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## SHORT COMMUNICATION

**Predation of *Thereva nobilitata* (Fabricius) (Diptera: Therevidae) on *Agriotes obscurus* L. (Coleoptera: Elateridae)**W. G. van Herk<sup>1</sup>, R. S. Vernon<sup>1</sup>, E. M. L. Cronin<sup>1</sup> & S. D. Gaimari<sup>2</sup><sup>1</sup> Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Agassiz, BC, Canada<sup>2</sup> Plant Pest Diagnostics Branch, California Department of Food and Agriculture Sacramento, CA, USA**Keywords**

introduced species, predator, therevid, wireworm

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**Abstract**

Little is known about the natural enemies of wireworms (Coleoptera: Elateridae), but there are frequent anecdotal reports of (usually unnamed) stiletto fly larvae (Diptera: Therevidae) preying on various species. We observed larvae of *Thereva nobilitata* (Fabricius) feeding on larvae of the dusky wireworm, *Agriotes obscurus* L., during the summer of 2011, in Agassiz, British Columbia. This finding is of interest as: both the predator and the wireworm are introduced species to this area from Europe; *T. nobilitata* is uncommon in North America; and this predator has not been associated with any wireworm species previously. We observed that larvae of male and female *T. nobilitata* will feed on various sizes of *A. obscurus* larvae, most feeding being carried out by the smallest *T. nobilitata* larvae. These findings suggest future work should assess the potential for therevid larvae as top-down regulators of *Agriotes* larvae under field conditions.

**Introduction**

Various species of wireworms, larvae of click beetles (Coleoptera: Elateridae), are pests of economic importance on many crops around the world (Vernon and van Herk 2012). In North America, wireworms are becoming increasingly important due to (a) the decline of persistent organochlorine insecticide residues in fields, (b) the replacement of effective insecticides with products (i.e. neonicotinoids and pyrethroids) less toxic to wireworms and, (c) the introduction of three exotic European species from Europe – *Agriotes obscurus* (L.), *A. lineatus* (L.) and *A. sputator* (L.) – particularly into Canada (Vernon and van Herk 2012). Of these species, the dusky wireworm (*A. obscurus*) was introduced into the Agassiz region of British Columbia over a century ago (Wilkinson 1963) and has become a serious crop pest in this and other areas of British Columbia (BC), the American Pacific Northwest and Atlantic Canada (Eidt 1954; Vernon et al. 2001).

There is limited information on the natural enemies of wireworms, but anecdotal reports of stiletto fly larvae (Diptera: Therevidae) preying on various

wireworm species recur in literature. Larval therevids are active predators mainly of coleopteran immatures, move rapidly through friable soils and paralyze prey quickly with a potent venom (Stubbs and Drake 2001); they have also been reported to feed on lepidopteran, dipteran, hymenopteran, orthopteran and neuropteran immatures, as well as earthworms (Collinge 1909; Engel and Cuthbertson 1938; English 1950; Hildebrand 1952; Greathead 1963; Kurir 1977; Gepp and Klausnitzer 2005). Direct observations of therevid larvae feeding on wireworms are limited; however, the species involved are generally unknown. Exceptions are *Cerocatus rufiventris* (Loew) [on *Horistonotus uhlerii* Horn; Tenhet and Howe 1939], *Ozodiceromya argentata* (Bellardi) [on *Limoniuss californicus* (Mannerheim); Stone 1941] and *Thereva egressa* Coquillett (on an unnamed wireworm species; Hyslop 1910). Rabb (1963) and Conradi and Eageron (1914) observed therevids of unknown species preying on *Conoderus vespertinus* (Fabricius) and *Horistonotus uhlerii*, respectively. Rabb (1963) also mentions some *C. vespertinus* larvae fed on the therevid pupae. All other reports of therevids preying on wireworms we have found are anecdotal. We

frequently find therevid larvae together with *A. obscurus* larvae during our field studies and undertook this small laboratory study to determine whether these therevids were predators of wireworms and if so, what species was involved. This knowledge will contribute to our overall understanding of wireworm biology.

## Methods and Materials

During field collection of wireworms at the Pacific Agri-food Research Center (PARC) in Agassiz, BC, in May 2011, a therevid larva was found eating a partially consumed larva of *A. obscurus* in a field of long-term pasture. Four additional therevid larvae were collected from this site (49.24526°N, 121.76208°W) in May and June, 2011. A sixth was collected in late May 2011 in a field in dry land wheat production on the Blood Reserve near Lethbridge, Alberta (49.63845°N, 113.04948°W), associated with a population of *Hypnoidus bicolor* (Eschscholtz). These therevid larvae were kept in separate 550 ml containers with approx. 150 g sandy-clay loam soil (23% moisture w/w) at 14°C. Initially, two therevids were placed in a single container, and one was quickly cannibalized. The remaining five were weighed (Sartorius, model CP-64) on 15 June. Larvae of *A. obscurus* were collected from the same site at PARC in May–June 2011 and added to the five containers with the remaining therevid larvae, between 16 June and 7 August. Each therevid was initially (16 June) provided a small (1.7–6.7 mg), medium (16.1–22.0 mg) and large (27.3–39.8 mg) wireworm, and wireworms that were killed and/or eaten were immediately replaced with one of similar size. Careful excavations of the containers to observe therevid predation and pupation were made weekly throughout June–August. All containers were kept at 14°C until 3 August and at 18°C thereafter.

