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INTRODUCTION

As bamboo commerce and cultivation has expanded throughout the world, so too have the insect and mite residents of bamboo. Some of the most troubling residents of bamboo are the bamboo mites, a number of mite species, which feed on bamboo potentially lowering its aesthetic and economic value. A wide variety of mites occur on bamboo. Forty-five species of mites from 23 genera and 9 families were collected from moso bamboo in Fujian, China (Lin et al, 2000). Of most concern in the production of bamboo are mites from the families Tetranychidae, Eriophyidae, and Tarsonemidae.

The bamboo spider mites in the genus *Schizotetranychus* have been implicated as the most damaging mites in bamboo production. Schizotetranychids are found worldwide, including Asia, Europe, and America (Banks and Tuttle, 1994; Ostoja-Starzewski, 2000; Flechtmann, 1995). In the U.S., mites of bamboo are thought to be *Schizotetranychus celarius*. First described as *Stigmeopsis celarius* by Banks in 1917, it was renamed *Schizotetranychus celarius* by McGregor in 1950 (Baker and Tuttle, 1994). *S. celarius* is actually a complex of

mites. These mites have been further delineated as separate species; *S. celarius* Banks, *S. miscanthus* Saito, and *S. longus* Saito (Saito, 1990). Baker and Tuttle (1994) list the distribution of *S. celarius* as California, Florida, and Georgia. *S. longus*, previously known as the long setal form of *S. celarius*, is the species of bamboo mite isolated from two sites in Oregon (Pratt and Croft, 1999). *Schizotetranychus longus* Saito was originally described from specimens collected from *Sasa senanensis* (Franch. et Sav.) on the island of Hokkaido in Japan (Saito, 1990a). Bamboo mites have also been reported from Maryland, Virginia, and Louisiana.

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BIOLOGY

Bamboo mites have a flattened body, which is straw-colored to greenish yellow with small blackish green spots. These mites form colonies on the underside of the leaves and live under a densely woven web. Generally the mites remain under the web to feed and lay eggs, leaving to defecate in black fecal piles slighted removed from the nest. Adults and nymphs can sometimes be found outside the webbing, particularly as they begin to form new nests. Multiple males and females can be found in the web nests and often many webbed nests will form alongside each other running down the underside of the bamboo leaves. Saito and Ueno (1979) report 26 generations per year for *S. celarius* Banks reared in controlled laboratory environments.

Multiple life stages

Egg mass

There are preferred bamboo host species for *S. longus*. *Sasa* appears to be one of the

most susceptible hosts. The other reported preferred hosts are bamboo plants of the genera: *Indocalamus*, *Phyllostachys*, and *Pleioblastus* (Cooper, 97). It is thought that leaf pubescence may deter the mite.

Cultivar effects - Note increased damage on *Sasa*

Mites outside web

United web

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DAMAGE

The mite feeding on the plant cell contents leaves a distinct pattern of damage visible on both sides of the leaf. The feeding site damage is yellow and may look similar to variegation. This damage is thought to vary slightly amongst the bamboo mite species and may be a helpful indicator of which species is present. Research by Yu Huaxing and Shi Jimao (mentioned in Insect Pests of Bamboos in Asia), measured a population of Schizotetranychid mites in an outbreak on bamboo in China, averaging 85.2 mites per leaf, and the impact of their damage on new shoot production was quantified as a 200 kg per hectare reduction.

Damage along vein

Severe damage

Fecal spots (leaf underside)

Fecal spot closeup (leaf underside)

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CULTURAL CONTROL

The best way to control a pest is to avoid it like the plague. Think of bamboo mites as contagious. Is this something you want to share with your friends? If not, then consider implementing a preventative pest management program. That can be best accomplished by the use of
· inspection,
· quarantine, and
· hot spot eradication.
Bamboo mites are monophagous mites, limited to few plant species. This works to our favor in control of the mite, as reintroduction potential is limited. Meticulous inspection of all new plant material is critical. Trade plants, not pests.

Quarantine new plant material away from other susceptible plants, downwind if possible. Systemically monitor new and existing plants on a regular basis to locate possible mite populations. If possible, isolate infested plants from non-infested plants. Work from the non-infested areas of the nursery prior to working in infested areas. Many spider mite species hitchhike on clothing.

Repeated spot applications in infested areas have been successful in some sites.

Several growers are working with the 'slash and burn' concept. They remove most of the above ground foliage of infested plants and burn or otherwise dispose of the foliage. They then treat the emerging foliage to kill any remaining pest mites. Although severe, this treatment may be the only practical solution for heavily infested sites, particularly where chemical application presents difficulties. The U.S.D.A. Agriculture Handbook 193 mentions the use of hot water treatment for dormant rhizomes to eliminate mites. It suggests immersing them for ten minutes in hot water at 50ºC (122ºF) then heeling into sand or sawdust and kept cool until planting time in the spring.

