# Can insecticides protect citrus from HLB infection?

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***Figure 1.*** *Electrical penetration graph (EPG) monitor for recording psyllid feeding behaviors on insecticide-treated and untreated citrus.*

Use of insecticides for control of the Asian citrus psyllid is an important component of HLB management programs used by Florida citrus growers. The rationale for use of insecticides is to keep psyllid (vector) populations as low as possible to minimize the potential for pathogen spread. However, what has been unclear is whether insecticides may have an added benefit in terms of preventing pathogen transmission (acquisition of the pathogen by psyllids from infected plants and subsequent inoculation of uninfected plants by adult psyllids).

The ability of insecticides to protect plants from becoming infected with HLB is an important consideration for citrus growers faced with the decision of whether or not to replant/reset groves where HLB is present. If young trees cannot be protected from HLB, then replanting is a tremendous financial gamble for citrus growers. Currently, we are investigating whether soil-applied systemic and broad-spectrum foliar insecticides provide any benefit in terms of preventing healthy citrus trees from becoming infected with HLB. Our results to date are promising, suggesting that certain insecticides can provide plants some protection from becoming infected with HLB.

The most logical and definitive method for determining whether insecticides can prevent psyllids from inoculating citrus plants with the HLB pathogen is to expose insecticide-treated plants to psyllids carrying the HLB bacteria. Later, those plants would be tested for the presence of the bacteria to confirm that pathogen transmission occurred. While such experiments are in progress, they require a considerable amount of time to complete, due to the latency period of the pathogen within the plant (as long as 12 months or more) following inoculation and the fact that successful pathogen transmission by single psyllids occurs at a very low rate. For these reasons, we are using an electrical penetration graph (EPG) monitor (Figure 1) to examine psyllid-feeding behaviors on insecticide-treated plants, to determine whether the behaviors associated with successful pathogen transmission can be prevented.

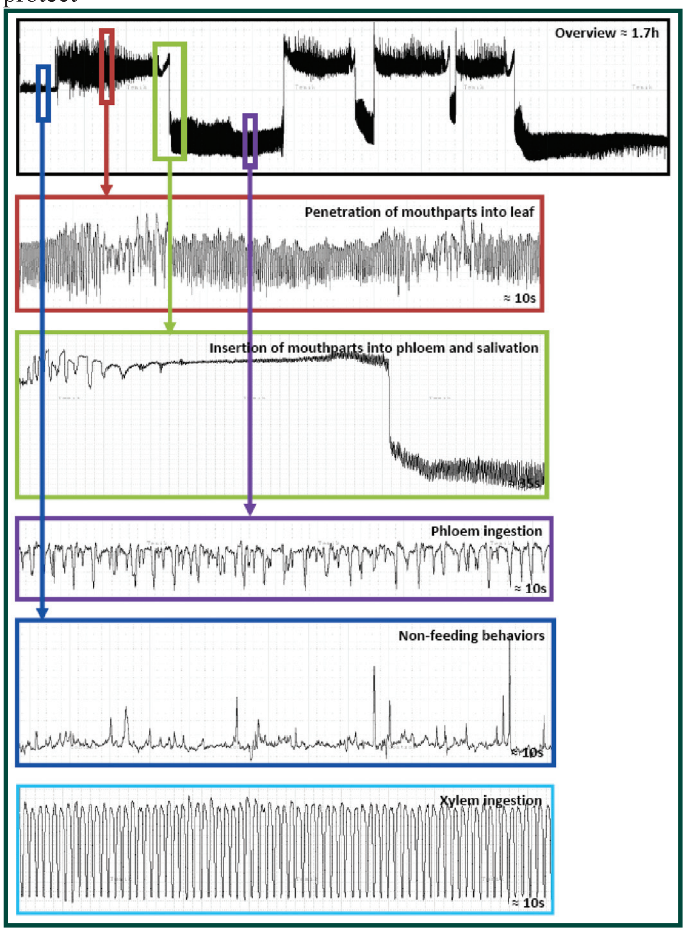


***Figure 2.*** *Example of psyllid-feeding waveforms recorded using EPG monitor.*

## WIRED INSECTS

EPG studies have been used to examine the feeding behavior of many sap-sucking insects in order to better understand the mechanisms of pathogen transmission by vectors. EPG is an electrical system that makes a plant and feeding insect part of a closed electrical circuit. This is done by applying electrical current to the plant using an electrode inserted into the soil at the base of the plant. The test insect is attached to a gold wire thinner than a human hair, which is then connected to amplifiers inside the EPG monitor. The amount of current passing through the insect while feeding on the plant is measured as voltage.

