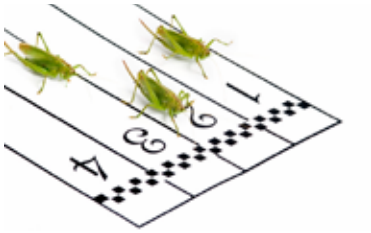

1ER PRIX DU CONCOURS DE RÉDACTION SCIENTIFIQUE GEORGES-MAHEUX

ODOURS, BRINGING PEST CONTROL IN ORCHARDS TO FRUITION

par Virginia Hock

Every spring they gather, meeting at the usual place as if it where a neighbourhood singles mixer. And what better place to meet than an apple orchard in spring (Photo 1); it has everything needed for a good time: food, shelter, and place for the little ones. Not to mention the beautiful smell of apple trees in full bloom.

And that is really the key, for many insects use smell to find suitable sources of food, shelter, and mates (Visser 1986), and the plum curculio (*Conotrachelus nenuphar* Herbst.) [Coleoptera: Curculionidae] is no exception. No bigger than half a centimetre, this beetle is capable of finding its way from the woodlands, where it spends the winter, to neighbouring orchards; being able to travel distances as great as half a mile (about 0.8 km) (Lafleur and Hill 1987; Whitcomb 1929). Don't let the small size fool you though, because this little insect can cause a lot of damage (Photo 2).

Native Pest

Found throughout North America (Quaintance and Jenne 1912), this native attacks numerous fruits. It can damage up to 90% of the harvest in unprotected apple orchards (Chagnon and Payette 1990; Vincent and Bostanian 1988; Vincent and Roy 1992), an important source of income in Quebec (Institut de la statistique du Québec 2008). In their wake, the apple is wounded and scarred, making it easier for diseases like brown rot to invade (Bobb 1952; Chandler 1958). Adults gather in apple trees where they eat, mate, and lay their eggs in developing apples. Their offspring hatch and eat their way through the apple, causing it to fall off trees early. Once on the ground, the larvae leave the apple and enter the soil where they pupate, emerging in late summer as adults to attack the remaining apples once more before hibernating in nearby woodlands (Chouinard *et al*. 1993; Lafleur and Hill 1987; Racette *et al*. 1992; Vincent *et al*. 1999).

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Photo 2. Adult plum curculio on an immature McIntosh apple.

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Photo 1. M. Ednie's McIntosh apple orchard in bloom, Franklin (Québec).

Every year, around five million dollars are spent in Quebec alone on the tons of pesticides used to prevent damage to apple orchards (Chagnon and Payette 1990; Chouinard *et al*. 1998; Statistics Canada 2005), a favoured host for this little beetle (Chapman 1938; Whitcomb 1929). While the pesticides used against this insect are effective, the quantity and cost are considerable, as are the undesired side effects such as death of beneficial animal species, environmental damage, and toxicity to humans (Jenkins *et al*. 2006; van der Werf 1996).

The problem of control : follow your nose

The question is: how to decrease the use of pesticides when no reliable and efficient monitoring system is available against the plum curculio to let the apple producers know when exactly to apply the insecticides? While various methods have been employed in the past (i.e. visual inspection, use of climate and temperature based models, pesticide treatments of trees along the edges of orchards, etc.) (Chouinard *et al*. 1992; Lafleur *et al*. 2003; Pinero and Prokopy 2003; Racette *et al*. 1992; Reissig *et al*. 1998; Whalon 2008), odour trapping has probably received the most attention. Using the insects own sense of smell, which is essential for it to find host trees and mates, against it by getting it to gather at traps instead

of host trees has proven to be a valuable tool against other insect pests (Hardee *et al*. 1996; Tedders and Wood 1994). But how exactly is this accomplished?

