Discovery of the tachinid *Triarthria setipennis* (Fallén) in Ottawa, Ontario, with notes on parasitism of the European earwig

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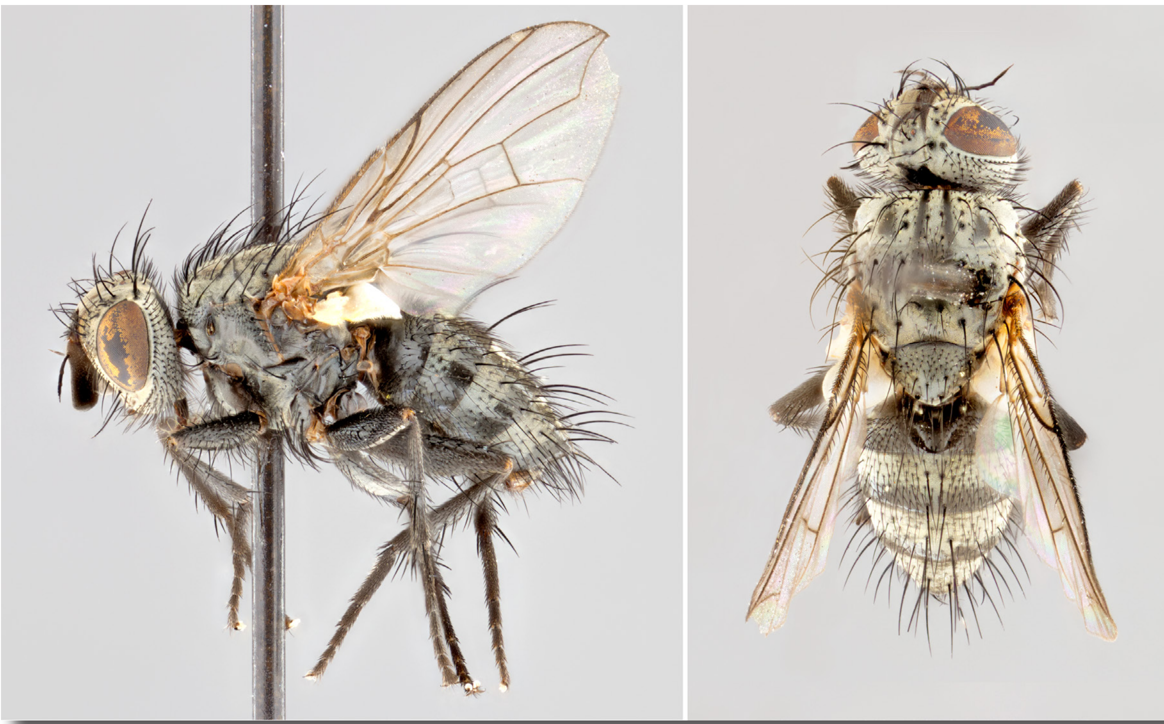


Figure 1. Lateral and dorsal views of a male *Triarthria setipennis* caught in Ottawa, Ontario in a Malaise trap on 19 June 2016 (CNC specimen number CNC557460).

Introduction

The European earwig, *Forficula auricularia* Linnaeus (Dermaptera), was accidentally introduced into North America early in the 1900s (Clausen 1978). It is now widespread throughout the continent and is locally common in parts of its range. It is an omnivorous species that favours dark and moist places and is most active at night. Earwigs can cause economic losses when they infest agricultural products but they are more commonly an annoyance around the home because of their propensity to creep into houses, invade patios, and disperse throughout gardens in search of food and shelter (Kuhlmann *et al*. 2002). There is a wide variety of insecticides, traps, and home remedies for earwig control.

