

**Bulletin 4**

**Suggested Control Tactics For Chestnut Gall Wasp And  
Other Specialized Insect Pests**

P.A. Rutter, December 1987. © BRC

**Introduction**

In the United States, the Oriental Chestnut Gall Wasp, *Dryocosmus kuriphylus*, is an introduced insect pest that has caused the demise of several commercially operating Chinese chestnut orchards in the southern regions. In the Orient it is a major pest, with economic damage running into the millions of dollars annually. It is a highly specialized insect, ovipositing only in the buds of trees of the genus *Castanea*, which then form galls for the benefit of the feeding larvae, causing extensive damage to the growth and fruiting of the tree, and in severe cases causing chronically affected trees to die.

Control may be possible with conventional insecticides, but timing of application is so critical that good control is often difficult. The adult insects are exposed for a relatively brief time, and larvae and eggs are protected by the chestnut bud or gall surrounding them. Use of systemic poisons is not possible because of concerns about residues in the fruit. In addition, control by release of sterile males is not possible, as so far no males have ever been observed for this species; it appears to be entirely female and parthenogenetic. Several parasites of the Gall Wasp, wasps themselves, exist and are used to a limited extent in control efforts. Results are mixed, and the use of parasites is expensive and labor intensive.

Dr. Jerry Payne, USDA ARS Byron, Georgia, has done work suggesting total pruning of all branches in an infested chestnut orchard, destroying all galls. Control has been achieved, but results in at least one year's total crop loss, and the pruning would probably have to be repeated at intervals, to eliminate reestablished populations of the wasp.

Dr. Joseph Norton, Auburn University, Alabama, has worked with Professor Huang Hong-Wen, Hubei Academy of Agricultural Sciences, to investigate the mechanisms of resistance in several chestnut trees observed to escape infestation. Reliably resistant chestnut cultivars would of course be an ideal solution to the problem, and this approach is promising.

In the process of thinking about how to control such a species, I developed the following schemes, which appeared to me to be novel approaches, and which may very well have much broader applications. They may be useful as control tactics for any pest which is specialized, and which at some point in its life cycle must identify and utilize some specific, limited, resource, either as food, oviposition substrate, or cover.

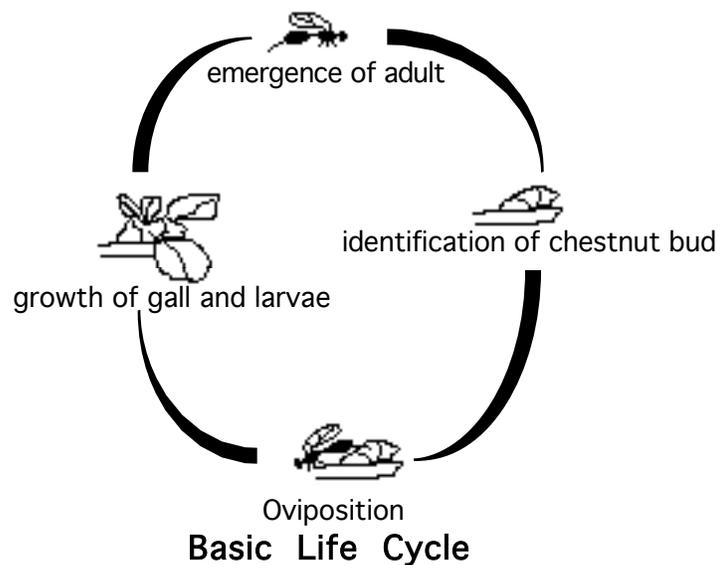
Dr. Ron Prokopy, Dept. of Entomology, University of Massachusetts (Amherst), has read this paper and believes that while similar ideas have been suggested for a variety of insect control situations, there are some interesting, and potentially useful possibilities here. He specifically warns, however, that the research necessary to identify the details of insect sensory mechanisms is demanding and very time consuming, requiring many years of painstaking work. Such research would be essential to the success of the proposed strategies.

In the following discussion, I will deal with the Oriental Chestnut Gall Wasp, but please keep in mind the potentials for other insects as well. The control techniques suggested are by no means simple, and would require considerable sophisticated research; but I believe they have the potential to be highly specific, essentially non-toxic, and once developed, highly effective and economical.

Please forgive the lack of literature references in this preliminary treatment. I am reasonably certain the facts are as presented, and the references should be easily available if reaction to this paper warrants pursuing the subject further.

