USDA Interagency Research Forum on Gypsy Moth and Other Invasive Species
January 16-19, 2001
Loews Annapolis Hotel, Annapolis, Maryland

AGENDA

Tuesday Afternoon, January 16

REGISTRATION
POSTER DISPLAY SESSION I

Wednesday Morning, January 17

PLENARY SESSION .... Moderator: J. Robert Bridges, USDA-FS
Welcome
Michael McManus, USDA-FS

The Siege of Invasive Species in Midwestern Ecosystems
Robert N. Wiedenmann, Illinois Natural History Survey

The Brown Spruce Longhorn Beetle in Halifax: Pest Status and Preliminary Results of Research
Jon Sweeney, Natural Resources Canada

PLENARY SESSION .... Moderator: Robert Mangold, USDA-FS

The National Council on Invasive Species
Lori Williams, Department of the Interior

A Multi-year Project to Detect, Monitor, and Predict Forest Defoliator Outbreaks in Central Siberia
Max McFadden, The Heron Group, LLC

Wednesday Afternoon, January 17

GENERAL SESSION .... Moderator: Cynthia D. Huebner, USDA-FS
Invasive Plants: Organismal Traits, Population Dynamics, and Ecosystem Impacts
Presenters: E. Nilsen, Virginia Polytechnic Institute & State University; D. Gorchov, Miami University of Ohio; F. Wei, State University of New York at Stonybrook; K. Britton, USDA-FS; C. D'Antonio, University of California at Berkeley

GENERAL SESSION .... Moderator: Kathleen Shields, USDA-FS
Research Reports
Presenters: J. Colbert, USDA-FS; J. Elkinton, University of Massachusetts; J. Cavey, USDA-APHIS

POSTER DISPLAY SESSION II

Thursday Morning, January 18

GENERAL SESSION .... Moderator: Victor Mastro, USDA-APHIS
Asian Longhorned Beetle
Presenters: M. Stefan, USDA-APHIS; D. Nowak, USDA-FS; S. Teale, SUNY College of Environmental Science and Forestry; B. Wang, USDA-APHIS; R. Mack, USDA-APHIS

GENERAL SESSION .... Moderator: Kevin Thorpe, USDA-ARS
Research Reports
Presenters: S. Frankel, USDA-FS; B. Geils, USDA-FS; D. Gray, Natural Resources Canada

Thursday Afternoon, January 18

GENERAL SESSION .... Moderator: Vincent D'Amico, USDA-FS
Gypsy Moth in the Midwest
Presenters: D. McCullough, Michigan State University; A. Liebhold, USDA-FS; W. Kauffman, USDA-APHIS; A. Diss, Wisconsin Department of Natural Resources; L. Solter, Illinois Natural History Survey; K. Raffa, University of Wisconsin

GENERAL SESSION .... Moderator: Vincent D'Amico, USDA-FS
Research Reports
Presenters: B. Hrašovec, University of Zagreb, Croatia; E. Burgess, Hort-Research, Auckland, New Zealand; C. Maier, Connecticut Agricultural Experiment Station

Friday Morning, January 19

GENERAL SESSION .... Moderator: Sheila Andrus, USDA-FS
Asian Longhorned Beetle: Detection and Monitoring Panel Discussion
Panel Participants: J. Aldrich and A. Zhang, USDA-ARS; R. Haack, USDA-FS; D. Lance and B. Wang, USDA-APHIS; D. Williams, USDA-FS; S. Teale, SUNY College of Environmental Science and Forestry; M.T. Smith, USDA-ARS; K. Hoover, The Pennsylvania State University

GENERAL SESSION .... Moderator: David Lance, USDA-APHIS
Asian Longhorned Beetle: Control Options Panel Discussion
Panel Participants: V. D'Amico, USDA-FS; T. Poland and R. Haack, USDA-FS; A. Hajek, Cornell University; L. Hanks, University of Illinois at Champaign-Urbana; M. Keena, USDA-FS; B. Wang and W. McLane, USDA-APHIS; Z. Yang, Chinese Academy of Forestry; M.T. Smith, USDA-ARS

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ABSTRACTS AND PAPERS OF PRESENTATIONS AND POSTERS

STUDIES ON MULTIPARASITISM OF *GLYPTAPANTELES PORTHETRIAE* AND *GLYPTAPANTELES LIPARIDIS* (HYM., BRACONIDAE) ON THE HOST LARVA, *LYMANTRIA DISPAR* (LEP., LYMANTRIIDAE)

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ABSTRACT

The effect of interspecific competition between the solitary endoparasitoid species, *Glyptapanteles porthetriae*, and the gregarious species, *Glyptapanteles liparidis*, was investigated in their multiparasitized host larva, *Lymantria dispar L.* Gypsy moth larvae were parasitized either by both species simultaneously in premolt to the second or third host instar on the same day or with a delay in parasitization of 4 days by the second wasp species. Five days after oviposition of the first wasp species, development of host larvae and parasitoid larvae were monitored by dissecting individual larvae every second day.