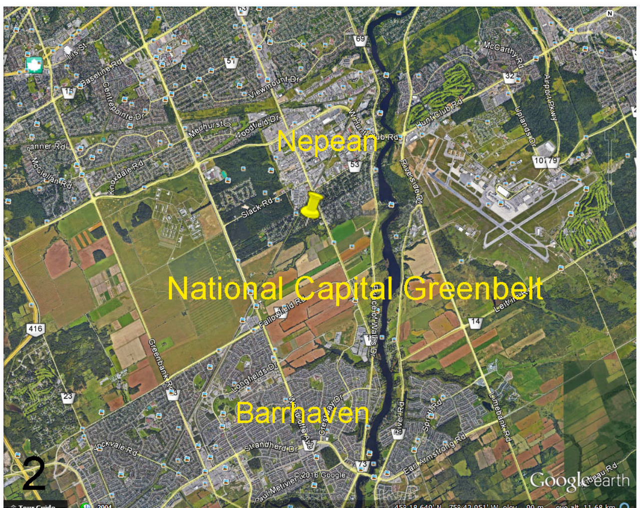
Two tachinids, *Triarthria setipennis* (Fallén) and *Ocytata pallipes* (Fallén), attack the European earwig within its European homeland and both were introduced into North America beginning in the 1920s (Clausen 1978). Only the former became established and through additional introductions and dispersal—presumably by humans and natu-

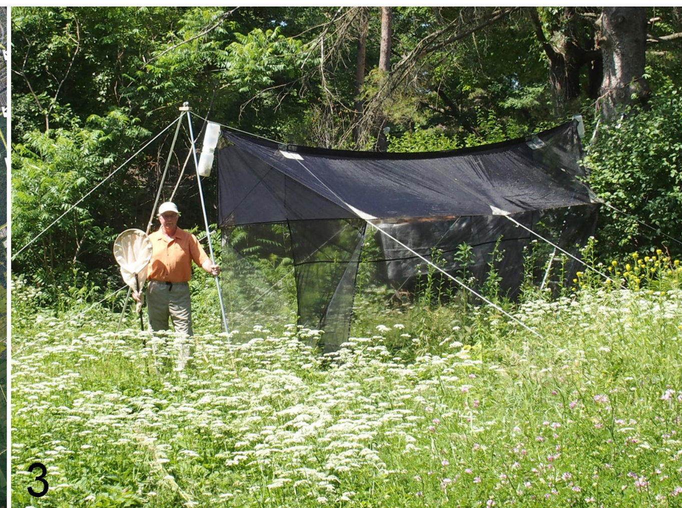
[1] http://bugguide.net/node/view/864396

[2] http://www.boldsystems.org/index.php/Public_SearchTerms?query=Triarthria

rally—is now recorded in the literature in the East from Newfoundland, New Hampshire, and Massachusetts and in the West from British Columbia south to California and inland to Montana and Utah (O'Hara 1996, O'Hara & Wood 2004). The true distribution of this parasitoid is clearly broader than these records suggest because the Internet site BugGuide has pictures of it from Wisconsin taken in 2013 and several records of it from southern Ontario, based solely on DNA barcodes (and without pictures), exist in the Barcode of Life Database (BOLD). The distribution of *T. setipennis* might well be transcontinental or nearly so in temperate North America. This is not surprising given that its host is readily transported by humans by a variety of means and new populations of *T. setipennis* could become established relatively easily in places where there are suitable conditions and a resident host population. This scenario of *Triarthria* expanding its geographic range is analogous to the sowbug (woodlouse) parasitoid *Stevenia deceptoria* (Loew) (Rhinophoridae) that was recently reported from Ohio by O'Hara *et al*. (2015).

We report here records for *T. setipennis* from Ottawa, Ontario. This is based on both wild-caught adults and parasitized European earwigs. This is the first report of *T. setipennis* for Canada based on examined specimens since the release and establishment of the species in British Columbia and Newfoundland. We also report that all specimens were of the light-coloured morph of *T. setipennis sensu* Kuhlmann (1992, 1995).





Figures 2–3. 2. Google Earth image showing the location of the Malaise trap (yellow pin) used in this study. The trap was situated on private property adjacent to the National Capital Greenbelt, a band of green space with woodlands, wetlands and farmland separating urban Ottawa from the suburbs of greater Ottawa. Woodland appears as dark green, farmland as light green or brown. **3**. The 6-metre Malaise trap shown *in situ* with JEOH for scale (photo taken on 24 June 2016).