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BIOLOGICAL CONTROL

Many growers are interested in the use of biological control of pest mites. They are interested for a variety of reasons including
· the desire to reduce the use of pesticides,
· increase worker safety,
· increase plant quality, and, occasionally,
· to reduce pesticide application costs.
Many sites are not well situated for chemical control and may have restrictions imposed by their sites. Examples of such are
· zoos,
· interiorscapes,
· hospitals, etc.
In these sites, biological control may be an option. By its nature, biological control generally requires low levels of the pest present in order to sustain the natural enemy population. These low levels would not be desirable for plants, which are to be sold or transported. A production nursery might use a biological control program to suppress bamboo mites below a damaging threshold, later to clean up their plants before sale with miticide applications.

There has been work to study and develop biological control programs for bamboo mites. Zhang and colleagues looked at the potential of *Amblyseius cucumeris* as a biocontrol agent against *S. nanjingensis* (Zhang et al, 2000). *A. cucumeris* is most readily known for its augmentative use against thrips. In their research, the number of prey consumed by predators increased with density. This numerical response is generally a good trait in predators helping to increase the suppression of pest mites as the pest population increases. *A. cucumeris* was not able to invade intact webs however, but was able to stay and lay eggs in broken nests, which were common. *Typhlodromus bambusae* Ehara is considered a specific predatory mite of the *S. celarius* mites in Japan, but is not present in the United States (Saito, 1990b). Pratt and Croft, as well as this author, have looked at the management of *S. longus* with an endemic predatory mite, *Neoseiulus fallacis* (Garman) that is commercially available. N. fallacis was able to feed, reproduce and develop on S. longus and significantly reduced the infestation levels of *S. longus* (Pratt and Croft, 1999). It readily entered nests of bamboo mite through natural openings or creating new holes.

This author has worked with *Neoseiulus fallacis* in a number of nurseries on a variety of different plant types. It has been successfully used to suppress
· two-spotted mites,
· citrus red mite,
· spruce spider mite, and
· bamboo mites in commercial operations.
The key to the successful use of biological control in these situations is good scouting and releasing the mite at the proper threshold. We use a very conservative threshold of one pest mite per every five leaves. These low levels of pests are not usually noticed without a rigorous scouting program. This particular predator mite requires 80% humidity easily found in the canopy of bamboo grown in the Northwest.

There are a number of other predatory mites, which might suppress bamboo mites and may deserve further investigation.
· *Galendromis occidentalis*, the western predatory mite, may do better in hot, arid climates.
· *Phytoseiulis persimilis* is often used in greenhouses and field releases for two-spotted mite. It tends to work very well at higher densities of prey than controlled by *N. fallacis* but is not as adapted to colder temperatures.

· *N. californicus* has been successful in many crops in California.
Research investigating inundative releases designed to eliminate the bamboo mite might be useful.

Another consideration with the use of predator mites, is the use of compatible pesticides if pest problems arise. There is some data on chemical available for *N. fallacis* and other predator mites. Suppliers of the predators may be the best source for this information for particular predators.

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CHEMICAL CONTROL

FOR COMMERCIAL NURSERIES

In order to reduce the movement of bamboo mites in commerce and to reduce the potential for aesthetic and economic damage, chemical treatment may be warranted.

Some factors to consider with chemical control are
· mode of action,
· residual,
· potential for phytotoxicity,
· selectivity,
· application efficiency,
· re-entry interval, and
· toxicity.

Few miticides have been registered specifically for bamboo with the exception of Floramite. Although most miticides will be efficacious, it is incumbent on the grower to test each new pesticide on a few plants and wait 7 to 10 days to check for phytotoxicity. Miticide activity varies and it is useful to know the

mode of action of a chosen pesticide to kill mites.

Some miticides kill immature and adult mites, some kill eggs and immatures only, some kill practically all stages.
For example
· Hexagon targets eggs and immature mites only but has a very long residual and also sterilizes the female mites.
· Oxythioquinox (Joust or Morestan) have ovicidal activity but the products are no longer manufactured (growers can use up existing labeled stock until September 30, 2002).
· Floramite has some ovicidal activity but targets immature and adults mites.

When using miticides without ovicidal activity, two applications against mites 7-10 days apart are recommended. Several of the newer miticides have restrictions on the number of applications per season to reduce development of mite resistance. Rotations between products with different modes of action will help reduce selection for resistance. It is very important to read all labels completely.

