The Organic Federation of Canada is pleased to present Organic Science Conversations, a series of podcasts presents the researchers of the Organic Science Cluster 3.

The bug war in organic strawberry production

In organic strawberry fields in Quebec, there is a war going on, a bug war, that is. Drs. Caroline Provost and François Dumont describe how the damsel bug *(Nabis americoferus)* and the minute pirate bug *(Orius insidiosus)* are used as mercenaries to control the tarnished plant bug. It's a riveting story of violence ("*Nabis* attacked the tarnished plant bug like a tiger attacks a sheep"), cannibalism and organic farming.

This podcast with Caroline Provost and François Dumont was recorded on December 2, 2019. Click here to listen to the podcast in French.

The following article is based on a transcript of the interview.

Hello, I am Nicole Boudreau, the coordinator of the Organic Federation of Canada. Today, I am pleased to interview Drs. Caroline Provost and François Dumont, both biologists working at the Mirabel Agri-Food Research Centre. Hello Caroline. Hello François.

CAROLINE & FRANÇOIS: Hello Nicole.

Caroline, your research activity with the Organic Science Cluster 3 is the "*Potential of predatory bugs Nabis and Orius as biological control agents of the tarnished plant bug* (Lygus lineolaris*) in organic strawberry fields.*" You're working with bugs, I believe; what is the problem that your research activity is trying to address?

CAROLINE: The main insect pest problem in strawberry fields is the tarnished plant bug, which causes significant damage to strawberry crops. It bites the strawberry or the flower and creates damage that will downgrade the quality of the fruit.

[Non-organic] strawberry growers use several chemical insecticides to control tarnished plant bug because there are few alternatives currently available to control this pest in strawberries. The situation is more complicated because we must also consider the different types of strawberries, such as day-neutral and fall strawberries. The extent of production and changes in strawberry production are making the tarnished plant bug increasingly difficult to manage.

There are, however, some alternatives. Trap strips, for example, and flowering strips also being tested. The option of using neutral agents, such as predatory bugs, is interesting and could become a more environmentally friendly avenue for managing tarnished plant bugs in the longer term.

So, it's a bug war: predatory bugs attack the tarnished plant bug. Do these predatory bugs damage strawberries?
FRANÇOIS: No, they are not known to damage strawberries. All true bugs have to feed a little bit on the plants to get water. But they won't sting the plant deep enough to damage it. Predatory bugs feed by excreting their digestive juices out of their body to liquefy their prey, and they drink some of that liquid.
However, tarnished plant bugs damage the fruit and the resulting high losses are a barrier to transition to organic strawberry production.

Are chemicals the only option available to control tarnished plant bugs in conventional production?
FRANÇOIS: Exactly, and it is often broad-spectrum pesticides that kill other species, including predators such as *Nabis* [damsel bugs] and *Orius* [minute pirate bugs]. Few of these predators remain in conventional strawberry fields because they will be killed by the pesticides or move to the edge of the field to escape their effect. Therefore, growers will not be able to benefit from the action of these predatory bugs.

CAROLINE: The broad-spectrum insecticides attack all types of bugs including tarnished plant bugs, but also attack the predatory mites that naturally control levels of strawberry tarsonemid mites and spider mites, which are also pests of strawberries (although less significant). Controlling the tarnished plant bug with insecticides will make it difficult to control the strawberry tarsonemid mites and spider mites because killing predatory mites doubles the number of pests. This is a vicious circle that shows that insecticide is really not a preferred option.

How do you carry out the research activity? Do you work directly in the field with predators to control tarnished plant bugs? Do you also do tests in the laboratory?
FRANÇOIS: We do both, actually, because we had very little data on the behaviour of *Nabis* and *Orius* on the tarnished plant bug. *Nabis* was observed in our plots in an earlier project.