Materials and Methods

Malaise trapping

All non-reared *T. setipennis* reported in this study were captured in a large 6-metre Malaise trap purchased from BioQuip Products Inc. (https://www.bioquip.com/search/DispProduct.asp?pid=2877). It was situated on private property on the southern edge of Ottawa in the urban community of Nepean at coordinates 45°19.02′N 75°43.20′W and at an elevation of 90m (Fig. 2). This is an urban property of one-quarter hectare with mature trees along the sides and it backs on to the National Capital Greenbelt (http://www.ncc-ccn.gc.ca/places-to-visit/greenbelt). On the south side of the property line is a 200m wide strip of mixed forest with a small stream and a 3m wide pathway passing through it. The pathway is lined with wildflowers in the summer and likely acts as a flight way for flying insects. South of this strip of woodland is a 2 km wide area of intensive agriculture including regular applications of fertilizers and pesticides during the growing season.

The Malaise trap was set up in late April 2016 and operated continuously until 11 October 2016 except for the period from 28 July to 19 August when it was used elsewhere. One end of the trap was attached to the trunk of a mature white pine (*Pinus strobus*) and the other end extended eastward into an open area dominated by a progression of wild flowers throughout the summer (Fig. 3). Two collecting heads were used for the first few days (one at each end) but the head next to the tree caught so few insects that its use was quickly discontinued. The single head was usually run "dry" with a piece of Ortho® Home Defense Max No-Pest® Insecticide Strip as the killing agent and a few strips of paper towelling to help prevent the larger insects from damaging the smaller ones. The collecting head was removed after dusk and reattached early the next morning to avoid capturing large quantities of moths. Tachinids were sorted and pinned daily or kept in a freezer and pinned a day or so later. Not all specimens of the commonest species, including *T. setipennis*, were kept from each day's catch. Each retained specimen was pinned, databased, and provided with a label giving the locality, date, collector and a unique identifier code linking its particulars to a record in the specimen database of the Canadian National Collection of Insects (CNC), Ottawa. This regular routine of daily sampling was interrupted twice, once during the period mentioned above when the trap was used elsewhere, and again from 23 September to 8 October when the trap was unattended but fitted with a collecting head filled with 95% EtOH. At the end of this period the head was emptied and the contents sorted. *Triarthia setipennis* and other tachinids from this sample were mounted from alcohol using the method described by O'Hara (1994b), then databased and labelled in the same manner as tachinids that were pinned fresh.

Earwig parasitism

Over the course of the summer of 2016, from June 14 to September 16, earwigs were collected on an irregular basis by the authors and a small team of friends, neighbours and family members. Earwigs were collected from various sites within greater Ottawa and from one community (Centreville) about 140 km southwest of the Malaise trap location (Table 2). They were found by searching dark, damp places where earwigs generally spend the day, such as under rocks, logs, and loose bark, and in and around patio furniture. More than half of the earwigs collected at the Nepean 1 site were found either alive on the mesh of the Malaise trap or dead in the collecting head. Some earwigs were kept alive in cages in the Diptera Unit of the CNC while others were killed and preserved in 75% ethanol. These preserved earwigs were later dissected and examined for signs of parasitism. Live earwigs from different collections were placed in separate cages and supplied with food and water. The first earwigs were provided with a variety of food items (Fig. 4) following Kuhlmann (1995) but this was soon changed to dry dog food (we used Kirkland's Nature's Domain Turkey Meal & Sweet Potato Formula) that was found to be satisfactory for earwig rearing by Carroll & Hoyt (1984) and others. Cages were examined frequently for the presence of puparia or adult flies. Tachinid puparia and adults were stored in a freezer and later mounted on pins, labelled, curated into the CNC Tachinidae collection, and databased into the CNC specimen database. Earwigs were kept in cages for several days to three months and then killed by freezing, dissected, and examined for signs of parasitism.