## Discussion

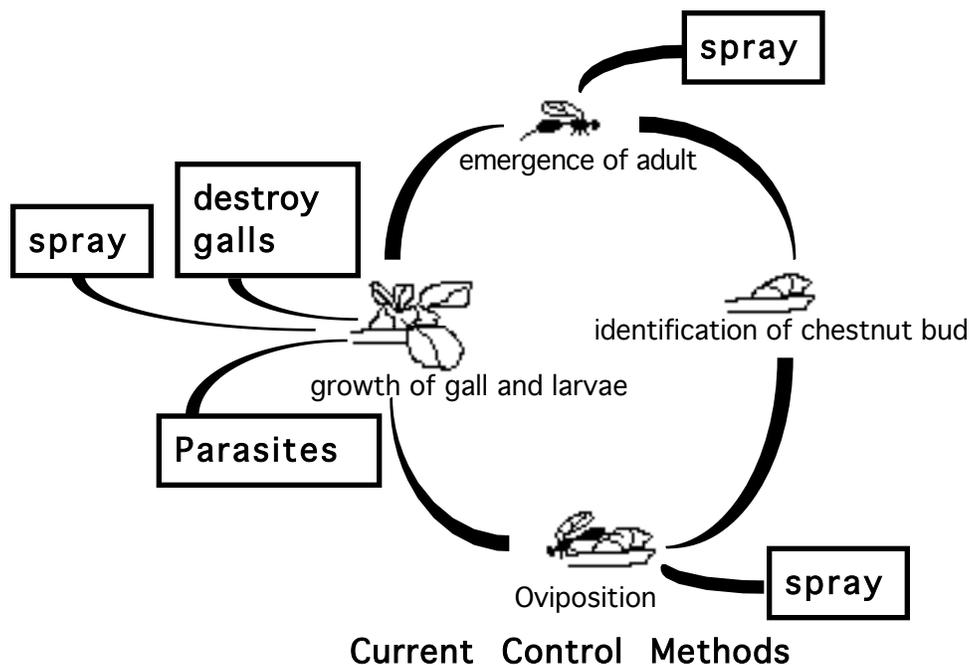
In seeking a way to selectively destroy the Gall Wasp, I attempted to analyze its life cycle, looking for any points where it might be especially vulnerable to attack. The important points are described in the first figure:



This appears to be a very simplified cycle, but in fact it is reasonably accurate. The adults emerge from pupae while in the galls, remain inside the galls for about a week, then leave the galls for a relatively short time, usually in late June and July. Adults are short lived, usually live outside the gall for one or two weeks, possibly waiting for the buds to become mature enough, then oviposit quickly and die. 3-10 eggs/bud hatch in August, and early instar larvae

overwinter in small galls, which resume growth and may develop deformed foliage in spring. The fact that the larvae and pupae are protected by the gall makes them difficult to control by non-systemic means.

Current attempts at control work as described in the next figure:



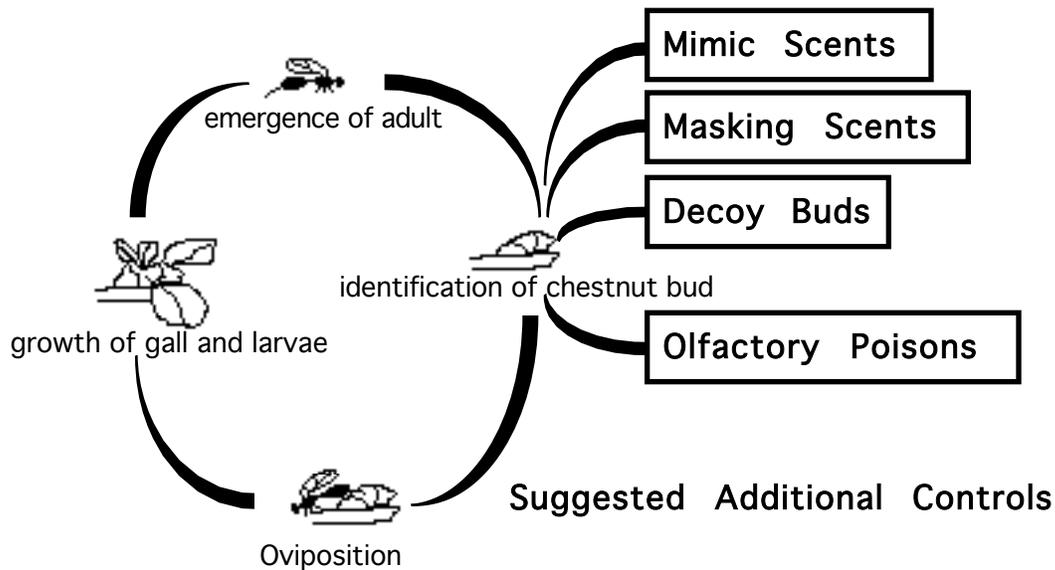
I have included the "identification of chestnut bud" stage in the cycle because it appears to me to be a critical restriction for this specialized species. It will oviposit nowhere else. Oak buds are not attacked, nor are chestnut twigs.

