# Tarnished Plant Bug

## *Current Status of Biological Control of the Tarnished Plant Bug in Northeast Alfalfa and Research on Extension of This Method to Other Crops*

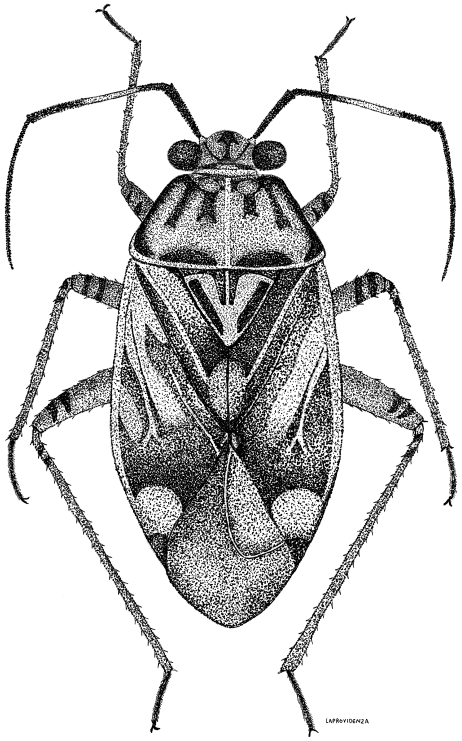
*William H. Day*
*Research Entomologist*
*USDA Beneficial Insects Research Laboratory*
*Newark, Delaware*

The tarnished plant bug (TPB), *Lygus lineolaris* (Palisot), is a native North American insect that causes moderate to severe damage to a large number and wide variety of important crops. Yield and quality losses have been recorded on numerous fruit, vegetable, and seed crops, and also on forestry seedlings and cotton.

Although the TPB is a native species, nearly all of the damaged crops are not native, and this is thought to be the reason why native parasites do not adequately control this pest. However, there are two closely related *Lygus* species in Europe, and they are significantly parasitized on several crops there — so there is some potential for introducing European parasites into the United States to reduce crop damage by our TPB.

Alfalfa was selected for the initial research for several reasons: we had an extensive knowledge of its pests and their natural enemies, both in the northeastern United States and in Europe; it is a widely grown crop here, so it could serve as a parasite "reservoir"; it is infrequently sprayed with insecticides in the Northeast; and *Lygus* spp. are an important pest of seed alfalfa in the northwestern United States.

Research on *Lygus* is complicated by the large number of crops attacked and several difficulties with the parasites (none of the previous attempts at six different locations were able to establish any parasites). However, we have made encouraging progress on alfalfa pests, having established European parasites of the alfalfa plant bug *(Adelphocoris)* as well as of the tarnished plant bug.



**Tarnished plant bug**

*Peristenus digoneutis* Loan, which attacks the TPB, is a small wasp that lays eggs in the young nymphs and kills them before they are old enough to reproduce. It has spread from our original establishment point in northwestern New Jersey into six additional northeastern states (Pennsylvania, New York, Connecticut, Massachusetts, Vermont, New Hampshire) and is likely also in Quebec, Maine, and Rhode Island. It has two generations per year and is well-synchronized with the two major TPB generations. In New Jersey, parasitism rates reached 60%, which reduced TPB numbers in alfalfa by 75%. Unfortunately, *P. digoneutis* has not become established south of New York City, probably due to climatic differences, so another species will have to be found for warmer locations.

Cooperating scientists in three states have assisted with following the dispersal of this parasite into new areas. I also have cooperators in New York (K. Tilmon, Cornell University) and in New Hampshire (Allen Eaton, University of New Hampshire) who have recently begun to research the ability of *P. digoneutis* to control the TPB in strawberries. In New Hampshire in 1998, parasitism ranged up to 55% on six farms, with an average of 15%. All para-

sites reared so far were *P. digoneutis*. Several years' work will be necessary to determine if this percentage will improve over time, and whether a reduction in TPB numbers and damage to strawberry yield and quality is occurring.

No research on vegetables has yet been started, but hopefully some will in the near future.

We have recovered a few *P. digoneutis* from seed alfalfa fields in Idaho, but it is too soon to tell if this parasite is permanently established there. While doing this work, we discovered a "new" (previously unknown) and effective parasite of the related "western TPB." Further research will be necessary to learn if either or both of these parasites can control *Lygus* in seed alfalfa. I have also released the Idaho parasite in Delaware, in hopes of obtaining biological control of the TPB in the mid-Atlantic region.

