Some Asian Imports we Don't Need

One statement I have heard some growers and sellers of bamboo in the United States make is that bamboos (sic) are practically pest-free (aside from a bit of bother with bamboo mites out on the West Coast or some troubles with leaf scale and sooty mold in the Deep South). Since there are only one, two, or three species (depending on who you talk with) of bamboo native to the continental United States (and these just to the Southeastern quadrant at that), for most of the United States, bamboos (sic) are a highly exotic species considerably different from other any plant native to their region. Even in the Southeast, much of the original canebrake acreage had been cleared for agriculture long ago (leaving for the most part dwarfed residual stands along field and stream margins), so any organisms that made their living off them would have been thinned out along with the canebrakes. So to most native insects, mites, and plant pathogens (and to those that hitchhiked here from Europe), bamboo is a very foreign food item, with a physical structure, growth habits, and a seasonal life cycle very different from those of the plants they are accustomed to feeding on. As a result, many pest insects and plant pathogens are unable to make the leap over to bamboo and most of those that do often infest close relatives such as the herbaceous grasses. But this situation is definitely not the case in Southeast Asia, a land with hundred's of native bamboo species and entire ecosystems (including many pest insects) that evolved along with bamboo through the eons.

Unfortunately a few of these Asian bamboo pests have managed to slip through the cracks to enter this country and continue infesting the same bamboo species that they infested back in their native haunts (and added a few additional bamboo species to their diet that they had never before encountered). Some of them came over back in the pre-USDA inspection days of the late 1800's/early 1900's, while others likely came over on plants smuggled into this country by those wanting to bypass (or ignorant of) the lengthy inspection/quarantine system. Some could have entered on recently made bamboo artifacts, while others may have entered as incidental organisms on non-bamboo plant materials that were not so rigorously inspected. But even though we have some Asian bamboo pests established here in the United States, those species currently in the United States are but a tiny percentage of the total number of pest organisms infesting bamboos (sic) in Asia. Many of those that aren't over here cause major headaches for the Chinese bamboo grower. And they would also cause major headaches for American bamboo grower if they did get loose on this side of the Pacific.

When a foreign pest insect gets introduced into a foreign land, there is no way to accurately predict how bad a pest it will prove to be in its new home relative to its pest stature back home. There are several factors that can cause a pest species to be much worse abroad than in its native land or alternatively it may be unable to survive in significant numbers in its new home. Often when an exotic pest gets introduced to a foreign land, it leaves behind the many predators, parasites, and pathogens that attacked it and kept its numbers in check back home in its native land. So unless some local predators and parasites are able to add it to their menu, the new pest species could run amuck, totally unchecked by any of the restraints that kept its numbers under control back home. But there are a number of factors that can keep down the population of an introduced pest or may cause it to eventually die out. It may require an alternate host plant species for part of its life cycle that is not present at its new home. Some local pathogens, predators, or parasites may add it to their menu. It may need vast continuous acreages of bamboo groves containing multiple bamboo species to survive, and thus be unable to survive in the postage stamp-sized, widely separated bamboo groves that are typical of bamboo status throughout most of the United States. Or the new bamboo pest may have trouble adapting to the vagaries of our eastern North American winter weather, which is much more severe with their warm and cold weather patterns than anything they had evolved for back in their native lands. Since many bamboo pests (such as scales, mealy bugs, and bamboo obligate aphids) require continuous access to the evergreen leaves and culms of bamboo to survive, they are often unable to survive (or survive only with great difficulty) in those portions of

the Upper South, Northeast, and Mid-West where bamboo groves can get defoliated or top killed on an occasional to regular basis.

In general, the larger the size of the bamboo pest, the larger the area of grove it requires to maintain a long-term stable population. A jumbo-sized bamboo pest such as a giant panda requires many dozens of square miles of bamboo grove to maintain a viable population, whereas a tiny one like the bamboo mite can maintain viable populations on the leaves of a single branch. Since bamboo groves tend to be few and far between over most of the United States (except for parts of the Southeast), and most of those that do exist are very small in area (relative to the size of groves in Asia), this would tend to put some damper on the activities of the larger-sized bamboo insect pests unless they are also able to feed on some of the surrounding non-bamboo plants.

From the standpoint of an obligate bamboo pest organism, most of the United States is a desolate landscape with only occasional small oasis of usable environment (the planted bamboo groves) scattered widely here and there across the countryside. Only in the Southeast, with its remnant groves of native bamboos and scattered feral groves of exotic bamboos, would the land be considered in any better terms than a bamboo desert, but even in the Southeast the land is bamboo impoverished when compared to the native bamboo regions of Southeast Asia. Because suitable bamboo habitat is so far and few between in this country, bamboo pests are unable to hop from grove to grove as they would in Asia. So outside of the relatively bamboo rich parts of the Southeast, most bamboo groves in the United States grow in splendid isolation from obligate bamboo pests. Which means in order to get a bamboo pest problem in your groves, you usually have to import the pest on bamboo plant material brought to your garden.

But for those growing bamboos in the Southeast within the native range of Arundinaria gigantea/tecta, there exists the possibility of encountering some of our native bamboo pests normally associated with native cane, which may find some of the exotic bamboos to their liking. Around here, a leaf-rolling caterpillar tentatively identified as Crocidophora pustuliferalis feeds on the leaves of some of my bamboos. This species is found throughout the Southeast and is listed in the USDA's "Bamboo in the United States" as having been found on A. tecta (where it can destroy up to 25% of the leaves) and on Semiarundinaria at Savannah, GA. But it is not on a list of caterpillars recently found feeding on A. gigantea growing in eastern North Carolina. There are 2 species of Crocidophora leaf-rollers listed by INBAR and one of these, C. evanoralis, has a life cycle and host range that jives with what I have observed with my local leaf-roller. Here, this leaf-roller is rather efficiently controlled by the local pathogens and predators, implying a native status. So at this point I am not sure whether this leaf-roller observed on my plants is a native species that has found exotic bamboos to its taste or if it is an exotic species that has spread widely across the Southeast. Here, I have observed it on Semiarundinaria fastuosa, Phyllostachys nigra, Pleioblastus graminius P. hindsii, Sasa kurilensis 'shimofuri', Hibanobambusa tranquillans 'shiroshima', and Yushania anceps. In my garden, this leaf roller is a minor pest with its numbers varying greatly from year to year. On some years, it is almost nonexistent, while on others it can render portions of their favored bamboo species unsightly with their leaf cases. It is active all summer with new cases of hatchling caterpillars appearing from early July through most of September. These caterpillars are attacked by some unknown parasite or pathogen and in late summer, leaf cases can often be found where some or all of the caterpillars have been killed while still inside of their case. This species is also present in Australia where it attacks Bambusa oldhami and other bamboo species, but is not listed for Asia.

Since A. gigantea isn't an commercially valuable crop, the organisms that feed on it haven't been studied anywhere near as rigorously as those that infest the Asian bamboos and those that have been best studied are those having pretty butterflies as their adult stage. Some of the nondescript moths found feeding on native cane have only recently been discovered and studied. There are over 16 species of native caterpillars listed as feeding on our native Arundinaria. These caterpillars include both leaf feeders and shoot borers, but so far, except for

this one leaf-roller, I have haven't seen any evidence of them feeding on any of my exotic bamboo species despite the presence of some A. gigantea (deciduous form) just across the road and A. gigantea (evergreen form) within ? mile of here. There is also some unknown insect that leaves tiny feeding pockmarks (sap sucking bug or beetle?) on the leaves of the local A. gigantea (deciduous form) found growing deep in the surrounding forests and I've also seen it on the leaves of Chusquea culeou growing here in my garden.

The remainder of this article is a survey of the vast range of insect and mite pests that attack bamboos in Asia (and the techniques used in Asia to control them), concentrating on those pests attacking the genera of temperate bamboos commonly grown in zones 8 and colder of the Southeastern US. Much of the following information was taken from the USDA publication "Bamboo in the United States, description, culture, and utilization", and the INBAR publication "Insect Pests of Bamboos in Asia: an illustrated manual" by Wang Haojie, R. V. Varma, and Xu Tiansen.