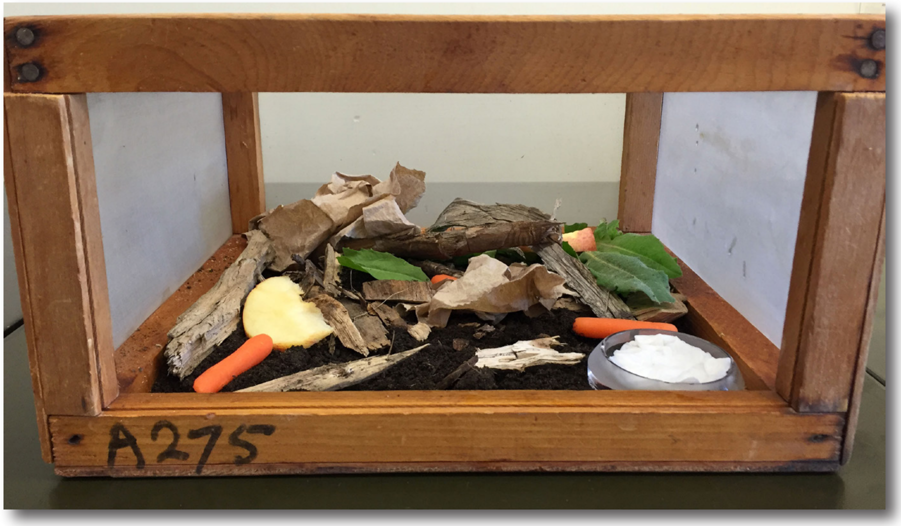


Figure 4. One of the cages used to rear earwigs.

Results

Malaise trapping

Triarthria setipennis was one of the more common tachinid species caught in the Malaise trap over the course of the summer of 2016. The earliest specimen was caught on May 31 and the last during the period of 23 September to 8 October. A total of 49 specimens of both sexes were pinned, labelled and databased, and the dates of collection of these specimens are shown in Table 1. Additional specimens caught on days when *T. setipennis* was common in the sample were not counted and were discarded. *Triarthria setipennis* was especially common during the second half of June and into early July. Although data is lacking for July 28 to August 19, *T. setipennis* was caught occasionally after this time in both August and September, establishing that adults are most likely present and active throughout the summer in the Ottawa area. All examined specimens were of the light-coloured morph of Kuhlmann (1992, 1995).

