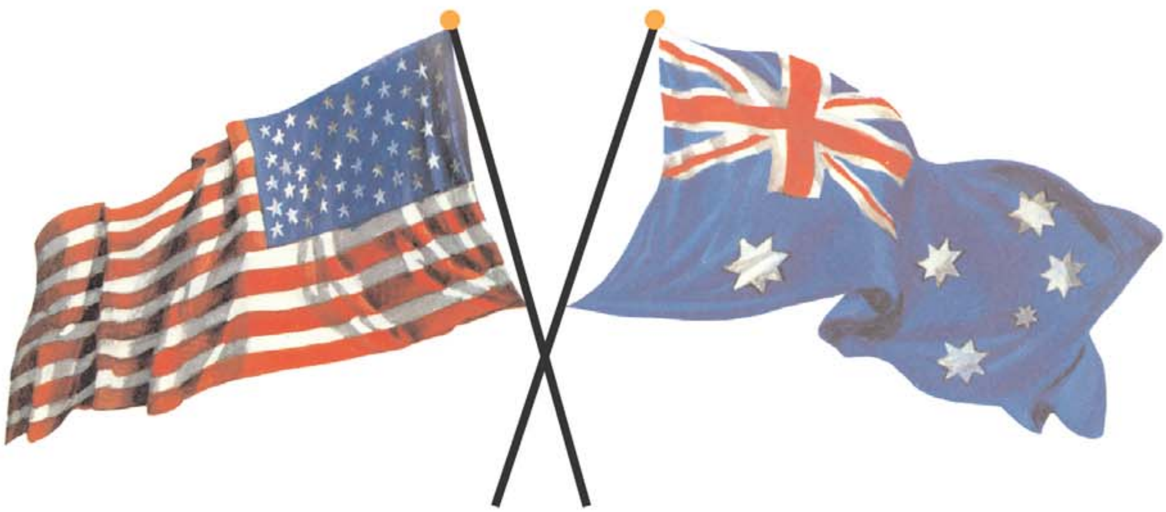
2001 Annual Report

Australian Biological Control Laboratory



United States Department of Agriculture
Agricultural Research Service
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Commonwealth Scientific and Industrial Research Organisation
Division of Entomology

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
OFFICE OF INTERNATIONAL RESEARCH PROGRAMS
AUSTRALIAN BIOLOGICAL CONTROL LABORATORY

2001 Annual Report

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January 1 – November 30, 2001

Dr. John A. Goolsby - Director and Research Entomologist
Mr. Tony Wright - Experimental Scientist
Mr. Matthew Purcell - Experimental Scientist
Mr. Jeff Makinson - Research Officer
Mr. Ryan Zonneveld - Research Officer
Mr. Dalio Mira - Plant Culture (part-time)
Mr. Gio Fichera – Research Officer (part-time)

CAUTION: The results in this report are preliminary and tentative. In order to prevent the spread of out-of-date or inaccurate information, this report should not be quoted or cited without verifying accuracy with the USDA-ARS Australian Biological Control Laboratory.

This report was originally prepared with digital images cited as figures. Images were deleted for size considerations. For a full report with pictures please contact Dr. J.A. Goolsby (ABCL).

Table 1. List of acronyms used in this report

ABCL	- (USDA-ARS) Australian Biological Control Laboratory
ANIC	- Australian National Insect Collection
APHIS	- (USDA) Animal and Plant Health Inspection Service
ARS	- (USDA) Agricultural Research Service
cNSW	- Central New South Wales, Coffs Harbour to Wollongong
CSIRO	- Commonwealth Scientific and Industrial Research Organisation
nNSW	- Northern New South Wales, north of Coffs Harbour
NQ	- North Queensland, north of the Tropic of Capricorn
NSW	- New South Wales
OIRP	- (USDA-ARS) Office of International Research Programs
QLD	- Queensland
SEL	- (USDA-ARS) Systematic Entomology Laboratory
sNSW	- Southern New South Wales, south of Wollongong
SQ	- South Queensland, south of the Tropic of Capricorn
TAG	- (USDA-APHIS) Technical Advisory Group on the Biological Control of Weeds
USDA	- United States Department of Agriculture

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*Page numbers may not be accurate in PDF version.

Executive Summary

This was a very productive year for the Australian Biological Control Laboratory, with research programs for the broad-leaved paperbark tree, *Melaleuca quinquenervia,* and Old World climbing fern, *Lygodium microphyllum,* reaching important milestones. Several agents, in the pipeline from ABCL to stateside collaborators, have now been field released or are in the final stages of the permitting process. In October, *Cyrtobagous salviniae* was released for control of the aquatic weed, *Salvinia molesta,* by ARS collaborators P. Tipping and T. Center. The melaleuca psyllid, *Boreioglycaspis melaleucae,* should be permitted in November, followed by the bud-gall fly, *Fergusonina* sp., and the melaleuca sawfly, *Lophyrotoma zonalis,* in 2002. For the Old World climbing fern, final host-range testing of *Cataclysta camptozonale* has been completed and a petition for release will be submitted to the Technical Advisory Group (TAG). Overseas testing was completed for the fern feeding pyralid, *Neomusotima conspurcatalis,* and it was forwarded this August to ARS collaborators in Florida. These results demonstrate the success of our team approach.

Research on the biological control of *M. quinquenervia* continued to focus on developing priority candidates while surveying new regions for more insect agents. Exploratory surveys by ABCL scientists were conducted for the first time in New Caledonia and at sites through New South Wales (NSW) in Australia. Several new insects were discovered and will be further evaluated. Host-range studies of the tube-dwelling moth, *Poliopaschia lithochlora*, in both the laboratory and at a field plot, were started during 2001. It is likely to be the next insect introduced into the Gainesville quarantine facility, once the melaleuca psyllid has been released into the field. Its preference for low-lying moist habitats makes it highly suitable as a biological control agent for the wetland areas in southern Florida, where *M. quinquenervia* is a massive problem. Shipments of psyllids from several sites in southeast Queensland were made to boost the genetic diversity of quarantine stocks prior to field releases in Florida. We also have forged further links with the National Centre for Environmental Toxicology in Brisbane to facilitate toxicity testing of the defoliating sawfly, *L. zonalis*. All host-range testing of this insect has been completed in Australia and in Gainesville, and its future release in Florida will depend upon the results of these toxicology tests. Field collections of bud-galls continued in Queensland and New South Wales to finalize identifications of all fly and gall species associated with trees in the *M. leucadendra* complex, which includes *M. quinquenervia* and its close relatives. Collections of *Holocola* sp. were also made in an attempt to colonize this promising moth. Larvae not only damage flowers and bind tips, but also possibly bore within the stems of young shoots as well. This insect has the potential to restrict the reproductive potential of *M. quinquenervia* in Florida, a major goal of our program. Additional research was also carried out on the modification of artificial diets to rear stem-boring larvae of cerambycid beetles and tortricid moths. Progress was made on evaluating the cecidomyiid flies, *Lophodiplosis* spp., the foliage-feeding moth, *Careades plana*, flower-feeding weevils, *Haplonyx* spp., and the leaf beetle, *Paropsisterna tigrina*.