For each feeding behavior performed by the insect, there are changes in voltage level

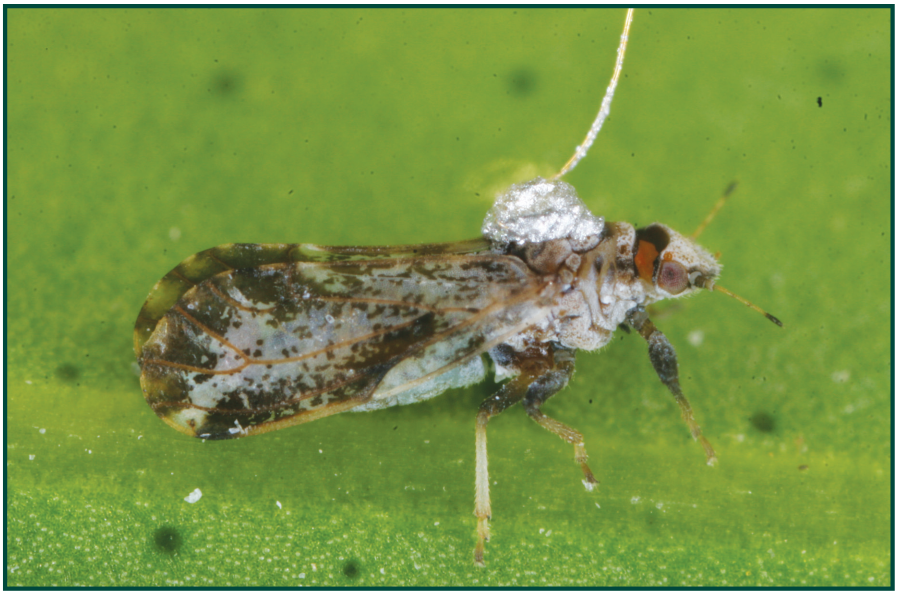

***Figure 3.*** *Adult psyllid connected to EPG monitor with a gold wire for recording feeding behaviors.*

that are recorded by the EPG monitor and displayed on a computer as waveforms that are specific to each psyllid-feeding behavior performed.

Here we group the psyllid-feeding behaviors into six main waveforms: 1) penetration of mouthparts into the leaf and searching for a phloem cell, 2) insertion of mouthparts into a phloem cell, 3) salivation into the phloem, 4) ingestion of phloem sap, 5) ingestion of xylem sap, and 6) non-feeding behaviors such as walking or jumping off the plant (Figure 2).

Since the HLB bacteria are restricted to citrus phloem cells and are carried into those cells by saliva, insertion of mouthparts into the phloem and salivation into the phloem are likely the most important feeding behaviors responsible for successful inoculation of healthy citrus with the HLB pathogen. In turn, ingestion of phloem sap is likely to be responsible for acquisition of the HLB pathogen. Thus, we were specifically interested in determining whether insecticides can reduce or prevent those phloem-feeding behaviors and thus reduce the likelihood of pathogen transmission.

Using the EPG monitor, we examined the psyllid-feeding behaviors on citrus plants treated with one of three insecticides applied at recommended field rates: aldicarb (Temik 15G), imidacloprid (Admire Pro 4.6F) and fenpropathrin (Danitol 2.4EC). Aldicarb and imidacloprid were applied as soil treatments 20 days prior to use in experiments, while fenpropathrin was applied as a foliar spray (and allowed to dry) on the same day of the study. Adult psyllids were "wired up" (Figure 3) to the EPG monitor and their feeding behaviors recorded for a period of 12 hours.

