Foreign Exploration for Biological Control Agents of Three Invasive Plant Species from Asia

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Introduction

In June 2005, a joint Florida International University (FIU) and University of Florida (UF) expedition to Malaysia was conducted to explore for potential insect biological control agents of three FLEPPC Category 1 plants: air potato (*Dioscorea bulbifera* Linn.), shoebutton ardisia (*Ardisia elliptica* Thunberg) and coral ardisia or coral berry (*A. crenata* Roxburgh.) (Fig. 1 A-C). This expedition, funded by the Florida Department of Environmental Protection, was led by Sharon Ewe (FIU) in collaboration with researchers from the Forest Research Institute Malaysia (FRIM).

Air potato growing behind the primary author's house in Osceola County, Florida.

All three Florida pest plant species are native to Southeast Asia, which has a high diversity of both the Dioscoreaceae and Myrsinaceae (Burkill 1935). Two field expeditions were undertaken during the trip. Fifteen natural areas, parks and forest reserves, as well as several dozen village compounds, home gardens, and "dusun" (small fruit orchards) were examined. Ewe and her partners traveled approximately 600 km in the urban and rural areas of Peninsular Malaysia (Fig. 2).

Air potato

The presence of air potato was first recorded in Florida in 1905 (Morton 1976) but the introduction of this species to North America can most likely be attributed to slave ships from Africa (Coursey 1967). It is believed to have originated in Asia but is found all over the tropics in Asia and Africa (Martin 1974). This plant has been cultivated in home gardens as a food source for such an extensive period that wide diversity is observed in species morphology throughout the Old World (Coursey 1967, Martin 1974). It remains an important food crop in sub-Saharan Africa (http://www.cgiar.org/impact/research/yam.html) where the tubers can be easily stored for up to 6 months as an emergency food source. It is less important in Southeast Asia where economic development has reduced the need for long-term food storage. Despite being noted in the floras of Central and South America, the air potato is not an important food source in the New World (Martin 1974).

In Florida, air potato forms a thick blanketing vine that can shade out both canopy and understory vegetation (Langeland 2003). At present, management of this species is limited to repeated physical and chemical methods, with no long-term alternatives. In describing this species, Martin (1974) observed that underground tubers were sometimes attacked by beetles and nematodes but appeared to be more resistant than tubers of other species. Ongoing work in Ghana by Overholt and African colleagues has revealed several species of insect defoliators, but none yet that are sufficiently host-specific to be considered as candidates for biological control agents.

In Northern Peninsular Malaysia, air potato is known in rural villages as "ubi takut babi" (potato afraid of pigs) because of its aerial tubers. Many older villagers recalled growing air potato in the 1950s, when the plant was widely cultivated primarily for its underground tubers. However, due to easy access to fast-food chains and marketplaces selling the common potato (*Solanum tuberosum* L.), air potato is no longer cultivated. We encountered several *Dioscorea* spp. vines on the expedition, primarily either in secondary forest or at the edges of home gardens. In addition to the air potato, we encountered *D. orbiculata*, *D. glabra* and *D. hispida*. Almost all individuals, including the air potato, had signs of leaf damage. It appeared, however, that herbivory was sporadic

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(1b) Shoebutton ardisia in the understory of remote south-western brackish mangrove areas in Everglades National Park; (1c) Fruiting coral berry growing in the shady understory in Tallahassee.

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or seasonal as some sections of vines had been completely consumed while younger or older leaves remained intact. In some areas, several feet of *Dioscorea* sp. vines were completely defoliated, possibly by the larval form of a sawfly that was not seen during this expedition but was observed during a previous trip in December 2004 (Fig. 3A; see http://www.fiu.edu/~ewes/www/Malaysia-trip.htm for a more complete description). In the home garden of the undergraduate volunteer (S. Ulamanathan), two air potato vines were found that showed signs of foliar insect damage but no insects. Two bulbils on a vine had healed wounds from borer damage; visual inspection revealed that the insects were no longer present. One Lymantrid (Lepidoptera) and two *Tagiades* (Lepidoptera: Hesperiidae) caterpillars were collected from the air potato plants during this trip. The Lymantrid remains unidentified as it emerged a wingless female. The *Tagiades* larvae did not develop into adults, but were probably *T. japetus* (Stoll) or *T. gana* (Moore) or both species, as there appeared to be two larval forms.