Thanks to the work of Eller and Bartelt (1996), we know that the male plum curculio emits a scent, or pheromone, designed to attract other members of their kind. Scientists can now recreate part of this pheromone by synthesizing the main molecule called grandisoic acid. The pheromone produced by the curculio is designated as an 'aggregative' or gathering pheromone because it has been proven to be attractive to both sexes of this insect (Eller and Bartelt 1996). However, traps baited with this pheromone alone don't quite do the job when it comes to accurately monitor the timing of this insect's orchard invasion (Leskey and Wright 2004a; Prokopy *et al*. 2000) – which is key in reducing the amount of pesticides used. Further research into odours that appeal to this pest have yielded promising results; for example, we now know that the smell of apple trees in bloom, and not just the smell of apples themselves, are desirable to the plum curculio. When odours such as benzaldehyde, which is produced by the twigs, flowers, and the fruits of apple trees, are added to traps along with the aggregation pheromone produced by male plum curculio, significantly greater numbers of this insect are attracted then traps with either of these odours by themselves (Leskey *et al*. 2001, 2005)

Various attempts have been made at finding the most suitable style of trap and the best type of scent to get these bugs to stop attacking apple trees (Lamothe *et al*. 2008; Leskey and Prokopy 2001; Leskey *et al*. 2005; Prokopy *et al*. 2000, 2001). One idea even has them attacking certain trees baited with attractive odours, called 'trap trees'. The idea is that if the insects are all localized on a few specific trees instead of throughout the entire orchard, then monitoring and therefore reducing insecticide applications would be infinitely simpler (Leskey *et al*. 2008; Prokopy *et al*. 2004).

Aromatic competion

The problem with putting an attractive odour in the middle of an apple orchard, which just happens to be one of this insect's favourite food sources, is of course competition. The odours of apples and other plum curculio are equally desirable to this beetle, making it difficult to maintain its attraction to traps over the course of its orchard invasion (Leskey and Wright 2004a, b). Unfortunately, it's not as simple as merely increasing the quantity of attractive odours to overwhelm all other competing fragrances present, since it has been shown that above certain levels the attractive odour has no greater effect and can even become repulsive (Leskey *et al*. 2005; Prokopy *et al*. 2004). Picture a perfume store, while the smell of your favourite perfume or cologne may be enticing, being hit by a large dose of it all at once can leave you and not to mention those around you, gasping for air. To further compound matters, only the main component of the pheromone (grandisoic acid) produced by plum curculio males has been identified (Eller and Bartelt 1996), but it is quite possible and even highly likely that there exist other secondary compounds produced in addition to this primary one that make up the whole of the aggregation pheromone, as was shown to be the case for other beetles (Innocenzi *et al*. 2001; Tumilson *et al*. 1996).

Therein lies the difficulty – finding the right components and their appropriate quantities to elicit the desired reaction from the insect. Like a bouquet of flowers that makes your senses tingle, scientist in North America are trying to unlock the exact odour combination that is irresistible to this insect, no matter what else may happen to be in its vicinity. That is what biologists Dr. Gérald Chouinard, Dr. Daniel Cormier, and Dr. Éric Lucas along with their teams at Institut de recherche et de dévelopment en agroenvironment (IRDA) and at Université du Québec à Montréal (UQAM) have been working on for several years. They coordinate their efforts with researchers from Université du Québec à Chicoutimi (UQAC) and from the United States Department of Agriculture – Agricultural Research Service (USDA-ARS).

This task is no simple one when you consider the numerous other smells found in nature that the curculio is attracted to. It is akin to being in a floral shop surrounded by all of your favourite flowers; which one do you pick?