In the first experiment, we compared psyllid-feeding behavior on citrus plants treated with a soil drench of imidacloprid (Admire Pro) versus untreated plants. At the end of the 12-hour recording period, 100 percent of the psyllids on imidacloprid-treated plants were dead while all the psyllids on the untreated plants were alive and feeding. Prior to the death of psyllids on imidacloprid-treated plants, feeding behaviors associated with phloem salivation and ingestion were reduced compared with those of psyllids feeding on untreated citrus (Figure 4). Psyllids on imidacloprid-treated plants also spent more time in non-feeding behaviors, such as attempting to jump off the plants, as a result of exposure to imidacloprid after penetration of mouthparts into the leaf. These results suggest that imidacloprid application may not provide 100 percent protection from being inoculated with the HLB pathogen; however the likelihood

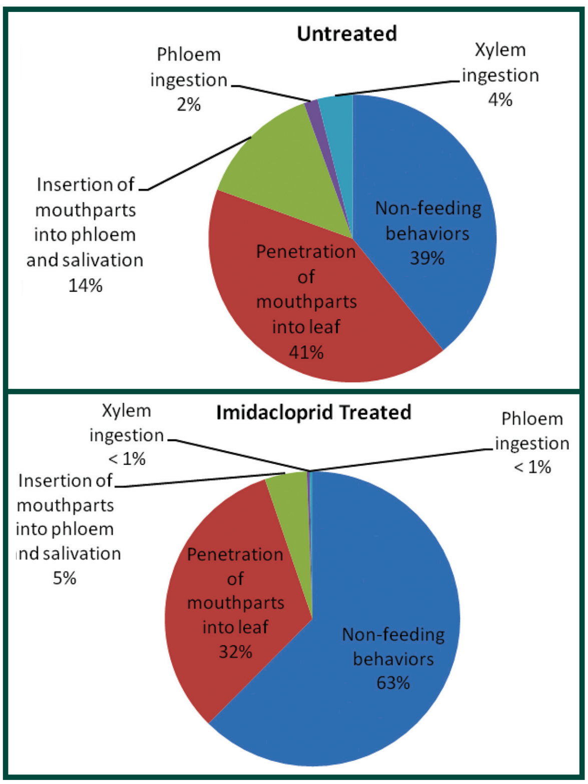


***Figure 4 (far left).*** *Comparison of the number of times all psyllids performed each feeding behavior, as a percentage of the total number performed, on imidacloprid-treated and untreated citrus plants.*

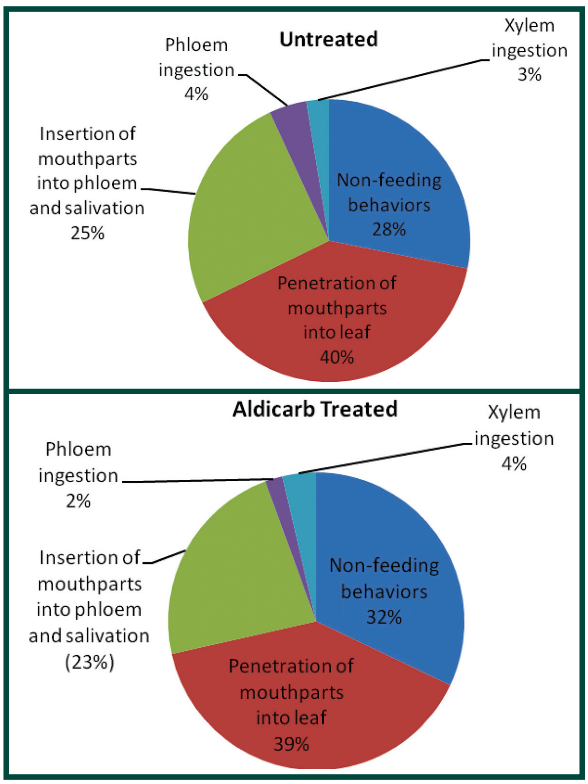


***Figure 5 (left).*** *Comparison of the number of times all psyllids performed each feeding behavior, as a percentage of the total number performed, on aldicarb-treated and untreated citrus plants.*

