CHALCID PARASITES IN ALFALFA LEAFCUTTING BEE POPULATIONS

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There are many parasites and predators of the alfalfa leafcutting bee. Several of these are tiny chalcid wasps which parasitize leafcutting bee larvae. Others are different species of bees which lay their eggs in the nectar and pollen provisions just before the female leafcutting bee completes the cell - the young "cuckoo bee" then consumes the pollen ball and the leafcutting bee larva. Some bee predators are stored product pests like carpet beetle or dried-fruit moth larvae, which will eat pollen, leaf debris, and may also consume young bee larvae. There are other beetles which consume several bee larvae during the course of their development. One fly species captures the adult female leafcutting bee and lays an egg on the surface of the bee which hatches into a larva that eventually consumes the contents of the leafcutting bee's abdomen.

A continuing problem in alfalfa leafcutting bee populations is the chalcid parasite, *Pteromalus venustus*. *Pteromalus* is a tiny wasp which paralyses and then lays eggs on the leafcutting bee prepupa, leaving an intact cell containing *Pteromalus* prepupae instead of a healthy leafcutting bee prepupa. *Pteromalus* is a cause for concern because it will parasitize as many leafcutting bee prepupae as possible in a relatively short time period. Opportunities for controlling *Pteromalus* are limited and the presence of this parasite can be a drawback in marketing of alfalfa leafcutting bee cells. The following information will concentrate on the life cycle and control of *Pteromalus venustus*.

CHALCID PARASITE HISTORY

Pteromalus venustus was first found in populations of the alfalfa leafcutting bee *(Megachile rotundata)* in 1968, the year after introduction of the bee into southern Alberta (Hobbs & Krunic, 1971). Hobbs felt that this chalcid parasite had previously been established in Alberta on another host insect. It is known to parasitize at least one of our native leafcutting bee species, *M. relativa* (Rank & Goerzen, 1981), so it may simply have broadened its host range. Managing alfalfa leafcutting bees for alfalfa seed production creates an artificially high concentration of bees, in turn providing a ready food source for parasites and predators. Thus, many of the parasites and predators which we have identified on alfalfa leafcutting bees have apparently moved from other hosts for this reason. Early alfalfa leafcutting bee literature from the United States does not mention *Pteromalus venustus* in lists of parasites and predators, although several other chalcid parasite species are noted. With the exception of the publication by Hobbs & Krunic in 1971, it was not until 1980 that *Pteromalus* began appearing in the literature as a problem requiring control in the United States (Eves et al, 1980).

CHALCID PARASITE LIFE-CYCLE

Pteromalus is an obligate parasite, which means that it is obliged to parasitize other species in order to reproduce. Adult parasites will feed on sugar water in laboratory experiments, so they probably feed upon nectar in the field. The adult parasites do not feed on either bee prepupae or adult bees. Adult female *Pteromalus* search for completed cells containing bee prepupae which have finished feeding and have spun their cocoons. The female parasite pierces the leaf and cocoon layers of the bee cell with her ovipositor, a sting-like apparatus modified for laying eggs, and stings the prepupa, thus paralysing it. She then lays eggs upon the surface of the paralysed prepupa. The parasite eggs hatch within 24 - 48 hours, and the young larvae begin to feed upon the paralysed bee prepupa, eventually consuming it almost completely.

If some of the parasite larvae are not finished feeding, they may then turn on their siblings and consume them as well. The parasite larvae then either pupate and develop into adults, or enter a diapause stage which requires a cold period, similar to their leafcutting bee host. Once temperatures rise sufficiently, development resumes, and the parasites pupate and emerge as adults through a small hole chewed through the alfalfa leafcutting bee cell. In the incubator, chalcid parasites usually emerge from day 8 through 13 of incubation at 30ºC, although they may emerge earlier.

POTENTIAL FOR PARASITE BUILD-UP

The male to female sex ratio for *Pteromalus venustus* is reported in the literature to be anywhere from 1:1 to 1:3 (Hobbs & Krunic, 1971; Richards, 1984; Whitfield & Richards, 1985). Time to development per generation depends on temperature: at an incubation temperature of 30ºC, *Pteromalus* can develop from egg to adult in 12 days (Whitfield & Richards, 1985); thus, a second generation can complete its development and emerge in trays during the incubation period.