Because of my own interest in evolution, orchids, mimicry, and several related topics, the problem of identification of a specific type of bud suggested to me the work done by Darwin and many others on the means by which orchids fool hymenopteran insects into pollinating them. Several orchids are essentially sexual parasites of wasps, in that their flowers mimic a female wasp so accurately that males attempt to mate with them, in the process pollinating the orchid. The wasp apparently gets nothing whatever out of the transaction.

Work done to discover the basis of the orchids' mimicry usually discloses that 3 senses are involved, all of which must be stimulated to evoke the crucial mating response. Patterns on the labellum of the orchid suggest a female wasp visually, correct to wasp eyes even in the ultra-violet, as might be expected. In addition, the orchid emits a chemical which closely mimics the wasp's sexual pheromone, and once the wasp lands on the orchid, it is stimulated further by the presence of hair patches on the orchid which mimic those of the female wasp. Removal of any one of these stimuli, visual, olfactory, or tactile, results in reduced success of the mimic. That is, the male wasp does not adequately perceive his target, and will not attempt to mate.

By analogy then, if we were able to interrupt or interfere with any or all of the senses used to identify a specialized resource, we might be able to keep the target insect from identifying and using that resource. If it is one the insect cannot use any substitute for, we have the potential means to control their population.

For the gall wasp, the following possibilities have occurred to me:



It seems highly likely that olfaction plays a major role in identification of the bud, though this supposition is not by any means proven. (Even if it should not in the case of the gall wasp, it certainly will in other pest species of interest.)

Assuming that olfaction may be the first link in the wasp's location of an appropriate oviposition site, any method of interfering with that olfactory location could yield great benefits to us, as prevention of oviposition must lead to decreased numbers in the next generation. Several specific, different, tactics suggest themselves, which have the great attraction of using what must be non-toxic agents, active only for a very specific insect target.

### **Mimic Scents**

If the chemicals the wasp is sensing can be identified, they, or adequate mimics, could be produced in quantity, and sprayed in the orchard at the appropriate time. {We are probably safe in making an initial assumption that what the wasp cues on is a mixture of chemicals, rather than one specific chestnut bud "signature" chemical. Some of these may be physiological waste products excreted by the bud; or small molecules that simply "leak" from the bud; or perhaps volatile elements of bud integument layers; or possibly chemicals emitted by other organisms resident on the bud, for example mites or various microorganisms.}

In this scenario, to the wasp everything smells like chestnut buds, and it may be unable to complete identification of real buds, or accomplish oviposition. If further stimulation beyond the olfactory is necessary to elicit oviposition, then many or most wasps will fail to oviposit. Some will succeed by fortuitously bumping into appropriate buds, but a repetition of the spray in future years could make the wasp population decrease rapidly to non-economic proportions.

If little beyond the scent is necessary to stimulate oviposition, then the wasps may lay eggs at random, with almost no chance of the larvae developing to maturity, with the same end result.

In addition to, or as an alternative to spraying the orchard, adjoining non-chestnut trees, such as oaks and poplars, and even grassy areas could be sprayed with the bud scent, so that wasps will spend time searching in those inappropriate places for chestnut buds.

## **Masking Scents**

The ability of the wasp to perceive the bud scent should be susceptible to disruption in another direction, where through the use of an "olfactory anesthetic", "confuser scent" or other such chemical the orchard is essentially "deodorized" to the wasp. In this scenario, nothing smells like a chestnut bud. Once again, the wasp will be unable to locate the critical oviposition site, and control of the population will result.

In a refinement of these two methods, the orchard would be sprayed with a masking scent, and the adjoining areas with the bud mimic scent, thus drawing the wasps away from the chestnut buds and into regions where any oviposition will be a sterile exercise.

Benefits:

- The scent associated with chestnut buds is unlikely to be very toxic, to anything.
- The only insect damaged by such a spray regime would be one searching for a chestnut bud; only the gall wasp (and possibly its parasites).

Problems:

- The scent of a bud is likely to be biochemically complex, and not stable. Durability of scent (and of simpler scent mimics) could be achieved by microencapsulating the mimic chemicals with preservatives in microcapsules designed to break down and release the scent at a steady rate; or by microencapsulating the components of the scent separately, so that as the microcapsules decay the components mix to form the proper stimulus.
- Evolution will have latitude to select those wasps able to locate buds by non-olfactory means.

## **Decoy Buds**

A more complex, but still conceivably useful possibility would be to manufacture actual "decoy" buds; small objects of wax or soft plastic which would contain the necessary scent stimulus, and also look and feel, to the wasp, like appropriate chestnut buds. This might be desirable if the wasps are not relying on olfaction as much as the two previous suggestions assume. If the wasps first "see" the buds, and then "feel" them to decide if oviposition is warranted, then the scent based tactics will not be effective.

