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Dissemination of *Lathrolestes ensator* (Ichneumonidae), a larval parasite of the European Apple Sawfly, *Hoplocampa testudinea* (Tenthredinidae), in Eastern North America

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HIGHLIGHTS

- *Lathrolestes ensator* is a larval parasite of the apple sawfly *Hoplocampa testudinea*.
- From 2002 to 2015 *L. ensator* was disseminated in eastern North America.
- Random samples of these fruitlets were dissected to estimate % parasitized larvae.
- *L. ensator* established in three localities of Quebec and one locality in Ontario.
- *L. ensator* is the only known natural enemy of *H. testudinea* in North America.

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ABSTRACT

The larval parasite *Lathrolestes ensator* Brauns (Hymenoptera: Ichneumonidae) has only one known host, *Hoplocampa testudinea* Klug (Hymenoptera: Tenthredinidae), a pest that attacks only one host: the apple tree. A classical biological program conducted from 1994 to 2001 successfully led to the establishment of *L. ensator* in Frelighsburg, QC, Canada. This paper reports on work conducted from 2002 to 2015 to disseminate *L. ensator* in eastern North America. Each year, fruitlets showing secondary damage of *H. testudinea* were collected in source orchards of Frelighsburg. Random samples of these fruitlets were dissected to estimate % parasitized larvae: the remaining fruitlets were used for releases in apple orchards located in Quebec, Ontario, Nova Scotia and New Hampshire. Collection of fruitlets with secondary damage in participating orchards showed that *L. ensator* successfully established in Quebec in Henryville, Saint-Hilaire, Magog and St-Georges de Windsor, and in Ontario in Hilton. *L. ensator* is the only known natural enemy of *H. testudinea* in North America.

1. Introduction

The European apple sawfly (EAS-Common name in Europe: Apple Sawfly), *Hoplocampa testudinea* Klug (Hymenoptera: Tenthredinidae), originates from Northern Europe (CAB, 1964; Fauna Europaea, 2015). It is a pest of apple (*Malus domestica* Borkh.: Rosaceae) trees of Western Europe (Miles, 1932; Zijp and Blommers, 1993), as well as Turkey (Birkardesler, 1958) and Croatia (Ciglar and Barić, 2002).

Found for the first time in North America in 1939 in Long Island, New York (Pyenson, 1943), it has also been mentioned in Vancouver Island, British Columbia (Downes and Andison, 1942; Downes, 1944). While there are no further mentions of EAS in western North America, it gradually invaded apple orchards of New England States (Garman and Townsend, 1952). In 1979, it was reported for the first time in Canada in Hemmingford, QC (Paradis, 1980). From there, it invaded all major apple producing areas of Quebec (Vincent and Mailloux, 1988). As of 1995, EAS has been observed in the Ottawa Valley, ON (Henri Goulet, pers. comm.), and as far west as Kingston, ON, in 2009 (Margaret Appleby, pers. comm.).

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EAS was first observed in New Brunswick in 1997 (Christopher Maund, pers. comm.), and in 2006 in organic orchards of Nova Scotia (Julia Reekie, pers. comm.). The economic damage caused by EAS is variable and can be considerable. For instance, in a commercial orchard located in Hemmingford, QC, 14% of the apples were damaged by EAS at harvest in 1986 (Vincent and Mailloux, 1988).

Adapted from Miles (1932), Dicker (1954) and Zijp and Blommers (2002a,b), a summary of the biology of the EAS follows. EAS overwinters in a cocoon in the soil, frequently beneath apple tree canopies. Adults emerge in spring and their flight is well synchronized with the bloom stage of apple trees. Females lay an average of 30 eggs, usually one per receptacle, between the bases of stamens and pistils. Eggs hatch after 12–15 days. First instars eat the tissues of the epidermis, leaving a typical ribbon-scar damage (hereafter primary damage) on fruitlets (Fig. 1A). Older instars generally feed somewhat deeper in the tissues of fruitlets or enter a nearby fruitlet and, doing so, leave excrement at the entry of the hole (Fig. 1B). Such fruitlets, bearing secondary damage, typically fall underneath apple tree canopies in June. Fruit with primary damage usually stay on apple trees until harvest.

All (about 25) papers published on natural enemies of EAS involve parasitoids. The first mention of *Lathrolestes ensator* Brauns (Hymenoptera: Ichneumonidae) (Fig. 1C) as a parasitoid of *H. testudinea* is credited to Velbinger (1939, cited *in* Zijp and Blommers, 1993). At the experimental Farm of Pursa in the Baltic region, Tchakstynia (1968) collected 28 *L. ensator* adults (14 males, 14 females) in 1965. In Poland, Dulak-Jarworska (1976) found, in decreasing order of importance, the following parasites from 928 EAS parasitized cocoons collected in 1973 and 1974: *Lathrolestes marginatus* Thomson (Tryphoninae), *Holocremma bergmanni* Thomson (Ophioninae), *Microcryptus abdominator* Gravenhost (Cryptinae), *Thersilochus jocator* Fabricius (Ophioninae), and *Hemiteles aerator* (Cryptinae). Niezborala (1976) reported that 0.2–0.5 to 33.4% of EAS larvae were parasitized by *Lathrolestes citreus* Brischke (Ichneumonidae) in Poland. They found another unidentified parasite whose eggs were encapsulated and melanized, that parasitized 17.7–48.5% of EAS larvae. Jaworska (1987) found 7.6–79.2% larval parasitism by *L. marginatus* in Poland. Controversies related to the correct identification of *L. marginatus* versus *L. ensator* have been treated by Cross et al. (1999) and Zijp and Blommers (2002b). Although several larval parasite species of EAS have been reported in Europe, *L. ensator* is the most common. In the Netherlands, *L. ensator* is the only EAS larval parasite ever found (Zijp and Blommers, 2002b).

Recent publications on *L. ensator* issued from the Ph.D. theses of Babendreier, 1996, 1998, 2000; Babendreier and Hoffmeister, 2003; Zijp and Blommers, 1993, 2002a,b). *L. ensator* is a univoltine larval konobiont parasitoid that has only one known host: *H. testudinea*. Adults emerge a few days following the end of flight activity of *H. testudinea* (Zijp and Blommers, 1993). Females are proovigenic (they have fully developed eggs at emergence) and they are well synchronized with their only known host, probably because of chemical cues emitted by the frass of *H. testudinea* larvae (Boevé et al., 1996). Females carry loads of 125–175 eggs, but rarely lay more than 50% of them. They usually lay one egg per larva, mainly in second instars of EAS (Fig. 1D).

H. testudinea and *L. ensator* share the following characteristics. They 1) are Hymenopterans that originate from Europe, 2) are univoltine, 3) are active as adults in the field for <20 days, 4) spend most of their life cycle and overwinter in the soil, 5) may occasionally diapause for two or three years in the soil, 6) have only one known host, 7) have larvae that are concealed in their host so that

Fig. 1. (A) Ribbon scars (i.e., primary damage) left by first instar European apple sawfly on the epidermis of a fruitlet; (B) Frass at the entry of a tunnel caused by European apple sawfly larvae (i.e., secondary damage); (C) Adult *Lathrolestes ensator*; (D) *Lathrolestes ensator* larva (red arrow) developing inside a third instar European apple sawfly.