Exploration for new agents for the biological control of *L. microphyllum* continued in Australia and Southeast Asia. Intensive field studies in Thailand are planned to study and collect a stem boring pyralid moth and leaf mining buprestid beetle. Both insects were prioritized for additional research in a recent program review. Laboratory and field evaluation of the eriophyid mite, *Floracarus* sp., progressed rapidly with the collaboration of Dr. Sebahat Ozman, a visiting acarologist from Trakya University in Turkey. The life history of the mite was documented at two temperatures. Field studies of natural populations have shown that *Floracarus* sp. is active year round, peaking in the cooler, winter months. Chemical exclusion tests, to measure the impact of the mite on biomass production, show a 70% suppression of plant growth over a six-month period. Preliminary tests indicate that the mite's host range may be limited to *L. microphyllum* and *L.*

reticulatum. Full host-range testing will begin in 2002. Cold temperature studies of the pyralid moths, *Cataclysta camptozonale* and *Neomusotima conspurcatalis,* were conducted to assess the risk these species may pose to *L. palmatum,* which grows in the cool temperate woodlands of eastern North America. Pupae held at –7 ^{o}C (=23 ^{o}F) for two hours experienced 100% mortality, which indicates that these subtropical species could not establish in areas where *L. palmatum* is native.

Field surveys of parasitoids of *Pectinophora gossypiella* (Pink Bollworm) and *Maconellicoccus hirsutus* (Pink Hibiscus Mealybug) were conducted in northern Australia. Both insects are native to Australia and their distribution is similar to Melaleuca and *L. microphyllum*. Added funding from these programs allows for more frequent travel to the Northern Territory and Western Australia to conduct fieldwork. A new parasitoid species (*Apantales*) was reared from *P. gossypiella* in feral cotton near Darwin. It appears that this species oviposits into eggs or first instar larvae, which may make it useful in the cotton agro-ecosystem. Field studies to document the seasonal phenology of *M. hirsutus* in its native habitat continued for a second year. Populations of the mealybug remained at or below detection levels for the entire year.

A new program was initiated with Dr. Janine Powell (ARS-Stoneville) to investigate the biology and natural enemies of *Coptotermes formosanus*, Formosan subterranean termite, in its native habitat in Hong Kong. ABCL will collaborate with City University of Hong Kong to conduct the field studies.

Overview

The staff of the Australian Biological Control Laboratory (ABCL) actively search the natural areas of Australia and Southeast Asia for insects and other organisms that feed on pest insects and plant species that are invasive in the USA. Based in Brisbane, QLD, the ABCL is operated by the U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), hosted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). We collaborate closely with stateside scientists, including those at the USDA-ARS Invasive Plant Research Laboratory in Ft. Lauderdale and at Gainesville, Florida.

Many invasive weeds in the USA such as the broad-leaved paperbark tree (*M. quinquenervia*), Old World climbing fern (*L. microphyllum*), carrotwood (*Cupaniopsis anacardioides*) and Australian pine (*Casuarina* spp.) are native to this area of Australia. However, the native distribution of many of the weed species in this region continues northward from Australia into tropical and subtropical Southeast Asia, including Indonesia, Malaysia, Thailand, Vietnam, Papua New Guinea, New Caledonia, and southern China. ABCL scientists have the capability to explore this entire region to find the most promising biological control agents.

Research conducted at ABCL follows a sequence of events involving: determination of the native distribution of a weedy plant species, exploration for natural enemies, DNA fingerprinting of newly discovered species, ecology of the agents and their weed hosts, field host-range surveys, and ultimately preliminary host-range screening of candidate agents. Our research attempts to determine what regulates the plant in its native environment, which brings to light the full array of potential biological control agents. Organisms with a narrow host range and good regulatory potential are intensively investigated. The data we gather on potential agents is combined with information about the ecology of the weed where it is invasive. Our stateside USDA-ARS collaborators use a science-based process to make the final decision on which organisms are best suited to be biological control agents. This dual-country approach ensures the most successful outcome.

Environmentally adapted flora and fauna coupled with globalization of trade and travel between Australasia and the USA is now, and will continue to be, the cause of many serious weed and pest invasions. The Australian Biological Control Laboratory is committed to research and development of biological control solutions for U.S. weeds and insects of Australian and Southeast Asian origin. Our research is critical, not only because biological control offers the safest and most cost-effective approach to long-term management of widespread invasive weeds and pests, but also because in some instances it is the only viable control option.

Administration and Support

The ABCL is a research unit within the USDA-ARS, Office of International Research Programs under the direction of Arlyne Meyers (Assistant Administrator) and Dr. Richard Greene (Deputy Director). The personnel and facilities of the ABCL in Australia are provided through a co-operative agreement with CSIRO Entomology. The United States Embassy in Canberra provides the administrative support.

A coalition of federal, state and local agencies fund the overseas research on biological control of *M. quinquenervia, L. microphyllum, P. gossypiella* (Pink Bollworm) and *M. hirsutus* (Pink Hibiscus Mealybug). South Florida Water Management District, Jacksonville District of United States Army Corps of Engineers,

Florida Department of Environmental Protection, and the ARS-Western Cotton Research Laboratory contributed substantially to the research during 2001.

ABCL works closely with the following project leaders to co-ordinate the research: Dr. Ted Center (Melaleuca & Hydrilla), Dr. Bob Pemberton (Lygodium), Dr. Phil Tipping (Giant Salvinia), Dr. Alan Kirk (Pink Hibiscus Mealybug), and Dr. Steve Naranjo (Pink Bollworm). ARS National Program leaders are Dr. Ernest Delfosse (Weeds) and Dr. Kevin Hackett (Biological Control).

Staff and Facilities

Dr. John Goolsby is Laboratory Director and Research Entomologist. Four CSIRO personnel are employed full-time by ABCL: Mr. Tony Wright, Mr. Matthew Purcell, Mr. Jeffrey Makinson and Mr. Ryan Zonneveld. Mr. Dalio Mira and Mr. Gio Fichera work part-time for ABCL in greenhouse culture of test plants.

Several new pieces of equipment were purchased for the laboratory with funds from OIRP. These acquisitions include: two growth chambers, two 120 X dissecting scopes with a teaching bridge, and a new four-wheel drive.