The leaf eaters

Some of the worst insect problems on bamboos in China are caused by grasshoppers, of which there are 34 species that feed heavily on bamboo. Although our native grasshopper species will sometimes feed on bamboo, they are not behaviorally adapted to efficiently incorporate it into their diet. But in Asia, there are a number of grasshopper species that specialize in the eating of bamboo leaves. They are one of most important bamboo pests in Southeast Asia and can appear in the form of large plagues of locusts, which can totally defoliate a bamboo grove and can kill a bamboo plant if it gets repeatedly defoliated by the locusts. In China you will often find a number of different locust species feeding on a bamboo plant at the same time.

Ceracris kiangsu, the yellow-spined bamboo locust, feeds on the leaves of various bamboos in China, but especially enjoys those of Phyllostachys pubescens. It goes through one generation per year, over wintering as eggs, with the nymphs hatching in late spring. These nymphs will feed in large groups on the leaves of small bamboo plants and on those of various low-growing grasses before moving on to the taller bamboos as they grow and get larger. They will typically start feeding on leaves at the top of the culm and then work their way down the culm, eating as they go. The adult locusts lay eggs in the ground in late summer, mostly on hot, dry sites with loose soil. This species is one of most destructive pest insects on P. pubescens, often causing new culms to die and totally shutting down production of new shoots for several years following a severe plague of these locusts. In China, they are controlled by turning soil to expose eggs, by spraying with a white fungal locust pathogen, or by spraying with insecticides. Early in the year, they spray the nymphs while they are still feeding on low-growing plants and easily accessible. Some consider this to be the single worst bamboo pest, since when present in large numbers, they can totally defoliate a large grove and cause all of the new shoots to abort.

Another "bad" locust species is Hieroglyphus tonkinensis, which feeds on Bambusa, Sinobambusa, Dendrocalamus, and Phyllostachys in China. It has one generation per year, over winters as eggs with the nymphs hatching in the spring. The rest of its lifestyle and the damage it causes are very similar to that caused by the yellow-spined bamboo locust described above.

I couldn't find enough about the feeding habits of these locusts to find out whether it was a generalist feeder that happens to be very good at utilizing bamboo whenever it is available in its environment or whether it is a bamboo specialist feeder that requires the presence of bamboo in its environment is order to survive and successfully breed as an adult. If the former in the case, then this locust is likely to thrive if accidentally released into the United States and devour bamboo whenever they encounter it is a much more efficient manner

than any of our native locust species. But if the latter is true of this locust, then it probably wouldn't survive here outside of those portions of the Southeast where native Arundinaria is common. If it did get loose, hopefully our native bird life and insect predators would be up to the task of keeping these exotic grasshoppers under some degree of control.

There are 35 species of leaf beetles that cause some defoliation in the groves. One of these is Leptispa godwini, which feeds on Dendrocalamus, Phyllostachys, and Pleioblastus in Southern China where it has one generation per year. In the spring, the adult beetles lay eggs on the newly growing leaves. The hatching nymphs feed on the leaves in a manner that causes the leaf to curl up tightly lengthwise, wrapping the nymphs inside of the curled leaves and hiding them from predators. As they mature into adults, they continue feeding on leaves in the case and creating additional mini-leaf cases as needed. The adult beetles over winter inside of these leaf cases. If this beetle did get loose over here, it sounds like it would be more of a problem in the Deep South and would get killed out in the colder parts of this country where the occasional winter defoliation deprived this beetle of its over wintering leaf shelters.

Just as we have pine sawflies here in the pine-rich southeastern United States, in China they have bamboo sawflies. There is a single species, Eutomostethus nigritus, which attacks all Phyllostachys. It can appear in severe outbreaks that cause heavy defoliation and can result in the death of many culms. This nasty pest has 1 or 2 generations per year. It over winters as pre-pupae in the soil, with the adults appearing in late spring to lay eggs on the newly growing leaves. The resulting larvae feed in groups on the leaves, before eventually dropping to the ground to form pupae. The pupae will either emerge in late summer to start a second generation or else remain dormant to emerge as adults on the following spring. It is controlled by culm cavity injection of systemic insecticides. Needless to say, this is one Chinese import that we definitely don't want over here in our bamboo groves and it would be a real disaster if it got introduced into the Southeast and found A. gigantea to its liking. With its great mobility and having left all of its predators, parasites, and pathogens behind in China, it could create great devastation on bamboos throughout the Southeast.

Caterpillars are another group of bamboo pests that are very common on Asian bamboos with a multitude of species specializing on feeding on various parts of the bamboo plant, but the bulk of the species feed on the leaves.

Leaf roller caterpillars tie together bamboo leaves to form a case that hides them from predators and then eat out the inner layers of leaves inside the case. The remaining leaves on the case eventually wither and fall off long after the caterpillars have left the scene. In Southeast Asia, leaf rollers tend to occur in outbreaks and can cause serious defoliation, reduced vigor, and sometimes death of the culms when present in large numbers. Damage is usually most severe in the larger groves. Algedonia coclesalis, the greater bamboo leaf roller, is the most common and destructive of the 15 species of leaf rollers found feeding on bamboo in Southeast Asia. It feeds on many bamboo species including Phyllostachys, Arundinaria, Bambusa, and Dendrocalamus from India to Japan. It has several generations per year with the pest populations peaking while the local bamboo species are most actively growing new leaves. The adult form is a moth. In China, its natural predators include birds and many different insects as well as parasites and fungal pathogens, but often the natural enemies are unable to control the caterpillar populations, resulting in an outbreak of leaf rollers infesting the bamboo. In China, leaf rollers are usually controlled by light trapping of the moths at night, turning over the soil to expose the pupae, release of parasitic wasps, and by culm cavity injection of systemic pesticides. If these got over here they would probably cause damage similar to that caused by our local leaf roller species, but since we don't have the extensive acreages of bamboo groves that they do in Asia, they are probably unlikely to be more than just a localized nuisance.

There are many types of non-leaf rolling caterpillars also found feeding on bamboo leaves in Asian bamboo groves. There are 11 species of puss moths that feed on bamboo. One of these, Besaia goddrica, is found on Phyllostachys in China, where it often causes heavy defoliation within the groves. It has four generations per year and the larvae remain on the leaves all winter where they will continue to feed during warm winter days. Once mature, the larvae will drop to the ground and pupate in the leaf litter, followed later by the moths, which lay eggs on the leaves and continue the cycle. Various birds, insects, and parasites are the main controls over their population levels.

Another group of caterpillars found on bamboo are the tussock moths, of which there are 16 species that infest Asian bamboos. For the most part they just cause minor damage in the bamboo groves, but can be controlled by keeping the groves thinned out, destroying the eggs and pupae as they appear on the base of culms, and by light-trapping of the adult moths.

There are 4 species of leaf skeletonizer moths found on Asian bamboo. They usually cause only minor damage, but can occasionally appear in great numbers resulting in severe defoliation of the groves. An example of one of these is Artona funeralis, which feeds on the leaves of Phyllostachys, Bambusa, Arundinaria, and Pseudosasa from India to Japan. It prefers dry, hot conditions and is mostly found along the grove margins, in groves with a low culm density, and in groves growing on hot, dry sites. It has 3 to 5 generations per year, and over winters in the form of larvae. It lays its eggs on the undersides of the leaves and pupates under the leaf litter. Its numbers are kept in check by heavy rains, which kills eggs and young larvae, and is also controlled by parasites and a viral disease. Culturally, it is kept under control by keeping the culms thinned out and by turning the upper soil layers to expose the pupae to birds and other predators.

Slug moths, with 2 species infesting bamboo, are another group of bamboo feeders that cause mostly minor damage in Asia.

A more injurious group includes the 7 species of noctuid moths that feed on bamboo leaves. These can appear in sudden population explosions and can cause severe defoliation in the groves. One of these is a species of Eustolia, which attacks Phyllostachys in China where is has one generation per year. It lays its eggs on leaf undersides, and once hatched, the larvae will feed voraciously for 25 days before forming pupae and over wintering in the soil. It does best in hot and humid conditions. The Chinese control it by light trapping the adult moths, by weeding out the various flowering plants fed on the adult moths, and by spraying a fungal pathogen on the larvae. Here in the Southeast we have 10 species of noctuid moths that feed on Arundinaria gigantea/tecta, including both leaf feeders and cane borers. Some of these species are somewhat rare since they require culms of over ? inches diameter for their larvae to feed on, a culm size few of today's impoverished canebrakes can produce. I have no idea if any of these native moths will also feed on the non-native bamboos found growing in the Southeast.