Host selection experiments for oviposition revealed that both wasp species do not discriminate between host larvae that have been parasitized previously by the same or competing species or by unparasitized larvae; rather, the wasps usually parasitized the first caterpillar that they encountered. In delayed parasitism experiments, developing larvae of the primary species (first oviposited) never attacked eggs of the secondary species (those which were oviposited after four days). In these same experiments, larvae of the primary wasp species generally were successful in completing their development. However, larvae of the competing species were frequently attacked and killed or exhibited reduced growth. When *G. porthetriae* was the secondary parasitoid species, their larvae were never able to complete their development and to emerge successfully from host larvae. However, when G. *liparidis* was the secondary parasitoid species, their larvae completed development successfully from 12.5% of multiparasitized hosts.

When host larvae were parasitized more or less simultaneously by both wasp species, the rate of successful development of one or both species was dependent on the state of development of the host. In premolt to second instar parasitized hosts, 44% of *G. liparidis* and 28% of *G. porthetriae* emerged successfully, while both parasitoid species emerged successfully in 20% of the host larvae. Both species emerged successfully only when premolt to 2nd instar larvae were used. When host larvae were parasitized in the premolt to the third instar, *G. liparidis* emerged successfully from 90% of the multiparasitized hosts, as compared to only 8% of *G. porthetriae*. However, unlike the situation where larvae were parasitized in the premolt to second instar, we never observed successful emergence of both parasite species.

FACTORS AFFECTING THE SUCCESS OF THE GYPSY MOTH BIOLOGICAL CONTROL *ENTOMOPHAGA MAIMAIGA* IN MICHIGAN

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ABSTRACT

Entomophaga maimaiga, an entomopathogenic fungus, has become an important natural enemy of gypsy moth in much of the northeastern region of the U.S.. This pathogen has been established in Michigan since 1991 but its effects on gypsy moth dynamics have been less consistent than in the Northeast. We initiated major projects to (1) evaluate the suitability of climatic factors in Michigan and the north central region for *E. maimaiga* and (2) identify site or stand-related factors that may influence *E. maimaiga* persistence, germination, or infection rates.

Preliminary results of climatic modeling using 30-year mean temperature and precipitation data indicate that much of the north central region is similar to northeastern areas that have experienced repeated *E. maimaiga* epizootics. These areas should, therefore, be highly suitable for *E. maimaiga*. More intensive modeling using additional weather data from Michigan suggest that cold weather experienced in areas of northern lower Michigan and the western Upper Peninsula may limit the effectiveness of *E. maimaiga*. Precipitation is less likely to be a limiting factor. We intend to continue this work by comparing additional climactic data sets from Michigan and the north central region to conditions known to favor epizootics in the northeastern states.

To evaluate potential effects of site or stand factors on *E. maimaiga*, we selected 32 oak-dominated stands across northern Michigan; *E. maimaiga* was previously recovered from all stands. Stands were classified based on location and climatic regimes (e.g. lake effect, inland, or central frost pocket) and included low- to high-density gypsy moth populations. Results from field bioassays conducted in 1999 using freshly molted 4th instar larvae indicated that *E. maimaiga* infection rates were generally low, with means ranging from 5 to 7%. Laboratory bioassays were conducted under optimal conditions for the fungus, using

soil collected in each stand. Mean infection rates were roughly 25%, indicating that germination and/or larval infection was likely limited by weather or field conditions. Quantification of resting spores is in progress; results to date indicate that density was high enough in most stands to result in outbreaks if conditions were suitable.

Field and lab bioassays, resting spore analysis, and examination of gypsy moth cadavers collected from wild populations was repeated in 2000; dissection of cadavers and analysis of results are in progress. Bioassays will be repeated in 2001. Results from bioassays will be related to soil, vegetation, and other site or stand traits to identify factors associated with *E. maimaiga* success.

INTERCEPT™ PANEL TRAP, A NOVEL TRAP FOR MONITORING FOREST COLEOPTERA*

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ABSTRACT

A novel trap, the Intercept™ Panel Trap, has been developed for monitoring forest Coleoptera. The trap is made from corrugated plastic. It is lightweight, water proof, and durable. The trap performance was tested in the field for several forest Coleoptera and compared to that of the Phero-Tech 12-unit Multi-Funnel Trap. The trap was tested against the spruce beetle (*Dendroctonus rufipennis*), Douglas-fir beetle (*D. pseudotsugae*), western pine beetle (*D. brevicomis*), western balsam bark beetle (*Dryocetes confusus*), pine bark beetles (*Ips* sp.), larger pine shoot beetle (*Tomicus piniperda*), pine sawyers (*Monochamus* spp.), Asian longhorned beetle (*Anoplophora glabripennis*), buprestid beetles, wood wasps, and several other exotic forest pests. The Intercept™ Panel Trap captured equal numbers or more of most tested bark beetle species except for the spruce beetle when compared to captures in the multi-funnel trap. The Intercept™ Panel Trap captured a substantial number of Cerambycid and Buprestid beetles and Siricid wood wasps. In tests for the capture of exotic forest pests in Oregon, the Intercept™ Panel Trap captured substantially more insect species than the multi-funnel trap.