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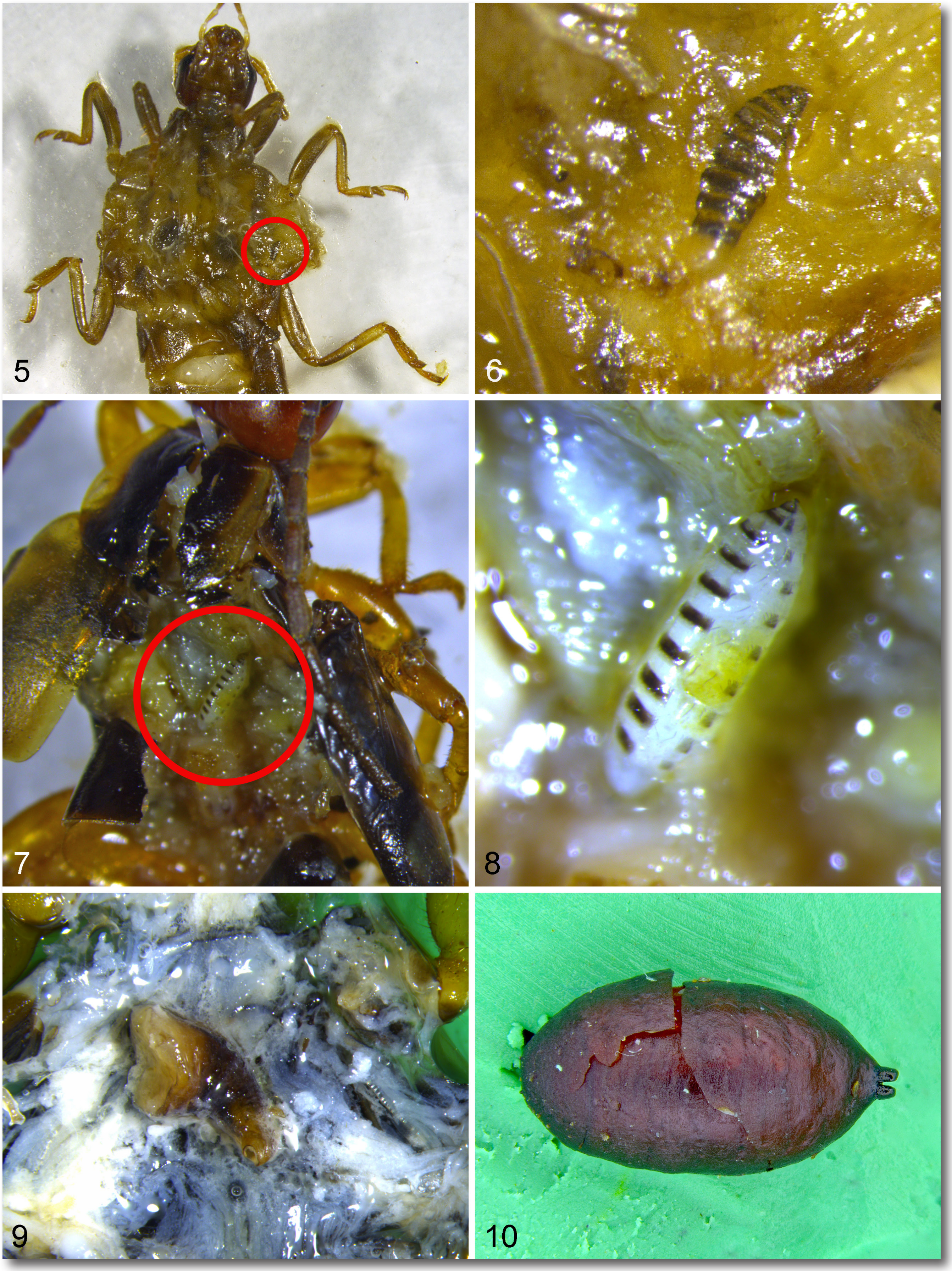
Table 1. Dates during May to September in 2016 when *T. setipennis* was captured in the Malaise trap. The trap was not in use during the period shown in light blue. It was generally run "dry" but 95% EtOH was used for the single sample covering the period of 23 September to 8 October.

Earwig parasitism

A total of 256 earwigs were examined throughout the course of this study (Table 2). Of this number, 145 were placed in 75% EtOH immediately or soon after collection and 111 were kept alive in cages for several days to three months. Seven incidences of parasitism were detected, representing parasitism rates of 0 to 6.5% among the seven sampled sites.

Location	Coordinates	Collection dates	No. of earwigs	No. of earwigs reared	No. parasitized	% parasitism
Ottawa, Nepean 1[1]	45°19.02′N 75°43.20′W	27.vi–7.ix.2016	50	0	0	0
Ottawa, Nepean 2[2]	45°19.01′N 75°43.22′W	4–29.vii.2016	31	7	2	6.5%
Ottawa, CEF[3]	ca. 45°23.4′N 75°43.0′W	21.vi–20.viii.2016	25	22	1	4.0%
Ottawa, Spadina Ave.	ca. 45°24.2′N 75°43.2′W	10.vii.2016	67	0	0	0
Ottawa, Barrhaven	45°16.00′N 75°45.59′W	13.vii.2016	17	17	1	5.9%
Ottawa, Osgoode	45°8.46′N 75°36.07′W	14.vi–17.vii.2016	61	61	3	4.9%
Centreville	44°24.31′N 76°54.59′W	19.vii.2016	5	4	0	0
Range/Totals		**14.vi–7.ix.2016**	256	111	7	0–6.5%

Table 2. Rates of parasitism of European earwigs by *T. setipennis* are shown for six locations within greater Ottawa and one location (Centreville) farther south. Earwigs that were not reared were killed in 75% EtOH and later examined for signs of parasitism.
[1] Malaise trap location.
[2] Property adjacent to Nepean 1.
[3] Central Experimental Farm (where the CNC is located), various locations.