Just as we several types of tent caterpillars that infest the trees over here, in China they have 4 species of tent caterpillars that specialize in feeding on bamboos. The most common of these is a species of Cosmotriche, which occasionally occurs in outbreaks causing heavy defoliation in Phyllostachys and Bambusa textilis groves. It has 2 generations per year. The moths lay their eggs on the leaves in late spring. The Developing larvae feed on the leaves all summer and fall, then descend to the ground to over winter in the leaf litter. In the spring, they climb back up the culms to resume feeding before finally pupating in late spring. The mature larvae form their pupae on the smaller branches of the culm. They are controlled by culm injection with systemic insecticides and by natural parasites.

There are 3 species of leaf mining caterpillars found on bamboo in Southeast Asia, where they are a minor pest

usually kept under control by the many parasites and predators that normally attack them. An example of one of these is Glyphipterix semiflavana, which mines the leaves of Phyllostachys in China and Japan. It has 1 generation per year. The adult moths emerge in spring and lay eggs among the newly growing leaves. The eggs hatch, releasing larvae that burrow into the newly formed leaves, where they begin mining out the interior of the leaf, working their way towards the tip, where they exit and then move on to another leaf. By summer the larvae have matured and form pupae where they remain until spring.

Here in the Southeast we have leaf miners that feed in a similar manner (but continue laying eggs on into early summer) on Arundinaria gigantea and in my garden also feed on the leaves of Chusquea (culeou, gigantea, valdiviensis) Borinda boliana, Fargesia nitida, Phyllostachys heterocycla pubescens, Sasaella masamuneata albostriata, Thamnocalamus (crassinodus, tesselatus), and Yushania (anceps, aff. chungii, maculata, maling). They are a minor pest that prefers to feed on the first few large leaves that appear on the end of new shoots and major branches.

There are 45 species of satyr butterflies whose caterpillars feed on bamboo leaves in Asia where they can cause some defoliation. One example is Neope muirheadi, which feeds on Phyllostachys in China. It has 2 generations per year. Its larvae feed in large groups, which as they get larger, start tying leaves together to form cases similar to those produced by the leaf roller moths. Their numbers are usually kept under control by the many parasites that attack them. Over here, we have 2 species of satyr butterflies whose larval stage feed on A. gigantea/tecta leaves. These are the southern pearly-eye (Enodia portlandia) anad the Creole pearly-eye (E. creola).

Another minor pest on Phyllostachys, Bambusa, and Dendrocalamus in southern China are the caterpillars of skipper butterflies, which has 27 species feeding on bamboo leaves. In the Southeast we have 4 species of native skippers feeding on the leaves of our native cane. These are the Carolina roadside skipper (Amblyscirtes carolina), the reversed roadside skipper (A. reversa), the lace-winged roadside skipper (A. aesculapius), and the yehl skipper (Poanes yehl).

The shoot eaters

There is another group of caterpillars that prefer to feed on bamboo shoots rather than on bamboo leaves. In Asia, there are 7 species of shoot boring caterpillars that attack bamboos, where some species can appear in numbers that cause the death of up to 90% of the new shoot crop. One of these, Oligia vulgaris, infests Phyllostachys in India, China, and Japan. Since bamboos only shoot once a year, this moth has only one generation per year. In late winter, the over-wintering eggs hatch, releasing larvae that feed on various species of Poa and Carax grasses while waiting for the bamboo shoots to start appearing. When the shoots arrive, they bore inside the soft tissue of the rapidly growing bamboo shoots and chew out many tunnels. Once mature, the larvae drop off the shoots and pupate in the leaf litter. The adult moths emerge in later that summer and lay eggs on grass leaves, where the eggs spend the winter. This pest is kept under control by keeping the intermediate grass host species weeded out from the area around the bamboo grove. This causes most of the larvae to starve before the start of the bamboo shooting season. It is also controlled by light trapping the adult moths and by removing and by destroying the damaged shoots before the larvae can mature. If accidentally introduced to US, to succeed, this species would need an acceptable local grass species to feed on (fairly likely), and it is a bamboo pest we definitely wouldn't want to get established over here.

There are 20 species of flies whose larvae specialize at feeding on shoot tissues. One of these shoot flies is Pegomyia kiangsuensis, which attacks Phyllostachys in China. It has one generation per year, and over-winters

as pupae in the soil. In the spring, the adult flies emerge and feed on shoot sap, gathering in numbers on any sap weeping from injuries found on the shoots (usually caused by other shoot boring pest species). They lay their eggs laid on the sheaths and the resultant larvae bore inside the shoot and feed on shoot tissue near the nodes. Once mature, the larvae drop to the ground and form pupae in soil, which remain dormant until the next spring. Several larvae feeding on a shoot can cause it to die. It is controlled by turning over the soil in winter to expose the pupae, by trapping adults in fly traps baited with fresh pieces of shoot (usually the byproducts of shoot harvesting/processing), and by removal of any damaged shoots to eliminate access to any non-trap food sources,

Culm, branch, and bud feeders

There are several species of boring beetles that prefer to bore into established culms rather than into fresh shoots. One of these is the brown long-horned beetle, Pterolophia trilineicollis, which attacks a number of bamboo genera in China. It has one generation per year, with the adults emerging in the fall and over-wintering in tunnels bored in culms. In the spring, they lay their eggs on young culms, and the hatching larvae bore tunnels in the culm wall. Heavily infested culms can be killed by these borers.

The red long-horned beetle, Purpuricenus temminckii, infests Phyllostachys in China, Korea, and Japan. It has one generation per year, and over-winters mainly as an adult. During the growing season, it lays its eggs on living and cut culms, and the larvae bore tunnels to feed on the inner culm tissue. They are the worst on dry sunny sites where their activity can kill living culms and damage harvested culms. This species prefers to infest older culms.

Several species of termites can attack the tropical clumpers (mostly in India). They mainly feed on dying or dead culms, but will occasionally attack living culms. The plant's response to termite feeding damage is to make congested culm growth.

Sap suckers

Another very large group of bamboo pests are the sap suckers. As their name implies, these insects and mites suck sap from the leaves, culms, and branches, which can be killed by severe infestations.

Some of the largest insects (over ? inches long) to suck sap from bamboos are the bamboo stinkbugs, of which there are 30 species that feed on bamboo. One of them is Hippotiscus dorsalis, which attacks Phyllostachys in China. It looks like a typical stink bug, but is yellowish-red in color. In China, this is considered to be most serious sap sucking pest in bamboo groves. It has one generation per year and over-winters as nymphs in the leaf litter. In the spring, these nymphs crawl up the culms and begin feeding in groups around the nodes. The adults appear in summer and continue feeding in groups around the nodes, but prefer to infest over-mature or stressed culms. They lay eggs on the undersides of the leaves of 1 to 2 year old culms where the hatching nymphs suck sap from twigs, branches, and culms for the remainder of the summer before descending down to the leaf litter to spend the winter. Heavy infestations can cause metabolic disorders in the bamboo plant. They are controlled naturally by parasites and culturally by painting the culm bases with sticky substances to prevent the flightless over-wintering nymphs from climbing back up the culms in the spring. This insect sounds like it would be a major pain for American bamboo growers if it got established over here with none of the parasites around that normally keep its numbers in check in China. There are two additional stink bug species (Aenaria pinchii and Brachymna tanuis) which often found mixed with H. dorsalis infestations, but which over-winter as adults and then lay their eggs on the leaves in the spring.

There is one species of lygaeid bug, Pirkimerus japonicus, that attacks Phyllostachys in China and Japan. This bug has 4 generations per year. This is a sneaky bug that stealthily makes its way into the hollow interior of the culm either through a wound opening that it finds on the culm (which in Asia are often caused by shoot borers and weevils) or through any cracks that it can find on the culm. Once inside, it sucks sap from the interior surfaces of the culm cavity, lays its eggs inside the cavity, and the hatching nymphs remain inside feeding on sap, so you would never know that this bug was there until the damage started appearing. Infested culms blacken and are weakened, becoming susceptible to wind breakage.