The results to date have been encouraging. My hope is that sufficient research will be done during the next decade in the northeastern United States to develop permanent biological controls for the tarnished plant bug on many fruit and vegetable crops. This will require increased research efforts, and some of you may be able to assist with this important task.

## *Tarnished Plant Bug*

*Jake Guest*
*Norwich, Vermont*

Tarnished plant bug (TPB) is by far Vermont's most important vegetable and berry pest. All organic growers as well as those conventional growers trying to reduce pesticide use suffer moderate to severe losses caused by the feeding activity of this ubiquitous native bug.

TPB is a highly adaptable, cosmopolitan feeder able to feed and breed on a remarkably large number of crop and noncrop plant species. Moreover, it overwinters successfully; has few significant natural enemies or diseases; and is able, as an adult, to move freely from host to host. TPB can produce several generations in a season and is moderately active even in the cool of spring and fall.

Crop damage from TPB feeding can take many forms, depending on the crop, and includes blossom abortion (peppers, eggplant), deformation of growing tips (celery, spinach), and cosmetic damage to marketable parts of crop plants (broccoli, lettuce). Damage to individual crops may be light to severe, but because so many crops are likely to be involved, economic impact on Vermont's typical mixed vegetable and berry farms can be substantial, especially for those farms relying on nonchemical pest control.

A recent informal survey of several Vermont vegetable and berry growers revealed that economic loss from TPB may be much more extensive than previously assumed:

1. Many growers are apparently unaware that losses they have observed were the result of TPB feeding. Blossom drop in peppers and eggplant, for example, is often attributed to temperature extremes rather than TPB. Likewise, deformation of growing tips, as in celery and spinach, is often blamed on boron or calcium deficiency.

2. Some growers have simply stopped growing certain crops because they have been unable to control TPB damage. Summer lettuce is an example. Other growers have either stopped growing organic strawberries or have never started, solely because of likely severe cat-facing of berries from TPB feeding. Growers often state that fear of TPB feeding damage was the only reason for not growing an otherwise profitable crop.

3. Most nonchemical growers have been unable to find adequate methods for controlling TPB, even with organically approved sprays labeled for TPB. Equally discouraging results have been achieved with row covers, parasitic wasps, and repellent sprays. Generally, a lot of money has been spent with few positive results. One grower spent $8,000 on a large, tractor-mounted bug vacuum, only to find that TPB was able to fly ahead of the machine and escape.

## Discussion: Tarnished Plant Bug

*Bill Day:* The USDA (U.S. Department of Agriculture) lab has been in Newark, Delaware the past 25 years and was in Moorestown, New Jersey for 50 years before that, so it is relatively old. The laboratory has five scientists along with support staff and has a mission to develop classical (that is, permanent) biological controls for agricultural pests, primarily those that have been imported through commerce; the bugs are here and their enemies are not. The USDA has a similar lab in Europe that identifies the natural enemies of our problem insects and ships them to Newark. The Newark lab tries to establish biological controls, to reduce the levels of pests and eliminate chemical use. They are often successful, but sometimes can only lower populations somewhat.

*Audience:* How do you identify which insects to study and bring in natural enemies for?

*Bill Day:* We talk to farmers and agricultural agents. If they have a problem, we will try to fit it into our schedule, though we usually must finish other projects before we can start new research. The initial research focuses on feasibility: Is the pest of foreign origin? Are there effective natural enemies there? Are they safe?

*Audience:* What about flea beetles? They seem to be controlled in Europe but not in the United States.

*Bill Day:* If someone could get the name of that flea beetle to me, I would work to put it forward. It takes us a number of years to start a project, but I will start the process.

*Audience: Phyllotreta cruciferae.*

*Bill Day:* Thank you. This is a pest that was introduced accidentally from Europe. I am told it has become an important pest and warrants some biological control research, but I am not aware of any being done. (See session on flea beetles, page 32, for more information.)

There are three kinds of natural enemies of insects that are used in classical biological control: parasites, predators, and pathogens. Parasites, like parasitic wasps that lay eggs in insect eggs, are very effective and are used most frequently in biological control. Predators, like lady beetles, also kill pests. The difference is that one parasite will kill one pest, while one predator will kill many pests. However, the mother of a parasite will lay many eggs, and parasites are usually more specific so they will reduce a single species of pest insect on the crop, which a general predator won't necessarily do.

