editor's note

The goals of the Exotic Pest Plant Council include building public awareness about the serious threats invasive exotic plants pose to wildlands. On September 9th of this year, a workshop was held to provide an overview of the problems that skunk vine (*Paederia foetida*) is causing in Central Florida, share what is known about its control, and gain input from land managers and the public. Kudos to Sheryl Bowman, Brian Nelson and Tony Richards for spearheading this cooperative effort. Jennifer Possley and Dorothy Brazis have provided a workshop summary (see p. 11). I hope it encourages other groups to get together to share information about pest plants in their area. Remember, misery *loves* company.

It's our job to bring these problems to the forefront, and education is the key. The problems caused by invasive plants are not always easy to see and are sometimes hard to explain. Their effects can be complex and are sometimes not immediately obvious (see "Fatal Interactions?", p. 5) "What's green is good" just doesn't cut it anymore. Escaped exotic organisms are beginning to be termed "smart pollution" by the press. People are beginning to understand that plants can actually *harm* the environment. EPPC needs to continue to fulfill its goals and help lead the charge in educating the public about the real threats these plants pose. – Amy Ferriter

Fatal Interactions?

When exotic plants are lethal to native insects

By Tracy S. Feldman

Effects of introduced plants on native flora and fauna remain virtually unstudied. Many areas in the United States (e.g.: Florida and Hawaii), for better or for worse, would likely prove fertile ground for such work. However, the following example comes from investigations I conducted in Monteverde, Costa Rica.

Many butterflies are fairly specific in their oviposition requirements—they will choose only certain plant species in one or a few plant families. Visual cues and plant chemistry often play very important roles in insect oviposition choice. Photo by Tracy S. Feldman.

Many species of flora and fauna make their homes in forest patches and pastures outside of the famed Monteverde Cloud Forest Reserve, as well as within its boundaries. One herbaceous plant, with showy dark-green or purple leaves with pink splotches, is common in pastures and along roadsides. This African plant, called *Hypoestes phyllostachya* Baker (Acanthaceae), also "polka-dot plant" or "paint plant," was brought to Monteverde as an ornamental by a well-meaning resident over 40 years ago. Five to 15 years ago, it spread along roadsides and into pastures, forming sometimes dense stands. Typical of many invasive species, the plant is fed upon by few if any insects. Apparently, cows do not like it either, so it is considered a pest in pastures.

My studies in Monteverde centered on interactions between plants and butterflies. Much of my time there was spent following female butterflies, observing them laying eggs (ovipositing) on plants, and then assessing the suitability of those plants as larval hosts. Many butterflies are fairly specific in their oviposition requirements—they will choose only certain plant species in one or a few plant families. Visual cues and plant chemistry (Fraenkel, 1969) often play very important roles in insect oviposition choice. Larval feeding choices are often broader, at least in a laboratory setting (Wiklund, 1975). However, the larvae are often restricted to feeding on plants from one or a few plant families.

On several occasions, I followed females of two species of *Anthanassa* butterflies, only to observe them searching and ovipositing on the exotic *H. phyllostachya*. These butterflies laid clusters of 28-177 eggs on the undersides of the leaves, perhaps putting up to 11% of their reproductive effort on any one leaf (Feldman, in preparation a).

I collected several egg clusters to rear the butterflies, and found that *Anthanassa* larvae readily ate most native plants in the family Acanthaceae. However, they always died when confined on *H. phyllostachya* (Feldman and Haber, in press). Larvae could not survive past the first of their five larval instars on this alien plant.

Only three native species of the Acanthaceae are recorded as oviposition sites for these butterflies (Feldman and Haber, in press)—two of these (*Dicliptera unguiculata* (Nees) and *Pseuderanthemum cuspidatum* (Nees)) are sympatric with *H. phyllostachya* in Monteverde. In laboratory paired-plant tests, at least one *Anthanassa* species preferred ovipositing on *D. unguiculata*, a common native host plant, rather than on the exotic (Feldman, in preparation a). However, most females in the tests laid some eggs on each of the two plant species.

In other recent studies conducted in Monteverde (Feldman, in preparation b), fewer *Anthanassa* eggs were lost to predators on the exotic than on *D. unguiculata*. However, because larvae will not accept *H. phyllostachya* as a host plant, larvae from eggs laid on this exotic must crawl to nearby native acanths in order to complete development. I found that larval mortality from crawling between plants was high enough to overshadow any benefits in egg survival. It is likely that all of the progeny from eggs laid on this exotic die.

In the 1970s, biologist F. S. Chew studied host plant relationships between native pierid butterflies and mustard plants in Colorado and Vermont. She found that females of two species each oviposited on one exotic mustard plant that is lethal to the larvae (Chew, 1977a, 1977b). Rodman and Chew (1980) and Huang et al. (1994), working on the same systems, found that chemicals adults use to determine the suitability of native hosts for oviposition were also present in the exotics. The situation I observed in Costa Rica may be similar. Visual, chemical, and tactile cues in *H. phyllostachya* that are similar to cues in native host plants may stimulate adult oviposition on the exotic. Even so, females may detect some differences between these plants, and may not prefer to lay eggs on it, given equally available native hosts.

In many cases, *H. phyllostachya* is more abundant than native acanths in areas where I have observed female *Anthanassa* in the Monteverde community. Although this exotic plant has not been recorded in the Cloud Forest Reserve, the population of *Anthanassa* found there is likely continuous with that found in the community (Haber, pers. comm.).