Mirid bugs, of which there are 2 species on bamboo, are one of the most damaging insect pests on bamboos in Taiwan, where they can cause over a 95% reduction in the shoot yield on Bambusa oldhami and Dendrocalamus latifolius. The main species is Mecictoscolis scitetoides, which attacks Phyllostachys , Bambusa, and Dendrocalamus throughout southeast Asia. It has several generations per year, with the nymphs and adults sucking sap from the leaf undersides, resulting in a reduction of shoot yields and overall plant vigor. Its main control is through parasites. Sounds like another one we don't need over here.

There are 28 species of coreid bugs sucking bamboo sap in Asia where they are a common sight on bamboo shoots. One of them is Notobitus montanus, which infests Phyllostachys in China, where it has one generation per year. It over-winters as an adult and emerges during the spring shooting season to start sucking sap from the young shoots. Between meals it lays its eggs on the underside of bamboo leaves and the resultant nymphs gather in groups on the shoots to feed on sap and quickly grow into adults during the course of the shooting season. Once the shooting season is over, they leave the bamboo plant and gather in dry locations in and around the grove to find places to over winter. An infestation of this bug causes a reduction in the vigor and growth rate of the bamboo plant and heavy infestations can cause the shoots to wilt and die.

A spittlebug (Aphrophora horizontalis) is common on P. pubescens in China where heavy infestations covers the branches with their bubble nests. This species over-winters as eggs inserted in slits made in the small branches by the egg-laying adults. In the spring, these eggs hatch, releasing nymphs that hide in the spittle nests they create and suck sap from the leaf bud, leaf sheaths and twigs. Adults begin appearing in summer and feed in the upper crown, but move down to the lower branches in late summer to lay their eggs. A heavy infestation can cause defoliation and wilting of the twigs and branches, but can be controlled by culm cavity injection of systemic insecticides.

There are 37 species of planthoppers found on Chinese bamboo, but they usually don't cause any major problems. There are also a number of leafhopper species normally infesting field crops that will also feed on bamboo, sometimes causing minor damage.

Aphids love bamboo! There are over 50 species of Asian aphids known to feed on Asian bamboos. A good example is Astegopteryx bambusifoliae, which sucks sap from the leaves of Bambusa, Phyllosachys, and Dendrocalamus throughout Southeast Asia. It over-winters on the bamboo plant, where it sucks sap from the leaf undersides and culms. It is the most common during the winter and spring, and disappears during hot summers. It is controlled by lady beetles. In general, aphids aren't a major problem since there are so many organisms that prey on them, but they can appear in an occasional outbreak that causes wilting of the leaves and shoots, a reduction in vigor, and stunted growth. They can also transmit fungal diseases, such as black mildew (Meliola sp).

Unfortunately several Asian bamboo aphid species have made it over here to North America. These include three Takecallis aphid species. T. arundicolens (a.k.a. Myzocallis arundicolens) has been reported in the United

States on Pseudosasa, Sasa, Bambusa and A. gigantea. T. arundinariae (Myzocallis arundiariae) has been found in the US on Arundinaria and on Bambusa, and T. taiwanus is also listed as being present in this country. In addition, Rhopalosiphum arundinariae (Anuraphis arundinariae) has been reported on Arundinaria tecta in Florida and Paracolopha morrisoni (Dryopeia morrisoni) was found on a Phyllostachys bamboo in Maryland. I'm sure the situation with bamboo aphids in the United States is poorly characterized. All of us have seen aphids on the various bamboos we are growing, but have no idea what species are involved. Some of these could be natives that also infest our native cane, some could be generalists that can suck sap from a wide variety of plants, and some could be Asian or other exotic species that may or may not be bamboo specialists.

There are 40 species of pseudococcid scales (otherwise known as mealy bugs) common on bamboos in Asia. Many mealy bugs are stealth bamboo pests. Unlike aphids, which hang out on the undersides of leaves, and scales which plaster themselves all over the outside of the culms and small twigs, many species of mealy bugs secrete themselves in between the leaf sheaths so often the only sign of their infestation is an accumulation of sooty mold all over the leaves. One of these sneaks is Nesticoccus sinensis, which infests Phyllostachys and Pleioblastus in China. It has one generation per year and over winters as an adult. The nymphs appear in late spring/early summer.

Another mealy bug common in China is Antonina crawi, which feeds on many bamboo species in China. It has 2 generations per year, over-wintering as an adult, with the adult female and nymphs sucking sap from the leaf sheaths. Unfortunately this species has managed to immigrate over here, so we also have to deal with them on Phyllostachys and Pseudosasa japonica. As with the aphids, we have several species of Asian mealy bugs at large within the United States. In addition to A. crawi, we also have its close relative Antonina pretiosa (sometimes called the noxious mealy bug) in the US on Phyllostachys and Bambusa. Additional Asian species found in the United States includes Chaetococcus bambusae, found on Bambusa, and the long-tailed mealy bug (Pseudococcus adonidum), common on many plants, including bamboo. This one is the white mealy bug often found on houseplants.

Pit scale insects, of which there are over 50 species, are very common on bamboos. One of them, (Asterolecanium bambusae), infests Bambusa in Southeast Asia, where it sucks sap from the culm sheath and stems. It has a waxy covering, making it difficult to control by insecticidal sprays. Systemic insecticides are much more effective on this scale. Unfortunately it (along with the related Asterolecanium miliaris) have slipped into the US where they infest Bambusa.

Another pit scale is Bambusapis hemispherica, found in Phyllostachys in China and Japan. It has 1 or 2 generations per year, and the female adults and nymphs suck sap from the twigs and stipes of the bamboo. Its relative, B. bambusae, has been found on Bambusa multiplex in Florida.

Another type of scale, the armored scale, has 60 species sucking bamboo sap. One of the more notorious species is Kuwanaspis pseudoleucaspis, which infests Phyllostachys in China through Japan. It has also gotten over here and is common on Phyllostachys in the US where it is known as thread scale. It has 2 generations per year, preferring the older culms and wet, shaded sites. They are worse in dense, over-mature groves, where the nymphs and females feed on culm sap and when present in large numbers, can reduce the vigor of the plant and make the culms commercially worthless. In Asia they are controlled naturally by parasites and lady beetles, and culturally by thinning out the older culms, and by culm cavity injection of systemic insecticides. Other species of Asian thread scale present in the US include K. vermiformis (which will infest A. gigantea), K. howardi (infests Bambusa), and K. hikosani that can infest various bamboos (observation by Adam Turtle).

Other scales found on bamboo include Unachionaspis bambusae, found on Phyllostachys in China, where it has

3 generations per year. These scales suck sap from the young leaves in the lower crown and heavy infestations can cause partial defoliation. In Asia, it is kept under control by parasites and predators. Odonaspis penecillata is found on various bamboos in China and has one generation per year, over-wintering as an adult. Female adults and the nymphs suck sap from the culms and branches. It has also been imported to the US, where it has been found on Bambusa multiplex. Another import, O. secretus, has been found in the US on Pseudosasa japonica.

There are many species of white flies feeding on bamboos in Asia. Some of these are the various species of Aleurocanthus, which feed on Bambusa in southeastern Asia. Its larvae and adults suck sap from the leaves and are a minor pest in Asia.

There are at least 12 species of leaf mites found on bamboo. In China, often several species can be found together sucking sap on the leaves, where they go through 6 to 8 generations per year. Damaged leaves show striped and spotted chlorosis and drop off prematurely. A severe infestation can reduce the vigor of the plant. In Asia, they are often kept under control by predatory mites. In China, one of the most common species on Phyllostachys is Schizotetranychus nanjingensis. It over-winters as adults and eggs, and feeds on the leaf undersides under a protective webbing. S. celarius and S. longus.are the "bamboo mites" currently present in the US.

Not all bamboo leaf mites make web nests. Aponychus corpuzae is a species native to China that doesn't make nests.