Figures 5–10. 5. First instar of *Triarthria setipennis* (circled in red) in the thorax of a European earwig. **6.** Enlarged view of first instar in Fig. 5. **7.** First instar of *T. setipennis* (circled in red) in the thorax of an earwig. **8.** Enlarged view of first instar in Fig. 7. **9.** A respiratory funnel of a *T. setipennis* larva in the thorax of an earwig. **10.** Puparium of *T. setipennis* discovered in an earwig cage.

Details about each incidence of parasitism are as follows (in chronological order based on date of collection):

1. A live adult *T. setipennis* was found on August 2nd in the cage with earwigs collected from the Osgoode site on July 3rd. The puparium was not found.
2. A respiratory funnel of a *T. setipennis* larva was found in the thorax of an earwig collected from the Osgoode site on July 3rd and killed on October 4th (Fig. 9).
3. A first instar of *T. setipennis* was found in the thorax of an earwig collected from the Nepean 2 site on July 4th and killed on July 8th (Figs. 5–6).
4. A respiratory funnel of a *T. setipennis* larva was found in the thorax of an earwig collected from the Barrhaven site on July 13th and killed on October 17th. No larva was found in the earwig and no puparium or adult fly was found in the cage.
5. A live adult *T. setipennis* was found on August 8th in the cage with earwigs collected from the Osgoode site on July 17th. The puparium was not found.
6. A first instar *T. setipennis* was found in the thorax of an earwig collected from the Nepean 2 site on July 25th and killed that day (Figs. 7–9). This larva was larger than the one in (3) above but it was clearly a first instar based on the shape of the cephaloskeleton.
7. A puparium of *T. setipennis* was found in the cage with earwigs collected from the CEF site between August 10th and 20th (Fig. 10). An adult fly did not eclose. The puparium was not discovered until the cage was terminated in November.

Discussion

This study documents for the first time the presence of *T. setipennis* in the Ottawa area. We cannot say for sure how long it has been in the area, but former Ottawa dipterists who collected frequently in the area up until a decade ago, in particular D.M. Wood and J.R. Vockeroth, did not come across the species. A small release of *T. setipennis* in Ottawa in 1992 (O'Hara 1994a) was thought to have failed in establishing the species, but no special monitoring of earwig populations was undertaken in the years following the release. We cannot rule out the slim possibility that the release was successful. Regardless of whether *T. setipennis* was successfully introduced into Ottawa or arrived here by other means, the lack of any specimens of it in the CNC prior to last summer (2016) suggests that it has not been in the area for many years.

Ours was not a rigorous experimental study of *T. setipennis* biology, but it did establish, as expected, the European earwig as a host for the Ottawa population of this species. We detected parasitism at four sites in the Ottawa area even though a relatively low number of earwigs were examined. Rates of tachinid parasitism are typically dependent on a number of factors and fluctuate from year to year and from place to place, so the rates reported here (0 to 6.5%) from a few sites during one summer may not be representative of "typical" parasitism for the region. A large scale study conducted over three years in central Europe by Kuhlmann (1995) found that parasitism rates of *T. setipennis* in the European earwig were generally in the range of 0–13%, although one sample had a rate of 20.7% and another 46.9%.

The present study provides data on an interesting morphological aspect of *T. setipennis*. Current authors recognize *T. setipennis* in Europe as a single species (e.g., Cerretti 2010, Tschorsnig *et al*. 2013), although it has a dark and light colour morph. The former has a broad black vitta antero-medially on the dorsum of the thorax and the latter has two narrow black vittae in place of a single broad one (cf. images in plate II D–E in Kuhlmann 1992 and drawings in fig. 3 in Kuhlmann 1995). Some earlier authors (e.g., van Emden 1954) recognized the dark morph as *T. setipennis* and the light morph as *T. spinipennis* (Meigen). Kuhlmann (1992, 1995) found differences in the biology of the two morphs, and though he treated both as *T. setipennis*, he had some reservations in doing so (see also Kuhlmann *et al*. 2002). He realized that the biological differences in the morphs might have implications for the broader establishment of the species in Canada, writing (Kuhlmann 1995: 515): "It could be possible that both morphs of *Triarthria* were previously introduced to Canada. If this is the case then long-term field studies should be conducted to determine which morph is the best adapted." We found only the light morph during our study (Fig. 1).

Acknowledgements

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