Immediately after pupation, reared adult specimens were pinned with their respective pupal exuviae, were identified by the last author and were deposited in the California State Collection of Arthropods, Sacramento, California, USA (1♀, 1♂ from BC), and the Canadian National Collection of Insects, Ottawa, Ontario, Canada (1♀, 1♂ from BC; 1♀ from Alberta).

## Results

All five therevid larvae had commenced pupation by 5 August and completed it by 17 August. The four therevids collected in Agassiz, BC, were identified as *Thereva nobilitata* (Fabricius). Of these, the smallest

larva (♂, initial weight: 23.9 mg) killed and partially consumed all three wireworms by 21 June, but did not feed on wireworms provided thereafter. This larva had initially cannibalized another therevid and initiated pupation on 27 July. The second larva (♂, 55.4 mg) consumed only the smallest wireworm by 21 June and began pupation on 20 July. The third larva (♀, 68.4 mg) consumed the medium-sized wireworm by 20 July and began pupation on 27 July, and the fourth larva (♀, 58.0 mg) did not feed on the wireworms provided and commenced pupation on 5 August. The interval between the last observed feeding and start of pupation ranged from 7–36 days, and the duration of pupation was 18–27 days. The larva collected in Alberta (58.5 mg) was identified as a female of *Thereva* sp. (not *T. nobilitata*), did not feed on the wireworms provided and began pupation on 20 July. Therevid feeding was characterized by a piercing of the pleural membranes between the abdominal sclerites, after which the wireworm was hollowed out.

## Discussion

*Thereva nobilitata* is an introduced species in North America first reported in 1970 and hitherto known only for the Vancouver, BC, area (Holston and Irwin 2005). The species is widespread throughout western Europe, from where it was likely introduced (Webb et al. 2013). Introductions of both *T. nobilitata* and *A. obscurus* were likely made with nursery stock that arrived with large quantities of bagged soil prior to 1965 or in the soil ballast of commercial sailing vessels in the late 1800s (Spence and Spence 1988; Wilkinson 1963). The larvae of *T. nobilitata* are described by Collinge (1909) and with much greater detail by Engelhardt (1916). General therevid rearing methods are described by Owen (1993), Holston (2005) and Stubbs and Drake (2001), although there are many other rearing accounts and observations in older literature. Therevid larval ecology is generally poorly described and for most species remains unknown (Stubbs and Drake 2001). For *T. nobilitata*, Collinge (1909) reported an observation of predation on small earthworms and reared larvae on weevil larvae in the genus *Ceuthorrhynchus* Schonherr.

This is the first record of *T. nobilitata* feeding on a wireworm. Larvae of both males and females fed on various sizes of *A. obscurus* larvae, and most feeding was observed by the smallest therevid larvae. The pupation of the non-feeding *T. nobilitata* larva suggests a larval weight of approx. 55 mg is sufficient for this species to pupate. These observations also suggest

*T. nobilitata* larvae is a potential regulator of *A. obscurus* populations in the field. In other species, nearly mature, field-collected *Ozodiceromya argentata* larvae consumed an average of 3 (up to 9) *Limoniuss californicus* larvae in 50 days (Stone 1941). Looking at predation of other beetle groups, in this case weevils, larval *Thereva candidata* Loew and *Cerocatus rufiventris* (Loew) each consumed on average more than four *Smicronyx fulvus* LeConte larvae in overwintering cages, which represented a mortality rate of up to 5.1% for the weevil based on expected adult emergence (Pinkham and Oseto 1987).

The little that is known about therevid predators of wireworms and their apparent common occurrence as wireworm predators suggest further research should be conducted to improve our understanding of their possible role in reducing wireworm populations in the field. Ideally, such studies would observe therevid interaction with wireworms under a variety of conditions (e.g. soil moisture, temperature, size of predator and prey, presence of other potential prey). As *Thereva* sp. are generalist predators (Stubbs and Drake 2001) and the feeding of *T. nobilitata* on *A. obscurus* reported here was under no-choice laboratory conditions, the incidence of predation on wireworms by this species in the field would need to be assessed (e.g. with molecular gut content analysis) (Pompanon et al. 2012; Traugott et al. 2013). As both *T. nobilitata* and *A. obscurus* were introduced to the Fraser valley of BC from Europe, it is also of interest to determine whether this predator accompanied the wireworm and what will happen to its distribution as *A. obscurus* continues to spread to new areas in North America.

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