In scientific literature, there are many other examples of ovipositions on introduced plants that are toxic to larvae ("oviposition mistakes")—most of an anecdotal nature (Plagens, 1986; Sevastopulo, 1964; Straatmann, 1962; Tuskes & Emmel, 1981). When these interactions are fatal, they are difficult to detect unless oviposition is directly observed, or unless eggs are found on the plants. Thus, it is possible that there are many other as-yet undetected instances of oviposition on exotic plants lethal to larvae.

Species are not islands

In most cases, introduced plants are likely not isolated entities. In their new environment, these plants come into contact with other species, and interactions occur that are beneficial, detrimental, or have no net effect. Native phytophagous (plant feeding) insects may feed successfully, may die, or may simply rest on these plants en route to other plants. The above examples suggest that non-indigenous species may actively affect other species by corrupting evolved behavior patterns. In the discussion that follows, I separate out "passive

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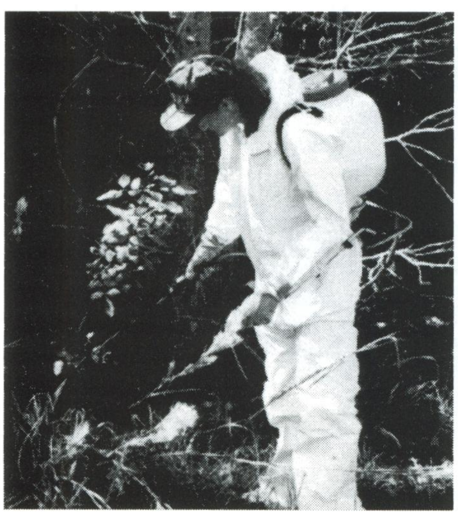

effects" from "active effects." I define passive effects as those that do not involve native insects feeding on, ovipositing on or otherwise directly using exotic plants. Alternatively, active effects are those that involve direct interactions between native insects and exotic plants (e.g.: feeding or oviposition). I use examples from literature on Lepidoptera, which include some of the best studied cases.

Passive effects

When exotic plants spread, they cover more ground—ground that was presumably originally covered with native plants. If actual displacement of native species occurs, native hosts of phytophagous insects may be more difficult to detect, perhaps increasing the time spent searching for oviposition sites. Singer (1982) found that female *Ephydryas editha* butterflies would more readily accept less-preferred plants the longer they searched without ovipositing. More data are needed to determine if this is the case for *Anthanassa* butterflies searching in areas invaded by *H. phyllostachya* —even if they do not prefer the exotic, they may be overwhelmed by its presence along roadsides and in pastures in Monteverde.

Native phytophagous insects may not even respond to suitable non-indigenous host plants because they have not evolved mechanisms to do so. In this case, species diversity, or at least abundance of phytophagous insects on such plants would be lower (Beerling & Dawah, 1993). Predators and parasitoids of phytophagous insects may use cues from the host plants to locate their prey (Camors & Payne, 1971; Price, et al., 1980), and so may search less often or less efficiently on a "new" plant. Even generalist predators randomly searching on vegetation may not search as often on plants with fewer insects. This may be one reason why the rate of egg survival was greater on *H. phyllostachya* —if fewer predators are present in clumps of this exotic plant, eggs laid there would likely have a better chance of surviving. However, once *Anthanassa* larvae emerge on the exotic, their chances for survival are slim.

Active effects

In many cases, native insects do feed successfully on exotic plants. If the introduced host plant becomes more common, but does not displace native hosts, more oviposition sites and larval food would be available within the insect's normal range. Also, new hosts may be used in areas where native hosts are not available, thus aiding in range expansions. This has been documented for the butterfly *Pieris virginiensis* and for other insect species that use non-indigenous mustard plants as hosts (Shapiro, 1975; Root and Tahvanainen, 1969). In addition, some butterflies may use exotic hosts more commonly than native ones in urban or disturbed habitats (Brown, 1990). These plants may be important for maintaining or increasing population sizes of those insects.

In the cases of *Anthanassa* butterflies ovipositing on *H. phyllostachya*, or of pierid butterfly species that cannot survive on exotic mustard plants, exotic plants are actually "causing" butterflies to waste reproductive effort.

> *"Every year, between 1,000 and 4,000 species of exotic plants come into Florida alone."*

If insects with restricted distributions make such oviposition mistakes, their populations could decrease in size, until selection pressure is great enough to cause insect species to adapt to the exotics—larvae may evolve to be able to feed on the plants, or adults may evolve to avoid them as oviposition sites. However, heritability of oviposition preference in some species or populations may be low. This would result in low response (or no detectable response) of these insects to selection pressures. Tuskes and Emmel (1981), studying the rare sphinx moth *Euroserpinus euterpe* Hy. Edwards, found that females in a recently rediscovered population were ovipositing on an introduced weed, *Erodium cicutarium* (L.), and that larvae did not feed successfully on this plant. They suggest that "such oviposition errors may contribute to the scarcity of the moth." Areas overwhelmed by exotics may serve as "sinks" (Pulliam, 1988) where the reproductive efforts of phytophagous insects are largely in vain (i.e. local populations may go extinct if immigration from nearby populations stops).

Conclusions

Phytophagous insects may be subject to either passive or active effects, or both, of exotic plants invading wildlands. Every year, between 1,000 and 4,000 species of exotic plants come into Florida alone (Castaneda, pers. comm.). Nearly 1,200 plant species have become naturalized in Florida (Wunderlin, 1998); 3757 in the United States (Kartesz, 1998). As more and more plant species are introduced, more will become naturalized, and both passive and active effects on native insects will likely become more common. It may be impossible to predict which species will have such effects. In addition, active effects of exotics even outside of wildlands could change population dynamics of insects with restricted distributions partially within wildland boundaries. If habitats are lost or modified by plant introductions more quickly than selection can act on a species, native insect populations or species that do not adapt may be lost as well.

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