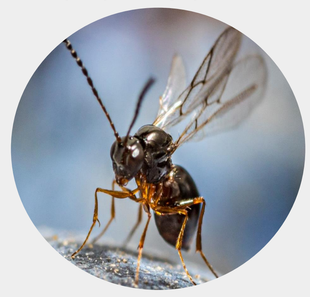
Will introduced SWD parasitoids be able to survive cold Eastern Canadian winters?

Ariane Vossen[12], Jacques Brodeur[2], Simon Legault[2], Paul K. Abram[3], Annabelle Firlej[1]

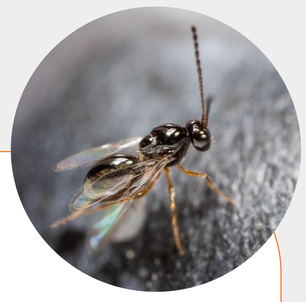
(1) Institut de Recherche et Développement en Agroenvironnement (IRDA), St-Bruno-de-Montarville, Québec, Canada
(2) Université de Montréal, Institut de Recherche en Biologie Végétale (IRBV), Montréal, Québec, Canada
(3) Agriculture and Agri-food Canada, Agassiz Research and Development Centre, Agassiz, British-Columbia, Canada

Drosophila suzukii

Leptopilina japonica



Ganaspis brasiliensis



Photos: Warren Wong

Background

- Spotted wing drosophila (SWD; *Drosophila suzukii*) is an Asian vinegar fly that has been an important berry pest in North America for the past decade[1].
- Two Asian larval parasitoids have been identified as potential biological control agents: ***Leptopilina japonica*** and ***Ganasapis brasiliensis*** (Hymenoptera : Figitidae)[2].
- These species have been established in British Columbia since 2019. They can overwinter in this region which has relatively mild winters, compared to Québec's colder winters in the Eastern Canada[3]. Curently, there are no records of these parasitoids in Québec.
- *Leptopilina japonica* enters winter diapause using temperature, not photoperiod, as a seasonal cue; the relative importance of photoperiod versus temperature is not clear for *G. brasiliensis*[4].
- The ability of these parasitoids to survive in Eastern Canada will depend on whether the seasonal cues to enter diapause in the fall are present, and whether they can tolerate much lower winter temperatures.

Objective

Determine the capacity of *G. brasiliensis* and *L. japonica* to **survive cold Eastern Canadian winters** in the province of Québec to indicate whether they might be able to establish, either from intentional releases (*G. brasiliensis*) or from the spread of adventive populations (*L. japonica*).

How?

- By studying their **seasonal cues for entering winter diapause** with lab and field experiments.
- By conducting a **winter survival** experiment with diapausing parasitoids in two different outdoor locations in the province of Québec.

1. Diapause Induction

Determine the influence of **temperature** and **photoperiod** on diapause initiation.

Experimental Conditions:

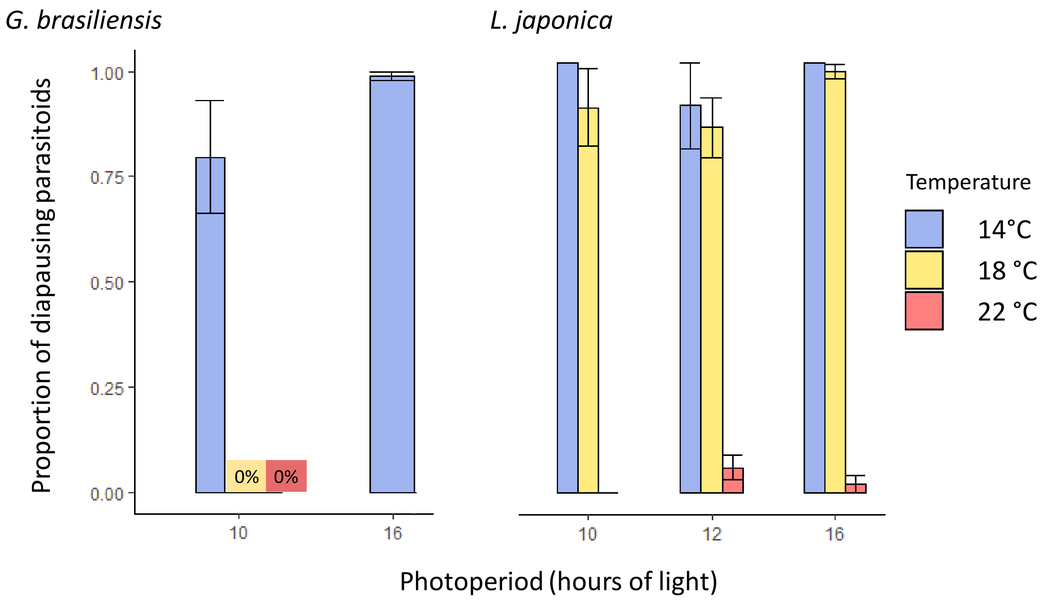
- Photoperiod: Light (L): Dark (D)
  - 10L:14D
  - 12L:12D
  - 16L:8D
- Temperature: 14°C, 18°C and 22°C

Observations intervals were based on predicted adult parastioid emergence times in a published degree-day model[5].