Travel and Visitors

In August, John Goolsby attended the symposium, “The Practice of Biological Control” in Bozeman, Montana. Two presentations were made: *Critical Issues in Foreign Exploration*, and *Methods for Classical Biological Control of Subtropical Pests and Weeds.*

In August, Tony Wright and Matthew Purcell attended the 4th Asian Pacific Conference of Entomology in Kuala Lumpur, Malaysia. Two posters were presented on ABCL research in Southeast Asia.

Dr. Al Dedrick, Associate Deputy Administrator for Natural Resources and Sustainable Agricultural Systems, National Program Staff, Beltsville, Maryland, visited ABCL to tour the laboratory and update staff on NPS goals. Dr. Alan Kirk, EBCL visited in July 2000 to travel with Dr. Goolsby to the Pilbara Region of Western Australia.

Drs. Bart Drees, Charles Barr (Texas A&M University) and Sanford Porter (ARS-Gainesville) were hosted in June by ABCL as consultants to the Queensland Department of Primary Industries, Fire Ant Eradication Program.

Deborah Payne and Presha Kinnard spent three months each (June - November) at ABCL as USDA student interns from Berea College, Berea, Kentucky. Both students took time out from their studies in agriculture to assist in the research at ABCL. We appreciate the support of Dr. Panciera (Berea College) and OIRP staff: Arlyne Meyers, Rich Greene and Heather Phelps for arranging the internships.

Dr. Robert W. Pemberton, Research Entomologist and Botanist, USDA-ARS, Ft. Lauderdale, FL visited ABCL in August to review the Lygodium program and to visit field sites in Australia, New Caledonia, Singapore and Thailand.

Biological Control of Melaleuca

The Australian broad-leaved paperbark tree, *Melaleuca quinquenervia*, has become a serious weed in south Florida, and is a threat to the unique Everglades ecosystem. This tree was introduced into Florida as an ornamental, probably in the early 1900's. Since that time it has rapidly expanded its range. During the last 30-40 years it has grown exponentially and it now infests over half a million acres. In Australia the tree grows mainly in coastal wetlands and swamps along the east coast from Sydney north to Cape York Peninsular. Although the stands are extensive, many grasses, ferns and other plants grow beneath the canopy (inset left) and these areas are home to unique communities of birds, mammals and other wildlife. Indeed, many areas are under threat due to clearing of coastal areas for development. In contrast, the tree forms massive monocultures in southern Florida (inset below) where the stands are thick and impenetrable. Most other native vegetation is excluded and the stands are usually devoid of many native animals, creating the perceived effect of a "biological desert". Additionally, the tree is a major fire hazard with hot canopy fires generated by the high oil content of the leaves of *M. quinquenervia*. Human health is also affected as the pollen generated during flowering could possibly cause respiratory problems. Recreation and tourism are also impacted as a result of large-scale degradation of natural areas previously used for hiking, boating etc.

Melaleuca quinquenervia is placed with 14 other closely related *Melaleuca* species in the *M. leucadendra* complex. The center of origin of this complex is believed to be in north Queensland (NQ), where most of these species occur. Many of these species, such as *M. quinquenervia* and *M. cajuputi*, occur naturally in wetland habitats, while others such as *M. nervosa* and *M. dealbata* prefer, or tolerate, drier conditions. The species are distinguished by differences in fruits, flowers, leaves and leaf proportions. There are up to 250 species in the genus *Melaleuca* throughout Australia, though most are shrubs with needle-like leaves and do not resemble species in the *M. leucadendra* complex, and many grow in the drier regions of the continent.

The most extensive stands of *M. quinquenervia* are found in southeastern Queensland (SQ) and northern New South Wales (nNSW). It is a popular ornamental planting, especially in areas that are permanently or seasonally inundated such as golf courses, parks and artificial wetlands. Since 1986, exploratory surveys for biological control agents have been focused in the SQ and nNSW region and in NQ on *M. quinquenervia* and other closely related species. Insect herbivores significantly impact upon the growth of *M. quinquenervia* (Balciunas and Burrows 1993). There are over 450 insect species that attack this tree in Australia. One insect, the melaleuca snout weevil, *Oxyops vitiosa* (Coleoptera: Curculionidae), has been released in Florida and is damaging *M. quinquenervia* significantly (Center et al. 2000). Several other insects have been evaluated and are awaiting permission for release from quarantine.

<u>Melaleuca Field Collections and Exploratory Surveys in 2001</u>

2–4 May: - Surveys between Townsville and Cairns to collect *L. zonalis* (Hymenoptera: Pergidae) larvae for toxicity studies, *Careades plana* (Lepidoptera: Noctuidae) larvae, and *Fergusonina* spp. (Diptera: Fergusoninidae) galls.
19-26 May: - Surveys for new agents in New Caledonia, one of the few locations outside Australia where *M. quinquenervia* is native.

18-20 June: - Surveys between Townsville and Cairns to collect *L. zonalis* larvae for studies in the United States, *Careades plana* larvae, *Haplonyx* (Coleoptera: Curculionidae) weevils and *Fergusonina* spp. galls.

30 July – 2 August: - Surveys for temperate agents in central NSW (cNSW). Conducted surveys of stands in the Myall Lakes and near Forster, Port Macquarie and Kempsey.

Most of the field collections during 2001 were conducted to collect flower-feeding tortricid moth larvae and the tube-dwelling moth, *Poliopaschia lithochlora* (Lepidoptera: Pyralidae), for colony establishment and laboratory testing. Most collections were of *M. quinquenervia* (101) mainly in SQ. Exploratory trips were also conducted in cNSW and New Caledonia to find new insects. A summary of all collections relating to the Melaleuca project is given in Table 1 while a complete list of collection records appears in Appendix 1.

Table 1. Summary of field collections, relating to *Melaleuca* research, made during 2001 in north Queensland (NQ), southeast Queensland (SQ), northern NSW (nNSW), central NSW (cNSW), New Caledonia (NC) and Thailand (TH).

Plant		Number Collections	Number Sites	Regions
Family	**Species**			
Myrtaceae – *M. leucadendra* complex	*M. argentea*	1	1	NQ
	M. cajuputi	1	1	TH
	M. dealbata	1	1	SQ
	M. fluviatilis	4	3	NQ
	M. leucadendra	1	1	NQ
	M. nervosa	2	2	NQ
	M. quinquenervia	101	67	NC/NQ/SQ/ nNSW/cNSW
	M. viridiflora	3	2	NQ/SQ
Other Myrtaceae	*Callistemon* sp.	1	1	SQ
	Eucalyptus tereticornis	2	2	SQ
	Leptospermum sp.	1	1	SQ

New Caledonia Survey. During May ABCL scientists traveled to New Caledonia to survey stands of *M. quinquenervia*. New Caledonia is one of the few places outside of Australia where *M. quinquenervia* is native. It is the unofficial national tree, locally known as Niaouli. On the west coast *M. quinquenervia* was abundant in the coastal lowlands, growing in similar habitats to where it occurs along the east coast of Australia (Fig 1, p.15). Interestingly, it also grew on the lower hillsides through to steeper regions bordering on rainforest (Fig 1). Why this occurs is unknown, though the lack of competition from *Eucalyptus*/*Acacia*, as occurs in Australia, may be a factor. It is certainly the dominant tree in many areas, especially along the west coast.

