

The ambermarked birch leafminer, *Profenusa thomsoni* Konow (Hymenoptera: Tenthredinidae), is a Palearctic sawfly native to Europe, central Asia, and Japan (Benson, 1959; Smith, 1971). *P.*

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thomsoni is considered a minor pest of birch trees (*Betula* spp.) in Europe and is found only at low densities (Benson, 1950, 1959). *P. thomsoni* invaded North America in the early 1900s and was first recorded in the eastern United States in the 1920s (Smith, 1971), where it never reached high densities. By the 1950s, this leafminer was found throughout Ontario, Canada (Martin, 1960) and the mid-western United States (Benson, 1959; Martin, 1960; MacQuarrie et al., 2007). It is presumed that this spread was by nursery material or spread of adults naturally or in vehicles. Such movement provides opportunities for the host to establish populations in the absence of its parasitoid.

P. thomsoni was found in Alberta by 1970 (Digweed et al., 1997), where it became a significant pest until it came under fortuitous biological control by the wasp *Lathrolestes thomsoni* Reshchikov (Hymenoptera: Ichneumonidae) (then designated as *Lathrolestes luteolator* Gravenhorst) in the early 1990s (Digweed et al., 2003). *P. thomsoni* invaded Haines, Alaska in 1991 (USDA Forest Service, 1992), and high density infestations soon developed around Anchorage (Snyder et al., 2007). From 2003 to 2006, the pest was found throughout the south central region of Alaska, and in 2003, 12,800 hectares of forest was visibly damaged in the Anchorage bowl and Matanuska-Susitna Valley (Wittwer, 2004; Snyder et al., 2007). Infestations also were detected in the Fairbanks area.

P. thomsoni is a parthenogenetic (Benson, 1959), univoltine sawfly, with adults emerging from mid-to-late June in Anchorage (MacQuarrie, 2008). Eggs are laid singly in birch leaves (Martin, 1960; Digweed, 2006), where larvae develop and form blotch-shaped mines (Martin, 1960; Digweed et al., 1997). In Anchorage and Alberta, mature larvae drop to the soil in mid-to-late August, where they form an earthen cell and overwinter as prepupae (Digweed, 2006).

The obvious damage to birch trees is, but infestations may also reduce tree growth and increase susceptibility to pathogens (Hoch et al., 2000; Snyder et al., 2007). In North America, *P. thomsoni* attacks at least 7 native *Betula* species*: Betula aleghaniensis* Britton, *Betula glandulosa* Michx., *Betula lutea* Michx., *Betula neoalaskana* Sarg., *Betula occidentalis* Hook., *Betula papyrifera* Marsh., and *Betula populifolia* Marsh. (Digweed et al., 2009).

In 2003, a highly specialized parasitoid, *L. thomsoni* Reshchikov (previously given as *L. luteolator* Gravenhorst) (Hymenoptera: Ichneumondiae) (Reshchikov et al., 2010) was selected for release in Alaska because it had previously been associated with the collapse of a high density ambermarked birch leafminer population in Edmonton, Alberta (Digweed et al., 2003). Adults of *L. thomsoni* attack 1st to 3rd instar sawfly larvae, laying one or more eggs inside each host (personal obs.). The species is a koinobiont endoparasitoid, and the eggs stay dormant until the host larva pupates (MacQuarrie, 2008). The parasitoid larva overwinters as a late instar, pupating and emerging as an adult in the spring of the following year (Pschorn-Walcher and Altenhofer, 1989; MacQuarrie, 2008).

A population of *P. thomsoni* from Canada was the source of the parasitoid *L. thomsoni* that was released in Alaska, using a combination of parasitized host larvae and adult parasitoids. The goal of this study was to assess the establishment of *L. thomsoni* populations in Alaska, its spread, and impact on leafminer abundance.

2. Materials and methods

2.1. Host collection, parasitoid rearing and release

L. thomsoni parasitoids were collected either as immature stages inside parasitized host larvae in the year preceding their release or as adults in July and August of the year of release. All parasitoids originated from leafminer populations in Canada in Edmonton, Alberta; Edson, Alberta; and Hay River, or Fort Smith, Northwest Territories (Fig. 1).

Most adult parasitoids released in Alaska were reared from parasitized leafminers using techniques modified from Fuester et al. (1984) and described in detail by MacQuarrie (2008). Infested leaves were collected from urban birch trees (located in city parks or landscaped yards) between late July and early September and were placed in net bags inside a large, clear plastic bag (60–70 L) in the laboratory. The bag was hung from the roof and emerging larvae were collected from the bottom of the bag. Emerging larvae were counted daily and placed for pupation in rearing tubs (30 cm L × 45 cm W × 15 cm D) filled to the top with potting soil and sand in a 3:1 ratio where leafminers overwintered. Leafminers in tubs were either overwintered in Alberta and taken to Alaska in the spring, or were transported in fall to Alaska and overwintered there. For overwintering, larval tubs were buried outdoors, covered with leaf litter. In spring, tubs were dug up and placed in outdoor cages (0.5 m × 0.4 m × 0.6 m) screened with mesh fabric (“no-see-um” netting) and located at secure, forested sites in the Anchorage area. Cages were checked daily for insect emergence from the date of installation in mid-June until parasitoid emergence ended, typically around mid-August.

When adults emerged, all *L. thomsoni* wasps were counted, sexed, and then held for release. Adults of *P. thomsoni* were counted and destroyed. Parasitoids were held in paper cups with water and honey in a refrigerator at 5 °C. Parasitoids being held under refrigeration were placed under room temperature (approx. 22 °C) for 1 h each day to allow them to drink water and eat honey. We held parasitoids for a maximum of 5 days or until a minimum of 35 adults were available for release (whichever came first). Time in chill varied from 1 (at the peak of parasitoid emergence) to 5 days.

To supplement parasitoids obtained from rearing, adults were collected from the same populations in Canada from which parasitized larvae were obtained in Alberta and the Northwest Territories. Adult parasitoids (recognized by their distinctive yellow clypeus) were aspirated from mined birch foliage into vials, which were placed in a cooler and taken to Alaska within 36 h. Upon arrival these parasitoids were immediately released onto birch foliage with host mines. From 2004 to 2008, parasitoids were released at 9 sites (Table 1 and Figs. 1 and 2), principally in the Anchorage area.

2.2. Monitoring for parasitoid establishment, spread, and impact on leafminer abundance,

At the seven of the nine release sites, host abundance, parasitoid (*L. thomsoni*) establishment, and parasitoid spread were assessed. Establishment and spread were determined using sweep net sampling to collect adult parasitoids. Host abundance of *P. thomsoni*, which is univoltine in Alaska, was characterized as the percentage of leaves mined in the third week of July and August of each year.

At 20 additional non-release long-term monitoring sites (each a single white birch, *B. papyrifera* Marsh) we measured percent parasitism (based on dissection of host larvae) and percent of leaves mined annually, from 2006 to 2011. These sites were selected on the basis that we would have access to them for a long period of time (in city parks or on public property) and that they would not be sprayed with pesticides for the duration of the study.

2.3. Monitoring for parasitoid establishment

Establishment of parasitoids at release sites was determined using sweep samples taken weekly between 18 June and 24 September 2010. At each site, three sets of 20 sweeps each were