*The assistance of Dr. Steve Munson, USDA, FS, Ogden, UT is gratefully acknowledged. This is a report of research only. No endorsement by USDA of products or services mentioned is intended or implied.

ATTRACT AND KILL TECHNOLOGY FOR MANAGEMENT OF EUROPEAN PINE SHOOT MOTH, *RHYACIONIA BOULIANA*, AND WESTERN PINE SHOOT BORER, *EUCOSMA SONOMÁNA**

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ABSTRACT

Last Call™, an attract and kill bait matrix, was deployed for management of European pine shoot moth (*Rhyacionia buoliana*) and Western pine shoot borer (*Eucosma sonomana*) in pine plantations and tree nurseries. *R. buoliana* is an introduced pest of native and ornamental pines throughout the northeastern and northwestern United States and adjacent Canadian provinces, and a serious pest of pine plantations in South America and Europe. *E. sonomana* causes substantial economic losses in ponderosa, lodgepole, and Jeffrey pine in the western United States. Due to the cryptic larval habits of these shoot borers, conventionally sprayed insecticides are not very effective. Attract and kill (A&K) technology very selectively removes male moths of the target species from the ecosystem with negligible impact on non-target organisms. Baits combine the selectivity of pheromone (only 0.21 g/ha, compared to 3.5-20 g/ha for mating disruption) with rapid toxicity of insecticides (only 7.92 g/ha, compared to 500-800 g/ha for conventional sprays). Last Call™ retains the insecticide within a hydrophobic matrix that precludes run-off or drift, thus preventing ecosystem contamination and damage. The toxicant is partitioned so that non-target organisms, such as beneficial parasites and predators, are not harmed.

The pheromone trap capture data showed that, in comparison to the number of male *R. buoliana* captured within untreated plots, male moth populations in plots treated with a formulation containing 0.16% (w/w) of pheromone and 6% permethrin were reduced by 86.6% to 100%. The trap captures of male *E. sonomana* in A&K treated blocks were reduced 76% to 93% when compared to that of untreated blocks. Damage to Ponderosa pine by *E. sonomana* was significantly reduced in Last Call™ treated plots over two seasons, while damage in untreated plots remained unchanged.

*This abstract reports the findings of research only. No endorsement by USDA of products or services mentioned is intended or implied.

NOVEL NEW ATTRACTANT AND FORMULATIONS FOR CONTROL AND MONITORING OF TEPHRITID FRUIT FLIES*

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ABSTRACT

A novel plant-based attractant (EGO) has demonstrated activity as an attractant for three species of *Ceratitis* fruit flies: Mediterranean fruit fly (Medfly, *C. capitata*), Natal fruit fly (Natal fly, *C. rosa*), and Marula fruit fly (Mango fruit fly, *C. cosyra*). In field trials in Hawaii, South Africa, and Kenya, EGO captured more Medfly males than commercial formulations of trimedlure. It has attracted Marula fruit fly and Natal fruit fly to traps. EGO can be obtained very economically from natural sources. EGO was formulated with a toxicant in IPM Technologies' Last Call™ paste matrix and demonstrated attracticidal reduction of Marula fruit fly and medfly numbers and damage to citrus in South Africa.

The multispecies activity of EGO presents a very useful new tool for regulatory agencies and others involved in monitoring and control of *Ceratitis* species.

Also, the Last Call™ matrix has been used successfully to dispense cuelure and methyl eugenol to attract and capture Oriental and related fruit flies (*Bactrocera* species) in field traps. Tephritid fruit fly attractants can be easily and precisely dispensed in the field for either control or monitoring purposes using highly portable, stable, and environmentally safe Last Call™ formulations.

*The assistance of Dr. Roger Vargas, USDA, ARS, Hilo, Hawaii, Dr. S. Lux ICIPE, Nairobi, Kenya, and Dr. Tim Holler, USDA, APHIS, Gainesville, Florida, is gratefully acknowledged. This is a report of research only. No endorsement by the USDA of products or services mentioned is intended or implied.

ATTRACTANTS FOR THE LARGER PINE SHOOT BEETLE, *TOMICUS PINIPERDA**

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ABSTRACT

A new and more effective lure for the larger pine shoot beetle (*Tomicus piniperda*) has been developed. Five candidate beetle attractants (α-pinene, α-pinene oxide, nonanal, myrtenol, and *trans*-verbenol) were tested singly and in binary, tertiary, and quaternary combinations as the bait in 12-unit multi-funnel traps. Trap captures of *T. piniperda* were increased by from 175 to 433% in traps baited with binary or greater combinations when compared to α-pinene alone. Trap captures with tertiary and quaternary blends were more effective and consistent from year to year than captures with binary combinations. This study demonstrated that, at the least, a tertiary combination of α-pinene, α-pinene oxide, nonanal, and *trans*-verbenol released at high rates is required to assure optimum trap captures.

*This is a report of research only. No endorsement by USDA of products or services mentioned is intended or implied.