About 40% of agricultural insect pest problems in the United States are imported. They are the result of insects coming here without their natural enemies. The Europeans do not put a large emphasis on insects that are under control there, so the USDA started a lab in France early this century to research their natural enemies of our immigrant pests. Our lab works with the lab in Europe to develop classical biological control. In classical biological control, you release the parasite or predator, then you follow up to make sure it is established and to see what effect it has on pest populations. Once it is established, it is permanent. You never have to release it again. In "augmentative" biological control, you put out natural enemies that don't last long so you have to keep putting them out. You must keep buying them, and it becomes another input cost.

Biological control did not have a good reputation in the past. The lab's work with the alfalfa weevil reversed that. The larva of the alfalfa weevil does most of the crop damage; the adult lays 3,000–4,000 eggs. Our lab worked over a ten-year span with our European lab to introduce 13 parasites. Seven established in northeastern states, four did a bang-up job reducing weevil populations. All seven are parasitic wasps. In the late 1960s and early 1970s, the sales of insecticides used to control of alfalfa weevil plummeted in the Northeast due to biological control. I estimate savings of $100 million a year due to this one project. In addition, the farmer has to do nothing to keep this going; the natural enemies are out there and are doing it all by themselves.

By 1984, I had determined that the small parasite of the TPB, *Peristenus digoneutis,* was established in northwest New Jersey. It had been released in a number of different places since it is not possible to be certain in advance where a natural enemy will establish. By 1996, it had spread to parts of New York, Vermont, New Hampshire, Connecticut,

Massachusetts, and Pennsylvania. Some additional establishment was attempted, but the parasite seems to move very well by itself in the direction of prevailing winds (northeast). By 1996, it was established in 37 counties in seven states. It had spread hundreds of miles northeast but only a few miles south. The parasite does not seem to like a warm climate. The parasite came from northern France at a latitude about that of Montreal and was not found in Mediterranean regions to the south. You can't always take a parasite from another country and expect it to establish here. We will need to find another species to replace it south of New York City, and our lab is working on this.

*Audience:* Is it found in Scandinavian countries?

*Bill Day:* No one knows. The *Lygus* bugs it attacks are generally not a problem there so they haven't researched it. I am assuming that the parasite will spread west, north, and east. It is probably in Maine already.

*Audience:* Is there any impetus to spread it by helicopters over larger areas?

*Bill Day:* We should probably let nature take its course. We tried to spread it early on, and it didn't work. The parasite is very delicate and difficult to raise. This parasite will probably take care of our problems in the Northeast, but it is not yet certain how many crops will benefit.

The female lays her eggs inside the nymph of the TPB. They hatch, eating and killing the nymph. They pupate underground and overwinter there, too. There are two full generations of the parasite in New Jersey every year, coinciding with two full generations of the TPB; there is sometimes another partial third generation of both. The parasite is doing a good job controlling the TPB. Since parasitism started to become common in 1984–1985, the TPB/alfalfa ratio has taken a nose-drive. Subsequently, parasitism has also fallen as the TPB has become scarcer.

The parasite has a good effect on TPB in alfalfa, but will it have the same effect on other crops?

In New York, Kelley Tilmon is looking at parasites in strawberries. In her research, she found that three of four fields had parasites. The parasite is therefore going into strawberry fields by itself. Alan Eaton in 1997 looked at strawberry fields in New Hampshire and found an average damage due to TPB of $300/acre. In 1998, he sent samples to our lab for analysis; we found the parasite in four of six fields, with parasitism ranging from 5 to 55% in the four fields. Two of the three fields that had low levels of parasitism had been treated earlier with insecticide for a different pest.

*Audience:* The numbers are a little deceptive. When you discuss parasitism rate, you're not looking at effect on overall population. Perhaps the overall TPB population is declining as well.

*Bill Day:* The first step is to find the parasite in strawberries. Once this has been done, multi-year studies are needed to look at its impact, and we also need to examine its effect on yield and quality. In general, if you can kill a third of bugs with a new parasite, you have a good shot at biological control, because this adds to the existing mortality.

I am also interested in alfalfa seed and carrot seed. Carrot seed used to have a low germination rate of 20–30%. In the 1930s, researchers showed that was not an inherent quality of the carrots; instead, it was due to the TPB. When TPB was controlled, the germination rate went up to 70–80–90%, comparable to other crops.

We haven't quite reached the rainbow in this project, but we have made some progress. Eight people have tried to establish parasites for the TPB in America, and I was the first one to succeed, probably due to my persistence. The parasite is now doing very well in alfalfa and is now flying into strawberries. We want to find some cooperators to look at lima beans and other crops.

*Audience:* And lettuce?

*Bill Day:* Including lettuce.