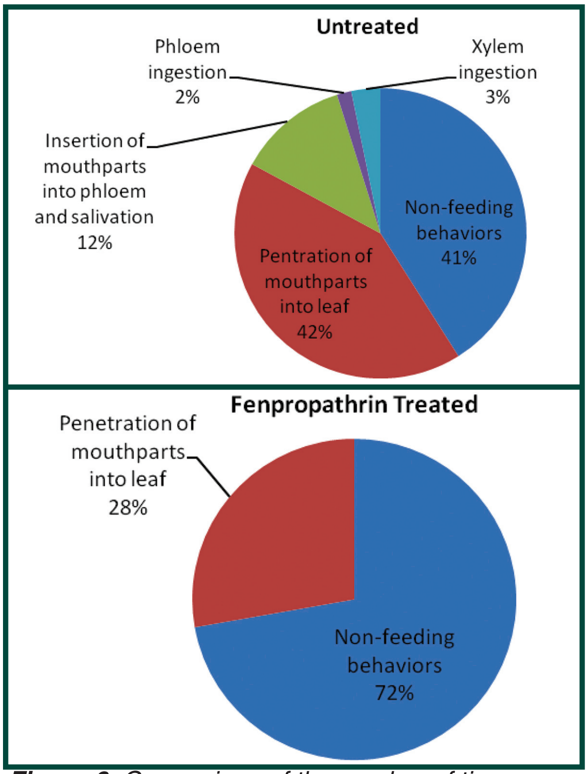


***Figure 6.*** *Comparison of the number of times all psyllids performed each feeding behavior, as a percentage of the total number performed, on fenpropathrin-treated and untreated citrus plants.*

of inoculation occurring is greatly reduced.

In a second series of experiments, we examined whether the soil-applied insecticide aldicarb (Temik 15G) would also cause disruption of phloem-feeding behaviors similar to imidacloprid. At the end of the 12-hour recording period, none of the adult psyllids had died yet as a result of feeding on aldicarb-treated plants, despite the fact that leaf-tissue analysis conducted immediately following the feeding studies confirmed the presence of aldicarb within the leaf tissues. In the comparisons of EPG results, there was no difference in psyllid feeding behaviors on aldicarb-treated versus untreated plants (Figure 5). This suggests that adult psyllids infected with the HLB pathogen are likely able to inoculate healthy citrus plants soon after migrating into a grove, before succumbing to the effects of aldicarb. These results suggest that aldicarb should not be relied on as a "stand-alone" tactic for psyllid control, and support the previous IFAS recommendation of using a dormant knockdown application in conjunction with aldicarb prior to the spring flush. The dormant spray application will provide control of the overwintering adult population, whereas aldicarb provides extended systemic control of any psyllid immature stages developing on the late winter or early spring flushes.

In the third set of experiments, we examined the effects of a foliar application of fenpropathrin (Danitol 2.4EC) on psyllid-feeding behavior. Because of the fast-acting effects of this pyrethroid insecticide, psyllids placed on fenpropathrin-treated plants were dead within eight minutes of initial contact with treated plants. As a result of such rapid mortality, none of the psyllids on fenpropathrin-treated plants were able to perform any phloem-feeding behaviors required for successful inoculation of healthy citrus with the HLB pathogen (Figure 6).

The results of our studies conducted to date demonstrate that it is possible for insecticides to provide some degree of protection from HLB, by causing mortality of pathogen-carrying psyllids before they are able to successfully perform the phloem-feeding activities required for pathogen inoculation. However, our results also demonstrate that not all insecticides are equal when it comes to disrupting these critical psyllid-feeding behaviors.

We are continuing this work by examining additional insecticides commonly used by Florida citrus growers to better understand the level of feeding disruption those products provide. One critical question we are also addressing with this work is, "How long does this protection last under field conditions, particularly with regard to soil-applied systemic products applied to non-bearing trees?" As we develop a better understanding of how each of these insecticides affects psyllid-feeding behaviors, psyllid management programs can be continually refined, with the goal of not only reducing psyllid populations, but also maximizing the level of protection from HLB-carrying psyllids through proper selection and timing of insecticide applications.

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