FIELD EVALUATION OF A CHINESE LADY BEETLE FOR BIOLOGICAL CONTROL OF THE HEMLOCK WOOLLY ADELGID

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ABSTRACT

The lady beetle (*Scymnus* (*Neopullus*) *sinuanodulus* Yu et Yao) was imported from China to the USDA Forest Service quarantine facility in Ansonia, CT, for evaluation as a potential biological control agent against *Adelges tsugae* Annand, the hemlock woolly adelgid (HWA). The impact of the beetle on HWA was evaluated for 2 years by caging individual, gravid females on infested branches.

Beetles were caged on branches using white nylon mesh bags. The experiment consisted of three treatments: (1) unbagged branch, (2) bagged branch without lady beetles, and (3) bagged branch with a single, previously mated female beetle. The experiment was initiated early in the spring, and branches were collected and brought to the laboratory for examination twice during each field season to coincide with the least overlap between HWA generations. Branches were examined under a microscope and HWA nymphs and *S. sinuanodulus* progeny were counted.

In 1999, bags and beetles were placed on trees in mid-April when the adults of the overwintering HWA sisten generation were at peak oviposition. In 2000, treatments were placed in the field earlier when adelgids were beginning to lay eggs and larger bags were used to enclose more foliage because of lower adelgid densities due to high winter mortality.

This field study and current laboratory experiments show that beetle oviposition is a function of prey density, quality, and phenology. More beetle progeny were present on branches with higher initial HWA densities. The presence of a lady beetle resulted in decreased HWA population growth, but the impact was lower when measured across both HWA generations. Despite reduction in the growth of HWA populations of 66% (1999) and 76% (2000) compared to bagged controls, the impact was not sufficient to prevent an increase in HWA populations.

Tri-trophic feedback from the host trees may have influenced beetle performance. Deterioration in the health of the hemlock trees was visibly dramatic during the course of the experiment, and the quality of HWA as food may have been reduced, lowering lady beetle fecundity. The timing of beetle placement in the field experiments may not reflect the beetle's natural synchronization with HWA phenology, and thus may have reduced the impact of the beetle on HWA.

ADAPTIVE PHYSIOLOGICAL TRAITS AND CONSTRAINTS ON THE DISTRIBUTION OF INVASIVE LEGUMES

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ABSTRACT

While traversing the planet for many centuries, humans have introduced non-native species to many ecosystems. Some of these introduced species were hitchhikers while others were carried for agricultural or horticultural reasons. However, naturalization of non-native plant species has greatly accelerated in the past few decades (Lodge 1993), resulting in a homogenization of species unprecedented in geological time. Naturalized, non-native species become an ecological problem when the results of the naturalization ramify throughout the invaded community and ecosystem. Some of the common ecological consequences of non-native plant species invasions are a reduction of native plant diversity, a loss of animal habitat, a change in the frequency and severity of disturbances such as fire, a reduction in resource availability to native species, and an alteration of ecosystem services. In fact, the changes in diversity, species distributions, extinctions, and ecosystem services due to non-native species invasions dwarf the effects of global climate change on these processes. Non-native invasive species are widely recognized worldwide as posing a threat to diversity and ecosystem stability second only to habitat destruction. A majority of the research on non-native introduced plant species directly concerns mechanisms for control of their population growth and persistence in the community. However, some recent studies have attempted to develop a body of ecological theory about non-native plant introductions.

The two major questions addressed by this burgeoning theory are: (1) What characteristics of ecosystems make them prone to invasion by non-native species? (2) What characteristics of non-native species make them likely to naturalize and induce ecological change? Davis et al. (2000) have recently addressed the first question in a synthesis article. They concluded that ecosystems become vulnerable to invasion when they experience an increase in resource availability induced by either a loss of vegetation or an increase in resource input. Therefore, the vulnerability of ecosystems to invasion is not constant and successful invasions will occur only when there is a rise in resource availability that coincides with the availability of invading propagules.

The second question has resisted the development of theoretic consensus. The diversity of naturalized species, diversity of habitats invaded, lack of research on unsuccessful invasions, and the focus on remediation rather than prevention are all causes for our inability to characterize the traits that make plants invaders. However, there are some generalized traits that are common to most invading non-native species. Baker (1965) was the first to formally

compile a list of traits common to invading species. His list of 14 traits was focused on reproductive characters such as fast maturation to reproductive age, high output of seeds, extended seed longevity, discontinuous seed germination, the ability to produce seed over wide environmental conditions, both long and short distance seed dispersal mechanisms, and the ability to reproduce by vegetative means from rootstock. Another study by Rejmanek and Richardson (1996) on invasive and non-invasive members of the Pineaceae also identified reproductive traits as those that characterize invasive species (short juvenile period, short interval between seed crops, and small seed mass). There are many different combinations of plant traits that can promote a successful invasion, but our ability to decipher and quantify those suits of traits remains poor (Mack et al. 2000). More recently we have come to recognize the importance of mutualistic relationships among species (such as mycorrhizal or rhizobial mutalisms) for successful naturalization of species (Richardson et al. 2000). However, reproductive traits and mutualisms are only two aspects of the entire cycle required for successful naturalization.

