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First report of *Harmonia axyridis* Pallas being attacked by *Dinocampus coccinellae* Schrank in Canada

Annabelle Firlej[1,2,*], Guy Boivin[2], Éric Lucas[1] & Daniel Coderre[1]
[1]*Université du Québec à Montréal, Succursale Centre-ville, C.P. 8888, Montréal (Qc), Canada H3C 3P8;* [2]*Agriculture et Agroalimentaire Canada, Centre de Recherche et de Développement en Horticulture, 430, Boul. Gouin, St-Jean-sur-Richelieu (Qc), Canada J3B 3E6;* **Author for correspondence (Agriculture et Agroalimentaire Canada, Centre de Recherche et de Développement en Horticulture, 430 Blvd. Gouin, St-Jean-sur-Richelieu (Qc), Canada J3B 3E6; e-mail: firleja@agr.gc.ca; fax: +1-450-346-7740)*

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Abstract

Field parasitism of two lady beetles, a recently introduced species, *Harmonia axyridis* Pallas, and an indigenous species, *Coleomegilla maculata lengi* Timberlake, by *Dinocampus coccinellae* Schrank (Hymenoptera: Braconidae) was investigated in southwestern Québec. Adult coccinellids were sampled from June to September 2001 in alfalfa and corn fields. Parasitism rates were recorded by dissection and rearing of coccinellids in controlled condition. The average proportions of coccinellids with a parasitoid larva were 4.6% for *H. axyridis* and 32% for *C. maculata* but 0% of the *H. axyridis* and 5.9% of the *C. maculata* were successfully parasitized. In July, more *C. maculata* than *H. axyridis* were found to be parasitized and among all individuals dissected, *C. maculata* were more frequently found superparasitized than *H. axyridis*. Our results suggest that *D. coccinellae* is not well adapted to *H. axyridis* in Quebec. This is the first mention of *H. axyridis* being attacked by *D. coccinellae* in Canada.

Classical biological control, the introduction of non-indigenous species to control exotic pests, has been used in North America for over 100 years but with variable success. The introduction of exotic species can have both ecological and genetic impacts on native communities (Simberloff and Stiling 1996; Mooney and Cleland 2001; Sakai et al. 2001; Lee 2002). An exotic coccinellid, *Harmonia axyridis* Pallas, was introduced in the United States from Asia in 1916 and repeatedly from 1979 to 1986 (Tedders and Schaefer 1994). A few years after its re-introduction, *H. axyridis* was established in southeastern United States (Chapin and Brou 1991) and spread up to northeastern United States and Quebec where it was first observed in 1994 (Coderre et al. 1995). There are still some doubts on which *H. axyridis* population get established in North America and accidental seaport introduction remains possible (Day et al. 1994). This species has invaded several habitats and exerts a strong pressure on both native and exotic coccinellid species through intraguild predation (Cottrell and Yeargan 1998; Burgio et al. 2002) and competition by exploitation (Brown and Miller 1998; Colunga-Garcia and Gage 1998). *Harmonia axyridis* is also considered as a nuisance in North America because it overwinters in houses and buildings causing structural damage and unpleasant odour and allergies (Tedders and Schaefer

1994; Nalepa et al. 1996; Yarbrought et al. 1999).

While native natural enemies are not expected to affect the establishment and dispersion of exotic species in the early stage of invasion, they could later reduce the impact of an exotic species by regulating its populations through local adaptation (Crawley 1989; Shea and Chesson 2002). Therefore, parasitism rate of native natural enemies present in the geographical range of *H. axyridis* establishment could potentially increase locally. Only two parasitoid species were recorded to attack *H. axyridis* in North America: the Diptera *Strongygaster triangulifera* (Loew) and the Hymenoptera *Dinocampus coccinellae* Schrank (Nalepa et al. 1996; Katsoyannos and Aliniazee 1998; Hoogendoorn and Heimpel 2002; Nalepa and Kidd 2002). *Strongygaster triangulifera* is an indigenous North American parasite of Coleoptera (Thompson 1954) and to a lesser extent of Lepidoptera, Dermaptera and Hemiptera (Sabrosky and Braun 1970). It successfully emerged from 4% of *H. axyridis* adults in North America (Katsoyannos and Aliniazee 1998; Nalepa and Kidd 2002). In central Canada (Ontario), its presence was recorded on *Coleomegilla maculata lengi* Timberlake and *Coccinella trifasciata perplexa* Mulsant (Smith 1960) but no parasitism on *H. axyridis* was mentioned in Ontario and Quebec.

Dinocampus coccinellae is a generalist parasitoid of nearctic and palearctic coccinellids (Hodek and Honěk 1996) and in North America, *C. maculata* is its preferred host (Hudon 1959; Smith 1960; Parker et al. 1977; Obrycki and Tauber 1979). Parasitism of *H. axyridis* by *D. coccinellae* has rarely been recorded in North America (Nalepa et al. 1996; Hoogendoorn and Heimpel 2002) or Japan (Maeta 1969) and Hoogendoorn and Heimpel (2002) suggest that *H. axyridis* represents an egg-sink for *D. coccinellae* because of a high rate of unsuccessful development. The recent establishment of *H. axyridis* in Canada in 1994 represents an opportunity to study the evolution of the host-parasitoid relation between *H. axyridis* and *D. coccinellae*. In this study, we report field parasitism rates of *D. coccinellae* on the native species *C. maculata* and the exotic species *H. axyridis* in Québec. We predict that parasitism of *H. axyridis* should be lower compared what is observed in the native host *C. maculata* because of the relative novelty of the association with *H. axyridis*.