Ardisia

Shoebutton ardisia (*Ardisia elliptica*) was introduced into Florida as an ornamental in 1900 (Gordon and Thomas 1997). Having escaped cultivation, this primarily bird-dispersed species can now be found in most South Florida counties (Wunderlin and Hansen 2004) where it often displaces native understory species by forming dense monospecific stands (Koop 2003). Coral berry (*Ardisia crenata*) was introduced into Florida about the same time as the shoebutton ardisia. This species is now recorded in 14 northern Florida counties as well as in Texas (Singhurst et al. 1997). Like shoebutton ardisia, this species is shade-tolerant and can form monospecific carpets that displace native communities (Langeland and Craddock-Burks 1998). These plants represent a significant threat to the remaining closed-canopy natural areas in Florida as they can shade out and outcompete native understory species, altering forest structure and function (Gordon 1998). They also have the capacity to displace native species such as *Ardisia escallanoides* (marlberry) and the endangered *Argythamnia blodgettii* (Blodgett's silverbush).

Although there is no record of human use of either species in Florida, fruits of shoebutton ardisia are eaten by locals in Peninsular Malaysia and described as tasting similar to java plum (*Eugenia jambolana*) (Burkill 1935). Burkill (1935) also reports that seeds of coral berry are eaten by the Malays while the indigenous people of the Peninsula and the Javanese use the leaves as a salad. Leaf and root juices of coral berry are also used to treat fevers, coughs, diarrhea, ear-ache, and other ailments.

An elongate bagworm leaf herbivore on shoebutton ardisia.

In Peninsular Malaysia, shoebutton ardisia was found as a cultivated ornamental. Although this plant was cultivated in coastal areas and as a roadside plant, shoebutton ardisia appeared to be a difficult species to maintain because of the prevalence of herbivores. Eight species of herbivores were observed on five populations of shoebutton ardisia in June 2005. The most frequently encountered herbivore was the pagoda bagworm, *Pagodiella hekmeyeri* Heylaerts (Lepidoptera: Psychidae). This caterpillar was present in large numbers and caused significant damage by excising round holes (diameter range ≈ 3 – 20 mm) from the leaves (Fig. 3B). An elongate species of bagworm also was found on shoebutton ardisia. (Fig. 3C). Although larvae of the latter species were larger (approximately 4-5 cm long), density of this herbivore on shoebutton ardisia was lower, resulting in less damage. Additionally, we also found a cocoon on the underside of a leaf and some small red-brown chrysomelid beetles that scraped the undersides of leaves (Fig. 3D). The insect that emerged from the cocoon was later identified as a moth, *Birthama congrua* Walker (Lepidoptera: Limacodidae), while the beetles were determined to be *Rhyparida* sp. (Chrysomelidae: Eumolpinae) and *Manobia* sp. (Chrysomelidae: Alticinae). We visually estimated that damage to shoebutton ardisia ranged from approximately 10-80% of leaves damaged and/or consumed by herbivores. Greater damage was observed on smaller trees (often ≥ 50% leaf area consumed), possibly leading to the death of a planted individual along a trail in a forest recreation park.

Figure 2 (A) Outline of expedition trips (dotted line) within Peninsular Malaysia. The first trip explored home gardens and forested areas of midwestern Peninsular Malaysia while the second trip focused on rural home gardens and plantations in northwestern Peninsular Malaysia. **(B)** Geographical location of Malaysia relative to other countries in South East Asia.