The processes required for a successful invasion can be presented as a spiral of increasing population size with specific checkpoints along each cycle. The most significant checkpoints in this spiral are the presence and effectiveness of a distribution vector, abundance of safe sites for establishment, appropriate abiotic conditions for growth, the presence of a pollination vector, and the absence of strong propagule predation. Any one of these checkpoints can hinder the success of an invader. Moreover, changes in these checkpoints may be effective mechanisms of abating the population rise of an invader. An additional complication to this scenario in plant systems is their ability to utilize vegetative as well as sexual reproductive means. In species that rely on vegetative reproduction, abiotic conditions, safe sites, and propagule predation become the most important checkpoints.

Physiological characteristics of the invading plants are most significant for the establishment, growth, and reproductive phases of the invader's population cycle. In particular, the physiological ability to withstand the stresses imposed by the ecosystem and the ability to effectively acquire resources are of paramount importance to invasion success. Although there are many studies on the reproductive traits of invasive non-native species, generalities on physiological characters are poorly developed. The best generalities we can state now is that invasive non-native species have a high resource demand, often depend on mutualism to improve resource acquisition, and often have a wide tolerance of environmental stressors. One of the best ways to begin to improve our understanding of physiological traits in non-native invasive species is to examine a phylogenetically constrained group of invasive plants.

Legumes are one of the most important invasive, woody plants in non-agricultural systems. Of the 78 species considered the most invasive plants in California, 9 are legumes (Bossard et al. 2000). Are there common physiological traits among these species that make them particularly effective invaders? Do these traits also constrain their possible expansion into a diversity of habitat types? Answers to these two important questions can elucidate the potential extent of a particular species invasion, the likelihood that other legumes with a similar physiology will be invasive, and the potential that certain management protocols against plant species invasion will be successful. Here I will focus on the invasive and indigenous legumes in California; nevertheless, the physiological traits and constraints on distribution apply to many legumes in other systems.

The nine invasive non-native legumes in California are predominantly spiny, drought tolerant shrubs with green stems inhabiting disturbed sites or old fields. Patterns of photosynthetic response to abiotic environmental conditions in these species could provide an understanding of physiological adaptation to climate and habitat preference. Moreover, a comparison between the invasive non-natives and indigenous species that have similar growth forms may lead to an understanding of important traits of invasive plants.

Temperature tolerance of the invasive legumes in California is relatively broad. Photosynthesis is maintained between 5 °C and 40 °C in many species. On the other end of the scale, several of these invasive legumes are very sensitive to cold-induced damage.

Light response of photosynthesis is one of the most dramatic characteristics of these species. Light saturation points are high (greater than 1200 $\mu E/m^2/s$) for both leaf and stem photosynthesis. In addition, light compensation points are relatively high in leaf and stem indicating a relatively high respiration rate and an intolerance of low light conditions. In fact, we could consider invasive legumes as obligate heliophytes.

One of the most prominent characteristics of invasive legumes in Mediterranean systems is stem photosynthesis. All nine of the non-native invasive legumes in California have prominent green stems, and many of these have documented net carbon gain by photosynthesis. Photosynthetic stems provide several advantages for legumes colonizing disturbed sites. They provide increased drought tolerance, increased tolerance of leaf herbivory, effective use of nitrogen, and increased carbon acquisition capacity. Several native legumes also contain this trait, but are not invasive. Therefore, this trait does not define an invasive plant, but it does enhance a plant's ability to withstand the stresses of a recently disturbed site.

The invasive, non-native legumes do show significant drought tolerance. The ability to avoid drought stress by defoliating and tolerate drought stress by osmotic adjustment in the stem tissues is a characteristic of both non-native and indigenous legumes.

Photosynthetic responses to light indicate a limited ability to tolerate lower radiation. However, these photosynthetic properties could change in shaded habitats affording a higher degree of growth than predicted by light response curves of plants in disturbed habitats. An examination of photosynthetic flexibility to different light availability of two non-native, invasive legumes indicated no capacity to change photosynthetic light response when grown under low light conditions. This lack of physiological flexibility caused severe effects on growth and resource allocation in lower light environments. Fifty percent of full sun or lower caused significant decreases in growth for both species. Allocation away from stem area to leaf area and weak stem development suggested greater sensitivity to drought and cold stress for plants growing in shaded conditions.

Nitrogen availability is a major limiting factor for plants in natural systems. Legumes have an advantage over many other plants because they form mutualisms with bacteria, and these associations (nodules) are able to convert di-nitrogen gas into amino acids. Therefore, legumes have the capacity to survive in low nitrogen sites. When soil has a relatively high amount of nitrogen, the association between bacteria and legumes is inhibited and the legumes survive on soil nitrogen. Increases in soil ammonia inhibit the growth of these invasive legumes (Nilsen 1992).

These physiological traits of invasive legumes will constrain their distribution in nature. The lack of flexibility to shade restricts these species from forested regions. Moreover, their growth form in shaded habitats limits their stress tolerance. Their sensitivity to ammonium limits their range to regions of low fertility and relatively high pH soil. As a consequence most invasive legumes are restricted to high light sites with low nutrient and are unlikely to invade into established communities from the edges of disturbances.