Contact is one of the most important issues for applicators trying to eliminate bamboo mites. Thorough coverage of the bamboo leaves, particularly the leaf underside housing the mites, is required for good activity. This is particularly important with bamboo mite, as this mite produces thick webbing, which may reduce pesticide penetration. High pressure and electrostatic sprayers may increase coverage. Some miticides, such as Avid, have systemic activity (translaminar movement of the pesticide) and can increase mite suppression particularly where thorough coverage is difficult. The natural waxiness and near vertical growth of bamboo leaves often cause pesticides to bead up and roll off of the leaves. The addition of a surfactant can reduce this occurrence, ideally spreading the chemical evenly over the leaf for good contact. Don Emenegger of Uniroyal Chemical Company has evaluated the use of surfactants alone and with Floramite for control of bamboo spider mite. His findings show that the surfactant rate used is much more important than the particular surfactant itself (Emenegger, pers. comm.). As many surfactant labels give a range of rates, it was important to adjust the surfactant rate on any given plant variety until spray droplets spread instead of beading up on the leaf surface. Additionally, although not registered pesticides, many of the surfactants themselves had direct activity on the mites. Mite eggs, however,

were not affected and the mite population eventually rebounded. Silicon-based surfactants (Silwet and Silgard) are recommended for Floramite. Latron is recommended for Kelthane. Oil may enhance Avid activity. Oil, itself, has miticidal activity upon direct contact, including the ability to smother mite eggs. There is no residual activity in oil and insecticidal soap products, however, and frequent applications may be necessary.

Selectivity of the pesticide targeting mites is also an issue. Where multiples pests are present (for example, bamboo aphid and bamboo mite) some growers choose a pesticide with broad-spectrum activity such as Talstar. More selective miticides may be indicated for sites using biological control or interested in conserving natural enemies. Floramite has been used in conjunction with predatory mite releases in Oregon with no apparent impact on the predatory mite, *Neosieulus fallacis*. Oils and soaps, though they can kill on contact, have no residual, leaving immigrating natural enemies unharmed. Although homemade concoctions of oil and soap applications may very well have an effect on the mites, the base products are not formulated for plant use and may cause phytotoxicity. It is also important for applicators at commercial nurseries to use pesticides legally registered by the EPA and licensed in their state.

Toxicity and re-entry levels vary tremendously. The chart provided of specific products, gives this information for several of the most commonly used miticides. Additional information on chemical control of bamboo might may be found on the web at http://www.ent.orst.edu/urban/home.html.

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LINKS

Oregon State University's Urban Entomology Bamboo Spider Mite Page:

WSU Cooperative Extension Bamboo Research

American Bamboo Society

European Bamboo Society

International Bamboo Association

Internation Network for Bamboo and Rattan

Florida Department of Agriculture and Consumer Services: Bamboo Mealybug

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YOUR TURN

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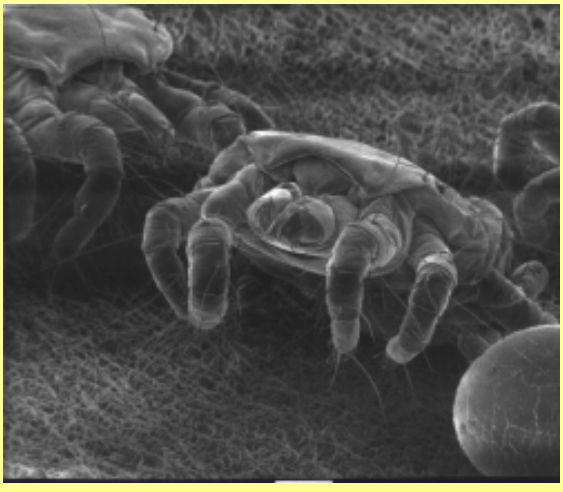

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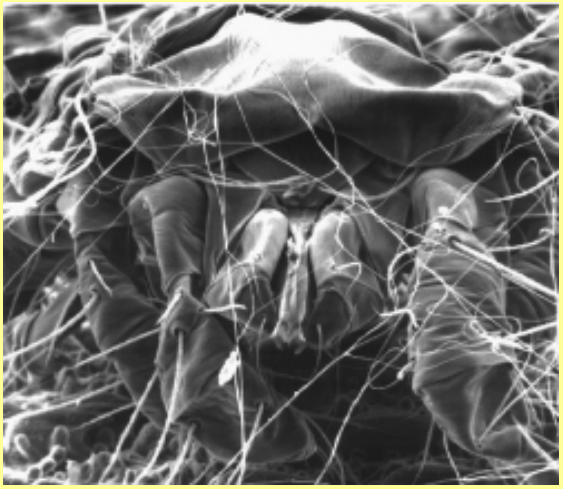

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