Another group of mites we're just beginning to discover on bamboos are the eriophyid mites. These are very tiny, spindle-shaped mites about 1/5 as long as a Schizotetranychus bamboo mite. They are invisible to the naked eye and practically so with a hand lens. I found a unknown species of eriophyid mite here on a Yushania exilis (Y. aff. chungii) bought at the Atlanta ABS bamboo auction. At 30X under the dissecting scope, this mite looks like a tiny, shiny black carrot with 2 sets of legs at the head end. It is found mostly on the lower side of the leaf, commonly clustered near the leaf's midrib. An infestation of these mites produces a yellow stippling on the leaves and reduces the vigor of the plant. Unlike the spider and bamboo mites, this mite is not adversely affected by warm, humid climate and thrives here year around. I suspect this guy might have slipped through quarantine in low numbers (being so tiny and all), but then had the chance to start building up its population to noticeable levels once it got into a stable environment. Fortunately eriophyid mites tend to have a narrow host range commonly confined to a single species, genera, or a few closely related genera. So this mite is likely a problem only on Y. exilis or on Yushania in general.

In Asia, there are 18 species of weevils that feed on bamboo shoots. One of them, Otidognathus davidis, feeds on Phyllostachys, Pleioblastus, Pseudosasa, Sinobambusa, Indocalamus, and Semiarundinaria in China. It has one generation per year and over-winters as adults. In the spring, it feeds on the sap from the shoots, leaving rows of feeding holes on their outer surface. It then lays eggs in the feeding holes, where the hatching larvae bore holes to the nodes and then feed on the branch buds. Mature larvae drop off the shoot and pupate in the soil, emerging as adults in mid-summer, but remaining inside the larval cocoon until spring. Feeding damage by the adults and larvae results in stunted and deformed shoots with few branches and with many holes in the culms that provide openings for other pests to invade the culm. It can be controlled by culm cavity injection into the base of shoots of the larger bamboo species or by spraying insecticides on the shoots of the smaller bamboo species, and culturally by turning up the soil during the winter to expose the over-wintering adults. Sounds like another Asian import that wouldn't prove popular with bamboo growers over here.

There are several species of gall wasps found on bamboo in Asia. One of these, Aiolomorphus rhopaloides, infests Phyllostachys in China and Japan, where it goes through one generation per year. It over-

winters as pupae in the gall. In late winter the adults emerge and lay eggs in the slowly swelling leaf buds. The larvae's activities causes a gall to form and the larvae feeds on the inner tissues of the gall. The larvae mature and pupate in late summer, then remain dormant until late winter. Gall wasp infestations cause the twigs to have a deformed growth pattern and produce a reduced number of leaves, resulting in reduced vigor and an up to 60% reduction in shoot production. It is controlled by culm cavity injection in mid-spring to kill the larvae.

Another type of gall wasp is Harmolita phyllostachitis, which feeds on Phyllostachys. It lays eggs in holes bored in the smaller twigs of the upper canopy. Hatching larvae suck sap from inside of the holes, making the growing twigs grow thicker and with shorter internodes. It is controlled by cutting out and burning the infected culms. Interestingly, another wasp, Diomorus aioromorphi parasitizes H. phyllostachitis, but isn't useful as a control, since all it does is kill the A. rhopaloides larvae and then takes its place in the gall and continues feeding on the gall tissue.

The gall midge, Planetella conesta, infests many genera of bamboo in China. It has one generation per year, over-wintering as cocoons in soil, and with the adults emerging in the spring to lay eggs on the leaf sheaths and branch buds. The hatching larvae mine into the buds and feed on their sap. As they mature in early summer, they drop to the ground and pupate in the soil. Midge infested culms will end up with many of their buds aborting due to larval damage. They are worst in humid, rainy conditions, and are controlled by turning the soil in the summer and winter to expose the pupae.

Another pest of temperate Asian bamboos is the root fly, Chyliza bambusae, which troubles Phyllostachys pubescens in China. It has one generation per year and over-winters as pupae in the soil, but in moso groves that are alternately year bearing, some of the pupae will remain dormant for two years. Adults emerge in early spring just as the shooting season is beginning and feed on shoot sap. The females burrow down into the disturbed soil alongside the growing shoot until they reach the young shoot's developing root system where they lay their eggs. The larvae hatch and feed first on the root tips, then as they get older, they will burrow inside the root to feed. Mature larvae pupate inside the root until an upcoming spring. Their feeding activities damage the roots, causing the shoots to dry out or develop into weak culms easily toppled by the wind. It is controlled by mounding the soil up around the new shoots to deny egg-laying females access to the new roots and also by baiting the adults with insecticide treated pieces of shoot before egg-laying begins.

There are several groups of root beetles (Agonischius obscuripes, Agriotes sp., Lacon sp., Melanotus regalis) that attack various bamboo species in China. Their larvae feed on the young roots of new shoots and cause the death or weak development of the new shoots in a manner similar to that caused by root flies. It is controlled by spraying the soil with insecticide.

Since bamboo is such a prevalent part of the landscape in Southeast Asia, it is no surprise that there are several species of cicadas specialized to feed on bamboo. The bamboo cicada, Platylomia pieli, infests Phyllostachys groves in China. Like most cicadas, it takes several years to go through its life cycle. It over-winters in the form of eggs and larvae. The adults emerge in summer and feed on tree sap. They lay eggs in holes made in the smaller bamboo branches, causing them to die back. The eggs hatch in the following summer with the resultant nymphs dropping to the ground and burrowing underground where they remain for several years, sucking sap from the rhizomes and roots. They damage bamboo by weakening the rhizome system and by reducing the productivity of the grove. They are controlled by removing the dying, egg-infested bamboo branches from the grove.

Final Discussion

Now that's quite a load of bamboo pests, the vast majority of which we don't have over here, and for that we can be thankful. So far in the United States, we just have a few leaf mites, and a handful of scales, mealy bugs, and aphid species, all being pests that comprise the smaller end of the bamboo pest size spectrum. In addition, for those of us growing bamboo within the native range of Arundinaria gigantea, there are a number of larger bamboo pests that we've had to contend with, namely various caterpillars in the form of leaf rollers and leaf miners. Probably the worst aspect for the Asian bamboo farmer growing bamboo in the presence of all of these pests is that their effects are synergistic (especially with the shoot borers) with one pest creating damage that then allows another pest easy entry into the plant so they can then create their own form of damage. Fortunately the native predators in Asia keep most of these bamboo pests under some degree of control at least most of the time. I can think of nothing worse than for some of the most potentially destructive Asian bamboo pests to get imported into the United States and then to wreak havoc in our bamboo groves with no natural predators to keep them in check. There is also the possibility that one of these Asian bamboo pests could become so enamored with our native cane that they eat it into extinction or near-extinction.

How they Control these Pests in Southeast Asia

Cultural controls

So how does the Asian bamboo farmer manage to grow bamboo in the presence of so many potentially damaging pests? In addition to whatever native predators and pest diseases (fungal, bacterial, and viral) happen to be present (of which there are quite a few since this is their native environment), they use many different cultural controls and some insecticides for control when pest numbers threaten to reach damaging numbers. These cultural controls include management of the culm population, such as removing or reducing the culm age population most favored by the pest, or by adjusting the culm density to modify the grove's environment to make it less favorable for the most prevalent pest. Another method used is to turn over the soil within and around the grove during in the fall and winter to expose buried pupae to the cold and bird predation.

Another technique commonly used in China, light trapping, is very effective at controlling moth pest species in rural China where there are few artificial lights. But in the US, the many lights in the typical US suburban/rural environment already causes much mortality in the native and exotic moth population through increased exposure to predators, physical damage from batting against the light all night long, disruption of natural behavior patterns, and by being cooked by the heat of incandescent lamps. In the presence of so much selective pressures, the moths would evolve not to be attracted to lights, as is already happening with some of our native moth species and would likely also eventually happen with the Asian bamboo moths if they ever became established over here. But if leaf rollers are a problem in your rural bamboo grove, you could try controlling them by putting a bug zapper out in the grove or placing a container filled with soapy water or insecticide solution underneath a light bulb out in the grove.

Bait trapping, either though use of baited traps or poisoned bait, is used to control some bamboo pests. In China, the bamboo shoot fly is baited with fresh bamboo shoot pieces (a byproduct of the shoot harvesting process) treated with insecticides. Bamboo locusts are also attracted to salty food and uric odors, baits which are used to lure them to their deaths.