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IMPORTANT GENERA OF LONGHORN BEETLES NATIVE TO SLOVAKIA:

PEST STATUS AND NATURAL ENEMIES

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ABSTRACT

More than 20,000 species of Cerambycidae are known worldwide and have been described in the literature. A relatively small number of species from this insect family (2,000 to 2,500 species) are native to the palearctic region (Europe and Asia). In Slovakia, there are 200 species of Cerambycidae represented in 86 genera. Of this number, only 20 species from several genera are considered to be forest pests.

Four genera are recognized as important forest pests in Slovakia: *Cerambyx*, *Monochamus*, *Saperda*, and *Tetropium* (syn. *Isarthron*). Species within these genera and their hosts are as follows: ***Cerambyx***: *C. cerdo* L., *C.scopoli* Füessly - pests of broad-leaved trees (oak, beech, etc.). ***Monochamus***: *M.sartor* F. (spruce stands), *M.sutor* L. (conifers – spruce, pine, fir). ***Saperda***: *S.* (syn. *Anarea*) *carcharias* L. (poplars), *S.populnea* L. (poplars). ***Tetropium***: *T.castaneum* L. and *T.fuscum* F. (spruce, fir rarely), *T.gabrieli* Weise (larch).

Natural enemies play an important role as bioregulation factors that influence the population density of Cerambycids in Slovak forests. The following natural enemies have been recognized and described from Central European longhorn beetle populations:

***Cerambyx* sp.**: Ichneumonidae - *Ephialtes mesocentrus* Grav., *Ephialtes tuberculatus* Foucroy, *Ephialtes manifestator* L., *Rhyssa amoena* Grav, *Rhyssa persuasoria* L., *Rhyssa superba* Schrnk. Braconidae - *Helcon dentator* F.

***Monochamus* sp.**: Ichneumonidae - *Mesostenus gladiator* Scop., *Ephialtes tuberculatus* Foucroy, *Perithous divinator* Rossi, *Pyracmon austriacus* Tschek. Braconidae - *Coelabracon initiator* Nees., *Iphiaulax flavator* F., *Doryctes striatellus* Nees.

Saperda sp.: Ichneumonidae - *Proscus suspicax* Wesm., *Cryptus viduatorius* F., *Xylophrurus lancifer* Grav., *Goniocryptus analis* Grav., *Brachycentrus brachycentrus* Grav., *Ephialtes populneus* Rtzb., *Ephialtes messor* Grav., *Ephialtes manifestator* L., *Glypta rostrata* Homgr., *Glypta teres* Grav., *Ischnocerus filicornis* Kriechb., *Deuteroxorides albitarsus* Grav., *Xorides praecatorius* F., *Rhimphoctona fulvipes* Holmgr.. Braconidae - *Coelobracon denigrator* L., *Bracon discoideus* Wesm., *Ascogaster rufipes* Latr.. Chalcidoidea - *Habrocytus tenuicornis*

Forst.. Larvaevoridae - *Atropidomyia irrorata* Meig., *Masicera silvatica* Fall., *Dionea nitida* Meig.

***Tetropium* sp.:** Ichneumonidae - *Ephialtes aciculatus* Hellen, *Ephialtes dux* Tschek., *Ephialtes terebrans* Rtzb., *Rhyssa persuasoria* L., *Poemia notata* Holmgr., *Neoxorides nitens* Grav., *Neoxorides collaris* Grav., *Xorides praecatorius* F., *Xorides irrigator* F, *Xorides niger* Pf., *Rhadinopimpla brachylabris* Kriechb., *Rhadinopimpla atra* Grav., *Coleocentrus caligatus* Grav., *Pyracmon austriacus* Tschek., *Pyracmon xoridiformis* Strobl.. Braconidae - *Coelobracon denigrator* L., *Coelobracon initiator* Nees., *Coelobracon neesi* Marsch., *Atanycolus initiator* Nees., *Doryctes leucogaster* Nees., *Doryctes mutillator* Thunb., *Helcon aequator* Nees., *Helcon dentator* F., *Helcon tardator* Nees., *Baeacis dissimilis* Nees.

Information about entomopathogens that infect species of Cerambycidae is seldom mentioned in the literature. We found no reference of entomopathogens for the genera *Cerambyx* spp., *Monochamus* spp., and *Tetropium* spp. In the genus *Saperda*, we found references to the following pathogens: Bacteria - *Pseudomonas aeruginosa* Schroeter and *Enterobacter cloacae* Jordan; Nematoda - *Pristionchus lheritieri* Maupas.

Most of the natural enemies listed are not commonly found in field collections because the population density of most Cerambyriad species is low. The higher number of natural enemies recorded for the genera *Saperda* and *Tetropium* reflects the greater abundance of species in those genera that are encountered commonly in the field.