We need some research collaborators in the New England area to look at the effects of the TPB. If they're in an area where the parasite is, we should look at the effect it is having. It will be another ten years of work before we fully understand the effects on many of the crops that the TPB damages.

*Audience:* Are you researching how vulnerable these parasites are to standard insecticides in the field?

*Bill Day:* No. They may be vulnerable, but I am told that growers don't put too many insecticides in strawberries. There are probably times of the year that you can release the parasites without having them killed. TPB in New Jersey have two main generations (20 June and 20 July). The parasite populations peak at just around the same times, so they come out of their cocoons as adult wasps a little earlier. If you spray at the beginning of June or the beginning of July, when the cocoons are still in the ground, there is no danger of killing them.

*Audience:* I was wondering whether the distribution on the map shown just shows where your collaborators are.

*Bill Day:* We found most of these new parasite records ourselves with help from Pennsylvania, Massachusetts, New Hampshire, and New Jersey. The distribution follows river valleys and roads and where the crops are, not collaborators.

*Audience:* Overwintering?

*Bill Day:* In the ground, in a cocoon.

*Audience:* I was wondering if there's a potential beneficial habitat we can provide on the farm for this parasite.

*Bill Day:* Well, we haven't really researched this. It might help to plant some alfalfa to provide a year-round reservoir for them. TPB are supposed to have over 300 host plants, most of which are weeds, but whether the parasite is in all these plants, we don't know.

*Jake Guest:* My wife and I have a certifiable organic farm in Vermont. We have 50 acres including cover crops and green manures, and about 25 acres in cultivation including sweet corn. When Kim had initially invited me to come to talk, she assumed I knew about research on fungi to control TPB that is going on at the University of Vermont, but they haven't found anything. In the last week, I called up several farmers and talked to them about TPB. It is still a major problem, just like in the previous survey.

The economic impact of TPB is probably much greater than people have been saying. For most of the growers, the figure they gave doesn't include the full estimate. It's expensive to be resigned to TPB and some amount of loss. Then there's the other big problem with TPB — what you do with it? Several people have tried sprays of various kinds. Sabadilla is difficult to use and not necessarily effective. I've tried copper rotenone dust almost every day but they would just walk over the dust. People have tried other forms of rotenone and pyrethrins, but it's difficult for a grower to assess how well the treatments are working. You don't see the tarnished plant bugs dead. The only way to assess results is to notice less damage. Pyrenone® is somewhat effective but only allowed in Maine and Vermont. Conventional growers don't have a problem with strawberries, since they can spray them with malathion, but they don't want to spray lettuce and broccoli, because malathion smells bad, and the damage is done right around the time you have to harvest. No one has tried neem products, so I can't report on that.

Some people have tried row covers, excluding the bugs out of the crop. This works fairly well in strawberries, but row covers are labor-intensive. TPB doesn't seem to overwinter in strawberries, since they aren't found feeding on strawberries in late summer.

*Anaphes iole* (another parasite of TPB which is commercially available) is not doing so well. One farmer who had released them for three years, ten days apart is going to do it again but is discouraged. It's expensive, about $70 per release per acre.

*Audience:* Did this parasite *(Anaphes iole)* come from California?

*Jake Guest:* Yes, originally.

*Audience:* I think The Green Spot in New Hampshire sells it. [Editor's note: It is listed in the catalogue from The Green Spot. The addresses of several suppliers are in listed under "Sources of Commercially Available Biological Control Agents" in appendix B, page 66.]

*Jake Guest:* The growers using it might also get it from California. The new day-neutral strawberries produce continuously, and in California they can't even spray enough. The rumor is that they are using *Anaphes* on a regular basis and getting good results.

I think that's still up in the air. It's expensive to buy

them and put them out in the right amounts. Maybe they could afford more than we could, since yields are higher in California. There is research looking at nymphal parasites, too. It's still small-scale. They're not going to make any recommendations to growers yet.

There doesn't seem to be anything else promising out there for growers to use now. When we heard about *Peristenus,* the growers in Vermont soon found out that no one is producing them commercially, but Bill's responses are promising.

*Audience:* Are there any specific procedures that must be followed to release *Peristenus?* How often would you need to make releases?

*Bill Day:* The wasps must be sent by overnight mail and in special containers so they don't die enroute.

To release them at the right time, when there are a variety of sizes of nymphs, you should be able to release two times in June and twice in July. It takes ten months to find out if they have successfully overwintered, because they diapause (spend ten months in the ground), so you won't be able to see if they have survived until the next March.