Chalcid parasite mating occurs either within the host cell prior to emergence or within minutes of emergence from the host cell, and adult females can begin to lay eggs within four hours of emergence. Each female lays from 7 to 26 eggs on each parasitized alfalfa leafcutting bee prepupa (Richards, 1984). The usual number of parasite generations which occur during the field season is not known, but is undoubtedly somewhat dependent upon date of bee release, along with temperature and duration of the pollination season.

The unique developmental and reproductive factors involved in the chalcid parasite life-cycle result in a large potential for build-up of the parasite population.

Hypothetical potential for parasite build-up:

> A population of leafcutting bee cells has a level of 0.1% parasitism, or 1 parasitized cell in 1000. The leafcutting bee cells are incubated. Each of the parasitized cells produces 20 parasites, which hatch between day 8 and 12, and this population has a 1:1 sex ratio, so 10 are females. Each female *Pteromalus* lays 20 eggs in each of three cells for a total of 10 x 3 = 30 parasitized leafcutting bee pupae. The parasitism level has now risen to 3.0%, or 30 cells in 1000.
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> All 600 parasites in these 30 cells hatch, mate, and are taken to the field. There are now 300 female parasites per 1000 leafcutting bees released. Each female, over the course of the summer, parasitizes three cells and lays 20 eggs in each, for a total of 300 x 3 = 900 parasitized cells. If none of these parasite larvae completes its development in the field and emerges from the host cell, there are now 900 parasitized cells; assuming a doubling of the bee population, this equals 900 parasitized cells in 2000, or 45% parasitism.

This example assumes that survival is 100% and that all parasitism attempts are successful, neither of which is true in the real world. However, survival may be enhanced and the number of generations in the field increased with long hot summers. It is therefore not surprising to see average *Pteromalus* levels rise and it is important to evaluate existing prevention and control programs, and to tighten up prevention of parasitism, rather than to rely only on a chemical control program during alfalfa leafcutting bee incubation.

PREVENTION AND CONTROL OF CHALCID PARASITISM

Alfalfa leafcutting bee cell sampling

A major step in controlling an chalcid parasites in an alfalfa leafcutting bee population is to thoroughly sample the bee cells prior to spring incubation in order to determine the number of parasitized cells present. If necessary, heavily parasitized bee cell lots may then be incubated separately from parasite-free cells.

Parasite-proof alfalfa leafcutting bee nest material

An important step in preventing chalcid parasitism in the field is tight nest construction. Nests must be "parasite-proof". The nest backing material should be tightly strapped to the block, with a bonded polyester fill inserted between block and backing. Nest corners can be used to stabilize the tightly-strapped nest block and various types of nest surrounds can also be utilized.

Chalcid parasite control measures

Control measures are generally aimed at the *Pteromalus* adults, because the larvae and pupae are difficult to control while they are developing within the cells. Black lights, which emit light in the ultraviolet spectrum, attract adult *Pteromalus*. If the lights are placed over trays of water containing a small amount of surfactant, the parasites tend to be attracted into the water-traps and drown. Black lights and water-traps may be utilized in the incubator throughout the incubation period. The water should be changed periodically in order to keep the water surface free of insects.

Hill et al (1984) tested different rates of dichlorvos resin strips (0.0, 0.16, 0.37, 0.71, and 0.99 strip / 1000 cubic feet) from day 9 to 12 of the alfalfa leafcutting bee incubation period to determine rate of chalcid parasite control and subsequent adult leafcutting bee mortality. While no significant differences in bee survival were found among treatments and the untreated control, re-parasitism was 35-44% in the untreated control, 36% with 0.16 strip, 23% with 0.37 strip, 13% with 0.71 strip, and 16% with 0.99 strip. It was therefore initially recommended that dichlorvos resin strips be utilized for chalcid parasite control in the incubator at the rate of 0.75 strip / 1000 cubic feet of incubator space, from day 9 to 12 of incubation. Additional research has also indicated that under certain conditions, a significant increase in dichlorvos-related alfalfa leafcutting bee mortality during incubation may be related to dichlorvos rate, treatment time, number of bee cells treated, bee cell position in the incubator, and incubation humidity (Goerzen, 1995).