POTENTIAL EFFECT OF AN ASIAN LONGHORNED BEETLE *(ANOPLOPHORA GLABRIPENNIS)* ON URBAN TREES IN THE UNITED STATES

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ABSTRACT

An Asian longhorned beetle *(Anoplophora glabripennis* Motschulsky) was recently found in New York City and Chicago. In an attempt to eradicate this beetle, thousands of infested city trees have been removed. Field data from nine U.S. cities and national tree cover data were used to estimate the potential effects of the Asian longhorned beetle on the urban forest resource. For the cities analyzed, the potential tree resources at risk to Asian longhorned beetle attack (based on host preferences) range from 12 to 61% of the city tree population, with an estimated value of $72 million to $2.3 billion per city. The corresponding canopy cover loss that would occur if all preferred host trees were killed ranges from 13 to 68%. The estimated maximum potential national urban forest impact of the Asian longhorned beetle is a loss of 34.9% of total canopy cover, 30.3% tree mortality (1.2 billion trees), and a value loss of $669 billion. More detailed information on this study is given in: Nowak et al. [In press]. Potential effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on urban trees in the United States. Journal of Economic Entomology.

EVALUATION OF SYSTEMIC INSECTICIDES TO CONTROL *ANOPLOPHORA GLABRIPENNIS* (COLEOPTERA: CERAMBYCIDAE)

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ABSTRACT

The use of systemic insecticides may prove useful in controlling Asian longhorned beetle (*Anoplophora glabripennis* (Motschulsky)) (Coleoptera: Cerambycidae) adults during maturation twig feeding and larvae when feeding in the cambium and sapwood. In 1999, we evaluated imidacloprid as a systemic insecticide against *A. glabripennis*. We used four injection methods: Mauget (Imicide, J.J. Mauget, Co.) and Wedgle (Pointer, Arbor Systems, LLC) trunk injectors, ACECAP trunk implant (Creative Sales Inc.), and Kioritz soil injector (Merit, Bayer Corp.). All injection methods were tested in four tree species which were known to be hosts in China and were infested in New York City and Chicago: American elm (*Ulmus americana* L.), boxelder (*Acer negundo* L.), quaking aspen (*Populus tremuloides* Michx.), and silver maple (*Acer saccharinum* L.). Tree samples were collected 4, 8, and 16 weeks after injection and presented to *A. glabripennis* adults and larvae. Testing of *A. glabripennis* was conducted in the USDA Forest Service quarantine facility in Ansonia, CT. Branch sections were presented to mating pairs of adults to test oviposition success, twigs were presented to individual adults to assess mortality during maturation feeding, and artificially reared first instar larvae were inserted into branch sections to assess larval mortality. Chemical residue analyses were conducted on foliage and twig samples at the USDA APHIS laboratory in Gulfport, MS. Overall, little adult or larval mortality occurred during the 2- to 6-week feeding tests. Adults fed on the outer bark of the twigs and thus not deep enough into the wood to receive a lethal dose. The highest levels of *A. glabripennis* larval mortality occurred in branch samples from boxelder trees that were collected 16 weeks post-injection. The chemical residue analyses suggested that the imidacloprid did not spread evenly throughout the trees. Of the four injection techniques, imidacloprid was most commonly detected in trees treated with the Mauget trunk injection method.

In 2000, in addition to imidacloprid, we also evaluated azadirachtin (the active ingredient in neem seed extract) and emamectin benzoate in both the U.S. and in China. In the U.S., we tested two doses of imidacloprid using Mauget trunk injection devices (Imicide), two doses of azadirachtin (Oranzin, Amvac Chem. Corp.) using both the Kioritz soil injector and systemic tree injection tubes (STIT), and one dose of emamectin benzoate using trunk injection (Shot One, Novartis). In the U.S., we tested imidacloprid in both boxelder and silver maple trees, whereas azadirachtin and emamectin benzoate were tested only in boxelder trees. Samples of trees injected with azadirachtin were collected 4 weeks after injection and larvae were inserted under the bark in the Ansonia quarantine lab. Larvae were

allowed to feed for 8 weeks prior to dissection of the branch samples. Samples from trees injected with imidacloprid and emamectin benzoate were collected 12 weeks after injection and larvae were allowed to feed for 4 weeks prior to dissection. Overall, we found very low mortality in all lab bioassays in 2000. Residue analyses are still being completed.

We are currently conducting laboratory bioassays with *A. glabripennis* and cottonwood borer (*Plectodera scalator* (Fabricius)) (Cerambycidae) feeding on artificial diet treated with various concentrations of imidacloprid and azadirachtin. The cottonwood borer is being reared in a non-quarantine laboratory in East Lansing, MI, as a surrogate for *A. glabripennis*. Preliminary results demonstrate a strong anti-feedant effect for both insecticides. As concentrations of imidacloprid and azadiractin increase in the diet, larvae feed less and lose weight. For *P. scalator*, no mortality was seen until 8 weeks of feeding. After 12 weeks, several larvae feeding on diet treated with concentrations of imidacloprid or azadirachtin greater than 50 ppm had died, while larvae on doses as low as .005 ppm lost weight and displayed various signs of decline. For *A. glabripennis*, mortality was first seen after 4 weeks of feeding and after 8 weeks, a few larvae had died and similar reductions in feeding, weight loss, and signs of decline were observed. These results may help explain why we observed such low larval mortality in the insecticide-treated branch samples in 1999 and 2000, i.e., that the larvae may require more time to feed before branch dissection and assessment of mortality. In addition, the small larvae that were inserted into the branch samples may not have received a lethal dose because they feed very little and primarily in the phloem tissue.