Physical barriers are effective at controlling insects that need to crawl up the culm to get to their feeding/egg laying sites on the plant. Typically these barriers are a sticky band applied around the base of the culms.

Removing alternate host plants from the area in and around the grove is a control method used with pests that require a certain non-bamboo host plant for a particular stage of their life cycle.

And of course the old standby, hand-picking, is useful for controlling the larger, slower-moving bamboo pests in small groves and on specimen plants.

Chemical controls

In China they use contact pesticides either by dusting as an economic way to control bamboo leaf feeders, or by spraying, which is effective against leaf feeders and some of the sap suckers (aphids, but not the wax-covered scales). Using smoke to fumigate a grove is sometimes used to control leaf feeders and some sap suckers in dense groves where a spray can't penetrate up to the top of the canopy and in groves on steep slopes, but this method requires windless conditions to be effective. Systemic pesticides are effective against most insect pests including leaf feeders, sap suckers (including those with waxy-coverings), shoot borers, and gall makers, but can't be used during the shoot harvesting season. One of the methods used for applying systemic pesticides is culm cavity injection. This is done by drilling a small hole into the culm and then injecting either 1.5 ml of 40% to 50% dimethoate (Cygon, Dicap, etc.), effective against caterpillars, locusts, shoot borers, various sap suckers, and bamboo mites, or 1.5 ml of 50% methamidophos (Monitor, Nitofol, Tamaron, Swipe, Nuratron, Vetaron, Filitox, Patrole, Tamanox, SRA 5172, or Tam) used against pseudococcid scale. The advantage of culm cavity injection is this method has a low release of pesticides into the environment, but has the added labor of having to drill a hole in each culm the first time it is applied. Systemics can also be delivered via root drench, which requires less labor, but causes a larger release of pesticides into the environment, since any pesticide that the roots don't absorb or that doesn't break down in the soil can eventually end up in the ground water. It can also upset the microfauna populations in the soil.

Status of bamboo pests in Southeast Asia

There are 638 insect species reported to attack bamboos in China, of which 60 species are reported to cause significant economic losses in bamboo groves. In Japan, there are 80 insect species reported to attack bamboo. Of these, leaf rollers and shoot-boring noctuids (which can attack over 50% of new shoots) are considered the worst in Japan. In general, pests and diseases cause heavy losses in the large scale commercial groves, but are less of a problem in small urban gardens where the urban environment and the closer attention possible in a backyard settling makes it easier to keep pests under control. In Zhejiang province, the most important bamboo pests are the bamboo leaf roller, puss moths, tussuck moths, stinkbugs, shoot-boring noctuids, and bamboo shoot weevils. The moth leaf feeders and stinkbugs tend to reach epidemic proportions in a 5 to 8 year cycle, but the shoot feeding pests tend to maintain a stable population from year to year. The main economic impact from pests is from the death of bamboo plants, reduction in new shoot diameter, and reduced yields of shoots. On the average, Chinese bamboo groves lose 10% of their potential yield to pests. Schizotetranycus leaf mites can appear in severe outbreaks in central China, causing a reduced shoot production on the following year. With leaf rollers, a heavy infestation on P. pubescens can cause a 45% reduction in shoot yield on the following year. A heavy infestation of bamboo stinkbugs can cause a 57% reduction in shoot yield, and a heavy infestation of shoot-boring noctuids can cause a 64% reduction in shoot yield. In China, the pest populations in "wild" bamboo groves with lots of biodiversity and no unusual environmental or human-caused stresses are usually kept under control by their predators/parasites/pathogens and tend to remain low, except for shoot borers, which can maintain a high population levels even in natural groves. But when man starts making changes to the environment, such engaging in large-scale bamboo monoculture, clearing the surrounding forests, spraying for pests, etc., then the population of the natural controls can be upset and the pest populations start to increase.

If you get nothing else out reading of this article, I hope it will make you think twice the next time you are tempted to try smuggling that rare bamboo cultivar into this country and bypassing the lengthy USDA quarantine process. In addition to your rare bamboo, you might also be importing a nasty bamboo pest into this country that will make things very interesting for the American bamboo grower for centuries to come. If you think the bamboo mite is bad in this country, you ain't seen nothing yet compared to what could come over here in the absence of any quarantine.

End of article

Asian Bamboo diseases (More of Asian Imports that we don't need)

Another group of organisms common among the bamboos of Southeast Asia, but rarely seen over here, are the diseases of bamboo caused by various pathogenic organisms. Some of these organisms can cause serious disease problems in the bamboo cultivating regions of Asia and have the potential to quickly kill out an established grove. But fortunately none of the "biggies" have made it over here so far. Little is known of the native diseases found on our Arundinaria gigantea/tecta, but whatever diseases are indigenous on our native bamboo are apparently either very uncommon or have not been very well studied. They also apparently don't find Asian bamboos much to their liking since they haven't been a noticable problem on the Asian bamboo species currently being grown over here. Plant pathogens can be divided into 4 main categories. These are the diseases caused by fungi, those resulting from bacteria and mycoplasmas, viral diseases, and those caused by nematodes. Except for nematodes, these diseases interact little with other organisms and so are rarely kept under control by natural predators as is the case with insect pests. The main factors determining how bad these diseases will be are the resistance of the host plant(s) and any environmental or cultural factors that can affect the vigor of the plant and affect how fast the pathogen can spread to new host plants. In general, these pathogens won't show much difference in infectivity when infecting their native host species in a foreign land than they do when infecting it back at home. So if they are a major problem on bamboo back in Asia, then they are also likely to be a major problem over here on their native host species in regions with a similar climate if they get introduced. But they can be a big problem if they can find a closely related host in the new region that they can also infect. If this new host has little or no resistance to the pathogen, then there is the potential for it to be rendered practically extinct by the pathogen such as happened to the American chestnut when the chestnut blight became introduced to North America and is currently happening to the butternut tree (Juglans cinerea). Much of the following information was taken from the INBAR publication "Diseases of Bamboos in Asia: an illustrated manual" by C. Mohanan and the USDA publication "Bamboo in the United States, description, culture, and utilization".

Fungal Pathogens

We'll start off with the fungal pathogens since they cause the most diseases on Asian bamboos. There are 18 species of Puccinia causing Leaf Rust on bamboos throughout Southeast Asia, where the various species attack many bamboo genera, including Phyllostachys, Bambusa, Dendrocalamus, Sasa, Fargesia, Pleioblastus, Sasaella, and Semiarundinaria. Since the closely related Puccinia graminius causes wheat rust, the USDA was afraid that the bamboo rusts would also infect wheat and so introduced the bamboo quarantine system back in 1918 to prevent the accidental introduction of additional Puccinia species into the United States. But since Puccinia

rusts are highly host species specific, this is unlikely to occur, but this was something they didn't know at the time. In bamboo, Puccinia causes spots along the veins of the lower leaf surface that are either yellowish-brown to dark brown (formed by urediniospores) or yellowish or dark brown or black (formed by teliospores). Severely infected leaves wither and are dropped prematurely. Not much is known about this disease or its alternate hosts in China, where it is a minor problem and control measures are rarely attempted. So far, only one species of bamboo Puccinia has made it to this country. This is Puccinia phyllostachydis, which has been found on Phyllostachys bambusoides (especially 'castellon'), P. aurea, P. nigra henon and it has recently been reported on A. gigantea in Florida.

Culm Brown Rot is caused by Fusarium solani, a very common soil fungus that consists of many different forms or races, each specialized for attacking a limited number of host species. The various races of this fungus combined attack a wide range of plants, have been found to kill baby sharks and shrimp in the ocean, and can sometimes infect people. On Chinese bamboo, this fungus has been found to attack mainly Phyllostachys (especially P. viridis), where it causes pale yellow spots on the lower culm, then spreads upward and produces violet/brown/black streaks along the culm. These slowly spread over the base of the culm and eventually kill it. This disease first appears in late spring and the infected culms start dying in the fall. It causes an average annual culm mortality rate of 10%. This fungus invades through wounds in the culm and no control method is known. F. solani is common in US, but whether the races currently in the US can infect bamboos isn't known. But ominously, the symptoms described for "Melanconium Culm Disease" described in the 1961 UDSA booklet "Bamboo in the United States" are identical to those of culm brown rot, so it may already be over here and accounting for those occasional culms that die out through the course of the summer in your Phyllostachys grove.