> *In the laboratory, we saw that Nabis attacked the tarnished plant bug like a tiger attacks a sheep. We found that very interesting.*

We successfully started breeding *Nabis* in the lab to test its voracity, that is how many tarnished plant bugs it can kill per day. The lab conditions are not natural, but give us a good idea of the bug's ability to kill tarnished plant bugs. We also observe other characteristics such as its development cycle. This is an important characteristic because once in the field, we want to know how long *Nabis* is active and when it is active. These parameters are defined in the laboratory, and then we go into the strawberry field to confirm the effect on tarnished plant bug populations.

Nabis americoferus, the voracious bug
Photo - Mathieu Lemieux

'Nabis is a lurking predator that will hide and then pounce on its prey. It can be hard to see if you don't really take the time to bend over or don't have the eye of an entomologist who spends a good day looking at small insects.
But once you've seen it, you get used to it and you see it everywhere afterwards.'

This is the second year of the Organic Cluster; what progress is being made?
FRANÇOIS: Progress is being made in the laboratory in the determination of the voracity of *Nabis* and *Orius*, and other tests, for example, whether *Nabis* and *Orius* are compatible with each other. We're looking at their development and at the more abstract and influential aspects, such as the genetic characteristics behind *Nabis*' aggressiveness. It attacks a host of other insects, including aphids. The level of intrinsic aggression of the insect will influence its diet and its ability to attack the tarnished plant bug, other predators, but also itself. *Nabis* bugs are cannibalistic. These observations influence our laboratory breeding techniques. We can estimate the density of populations that can be maintained and, finally, the commercial value of this predator if it were sold as a biological control agent.

But how do you test aggressiveness? Do you do genetic analysis per se, or do you just observe behaviour?
FRANÇOIS: We observe behaviour. The beauty of the genetics behind it is that we can select individuals. We re-test individuals in each generation to create populations that are, on the one hand, more and more aggressive and, on the other hand, less and less aggressive. Then we're going to test their voracity, their tendency to cannibalism, their reproduction; these characteristics influence their effectiveness as biological control agents.

Can we see the *Nabis* or *Orius* predators with the naked eye?
FRANÇOIS: Absolutely! *Nabis* is 2 to 3 cm long and slightly larger than the tarnished plant bug, which is commonly seen by growers. *Nabis* is a lurking predator that will hide and then pounce on its prey. It can be hard to see if you don't really take the time to bend over or don't have the eye of an entomologist who spends a good day looking at small insects. But once you've seen it, you get used to it and you see it everywhere afterwards.
Orius is much smaller. It's a very small insect, but it's very, very voracious and it attacks the young stages of the tarnished plant bug.

Do you breed thousands of them? Millions? How long is a breeding cycle? What do you feed them? You don't feed them strawberries, do you?
FRANÇOIS: No, we feed them in the lab with eggplant on which we have aphids. Ultimately, for mass rearing, we want to establish the cheapest possible diet, and get the largest possible number of individuals. You don't produce millions of them. In the best case, we produce 30 to 300 new individuals per week, depending on the intensity of our needs. The reproductive cycle lasts about five weeks.

When you go to test them in the field, do you go in the spring when the strawberry plants are in flower?
FRANÇOIS: Exactly! In fact, we already tested them last summer (2019). We started to calibrate our system to work with the day-neutral strawberry plants that we put in the field in May. They are in flower starting in July and the system will be ready for the 2nd generation of the bug. Tarnished plant bugs in Quebec have two generations; they spend the winter as adults under the snow and emerge in April. This first generation will reproduce on traditional strawberries around June, and their second generation will be synchronized with day-neutral strawberries in September. That's when the peak of the tarnished plant bug population is observed and our tests are done at that time.