The *M. quinquenervia* trees were heavily damaged by herbivores. The leaf-blotching mirid, *Eucerocorus suspectus*, was found at all survey sites, where it destroyed most of the young foliage. Specimens were collected for both classical and genetic identification to determine whether it is the same species that occurs in Australia. D2 analysis verified that it is the same as the Australian species. Tip binders and psyllids also attacked the young foliage at all sites, and several specimens were reared for identification. The small psyllid is not *Boreioglycaspis melaleucae* (Homoptera: Psyllidae), which is pending release in Florida. Flowers were severely damaged at most sites by moth larvae. In the northeast, near the town of Poindimie, woody galls that caused the death of all branches beyond the gall were observed on many trees. A small weevil was reared from one of the galls. Many trees over large areas were covered in sooty mould as a result of heavy infestations by the scale insect *Ceroplastes rubens* (Homoptera: Coccidae). The scales were protected from parasites by ant fauna, resulting in large populations. Although *C. rubens* occurs in Australia, it is heavily parasitized and sooty mold formation on trees is rare.

Seeds were also collected from a site near Noumea. These were sent to Allen Dray at the USDA-ARS laboratory in Fort Lauderdale. Plants grown from these seeds, as well as others grown from seeds collected from other regions within the native range of *M. quinquenervia*, will be analyzed to determine their chemotypes. This may determine the most likely regions from where *M. quinquenervia* was introduced into the United States.

New South Wales Survey. In July, Matthew Purcell and Jeff Makinson surveyed cNSW for new *Melaleuca* insect agents. As in 2000, collections were made near Forster, Port Macquarie and the Myall Lakes. New sites were visited near Port Macquarie, Kempsey, Coffs Harbour and Casuarina Beach in coastal regions of NSW. The main objective was to locate insects adapted to more temperate regions. Like the trip in 2000, most of the insects observed have been collected further north in sub-tropical and tropical areas. Nevertheless, a new weevil was located in the Myall Lakes that feeds on the young leaf buds. Only a few specimens were collected and no mating or oviposition was observed in the laboratory. Tip-boring Lepidoptera were found at many sites and were reared to the adult stage for colonization (see *Holocola* sp. section).

Melaleuca Defoliating Sawfly - *Lophyrotoma zonalis* (Hymenoptera: Pergidae)

Lophyrotoma zonalis larvae feed on the foliage of *M. quinquenervia*. Adult females lay their eggs along the margins of leaves. Larvae emerge and feed side by side as a feeding front, skeletonizing leaves. As they become older, these fronts split into smaller groups as well as individuals, and whole leaves are consumed. In large numbers, a tree can be completely defoliated, which heavily impacts its vigor, often resulting in no flowering in the season following defoliation. Larvae pupate after tunneling into the papery bark. Unlike many other sawflies, this insect completes its life cycle on the tree and could be very useful as a biological control agent in the wetland areas of southern Florida. Additionally, adults are very mobile, which could assist in dispersal following release. *Lophyrotoma zonalis* was shipped to quarantine in Florida in 1992. All quarantine host-range testing has been completed (Buckingham 2001) and the Technical Advisory Group on the Biological Control of Weeds (TAG) application for release has been approved. However, releases will not be made until questions over whether the larvae could be toxic to animals have been resolved.

Dr. Peter Oelrichs from the National Research Centre for Environmental Toxicology (NRCET) in Brisbane isolated two toxins, lophyrotomin and pergidin, from *L. zonalis* larvae (Oelrichs et al. 2001). These peptides occur in related sawflies in Australia and on two other continents, Europe and South America (Oelrichs et al. 1999). Dr. Oelrichs was the first to identify the sawfly toxins when he isolated lophyrotomin from *L. interrupta*, a sawfly that feeds on *Eucalyptus melanophloia*, which was implicated in cattle poisoning in Queensland, Australia (Oelrichs 1982, McKenzie et al. 1984).

The levels of the two sawfly toxins vary between sawfly species. *Lophyrotoma zonalis* has high concentrations of pergidin and lower levels of lophyrotomin, the latter being more toxic (Oelrichs et al. 2001). This differs significantly from other sawflies tested, in particular *L. interrupta*, where lophyrotomin is in higher concentrations. Therefore, toxicity tests conducted using other species cannot be a reliable guide to the toxicity of *L. zonalis*. There is also a significant difference between the pupation habits of *L. zonalis* and that of many other sawflies implicated in animal poisoning. *Lophyrotoma zonalis* larvae pupate individually in the bark, making large numbers inaccessible to many ground-dwelling animals, especially cattle and other large livestock. The other species pupate (sometimes on mass) in the soil. Additionally, larvae of *L. zonalis* regurgitate fluid as a defensive mechanism that may make larvae unpalatable. This is certainly true for other species.

Thousands of larvae are still in frozen storage for use in toxicity testing of large animals. In April, Matthew Purcell met with Professor Alan Seawright of the National Research Centre for Environmental Toxicology (NRCET) to discuss these tests. Professor Seawright will go ahead and perform toxicity tests on mice using an IP injection of a combination of lophyrotomin and pergidin. Previously, NRCET had tested each compound separately for toxicity. It is possible that the effect of one peptide may impede or cancel the effect of the second, even if the latter is more toxic. There are precedents for this occurring. Liver pathology is completely different for lophyrotomin poisoning than for pergidin poisoning, even though the chemicals are very similar. NRCET will also test the effects of oral dosages compared to IP injection. Previous experience has shown that this can have a dramatic effect on results. This would not be expected, as it has not been observed in trials of other sawfly larvae elsewhere. From the results, dosages for testing large animals will be calculated. Sub-lethal tests would then proceed depending on larval requirements. Ethics committees would not permit killing animals. Prof. Seawright suggested using smaller sheep in the trials to minimize larval requirements. Unfortunately, tests could not be started during 2001 due to NRCET commitments and trials are planned for 2002.