In June 2000, we injected 48 elm trees, 48 poplars, and 48 willows in Gansu Province, China. For each tree species, 24 of the trees were currently heavily attacked by *A. glabripennis* and 24 were lightly attacked. Equal numbers of trees were injected with imidacloprid using Mauget trunk injectors (Imicide, high dose), azadirachtin using systemic tree injection tubes (Ornazin, high dose), or emamectin benzoate using trunk injection (Shot One). In July, 4 weeks after injection, four mating pairs of *A. glabripennis* were caged on each of the lightly infested trees to ensure that some larvae would be present. In October, 4 months after injection, we cut down and dissected half of the trees. Mortality varied by *A. glabripennis* life stage, tree species, and insecticide. Overall, moderate levels of mortality were found for all three insecticides tested. The highest larval mortality rate (81% of the larvae that were in the sapwood) occurred on poplar trees that had been injected with imidacloprid. The remaining trees will be cut and dissected in May or June 2001. Additional doses and compounds will be tested in 2001. In addition, trees will be injected simultaneously with dye and each of the different insecticides using different doses and number of injection sites to determine translocation patterns and the optimal delivery protocols to ensure complete coverage.

THE USE OF MOLECULAR GENETICS TO IDENTIFY AND MONITOR INVASIVE PESTS

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ABSTRACT

Our group has been involved with pest identification issues that require the use of molecular techniques that complement morphometric and anatomical methodologies. The types of problems range from population differentiation (*Ceratitis capitata*) to strain differentiation (*Lymantria dispar*) to species differentiation (terrestrial slugs). Medfly can be invasive to California, Florida, and Texas. The Asian strain of the gypsy moth can be invasive to the forests of North America and exotic mollusks can be invasive to both disturbed and undisturbed habitats. These three identification problems require different methodologies using genetic markers specific to the task. We summarize here the results from these three projects and briefly present the differing methodologies.

EXOTIC AMBROSIA BEETLES IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Native bark and ambrosia beetles (Scolytidae) are among the most important forest insects, causing the loss of millions of dollars in forest products each year. Exotic species are also having an impact. In 1977, it was estimated that there were 37 species of Old World scolytids established in North and Central America. Since then, 10 additional species have been reported new to the United States. Recent surveys have found an increasing number of exotic ambrosia beetles established in the United States. Ambrosia beetles are usually considered secondary pests in their native habitats; however, increasing evidence has suggested that some species of ambrosia beetles are aggressively attacking healthy saplings and twigs of healthy trees.
An important first step in evaluating the impact of exotic ambrosia beetles on the health of forests is to determine what species are present. Surveys in the Northeast and mid Atlantic have found six species of exotic Xyleborini (the largest and most important group of ambrosia beetles) new to the area within the past 10 years. The purpose of this Forest Health Evaluation Monitoring project was to conduct a preliminary survey of the Southeast to determine the occurrence of exotic ambrosia beetles. Nine states in the southeastern United States (U.S. Forest Service Region 8) participated in this survey (Alabama, Florida, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia). In most states, ethanol-baited funnel traps were co-located with traps for the southwide southern pine beetle survey and were placed in pine stands at the time of dogwood bloom. Forest health workers in each state monitored traps and collected samples weekly for eight weeks. Fifty-five new state records for scolytids were recorded for 26 species during this survey. A total of 41 of these new state records were for ambrosia beetles and 28 for exotic species. Among the ambrosia beetles, this is the first record of *Xyleborus pelliculosus* Eichhoff in the South. *Dryoxylon onoharaensum* (Murayama), *Ambrosiodmus rubricollus* (Eichhoff), and *Xyleborinus saxeseni* (Ratzburg) are all exotic ambrosia beetles and were collected in every state during this survey. Two other exotic ambrosia beetles, *Xyleborus californicus* Wood (previously reported only from South Carolina in the South) and *Xylosandrus crassiusculus* (Motschulsky), were collected in eight of nine states. A total of 12 exotic species was collected, 10 of which were ambrosia beetles and of these, five have been reported for the first time in the Southeast in the past 10 years. Most of these "new" introductions are from Asia. Nine of the 12 exotics are from Asia and the two European exotics were introduced over 100 years ago. During this survey, 8,273 scolytids were collected. Ambrosia beetles accounted for 7,104 of these specimens (86%). The most numerous was *Xyleborinus saxeseni* with 4,375 specimens (53%). This exotic ambrosia beetle was found in every state and dominated most trap samples. Members of the tribe Xyleborini made up 77% (6,438) of the specimens collected. In the United States, there are currently 33 species of xyleborines; 14 of these are exotics.