Research bearing fruit

For this purpose the scientists at IRDA are conducting laboratory studies, which take place under a simplified and controlled environment. The aim is to not only identify and quantify the various components of the pheromone produced by curculios – and therefore replicate them artificially – but also to determine behaviourally when the insect is most attracted to the odour. To aid them in this task, they use equipment like an olfactometer, a device that allows them to record the insect's behavioural response to different sources of odour (Photo 3). The insect is placed in the center of the machine,

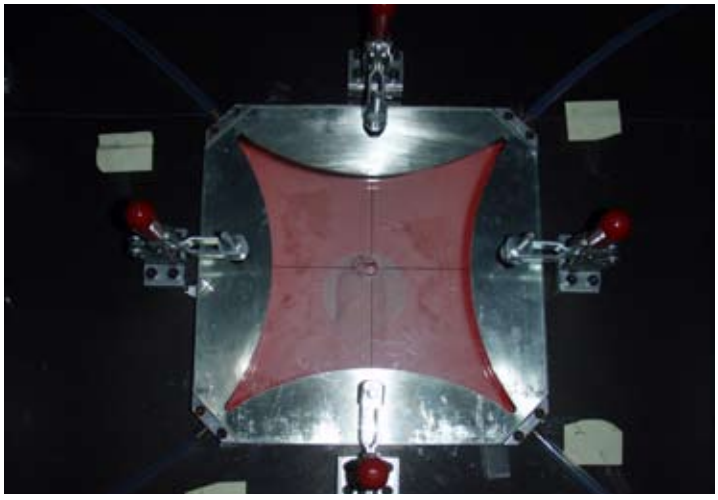

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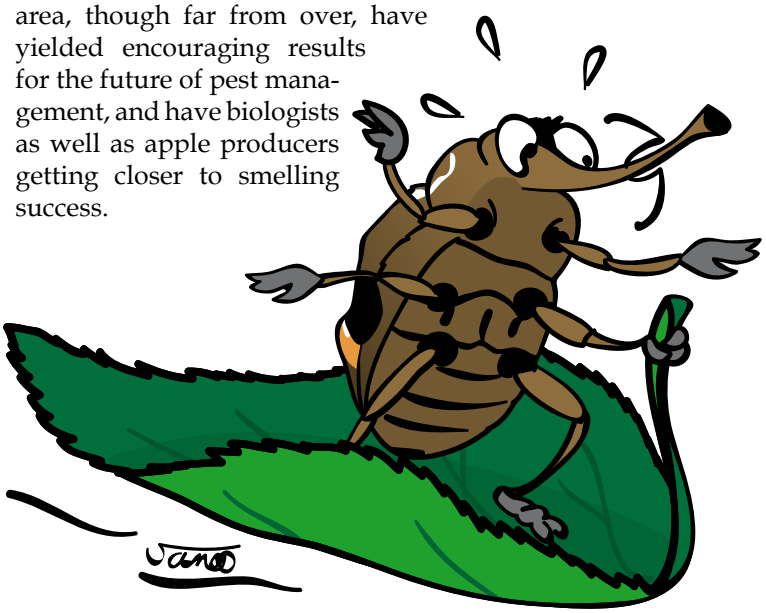
Photo 3. Top view of a 4-way olfactometer, a laboratory machine at IRDA, Saint-Hyacinthe (Québec), used in behavioural experiments to identify odours attractive to the plum curculio.

which is divided into four zones, and different odours are introduced via tubes from the four corners of the star-shaped observation area. The time the insect spends in each area or zone as well as its behaviour (for example walking, resting, etc.) is recorded and analyzed using computer programs designed specifically for that purpose. Similar machines have proven useful in the past in helping to understand other insects' behaviour towards various scents (Cormier *et al*. 1998). The results of such research can be employed in the more complex environment of fruit orchards, and when combined with field studies and knowledges about the plum curculio, would aide in developing reliable and effective monitoring techniques thus helping to reduce pesticides. An irresistibly attractive pheromone could also be used in traps for control purposes in what is called an attracticide trap, combining the pheromone and a pesticide inside a trap to eliminate the insect pest.

However they're employed, the advances in research in this area, though far from over, have yielded encouraging results for the future of pest management, and have biologists as well as apple producers getting closer to smelling success.



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