Prof. Seawright believes that known problems with *L. interrupta* toxicity are very isolated in Queensland, and that it does not occur throughout its native range. He believes that the risk to domestic animals is small since the life cycle of *L. zonalis* is completed on the tree, without congregations forming on the ground for pupation. There would never be enough sawflies accessible to cause serious mortality, as only sub-lethal dosages would be available. He suggested that there would be some value in testing non-pergid sawflies from the U.S. for the toxins. If sawflies with toxin already exist in Florida, then the release of *L. zonalis* would not be introducing novel compounds into the region.

Larvae of *L. zonalis* were quite common at sites visited in NQ during May. Though no complete defoliation of trees was observed, larvae were collected from *M. quinquenervia* at Edmund Kennedy National Park, *M. viridiflora* and M. *leucadendra* near Cairns, and from *M. nervosa* near Mareeba on the NQ tablelands. Larvae were reared in the laboratory until prepupae burrowed into foam provided. These individuals were shipped to the Gainesville quarantine facility for Dr. Gary Buckingham to pass onto Nathan Schiff, a USDA forest service sawfly specialist, for further study. During a second survey of NQ in June, only a small number of larvae were located, collected from a *M. viridiflora* tree near Cairns.

<u>Tube-Dwelling Moth – *Poliopaschia lithochlora* (Lepidoptera: Pyralidae)</u>

During 2001 we renewed our efforts in evaluating the tube-dwelling moth, *Poliopaschia lithochlora*. Research on this insect was scaled back during 1999 and 2000 to focus efforts on *Fergusonina* spp. Rearing *P. lithochlora* is very labor intensive and it takes some time to rear sufficient adults for host-range testing. The added support of the Berea interns was essential for carrying out this research.

The biology of this moth has been studied intensively at ABCL. Adult females oviposit lines of cream-colored eggs along the margins of *M. quinquenervia* leaves. The larvae hatch and form tubes, initially side by side, attached to the leaf surface. The tubes are made of frass-like material that are covered and bound together with silken threads. If a leaf is unsuitable, neonate larvae will drop on silken threads to other leaves on the plant. As larvae become larger, the colonies will often split into smaller groups or single larva. The tubes become convoluted and are no longer attached to the leaf surface; rather they are suspended between stems, branches and leaves by a mass of silken threads. The larvae move from these tubes to feed on the surrounding foliage. In the prepupal stage, a small bulb is formed at the open end of the tube. The bulb is eventually sealed and pupation occurs within. Adults become active on dusk and most oviposition occurs at night. Development from egg to adult is approximately 72 days and adults survive for approximately seven days.

The communal colonies are dark brown in color and are easily detected at field sites. Although many colonies are found on the lower branches of large trees, small saplings and suckers are preferred. Repeated defoliation can stress plants. After extensive field surveys at many sites in SQ and nNSW during 2001, we have been able to observe the preferred habitat of *P. lithochlora*. Most colonies were found in areas that were low lying, moist, and seasonally inundated. Sites where there was an under-story of grasses also appeared to be favored. Although these grasses and other plants were frequently used to suspend larval tubes on or near their host plant, feeding was only observed on *M. quinquenervia*. Due to the sheltered, moist environment, larvae often prefer roadside verges (inset right). During the latter half of 2001, SQ and nNSW experienced very dry weather conditions. There was a distinct drop off in larval numbers at most field sites, and collecting became difficult. Larval tubes were mostly found very low on saplings and suckers, usually amongst the grassy under-story. It is possible that these positions provided higher humidity, especially during the early morning period when dew formation increased moisture levels. Larvae and pupae were frequently parasitized by *Carcelia* sp. (Diptera: Tachinidae) and an Ichneumonidae (Hymenoptera) species.

Preliminary data from laboratory host-range tests conducted during 1999 indicated that *Callistemon* spp. might be alternate hosts of *P. lithochlora*. To test their preferences under more natural conditions, the moths were released into the experimental field plot. This field plot was started in 1996 as a three-year experiment to determine the field host-range of top priority biocontrol candidates. However, *P. lithochlora* was never recorded. The plot, which is still being maintained, is a randomized complete block array of nine plants (eight species) in five blocks (inset right). The nine Myrtaceae are: *M. quinquenervia* ex. Florida, *M. quinquenervia* ex. QLD, *M. alternifolia* (Tea Tree), *Callistemon viminalis* (Weeping Bottlebrush), *Eucalyptus cinerea* (Silverdollar Tree), *Eugenia uniflora* (Surinam Cherry), *Myrciaria cauliflora* (Jaboticaba), *Psidium guajava* (Guava), and *Syzygium jambos* (Rose Apple). These taxa were chosen on the basis of their phylogenetic relatedness to *M. quinquenervia*, economic importance to Florida and availability in Australia. Insects moved into the plot from the surrounding stands of *M. quinquenervia*. For the current releases of *P. lithochlora*, adults were reared from field-collected larvae and pupae. Emerging moths were placed into a mating cage for 24-48 hours prior to release. For release, the cage with the door removed was placed in the center of the plot on dusk for the adults to disperse, which could take 1-2 days. Plants were monitored for the presence of larvae. Over a six-week period from the end of July, 68 females and 83 males were released into the field plot. Unfortunately, no larvae have been subsequently recorded on any of the trees within the plot. We believe that the dry nature of the plot, without any under-story of grasses, was unsuitable for establishment. Further releases and augmentation of trees with immature moths within the plot are being considered for 2002. Additionally, techniques to improve humidity and the provision of a grassy under-story are being evaluated.

Preliminary host-range testing was also initiated in September. The tests include closely related Myrtaceae species that are grown and valued as ornamentals in Florida. Thus far, tests have begun on eight plant species with *M. quinquenervia* as the control. The design is a no-choice oviposition test with two pairs of adults released into a small gauze cage containing one potted plant. The adults are provided with a 10% honey solution for feeding. The cages are misted with water on a regular basis to increase humidity. In each test, two plant species are tested against a *M. quinquenervia* control. The test is completed when both females have died. Eggs are then counted on each plant and the resultant survival to adult stage is recorded. Preliminary results are given in Table 2. Due to the long development time from egg to adult (72 d), all tests are ongoing and will not be completed for some time. Therefore, survival data is not yet available. Eggs have been laid on only three species: *M. quinquenervia*, *M. alternifolia* and *Callistemon citrinus*. Average oviposition on the two test species is much lower than on *M. quinquenervia,* the preferred host. These tests will be completed early in 2002.

To further test these results, choice tests will be conducted in large screen cages (2m x 1m), with an *M. quinquenervia* control and a test plant placed in diagonal corners. Four pairs of adults will be released into the cage and maintained in the same way as for the no-choice tests. Only plants on which oviposition occurred in no-choice experiments will be tested.

With the onset of summer rains, we hope that *P. lithochlora* will become more prominent at field sites to boost our laboratory research. Meanwhile, a laboratory colony is being established to reduce the demand for constant field collections.