Producers have modified this original recommendation to suit their individual incubator designs. In general the modification includes use of dichlorvos resin strips for a somewhat longer time period. Since it takes time for the dichlorvos resin strips to charge the incubator atmosphere with dichlorvos vapour, many producers place the dichlorvos strips in their incubators on day 7, presuming that the first parasites will emerge on about day 8. The dichlorvos strips are generally left in the incubator until about day 13. Bee cells should be no deeper than one inch in incubation trays with solid bottoms (two inches in trays with screened bottoms), so that dichlorvos vapour can penetrate into air space surrounding the bee cells. Incubation trays should be stacked a minimum of four inches apart to allow for adequate air movement.

Vapour from the resin strips readily adheres to organic surfaces, such as wooden racks, incubator trays, and leaf pieces, so after the strips are removed, the incubator must be opened up and the air circulated for at least 24 hours. Ventilation after using dichlorvos should be active - opening the door and turning on the ceiling fan may not be enough. The air in the incubation trays must be exchanged many times in order to remove all traces of dichlorvos vapour. Adequate ventilation may involve removing incubation racks from the incubator for a 24 - 48 hour period while the air is exhausted, as well as moving air through the racks and over the cells.

Chalcid parasites found on alfalfa leafcutting bee nest blocks during the fall storage period are likely the "second generation" or emergent offspring of the field parasite population. These parasites can represent a threat to the leafcutting bee population since they will mate and attempt to parasitize developing bee larvae, causing both a decrease in live count and an increase numbers of parasitized bee cells. Use of water-traps under ultraviolet lights will help to control parasites in the fall. As well, studies on the fall use of dichlorvos resin strips indicate that exposure of nest blocks with backs removed to dichlorvos at a rate of 0.75 strip per 1000 cubic feet for up to seven days will not harm the alfalfa leafcutting bee prepupae within the nest blocks (Goerzen & Murrell, 1992).

SUMMARY

The chalcid parasite, *Pteromalus venustus,* can re-parasitize alfalfa leafcutting bee populations during the incubation period and during the field season, causing significant bee losses. Current chalcid parasite control measures include the use of well-built, parasite-proof nest blocks in the field, the use of black lights and water-traps in the incubator, and the use of dichlorvos resin strips at a rate of 0.75 strip / 1000 cubic feet during day 7 to 13 of the alfalfa leafcutting bee incubation period. The incubator should be actively ventilated for at least 24 hours following the parasite control period in order eliminate dichlorvos residue which may cause mortality in emerging alfalfa leafcutting bees.

REFERENCES

Eves, J.D., D.F. Mayer, and C.A. Johansen. 1980. Parasites, predators, and nest destroyers of the alfalfa leafcutting bee, *Megachile rotundata*. Washington State University WREP 32.

Goerzen, D.W. 1995. Alfalfa leafcutting bee mortality associated with use of dichlorvos for chalcid parasite control. Saskatchewan Alfalfa Seed Producers Assocation Extension Publication 1995-01; 4 pp.

Goerzen, D.W. and D.C.Murrell. 1992. Effect of fall dichlorvos treatment for control of a chalcid parasitoid on viability of the alfalfa leafcutting bee *Megachile rotundata* (Fabr.) (Hymenoptera: Megachilidae). Bee Science 2(1): 37-42.

Hill, B.D., K.W. Richards, and G.B. Schaalje. 1984. Use of dichlorvos resin strips to reduce parasitism of alfalfa leafcutter bee cocoons during incubation. J. Econ. Entomol. 77: 1307-1312.

Hobbs, G.A. and M.D. Krunic. 1971. Comparative behaviour of three chalcidoid (Hymenoptera) parasites of the alfalfa leafcutter bee, *Megachile rotundata*, in the laboratory. Can. Entomol. 103: 674-685.

Rank, G.H. and D.W. Goerzen. 1981. Native leafcutter bee species and associated parasites in commercial hives in Saskatchewan, Canada. Apidologie 12(3): 211-220.

Richards, K.W. 1984. Alfalfa leafcutter bee management in Western Canada. Agriculture Canada Publ. 1495/E.

Whitfield, G.H. and K.W. Richards. 1985. Influence of temperature on survival and rate of development of *Pteromalus venustus* (Hymenoptera: Pteromalidae), a parasite of the alfalfa leafcutter bee (Hymenoptera: Megachilidae). Can. Entomol. 117: 811-818.