Still, the stimuli necessary to elicit oviposition should be relatively simple, and lend themselves to mimicry. Wax or plastic pellets with the right size, color, texture, and density should be very cheap in large quantities (billions). Even "hairiness" of the buds could be mimicked by including appropriate fibers in the decoy matrix.

In this case control would be through competitive inhibition- those wasps laying eggs in decoys will not contribute to the next generation.

The possibility that the wasps are capable of oviposition before the chestnut buds are attractive does make it possible that decoys spread in the orchard before the real buds are ready could make an effective control.

Benefits:

- Non-toxic
- Specific

Problems:

- Complex, expensive; not reasonable unless economic damage is large.
- Evolution will select those wasps able to distinguish between decoys and real buds, leading to a need for constant improvement of the decoys.

## **Olfactory "Poisons"**

The most elegant possibility to be suggested here is that if the wasps are locating buds by olfaction, and the chemicals involved can be identified, it should be possible to create analog chemicals which would bind to the wasps' olfactory receptor cells irreversibly. This would in effect "poison" the receptors, with the result that the wasp would either smell chestnut buds everywhere; or if the neural signal from an irreversibly bound receptor cell decays, nowhere. This is not the same as using a "deodorant" chemical, which is temporary or local in its action. End result; inability to locate oviposition site.

Benefits:

- Small quantities of spray needed
- Highly specific

Problems:

- Possibly toxic, as most things that bind irreversibly tend to be.
- Evolution will have latitude to select those wasps able to clear their receptors.

I mention the ability of the wasps to evolve responses to these techniques because I feel it is time we recognized that eventuality on a regular basis. I nonetheless feel that the techniques have real promise for control of many specialized insects, with the understanding that the techniques in use will require periodic updating, in the long run, just as conventional insecticides do. It seems likely to me that these techniques based on interrupting the ability of the insect to locate a given resource might prove more durably useful than the standard toxins, however.

### **Other Insects**

Even some non-specific insects might be controlled using these techniques. For example, the periodic cicada oviposits in many tree species, with, however, varying rates. Some species are favored, and heavily damaged, others not favored, and seldom seriously affected.

It seems likely again that olfaction plays a role in such favoritism; if so, "repellent" scents from less utilized species might be put to work on trees usually badly hit, and any "attractive" scents from the favored trees might be masked. It is highly improbable that cicada damage could be completely stopped, but it might be reduced to acceptable levels. Currently, an outbreak of periodic cicada means a complete loss of the chestnut crop for that year.

Other insects that might be controlled:

Chestnut weevils, which feed and oviposit only on chestnuts in their burrs.

Any insect with a specific need for either food or reproduction.

An interesting question:

Does a notably hard-to-control generalist insect like the plum curculio have a generalized olfactory stimulus it uses to recognize fruits? If so, it may be vulnerable to some of the above techniques.

### **Turning Theory Into Fact:**

Methods for identifying olfactory substances are well worked out, but require specialized laboratories. In addition, when working with insects, it would be necessary to have available both insects and their plant prey in the appropriate stages of development, so that, for example, two different chemical fractions of "ripe chestnut bud" can be presented to an "oviposition-ready" wasp, so that its reactions can be observed and the appropriate fraction selected for further biochemical dissection.

I must necessarily remain only a theorist on this subject; it is not in my future to be able to work in such a laboratory, nor would I have the time to do so. Therefore, I solicit the help of the reader, should you be so motivated, in finding an investigator who would like to pursue this work.

Please feel free to pass copies of this paper on to any colleagues you think might be interested.

Your comments and suggestions would be welcome.

**My thanks** to Dr. Jerry Payne, Dr. Robert Bugg, Dr. Joe Louis, and Dr. Ron Prokopy for reading this treatment; for their comments; and for their expressions of interest.

Note, 2/96. An additional gall wasp control possibility, already discussed with my Chinese partners, is the planting of "trap" crops of *Castanea seguinii*, a bush. It has been noted in China that the seguin chestnut plants are often highly susceptible to the gall wasp, even more so than *C. mollissima*. It could be feasible to plant or interplant some seguin chestnuts in an orchard, using them to monitor infestation levels, coppicing the bushes in times of severe infestations to reduce the population, and/or using them to help rear populations of gall wasp parasites and diseases. It should be relatively easy to select strains of seguin chestnut (or others) specifically for their attractiveness/ susceptibility to the wasp. In the best scenario, the gall wasps would greatly prefer trap strains to main crop chestnuts, eliminating damage to the crop. North America.

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