From June to September 2002, adults of *H. axyridis* and *C. maculata* were collected once per month in three different fields of two of the most abundant crops in the Montérégie area (Québec): alfalfa (*Medicago sativa* L.) and corn (*Zea maïdis* L.). Alfalfa fields were sampled from June to July, and corn fields from August to September because of the differential abundance of aphids. From 3 to 30 km separated each fields depending of the locality. Coccinellids were collected with a vacuum by random sampling of plants situated from the edge to 50 m inside fields. Occasionally, coccinellids were also captured on various weeds in the edge of those fields (*Asclepias syriaca* L., *Taraxacum officinale* Weber, *Dactylis glomerata* L., *Trifolium repens* L., *Phalaris arundinacea* L., *Bromus inermis* Leyss, *Phleum pratense* L., *Daucus carota* L.).

In each field, the collect was stopped when 100 adults of each species of coccinellids were collected or until 2 h were elapsed. As the presence of eggs or larvae of *D. coccinellae* in coccinellid adults is impossible to detect by visual observation of adults, the total parasitism by *D. coccinellae* was determined by dissection and the successful parasitism by rearing the captured adults. Half the adults collected were then frozen at −10 °C and dissected under a stereomicroscope (×200) to record the presence and number of *D. coccinellae* eggs or larvae and the presence of black larvae (dead). The others were reared to determine the successful development of *D. coccinellae*. These adults were reared in plastic boxes (270 ml) and provided with pollen, artificial diet (Coderre, unpublished), aphids *Acyrthosiphum pisum* (Harris) and water at 20 ± 2 °C. The presence of parasitoid cocoons was monitored every 2 days and the experiment was stopped after 30 days at which time the development of *D. coccinellae* should have been completed (Wright and Laing 1978; Obrycki 1989).

Chi-squares were performed to compare the total and the successful parasitism rate obtained between *H. axyridis* and *C. maculata*. We performed also chi-squares to compare the observed percentage of coccinellids with more than one larva to expected (Sokal and Rholf 1981).

Table 1. Monthly data on parasitism of *H. axyridis* and *C. maculata* by *D. coccinellae* after dissection. Parasitism rates were compared between species within a month with a χ^2-test ($P < 0.05$).

Month	*H. axyridis*	*C. Maculata*	χ^2	*P*
June	6.00 ± 23.90	27.50 ± 44.76	10.377	0.0013
July	2.97 ± 17.06	55.04 ± 49.94	70.377	< 0.0001
August	2.67 ± 16.16	40.48 ± 49.68	48.150	< 0.0001
September	7.24 ± 8.26	16.00 ± 36.78	2.426	0.1193

The numbers of adults dissected and reared were respectively 453 and 489 for *H. axyridis* and 521 and 472 for *C. maculata*. The total parasitism rate for *H. axyridis* (4.6%) was significantly lower than for *C. maculata* (32.1%) ($\chi^2 = 117$; df = 1, 972; $P < 0.0001$). The successful parasitism rate was also significantly lower for *H. axyridis* (0%) than for *C. maculata* (5.9%) ($\chi^2 = 25.1$; df = 1, 972; $P < 0.0001$). Superparasitism (when more than one larva of *D. coccinellae* were present in a host) was found in 30.5% of the parasitized *C. maculata*, and in only 4.8% of the parasitized *H. axyridis*. The observed percentages were not different from those expected (30.8% and 4.4% respectively) ($\chi^2 = 1.02$; df = 1, 103; $P = 0.989$). A maximum of five larvae were observed in *C. maculata*. Significant differences in the level of total parasitism between *H. axyridis* and *C. maculata* appeared in June, July and August but, in September, rates were similar for the two species (Table 1). The maximum total parasitism for *C. maculata* occurred in July with 55%.

Our results confirm that *C. maculata* is an important host for *D. coccinellae* (Hudon 1959; Obrycki and Tauber 1979; Obrycki et al. 1985). The rate of total parasitism of *C. maculata* that we observed (32.1%) is higher than in the studies of Parker et al. (1977) (11%) and Hoogendoorn and Heimpel (2002) (17.4%). These differences stress the fact that there are considerable variations in the parasitism of *D. coccinellae* according to the localities and the season sampled (Hodek 1973).

We have observed parasitoid larvae surrounded by a thick melanic capsule or dead larvae with melanic spots on their body that could be the result of immunological reactions activated by the host. However, because of the low level of reaction both in *H. axyridis* (1.8%) and in *C. maculata* (7.1%) these reactions are not an important factor in reducing the successful parasitism rate.

Although *D. coccinellae* attacks more than 40 coccinellid species in the world, some variation appears in the degree of parasitism observed on those different species. All hosts are not equally suitable for the development of *D. coccinellae*. *D. coccinellae* does not seem to be well adapted to the Quebec population of *H. axyridis* as indicated by the low parasitism rate (4.9%) observed in Quebec. This level of parasitism is lower than what has been observed in Minnesota by Hoogendoorn and Heimpel (2002) (23.8% in 1999 and 8.9% in 2000).

All *D. coccinellae* immatures were unable to develop successfully in *H. axyridis* which support the hypothesis of Hoogendoorn and Heimpel (2002) that *H. axyridis* represents an egg-sink for *D. coccinellae* eggs and at the moment *D. coccinellae* has no impact on *H. axyridis* population. However, it is likely that parasitism of *H. axyridis* by *D. coccinellae* will evolve and eventually result in higher rates and successful larval development. The abundance of *H. axyridis* in Quebec, its competitivity in the coccinellid guild and its availability as a potential host are all factors that could act on the probability that *D. coccinellae* will eventually parasitize successfully this species.

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