Table 2. Results of no-choice oviposition/survival tests of *P. lithochlora* on eight plant species, with *M. quinquenervia* as a control.

Plant Family	Plant Species	No. Tests	Mean Oviposition (eggs/plant)
Myrtaceae	*Melaleuca quinquenervia*	7	125.0
	M. alternifolia	1	26.0
	M. linariifolia	2	0
	M. styphelioides	3	0
	Callistemon citrinus	3	4.3
	C. rigidus	1	0
	C. viminalis	1	0
	Eucalyptus camaldulensis	2	0
	E. citriodora	2	0

Gall Fly/Nematode Complex – *Fergusonina* sp.(Diptera: Fergusoninidae) / *Fergusobia* sp. (Nematoda: Tylenchida: Sphaerulariidae)

The bud-gall fly *Fergusonina* sp. and its obligate nematode, *Fergusobia* sp., form galls in the leaf and flower bud tissue of *M. quinquenervia*. It is likely that the nematode initiates gall formation (Giblin-Davis unpublished data). Galls of the leaf buds inhibit terminal and lateral branch growth, while galls of flower buds prevent or inhibit flower formation and seed set. During 2001, this complex has continued to be a high priority at ABCL. If released, it will be the first insect that will directly attack flowers, and hence the reproductive potential of *M. quinquenervia* in Florida. Collaboration continues between the ARS Invasive Plant Research Laboratory, ARS Systematic Entomology Laboratory (SEL), University of Florida, University of Missouri and taxonomists from the University of Adelaide in Australia, to determine the complex of *Fergusonina* spp. on broad-leaved *Melaleuca* species and other Myrtaceae. Extensive collections from *M. quinquenervia* and its close relatives have been made over several years. Manuscripts describing both the flies and nematodes are currently being produced and are close to submission. Dr. Robin Giblin-Davis and colleagues from the University of Florida have continued to research the biology of the fly/nematode association through sectioning galls.

Galls were first shipped to quarantine facilities in Gainesville in 2000. All quarantine host-range testing has been completed and a TAG petition for release is being prepared. The insects/nematodes appear to be highly specific to their hosts, and therefore safe to release in Florida.

During 2001, a small number of collections were made to supplement current data. In May, bud galls were collected from *M. fluviatilis* at Ross River Dam (inset right) in Townsville, NQ. Previous collections had indicated that there were two *Fergusonina* flies from this *Melaleuca* species. One was collected from Home Hill (also near Townsville) and another from the Ross River site. They emerged from two galls types, one with a smooth outer surface and one with a rough surface. Few specimens had been taken from Ross River in the past, and flies and their associated nematodes were reared/extracted from the galls and sent to Dr. Gary Taylor (entomologist) and Kerrie Davies (nematologist), taxonomists at the University of Adelaide describing the new species. Additional flies were also reared from galls collected from *M. viridiflora*. In a second trip to NQ in June, both gall types (rough and smooth) were collected from a single tree. Flies reared from these collections were also forwarded to Gary Taylor (classical taxonomy) and to Sonja Schaeffer (genetic taxonomy).

Additional shipments were made to various institutions for taxonomic purposes. They not only included the flies and nematodes from many *Melaleuca* species and *Eucalyptus tereticornis*, but also a wide range of parasitoids that attack the flies directly, or are inquilines within the galls. A paper on the parasitoids of *Fergusonina* spp. has been accepted for publication (Goolsby et al. 2001). Voucher specimens relating to this paper have been deposited at the SEL in Washington.

Defoliating Moth - *Careades plana* (Lepidoptera: Noctuidae)

The larvae of the noctuid moth, *Careades plana,* feed on the foliage of *M. quinquenervia*. The larvae, which are usually found in low numbers, prefer older leaves and feed individually in the canopy of both larger trees and smaller saplings. The larvae have a distinctive inflated thorax (inset left) that is easily recognized when surveying *M. quinquenervia* in the field. This moth has only been collected in tropical regions and we still have no specimens from south of Townsville. It has also been collected on the closely related *M. cajuputi* and *M. viridiflora* near the Daintree River in NQ and from *M. cajuputi* in southern Thailand. However, the majority of specimens have been collected from *M. quinquenervia*.

Careades plana larvae were collected from Edmund Kennedy National Park north of Townsville (NQ) in early May. Ninety-five larvae and five pupal cases were collected. Larval distribution was patchy within the collection site, with localized areas (or hotspots) where several larvae could be found. Most larvae were inactive through the day, usually resting 20-30cm from the end of a branch. On dusk they move out onto the outer leaves to feed. Several dead larvae were observed, apparently killed by pathogens. Pentatomid bugs had also killed two larvae. Once larvae are disturbed, they spit fluid from the mouth as a defensive act. They also drop from branches when disturbed, making collection difficult. Both *M.*

quinquenervia and *M. viridiflora* trees were surveyed at Edmund Kennedy, though larvae were only observed on the former.

The field-collected larvae and pupae of *C. plana* were hand carried to ABCL. Tachinid flies parasitized approximately 15% of the 96 larvae. No adults emerged from the field-collected pupae and a further 14 larvae died in rearing. The larvae pupate within silken cocoons attached to the leaves. Females emerge on average 16.7 d (n=23) following pupation and males 18.5 d (n=38). Emergence occurs on dusk or during the night. Several techniques were used to induce mating and oviposition. Large flight cages were set up in the newly constructed controlled environment glasshouse, in an attempt to simulate conditions observed in the native range of this moth in NQ. Adults were regularly released into the cage that contained several *M. quinquenervia* saplings. Additionally, moths were also placed onto cut *Melaleuca* stems in plastic containers in smaller controlled environment cabinets. Oviposition only occurred in the plastic containers. Several females oviposited on both the cut *M. quinquenervia* foliage and the walls of the containers. One female laid in excess of 50 eggs. Unfortunately all eggs were infertile. This is the first time that *C. plana* has laid eggs in culture. In 2002, further attempts will be made to induce mating, following which the females will be placed in plastic containers to recruit eggs. If colonization using this technique is successful, further biology and host-range studies will be conducted.

Leaf Beetle - *Paropsisterna tigrina* (Coleoptera: Chrysomelidae)

Paropsisterna tigrina was collected from NT in 2000. Larvae were collected feeding on the foliage of *M. cajuputi* in Darwin. These immatures were reared on *M. quinquenervia* at the ABCL in Brisbane and have since developed through numerous generations. In previous years we have also collected *P. tigrina* from *M. leucadendra*, *M. nervosa*, *M. quinquenervia* and *M. alternifolia*. *Paropsisterna tigrina* is a known pest of *M. alternifolia*, a small tree that is grown commercially in plantations for producing "tea tree" oil. In 2001, adults and larvae were obtained from the NSW Department of Agriculture, from *M. alternifolia* plantations in nNSW. These specimens were compared with those from our laboratory colony using D2 gene analysis and the results indicated they are the same species.