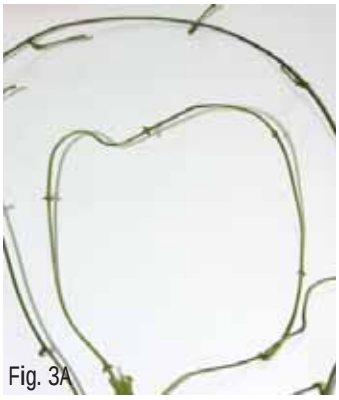
Fig. 3A


Fig. 3B


Fig. 3D


Fig. 3E

*(A) Sections of air potato stem that had been defoliated by unknown herbivores (possibly sawfly larvae). The damage appeared to be several months old. (B) Pagoda bagworm (*Pagodiella hekmeyeri*) to the right of a damage hole formed by removal of a circular disc of leaf lamina. The bagworm scrapes the chlorophyll off the leaf before incising cleanly around the area consumed. The excised leaf disc is then added to the bagworm's protective case. (D) Signs of Chrysomelid damage on the underside of a shoebutton ardisia leaf. The beetle scrapes out small patches on the underside of the leaf, resulting in a spot-like damage pattern. (E) Mealybugs observed on shoebutton ardisia during an earlier trip (Dec 2004).*

Although all plants were fruiting copiously, no fruit feeders were observed and most of the damage to foliage was restricted to the lower half of the canopies. Some of the damage to shoebutton ardisia also appeared to be seasonal. For example, fresh leaf miner damage was observed only on some plants even though there were exit holes of leaf miners on all plants. In December 2004, Ewe found some shoebutton ardisia growing in FRIM infested with a mealybug (Fig. 3E), probably *Rastrococcus spinosus* (Robinson) (Homoptera: Pseudococcidae), but none of these insects were found on the same plants in June 2005. The general appearance of the mealybug colony at the time suggests they may have been in decline due to natural control by predators and parasitoids.

Coral ardisia was less popular as an ornamental in Malaysia and usually found in the understory of primary forests. We found two populations of coral berry but only one species of herbivore, *Collix stellata* Warren (Lepidoptera: Geometridae), on this plant. This moth species has been recorded feeding on *Trigonostemon* sp. (Euphorbiaceae), *Ardisia* sp. (Myrsinaceae) and *Allophylus* sp. (Sapindaceae) in Peninsular Malaysia (Holloway 1997, in which the moth is referred to by its junior synonym, *C. griseipalpis* Wileman).

Conclusion

During our relatively short survey, we discovered a high diversity of herbivores on shoebutton ardisia in Peninsular Malaysia (8 herbivore species), and a lesser diversity on air potato (3 herbivore species). At least two bagworm species were found co-existing on shoebutton ardisia in June 2005 and, although present only part of the year, they caused significant damage to the trees. However, the same bagworms are considered pests of some commercial crops in Malaysia (Khoo et al. 1991), and thus are not likely to be sufficiently specialized to use in biological control. Some of the insects observed were possible specialists, such as the chrysomelid beetles found on shoebutton ardisia and the sawfly on air potato.

Despite their proximity to the equator (1-4ºN), the Peninsular Malaysian herbivores displayed a high degree of temporal variation in abundance, perhaps in response to wet and dry periods or as a result of natural fluctuations in population size mediated by natural enemies. Different suites of herbivores seemed to dominate the plants during the two different visits. More detailed and longer term studies will be required prior to introducing candidate biological control agents. The complete DEP report is available at: http://www.fiu.edu/~ewes/www/Malaysia-trip.htm.

Acknowledgements

We thank the Florida Department of Environmental Protection for research funding to Ewe and Overholt. We also thank Dr. M.S. Mohamedsaid for identifying the beetle specimens; Dr. J. Holloway, Natural History Museum, London, for confirming the identities of the adult moths; Dr. D. Lee (FIU), and S. Cheng and M. Azmi (FRIM), for research support.

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