*Audience:* If they have to spend ten months in the ground, that could really disrupt tillage.

*Bill Day:* It might, especially in an annual crop like lettuce. You might want to plant some alfalfa, or the wasps might be able to overwinter in strawberries, since they are a perennial.

*Audience:* Organic growers tend to keep strawberries around for two years, conventional growers five to seven. Organic growers tend to have weeds around, too. Maybe the wasps could overwinter in them.

*Bill Day:* Maybe. There's not much known at this point.

*Audience:* Some growers have used white sticky cards to use track flight of TPB and then expanded so that they have one every ten paces along row. But using white sticky traps as a control at $2 per trap is too expensive. Could you make the traps? Is there a pheromone used on them?

*Bill Day:* No, I think you could make the traps. It needs to be a similar color to attract the TPB. Probably you could also clean the sticky trap off and reuse it, adding new "Tanglefoot" or another similar product.

*Jake Guest:* The traps also collect everything, including beneficials. One company a few years ago came up with a tractor-driven vacuum machine that drives down a row and sucks them up. It's designed to smash them in the blades. But Randall McGerry says it doesn't work, because they outflew the machine; it didn't draw them in. He had bought a machine for $8,000 ten years ago; it was a prototype. Now that I'm growing strawberries myself, I realize there might be some mechanical things to do. If you can get rid of adults, then you could reduce the whole population. The conventional wisdom is that you don't want to mow alfalfa when strawberries are in bud. One grower in Maine, who was surrounded by dairy farmers, puts plantings of clover around his field, and he thinks that they prefer the clover and they go there instead of strawberry fields. He controls when the clover is cut, after the strawberries are done. But then you are feeding them and increasing their populations. There's no reason for euphoric optimism, but there are a few things that people have tried that seem to work. Most of them are cultural practices. I'm convinced that keeping weeds down, especially red-root pigweed, will help. If I can keep the weeds down, then I can control much of what goes on in my field.

On my own farm, I do not use clovers very much in any of my rotations, because the majority of my nutrition source is hen manure, so I don't need more nitrogen. I use hen manure to grow grass (rye or sudan) instead to increase organic matter. I don't have legumes in my crop rotation. Some of the speakers here this weekend have been talking about the benefit to the biological balance of having legumes, but I don't know what to say about that. Some of the larger growers plant TPB-susceptible crops in the center of fields away from hedgerows, and there's something to be said for that. Timing of mowing is crucial. Changes in cultural practices seem to hold the most hope.

In desperation, the Vermont vegetable and berry growers association heard that the University of Vermont entomology labs had done successful control of thrips for the maple industry using fungi. We approached them to work with TPB. We provided

them with a modest grant from our organization, and it was neat to see growers getting together with researchers. They got a program going and a Hatch grant for $20,000 to research fungi on TPB. First they had to figure out how to rear TPB. They have a pretty good technique for raising them. They had a lot of isolates for fungi and collected more, from all over the place. They came up with about thirty good isolates and narrowed it down to about five. These are fungi that will attack TPB and will in time infect the bug and kill it. They had to develop a bioassay technique. They started feeding the TPB beans, but the beans were killing the bugs because of insecticide residues in beans. Now they're growing their own organic beans and broccoli. They had to decide on temperatures, the size of cups, whether to cover them. They came up with a way to collect the eggs; there's a system where you take the beans and wrap them in a certain kind of toilet paper, and stick them in holes in PVC pipes in which the animals are inside. The TPB lay eggs in the toilet paper around the bean, then the researchers take the toilet paper and put it in a beaker and dissolve it, filter it out, and collect eggs. They put the eggs in individual petri dishes and hatch them out. After they hatch, they take second-instar nymphs. They take ten out of each dish and put them in amber containers, put the concentrates of fungi in with them, shake them up, strain them, and put them in plastic cups. This bioassay begs a lot of questions. It's not the way we'd do it in the field — we would never shake them up in solution. After fungi grow, the TPB turn white and fuzzy and die.

This is going in the right direction and might be a tool we can use. They have 95% mortality (in bioassays) and are now figuring out concentration. The next question is the time frame before death. It's pretty basic research, and I'm not sure it's ever going to work, but you have to do it with such an important pest.

*Audience:* Does this fungus live in the field? Does it have a life of its own?

*Jake Guest:* I don't know.

*Audience:* How do they make it grow? Do they need to let it grow on TPB?

*Jake Guest:* No, keeping it alive isn't a problem. They can culture it. They are getting a high mortality rate of TPB with the fungus, but it still may not work in the field.