In March, a larva pupated in a stem fork and on a leaf. Later in May, pupae were found in the stem at the base of the plant. A small bulge in the bark with a slight opening revealed pupae in a small excavation. Pupae were also found around the base of the potted plant. Many chrysomelids pupate only in soil. This indicated that *P. tigrina* was adaptable and could complete its life cycle without soil, even in inundated areas. Therefore, it was a prime candidate as a biological control agent for Florida wetlands. ABCL staff then proceeded with preliminary host-range testing.

Newly laid eggs from the colony cages were removed from the *M. quinquenervia* host plants and placed onto cut tips of six test plants and *M. quinquenervia*. The tips from each plant were held on filter paper in a petri dish. The dishes were held in a constant temperature cabinet at 25 ^{o}C. The immatures were monitored for survival. The plant material was replaced as necessary and the larvae transferred to larger, sealed plastic containers in the later instars. Before the prepupal stage, vermiculite was placed in the bottom of the rearing containers for pupation. The results of these tests are given in Table 3. Adults were reared on *M. quinquenervia*, *M. linariifolia*, *C. viminalis* and *E. citriodora*. *Callistemon viminalis* was equally as good a host as *M. quinquenervia*, while *E. citriodora* was preferred over both of these plant species. Because of this lack of specificity, further research on this insect has been given a lower priority. Oviposition tests may be considered in the future. The fact that the neonate larvae refused to feed on *M. alternifolia*, a known field host, raises some questions over the identification of this insect.

Table 3. Results of no-choice neonate larval survival tests of *P. tigrina* on six plant species and *M. quinquenervia* as a control.

Plant Family	Plant Species	No. Tests	Mean % Survival
Myrtaceae	*Melaleuca quinquenervia*	3	25.5
	M. alternifolia	3	0
	M. linariifolia	3	0
	M. styphelioides	3	1.1
	C. viminalis	3	26.6
	Eucalyptus camaldulensis	3	0
	E. citriodora	3	40.0

Pea Galls – *Lophodiplosis* spp. (Diptera: Cecidomyiidae)

Pea galls on *M. quinquenervia* are formed by two species of Cecidomyiidae, *Lophodiplosis indentata* and *L. denticulata.* Gagné et al. (1997) describes six new species of cecidomyiid flies reared from galls on *Melaleuca* spp, four of which are responsible for the formation of the galls, while two are inquilines. Pea galls are common on *M. quinquenervia* in its native range in Australia. These galls look like rounded blisters on the leaf and can cause severe deformation of young foliage. Like bud galls, when trees become severely infected, pea galls have the potential to act as significant nutrient sinks on the plant causing a reduction in vigor. Both cecidomyiid species on *M. quinquenervia* are found in NQ, however *L. denticula* has not been collected in SQ or NSW.

We made regular collections of pea galls throughout 2001. Adults were reared in the laboratory and released onto *M. quinquenervia* in oviposition cages. Few galls were formed on the potted saplings and further research is needed to determine preferred conditions for oviposition and development. Flies were also reared from stem galls and these will be sent to taxonomists to verify if the are *L. indentata*. A second species also attacked the stems of potted saplings held outside our glasshouses at ABCL. It is black in color and distinctly different from the red colored *Lophodiplosis*. These specimens will also be sent for identification.

Tip-Borer/Flower Feeder – *Holocola* sp. (Lepidoptera: Tortricidae)

During 2000, *Holocola* sp. became one of the top priority insect agents for *M. quinquenervia* at ABCL. These larvae feed within the stem of *M. quinquenervia* inflorescences causing complete or partial abortion of flowers (inset overleaf). Additionally, they also have been reared from tip-binding larvae. The major benefit of a dual mode of feeding is that this moth could persist year-round if released as a biological control agent. Host-specific insects that feed on flowers alone would die out between flowering periods.

During the flowering season this year, we made regular collections of flowers to obtain *Holocola* sp. for establishment of a laboratory colony. Not many specimens were reared and emergence was rarely synchronized so that sufficient pairs could be obtained for oviposition. Therefore, colonization attempts failed.

At several sites in SQ and NSW a high percentage of dead tips were observed on small saplings. Tip wilting and dead tips were usually attributed to feeding by the sap-sucking bug, *Pomponatius typicus* (Hemiptera: Coreidae), and other Hemiptera. However, dissections of tips collected from these sites revealed that Lepidoptera larvae boring within the tips damaged a high number. Up to 4.5 cm of some tips had been destroyed by the feeding of a single larva. The resultant damage could have a major impact on branch growth and tree structure, possibly impacting on the densities/spacing of trees, especially at an early age. At two sites north of Brisbane, Toorbul and Tronson Road, these moth larvae damaged 53% and 67% of the damaged tips respectively.

Several adults have been reared from field-collected larvae, and one adult was reared on artificial diet (see Cerambycidae section and Fig 4, p.15). Although it appears several species are involved, and most warrant further investigation, one adult was reared that superficially looks like *Holocola* sp. If it is the same species that attacks flowers and binds tips, then its value as a potential biological control agent has been greatly increased. We intend to verify if it is indeed *Holocola* sp., and renew our efforts at colonization during 2002. We will also modify the meridic diet to include tips in its content. This could add trace plant chemicals to the media making it more acceptable to the larvae. If artificial diets are acceptable to immatures, then our chances for colonization should increase by allowing us to synchronize emergence of adults.

Stem-Borers (Coleoptera: Cerambycidae)

Larvae of a stem-boring cerambycid (species one) were observed at most sites, mainly during the spring and summer months. These larvae feed within the stems of *M. quinquenervia*. They are long lived and we suspect that there is only one generation per year. Previous rearing attempts, using cut stems and transferring larvae to live branches, have failed. Once disturbed, the larvae fail to feed either immediately or within a short period of time. Artificial diets, based on a meridic diet (Harley and Willson 1968), were also used but have proven to be just as unsuccessful. During 2001, we tried modifications of the same diet with some success. Some larvae have been feeding for 1-2 months on the medium but as yet no pupation has occurred. We will continue to fine-tune the diet during 2002.

Many saplings and suckers appeared to be killed by the larvae of these insects, though we are uncertain if the trees re-shoot from the base. Large branches are also killed as the larvae become more mature. Larvae of a second species were collected from Stradbroke Island, east of Brisbane, in November. These have recently been transferred both to fresh stems on live plants and onto artificial diet. It differs from species one in that the larvae tunnel directly down the center of branches, creating small holes as they feed, through which frass is removed. In species one, the larvae tunnel in a spiral through the branches and the frass remains compacted within the tunnel.