Statistics: GLM with binomial error distribution

$G.brasiliensis$: $(\mathrm{GLM}, X^2_{1,16} = 0.63, \mathrm{p} < 0.001)$;
L. japonica: $(\mathrm{GLM}, X^2_{4,82} = 33.12, \mathrm{p} < 0.001)$

Incidence of diapause when reared under different temperature and photoperiodic conditions



Diapause induction were observed only at **14°C** for *G. brasiliensis* and at **14°C and 18°C** for *L. japonica.*

Ganaspis brasiliensis: diapause rate is similar between both photoperiods.

Leptopilina japonica: Photoperiod has little effect on diapause at lower temperatures, but longer photoperiod can induce some diapause at higher temperatures.

Ganaspis brasiliensis enters diapausing stage as a **late L1** and *L. japonica* as a **prepupa**.

2. Winter Survival in Québec

Our hypothesis is that the **Québec snow cover will help insulate overwintering puparia** on the ground.

Fall

- Induce diapause for *G. brasiliensis* and *L. japonica*
- Place padlocked briefcases outdoors for overwintering (CFIA confinement regulations):
  Sites: Montréal and Québec City
  Hight above ground: 0m and 2m

Winter

- Retrieve first set of briefcases: half of the diapausing parasitoids placed at 22°C and the other half at gradual temperatures of 4°C, 14°C and 22°C to observe spring emergence
- Mesure supercooling points of the overwintering puparia

Spring

- Retrieve second set of briefcases: steps from the winter repeated to observe spring emergence
- Mesure supercooling points of the overwintering puparia

- No parasitoids emerged from any of the treatments in the winter and spring of 2022.
- Supercooling points measured from a control sample of diapausing *L. japonica* in lab conditions averages at -25.9°C.
- Supercooling points from outdoor individuals varied between -10.1°C and -30.4°C for both species in all treatments.
- The experiment will be repeated during winter 2023.

3. Ongoing Experiment in British Columbia

Determine the predominant seasonal cue for **diapause induction** for **natural parasitoid populations** capable of overwintering in BC (September to December 2022):

- Controlling **minimum daily temperatures** with heat mats
- Exposure to **natural fall photoperiod** conditions

Infested Himalayan Blackberries

16°C, 22°C and Control (outdoor temperature)

Outdoor fall photoperiod

Conclusions

- Temperature is the main seasonal cue for diapause induction of both *G. brasiliensis* and *L. japonica*.
- Mortality of all parasitoids in the overwintering experiment may be explained by a severe cold snap of -25°C in December 2021, before a significant accumulation of snow cover. Experiments continue as of winter 2023.
- Having a better understanding of these parasitoids seasonal ecology will be beneficial for guiding potential releases of *G. brasiliensis,* or predicting the likelihood of adventive *L. japonica* populations estabishing in Eastern Canada.
- Studying diapause in the natural BC populations will allow us to determine for how long these species can attack SWD in the fall, which contributes to reducing the following year's pest population.

Acknowledgements: Thank you to **Kim Ostiguy , Élisabeth Ménard, Emei Yang-Larochelle, Jason Thiessen** and **Jessie Moon** for their help in the lab, as well as **Kim Hoelmer** and **Amanda Stout** (USDA) for providing the parasitoid colonies.
Funding: This work is part of Organic Science Cluster 3, led by the Organic Federation of Canada in collaboration with the Organic Agriculture Centre of Canada at Dalhousie University, supported by Agriculture and Agri-Food Canada's Canadian Agricultural Partnership - AgriScience Program.

References:
1. Tait *et al.* Journal of Economic Entomology, 114(5): 1950–1974.
2. Wang *et al.* Cabi Reviews, 2020.
3. Abram *et al.* Journal of Hymenoptera Research, 78:1-17.
4. Murata *et al.* Physiological entomology, 38(3): 211-218.
5. Hougardy *et al.* Environmental Entomology, nvac083.

irda Institut de recherche et de développement en agroenvironnement
Université de Montréal
Institut de recherche en biologie végétale
Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
CANADIAN AGRICULTURAL PARTNERSHIP / PARTENARIAT CANADIEN pour l'AGRICULTURE