A Nabis adult attacks a tarnished bug larvae.
Photo : Pierre Royer

Does the tarnished plant bug have to be an adult for *Nabis* or *Orius* to eat it?
FRANÇOIS: *Nabis* attacks all phases of the tarnished plant bug that are equivalent to its own stage. *Nabis* adults attack both adult and younger tarnished plant bugs. All of these bugs (*Nabis, Orius* and the tarnished plant bug) have five larval stages. The *Nabis* larva in stage five will attack the tarnished plant bug larvae in stage five or lower. The voracious *Orius* attacks the tiny tarnished plant bug when it emerges and is vulnerable. So *Orius* starts to do a little cleaning up, so to speak, and then *Nabis* takes over.

It's a real bug war. But is your predator going to spend the winter in the field, or do you have to launch a new army of predatory bugs every spring to control the tarnished plant bug?
FRANÇOIS: Actually, there are two ways of operating. *Nabis* and *Orius* are native species that can overwinter in Canada. *Nabis* overwinters as an adult in habitats that are very, very close to those of the tarnished plant bug, and its life cycle is really very similar to that of the tarnished plant bug. It emerges at about the same time in April and starts to attack the tarnished plant bug again.
It's already helping to regulate tarnished plant bug populations, but our agricultural practices don't encourage tarnished plant bug predation.

Because of the intensive use of insecticides?
FRANÇOIS: Large areas of land are developed with a single type of plant that may not be the *Nabis*' favourite plant. Then insecticides are used that will significantly interfere with its development in two ways, either by killing it directly or by killing the tarnished plant bug, which is the *Nabis*' food source. So even if *Nabis* survives the insecticides, it won't have any food to go on living. So, it has to migrate out of the field, or die.

Does *Nabis* have any other food source?
FRANÇOIS: It consumes very little plant material. It is mainly a zoophagous predator, which means it eats prey. It is a generalist predator that will also eat aphids, one of its main prey. It also feeds on other smaller pests, such as spider mite larvae, a relatively small mite, or other small prey when it is in a young stage of development. But it will capture larger prey as it develops. I've seen flies caught by *Nabis* because *Nabis* is very lively and voracious; its attack style is a bit like that of spiders.

CAROLINE: The beauty of this project is that the selected predators live here in Quebec, and are adapted to our climate or already integrated into our environment. We're looking to optimize, or even increase, their presence by observing how they act and interact, and how we can introduce them.
They are also generalist predators. If there are no more bugs in strawberry fields, predator populations may decrease, but they will be able to maintain themselves by eating other prey that live on the edges of the fields. We're not introducing an alien species into the system: it's really a predator from here that we're trying to use in an optimal way.

But if I want to pick strawberries, will I encounter several *Nabis* camouflaged in the strawberry plants?
FRANÇOIS: There is little interaction between this bug and humans. I have been bitten once and I handle them all day long, so I can say that the presence of predators will not affect the pickers' work. A person who picks their own berries will probably never notice the predatory bugs.

CAROLINE: It's an insect that will ambush its prey; it's often hiding. A person who's not used to seeing insects won't even see them.

But what is the predator of the *Nabis* and *Orius*: birds? They must also be prey in the wonderful food chain where one beast eats another.
FRANÇOIS: Spiders are excellent predators of the *Nabis*; they capture *Nabis.* And *Nabis* is also its own predator, through cannibalism. But in insects, we don't talk about a food chain. The trophic levels are quite complicated. *Orius* could feed on *Nabis*, but the tarnished plant bug is also capable of killing its predator because it is not an exclusively phytophagous insect [i.e., it doesn't just feed on plants], it can occasionally feed on prey. It's a circular predation, but spiders and some other insects are the main enemies of *Nabis*.

So, you're working in an organic strawberry field without applying pesticides to observe the true predatory nature of the two bugs.
FRANÇOIS: Exactly! We created small plots scattered across a field and our goal was simply to explore how to use the predators in the field. We determined when to introduce them. Is it when

you spot a tarnished plant bug in the field? Or, is it at the larval stage, or is it when the adults are established?
We also created plots with only one release of several *Nabis* bugs per plot; we want to know if the effect is local. Do the bugs stay on the plant on which they were released and in the nearby plot, or do the bugs move and interact elsewhere? They can reproduce, take some time to become established, and then perhaps die. They may need to be introduced every two weeks. Next year we'll go back to the field with a more refined plan.