Culm Base Rot is a disease caused by a fungal complex including Alternaria alternata, Anthrinium, and several other fungi associated with the disease. It attacks Phyllostachys pubescens in China where it causes a browning and necrosis at the base of the culm, eventually rotting out the culm base. It attacks shoots and mature culms and is especially bad if there are heavy rains during the shooting season. No controls are currently used.

Fusarium stilboides causes Culm Purple Blotch on Phyllostachys viridis in China, where it attacks and kills 2 to 3 year old culms. It is most common in dense groves located in hot, humid/rainy areas. It causes a slow death of the culm, starting with yellow mottled spots and stripes forming over the lower culm that spread and eventually turn purple-brown. The leaves on the infected culms turn yellow and drop off, then the branches wither, and the culm eventually dies. This whole process takes 1 to 3 years depending on how severe the infection is. This fungal pathogen is soil-bourn and infects the bamboo through wounds on the roots, rhizomes, and on the lower culms when conditions are very humid (during the rainy season). It spreads fastest under wet, warm, humid conditions, especially if water accumulates around the culms. No control methods are used.

Top Blight is caused by Ceratosphaeria phyllostachydis, which attacks Phyllostachys (especially P. pubescens) in China. This fungus over-winters in infected culms and produces spores in late spring. These spores land on the shoot or culm's surfaces and enter through natural openings or wounds at the branch forks of the growing shoots. By summer they are spreading through the culm's tissues. It mostly attacks young culms from the current year's shoots, but once infected, it can continue attacking the same culm over several years, causing browning and necrosis of the culm and branch internodes. It eventually withers parts of the culm varying from just the minor branches to killing out the entire culm. Symptoms appear in mid to late summer and this disease can cause serious damage to weak or drought stressed groves and those on dryer locations or on poor soils. The spread of this fungus is encouraged by high humidity and warm, but not hot, temperatures. It is controlled by cutting out infected branches and culms, by treating or eliminating alternate hosts (non-crop bamboos), and by spraying fungicides on the new shoots in late spring when the spores are released.

Witch's Broom is a common symptom caused by a bunch of different pathogens, including the fungi Balansia take, B. liniaris, Loculistroma bambusae, Epichloe bambusae, and E. sasae. In addition, a phytoplasma, and some bacteria have also been implicated with this disease. Witch's broom is found on Phyllostachys, Bambusa, Dendrocalamus, and other genera through Southeast Asia and is very common in older groves. The fungus over-winters as fructifications or as black rhizomorphs on infected plant material. The fructifications release spores in late winter, which land on and infect new culms. Often the initial infection will be on a branch from which it will spread via spores and rhizomorphs to other branches and to the rhizome. Symptoms include witch's brooms of the branch, where infected branches will develop shortened branches and small, pale-green leaves on mature culms. The alternative form is witch's broom of the shoots, which happens once a rhizome becomes infected and begins producing abnormally shortened shoots less than 2 feet high. Black fungal fructifications will develop after 5 to 6 months on these shoots. Often an occasional healthy shoot will form, allowing the infected rhizome to continue surviving and producing spores to infect other plants. It is controlled by pruning out infected branches, culms, and rhizomes and by cutting out old and weak culms to improve ventilation in the grove. This disease isn't over here, but would be a real nuisance to bamboo growers if it did get established in this country.

Other minor leaf diseases include Tar Spot, caused by Phyllachora phyllostachydis on Phyllostachys in Japan. Another species of Phyllachora, P. shiraiana has been found on leaves of Sasa kurilensis in Japan, on Arundinaria, Bambusa, and Dendrocalamus in India, and has been found over here in this country on Arundinaria gigantea in North Carolina. In China, both of these leaf spots can be controlled with fungicide sprays.

Culm Rust is caused by Stereostratum corticoides on Bambusa, Chimonobambusa, Phyllostachys (glauca, propinqua, congesta, meyeri) , Pleioblastus , Pseudosasa, Sasa, Arundinaria, and Semiarundinaria in China and Japan where it is a serious problem in groves. Urediniospores first infect the culm's surfaces through wounds, then 7 to 19 months later rusty patches develop on the lower culm surfaces and release either teliospores in the spring or golden-yellow urediniospores at other times of the year. The teliospores are thought to infect an unknown alternate host where it eventually also produces urediniospores. It is controlled by removing infected culms, scraping teleospore infected areas of the culm, and by spraying chemicals on the teliospore producing areas of the culm in the spring. This disease can be reduced, but not eliminated by control measures and a severe outbreak can kill a grove. This is definitely a disease we don't want to get established over here. Since it is a such a big problem in Asia and with such a wide host range (assuming this pathogen isn't composed of a number of host specific races), it is also likely to find A. gigantea to its liking and there is the potential that it could wipe it out as Endothia parasitica did with our native chestnut tree.

Culm smut (Ustilago shiraiana) is a disease of Phyllostachys in China. The chlamidiospores initially infect the new shoots from near the soil surface as the shoots are growing up through soil containing over-wintering fungal spores. As the disease progresses, it causes black patches on the culms, twigs and leaves. Later, the twigs swell up, stop growing and eventually produce black fruiting bodies that release spores. In severely infected groves all of the leaf buds become infected year after year. This fungus can live perennially in the bamboo rhizomes. It is controlled (but not eradicated) in infected regions by cutting out and burning the severely infected culms. The only way to eradicate it in an otherwise non-infected grove is by destroying the entire plant, including rhizomes. It accidentally got introduced at one of the USDA plant introduction stations in the early 1900's, but was destroyed before it spread off the station. This is another Asian import that would be unpopular over here.

There are 7 species of Uredo leaf rust attacking various bamboos in Southeast Asia. Uredo arundinaria attacks Asian Arundinaria and U. sasa infects Sasa in Japan where these rusts produce orange-brown patches on the lower surfaces of the leaves. Heavily infected leaves can blotch and prematurely drop off. Not much is known

of these rusts and since they are minor problem, they are pretty much ignored in the groves.

Ergot on bamboo is caused by Claviceps purpurea, Claviceps sp., Hypocreopsis phyllostachydis, and Hypocrella semiamplexa, which attack flowering Phyllostachys, Bambusa, and Dendrocalamus in Southeast Asia. They overwinter as sclerotia on or in the ground or mixed with seed. These sclerotia release ascospores that infect ovary of flower where the fungal sclerotium forms in place of the plant's usual ovary. It is controlled by removing the fungal sclerotia from the plant and seed collections.

There are a number of species of black mildew (Meliola bambusicola, M. pseudosasae, M. stomata, Haraea japonica, and Asterinella huigensis) which infect Phyllostachys, Sasa, Semiarundinaria, Bambusa, Dendrocalamus, and other tropical clumpers in southeast Asia. They are spread by the movements of aphids and immature scales to new locations, where they produce cobweb-like to powdery black patches on the upper leaf surfaces, eventually covering the entire upper surface with dense hyphal mat. They also infect the leaf sheaths and smaller branches. They adversely affect they plant both by their parasitic effect and also by reducing leaf photosynthesis by blocking sunlight. They are the worst in humid tropical areas and in dense groves with a closed canopy. They are kept under control by thinning and opening the canopy to reduce humidity, since high humidity and wet leaf surfaces favor the spread and growth of these fungi. Also they use systemic pesticide to kill their aphids and scale carriers together with a fungicide to kill the mildew.

Sooty mold, caused by Capnodium sp. and Spiropes scopiformis, is found on various bamboos throughout Southeast Asia. These are not parasitic, but by covering the upper and sometimes the lower leaf surface of the leaf with a mat of black mycelia, they reduce leaf photosynthesis by blocking sunlight. These fungi are saprophytic and live on the honeydew released by scales, aphids, mealy bugs, and other sap-sucking insects. They are worst in humid environments and can encourage other leaf diseases since they absorb moisture from the air and keep the leaf surfaces wet for long periods of time. Sooty molds of unknown species are common in the US on bamboos and other plants infested with sap-sucking insects.