Can this be applied in a greenhouse?
CAROLINE: Yes, *Nabis* is a generalist predator and we are starting to see it in different [crop] systems. It's a little easier to work in closed ecosystems. You lose fewer individuals and you control your numbers a little bit better, but you still have to determine at what stage [of the pest's life cycle] to introduce them.
FRANÇOIS: We tested the *Nabis* bug against the tarnished plant bug in a greenhouse with cucumber production; it was an exploratory year. The preliminary findings were interesting and showed that *Nabis* survives in the greenhouse. They were introduced in the middle of the heat wave, and we wondered if they would survive. And they did survive, reproduce, and attack tarnished plant bugs and aphids.

Did they behave as expected?
FRANÇOIS: Absolutely. We put tents in the greenhouse to contain the plants and do trials.
We wondered whether in the greenhouse, where the bug is completely free, if it would walk on the ground, go on the walls, or upwards. It remains to be determined what will happen in the greenhouse in order to draw a general conclusion that will apply to growers.

Last spring, there was very negative publicity about strawberries in the United States, where it was mentioned that strawberries are among the "dirty dozen," the fruits and vegetables that contain the highest levels of pesticides. Consumers are concerned about the quality of strawberries, so your research activity to find alternatives to insecticides is timely.
FRANÇOIS: Absolutely! I think the public is becoming more and more aware of the conditions under which strawberries are produced. The constraints that affect the work of growers are not well known. They often use pesticides to reduce losses and make their businesses more profitable. This leads us to reflect on the functioning of the production system and the management of strawberry fields. We can envisage building an environment favourable to predators, estimating that these predators will kill 85% of the pest population, and that the remaining 15% will cause damage at a low level that can be controlled in a reasoned manner. We need to think about the production system in a new way.

If your research activity is successful, how will a strawberry grower apply your results? Will the grower receive a box of predators with instructions on the best time to release them into the strawberry field?
FRANÇOIS: It's going to look something like that but we're not sure what stage the bugs should be delivered in (egg, adult, or larval, etc. stage).
The grower will receive the bugs in some form or another with the application instructions as with any biological control agent (at what rate to introduce them, on what acreage, and how often).

We're working on genetic selection right now. We could develop lines to maintain a continuous, more typical form of biological control by introducing a predator that will keep the pest population below a comfortable threshold (for the grower) for a long period of time.
Alternatively, one could produce very aggressive lines that can be used in a pesticide-like manner. Then we would apply a curative approach with an immediate effect by introducing very aggressive *Nabis* bugs at an intense concentration, like a blitzkrieg. It would have an instant effect, like a pesticide, but it would be biological. These are the ideas under development.

CAROLINE: I'd like to add that we're developing a lot of knowledge about farming, but raising millions of insects is quite a challenge. We could eventually partner with companies that are in the business of raising bugs given the immense challenge of producing such large numbers of natural predators and enemies. The potential of *Nabis* is very great.
Our research centre has developed good expertise in the breeding of insects for both human and animal consumption, but less expertise in the breeding of natural enemies. Several companies specialize in this field, such as Koppert Canada Limited, Anatis Bioprotection, especially in Quebec. These focus mainly on greenhouses where biological control is widely used. Producers in the field have less recourse to biological control, which represents, for them, a new method of using natural enemies.

We will be very curious to contact you again in 2023 to find out the results of your research. Consumers want strawberries without pesticides.

About insects…	
<u>Pests</u> tarnished plant bug (*Lygus lineolaris)* strawberry tarsonemid mites (*Phytonemus pallidus*) spider mites (Tetranychidae)	<u>Beneficials</u> damsel bug *(Nabis americoferus)* minute pirate bug *(Orius insidiosus)*

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