There are many types of leaf spots found on Asian bamboos, most of which are minor pests, causing partial defoliation at worst, and so no controls are attempted. Some of these are Coccodialla arundinariae and C. ochlandrae, which attack leaves of Phyllostachys, Sasa, Sasamorpha, and Ochlandra. They first produces small, yellow-brown lesions on the upper surface of the leaves, which then enlarge to form dark-brown, linear necrotic spots. The fungal spores are produced in the lesions. It is a minor pest and is not controlled.

Another leaf pest is Myiangium sp., which attacks Phyllostachys and Bambusa multiplex in China, where it causes severe malformation of leaves similar to that caused by Witch's Broom.

There are also a number of additional minor fungal pathogens that attack the leaves and branches of bamboo that are not economically important and have not been thoroughly studied.

Culm sheath spot is caused by Shraia bambusicola, Pestalozzialla bambusae, and Sarocladium sp. on Phyllostachys, Bambusa, and Dendrocalamus in China and India. It first produces small, brown lesions on the margins and tips of the culm sheaths, which then spread to form larger irregular necrotic spots with dark brown to purple margins. It is the worst on the culm sheaths near ground level. These fungi enter the plant through wounds in the culm sheath and its spread is encouraged by high humidity and wet plant surfaces. It is a minor problem since culm sheaths are shed or quickly die after shooting season, so these fungi have little effect on the bamboo plant as a whole.

Bacterial pathogens

Not many bacteria have been implicated in bamboo diseases. In addition to being one of the many pathogens producing Witch's Broom, bacteria have been found to cause only one other disease in bamboo. This is Little Leaf Disease, caused by a mycoplasma-like organism that attacks Dendrocalalmus strictus in India and Bambusa multiplex in Thailand. Infected plants develop a bushy, witch's broom-like clumps of needle-like leaves from nodes and branches of newly emerged culms. In lightly infected clumps only the branch nodes are affected, but in heavily infected clumps the entire culm is affected and these abnormal clumps continue to develop year after year, eventually becoming quite massive. In severely infected clumps every new shoot will become infected. Little is known about this disease, but in other plants, mycoplasma-like organisms are spread by sap-sucking insects. Tetracycline can be used to control this mycoplasma-like organism, but this treatment is not normally used on bamboo.

Viral pathogens

The status of viruses in bamboo is analogous to a dark room that has only been slightly explored. So far, only one virus has been well characterized, while two others have either been discovered or are diseases suspected to have viral origins.

The best-known bamboo virus, and one that is found here in the United States, is Bamboo mosaic virus (BoMV). This is a potex virus that originally infected Dendrocalamus latiflorus and Bambusa oldhamii in China, but in some studies B. vulgaris and certain Phyllostachys species have also been found to be susceptible. It has been found on B. oldhamii in the US. It causes mosaic on the leaves and also brown streaks inside the shoots. Infected culms show poor growth with shortened internodes, and infected shoots have a hard texture making them of poor eating quality. This virus is found in all parts of the plants and is mechanically transmitted from plant to plant (possibly in the wild by aphids). Any plants propagated from an infected plant will also be infected. This is a disease that is spread mainly as a result of large-scale propagation of bamboo while not confirming that the propagation source material is virus-free and by not taking steps to prevent mechanical transmission while propagating and caring for the plants within the bamboo nursery. It is controlled by destroying any infected plants and also by sterilizing shovels, saws, pruning shears, etc. with sodium hypochlorite solution (Chlorox) when moving between individual plants.

A potyvirus has been reported on a Pleioblastus (?chino) in Japan, but little is known about it, its symptoms, or its host range.

A suspected virus has been found to cause seedling leaf striping and stunting on Bambusa bambos seedlings in one seedling nursery. This pathogen is systemic throughout the plant and 6% of the seedlings came down with it. If this turns out to be a virus, then it could be one that is either seed transmissible at a low level or one that infected the seedlings (insect, mite, or mechanically transmitted) shortly after germination. It was found only in one location (Kerala) India, and has not been noticed since.

Nematode Pathogens

In general, nematodes don't appear to cause many problems with bamboo in this country, even in nematode-rich Florida, and I could find no references on problems with nematodes on bamboos in Asia.

In this country, a Korean species, the Bamboo Cyst Nematode (Afenestrata koreana) has been found on Phyllostachys aurea, and P. nigra in Florida, but it is not known what adverse effects are produced by its presence on bamboo roots. In general, cyst nematodes are worst on sandy soils and in warmer climates and

much less so on clayey soils and in colder climates.

Meloidogyne incognita, the southern root-knot nematode, has been found on Phyllostachys aurea and Bambusa sp. in Florida. This nematode is found worldwide and has a very wide host range with over 700 plant species it can infest. It has many generations per year and one generation takes 25 days at a soil temperature of 70F. Its eggs hatch to release juveniles, which seek out and penetrate roots near their tip. As the nematode feeds, it causes the formation of a gall on the root in which mature females lay a mass of eggs. An infestation of this nematode results in a reduced root system with many galls on it and a poorly growing plant with chlorotic or wilting foliage. On some crop plants it can be controlled by post-plant nematocides (don't know about bamboo)
Nematodes that have been found associated with our native Arundinaria gigantea at Gainesville, Florida include Mesocriconema, a ring nematode, Paratrichodorus teres, a stubby root nematode; and Xiphinema sheri and X. coxi, dagger nematodes. No mention of any adverse effects on the bamboo.
Nematodes found associated with Bambusa in Florida include Dolichodorus heterocephalus , an awl nematode; Meloidogyne incognita , the Root-Knot Nematode; and Radopholus similis , a burrowing nematode. The Root-Knot Nematode females were found in the roots of the bamboo. Again no mention of any disease symptoms.
Disease Situation in Temperate Asia

In general, bamboo diseases are the worst in the tropical portions of Asia, but do cause problems on bamboo in temperate Asia. The most serious temperate bamboo diseases are: Culm Brown Rot, which is mainly on Phyllostachys viridis with an annual average 10% culm mortality, Top Blight on P. pubescens, which is worst in drought years, Witch's Broom, that is very common on many bamboo species, and Culm Rust, of which a recent outbreak destroyed 200 hectares of P. glauca and it continues to effect edible shoot production with this species.

Chemical controls (fungicides)

Fungicides fall into two main groups, contact and systemic fungicides. Contact fungicides coat the plant and prevent initial infection, but they don't help once the fungus has entered the plant. They have to be applied when conditions are favorable for infection (during times of spore release or when climate conditions are humid). Many of these fungicides are water-soluble and must be reapplied after heavy rains to maintain a protective coating.

Systemic fungicides prevent initial infection, but can also kill out established fungal infections within a plant. The drawback of these fungicides is their greater cost and the fact that some fungi will eventually develop a resistance to a repeatedly applied systemic fungicide. These fungicides are translocated through the plant from the site of application to a greater or lesser degree. Some brands will only translocate from one side of a leaf to the other, while others are translocated throughout the entire plant. The following systemic fungicides are used to control leaf rust in grasses and may also work for controlling bamboo leaf rust: triadimefon (trade names Bayleton DF, Light Green), and propiconizole (Tilt, Alamo).

Conclusion

In this country, bamboo diseases are nowhere near the problem that bamboo insects and mites are. So far, the main diseases found on bamboo in this country are leaf rust and sooty mold. Thanks to chance and the plant quarantine system, very few Asian bamboo diseases have so far been introduced to the United States and the few that are over here include none of the "biggies" that cause problems for the Asian bamboo grower. If we are careful, we can keep it that way for a long time, although as the acreage of Asian bamboo groves increases in the

Unites States, it also slowly increases the almost infinitesimal chance that a chance pathogen fungal spore or bacterium might successfully be carried across the Pacific by the winds and infect a bamboo plant over here in the total absence of any human intervention.

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From: MKTurner7@aol.com
To: hotchkiss@alltel.net ; kingfish7423@earthlink.net ; ned@bamboogarden.com
Sent: Tuesday, February 27, 2007 4:53 PM
Subject: Re: Bamboo article

Mike H.

I still have that and the other articles I have written over the years. "Some Asian Imports we Don't Need" was written as a single article, but I split it into two parts to fit it into the newsletter. I have no problems with you guys reprinting it or any of my other articles. A word file of the "Asian Imports" article is attached.

Mike Turner
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