Species one appears to be very similar to larvae that attack *Callistemon* and specimens have been sent for D2 gene analysis to verify species differences.

Melaleuca Psyllid – *Boreioglycaspis melaleucae* (Hemiptera: Psyllidae)

It is expected that *Boreioglycaspis melaleucae* will be released into the field in Florida by the end of 2001. It will be the second biological control agent released against *M. quinquenervia*. New genetic stock was needed from Australia for pre-release mass rearing at the Gainesville quarantine facility. In November, psyllids were collected from three field sites in SQ: Silverwood Drive and Ewan Maddock Dam near the Sunshine Coast, north of Brisbane; and Stradbroke Island, east of Brisbane. Adults were reared from this field-collected material and set up in gauze sleeves over branches of *M. quinquenervia* saplings for oviposition. After 1-4 days, the sleeves and adults were removed. The branches were cut from the saplings and the ends placed into florist tubes filled with water to preserve the plant material during shipment. Each branch was placed in a new gauze sleeve before shipment. The eggs arrived in Florida before hatching.

Other Melaleuca Insects

During June, flower-feeding weevil larvae were observed at Edmund Kennedy National Park in NQ. The larvae damaged most of the flowers at the site, including those of *M. quinquenervia* and *M. viridiflora*. No pupae could be found, however *Haplonyx* sp. adults were found feeding on the young foliage of *M. quinquenervia* saplings and suckers. Larvae were brought back to the laboratory in Brisbane. When the larvae reached maturity, they exited the flowers in search of pupation sites. We tried several pupation media, including sand, vermiculite and paper. Unfortunately, only one larva pupated but failed to emerge. We could not verify if the larvae attacking the flowers were same species as the *Haplonyx* weevils attacking foliage. This will be confirmed by D2 analysis.

In October, a large weevil larva was found feeding at the base of a dead *M. quinquenervia* sapling near Beerwah, north of Brisbane. The larva readily feeds on the artificial diet being developed for cerambycids, but as yet it has not pupated. We suspect it may be the immature stage of one of the bark-feeding weevils previously collected from *M. quinquenervia*.

Plans for 2002

Research will focus on completing all studies on the tube-dwelling moth, *P. lithochlora*. This will probably be the next melaleuca insect introduced into quarantine in Gainesville. Most emphasis will be placed on finalizing host-range studies of this moth. We will continue to work with scientists at the NRCET to ensure the completion of *L. zonalis* toxicity studies. Hopefully this will fast-track the release of this sawfly in Florida. Developing the next suite of promising candidates will be a high priority. This will include research on the flower and tip-feeding moth, *Holocola* sp., and the stem-boring cerambycids. We will be developing artificial diets to assist in the rearing of these insects. Opportunistic studies will continue on *C. plana* moths and *Haplonyx* spp. weevils.

Biological Control of Lygodium

Old World climbing fern, *Lygodium microphyllum,* is an invasive weed in south Florida where it threatens many wetland communities in the Everglades ecosystem. *Lygodium microphyllum* is native to wet areas in the Old World tropics and subtropics including Africa, India, Southeast Asia, Australia and the South Pacific. The fern entered Florida as a commercial ornamental plant and was first documented to have become naturalized in 1965. However, its explosive growth and rapid spread is now causing concern because of its dominance over native vegetation in many communities. Amy Ferriter, of the South Florida Water Management District, reports that since the 1999 survey, over 1,000 acres of *L. microphyllum* was discovered in the backcountry Ten Thousand Islands area of Everglades National Park, and on scattered tree islands in Southern Miami-Dade County. The *L. microphyllum* is concentrated in short hydro-period coastal marshes dominated by low elevation woody vegetation (predominantly wax myrtle) adjacent to buttonwood/mangrove communities. The populations appear to be newly established, as no rachis material was present. Although newly established, the plant is extremely widespread and covers more than 107,000 acres. Old World climbing fern density and frequency is also increasing rapidly in Central Florida, with major infestations popping up along the Kissimmee River and in many bay swamps throughout the region, although there are no comprehensive regional surveys conducted outside South Florida.

The biological control program was initiated for *L. microphyllum* due to strong demand by stakeholders in south Florida for a biological control solution. Dr. Robert Pemberton (ARS-Ft. Lauderdale) is the project leader. *Lygodium microphyllum* is considered to be a good target for biological control. First, it belongs to a taxonomically isolated group, not closely related to native or economic plants in Florida. Second, the plant is not known to be a weed in its native range. Third, non-biological control methods are environmentally damaging and too expensive to use on the scale required to control the plant.

During 2001, 142 collections of herbivores and field data were made at 69 sites in Australia, Indonesia, Malaysia, New Caledonia, Singapore, Thailand, and China. Over 23 species of herbivores on *L. microphyllum* have now been collected (Table 4). Intensive field surveys were made in Singapore and southern Thailand to study and collect a stem-boring pyralid moth and leaf-mining buprestid. Both insects were prioritized for additional research in a program review. Laboratory and field evaluation of the eriophyid mite, *Floracarus* sp., progressed rapidly with the collaboration of Dr. Sebahat Ozman, a visiting acarologist from Trakya University in Turkey. The life history of the mite was documented at two temperatures. Field studies of natural populations have shown that *Floracarus* sp. is active year round, peaking in the cooler, winter months. Chemical exclusion tests to measure the impact of the mite on biomass production show a 70% suppression of plant growth over a six-month period. Preliminary tests indicate that the mite's host range may be limited to *L. microphyllum* and *L. reticulatum*. New methods have been developed. Full host-range testing will begin in 2002. Cold temperature studies of the pyralid moths, *Cataclysta camptozonale* and *Neomusotima conspurcatalis,* were conducted to assess the risk these species may pose to *L. palmatum,* which grows in the cool temperate woodlands of eastern North America. Pupae held at $-7\,^{o}$C ($=23\,^{o}$F) for two hours experienced 100% mortality, which indicates that these subtropical species could not establish in areas where *L. palmatum* is native.

Table 4. Herbivores collected from *Lygodium* spp. in Asia and Australia

Name	Collection Locations	Host Plant
Floracarus sp. Acarina: Eriophyidae	Australia, China, Indonesia, Malaysia, New Caledonia, Singapore, Thailand,	*L. microphyllum* *L. reticulatum*
Neomusotima conspurcatalis Lepidoptera: Pyralidae	Australia (Queensland and Northern Territory), Indonesia, Malaysia, Singapore, Thailand, Hong Kong	*L. microphyllum* *L. flexuosum*
Cataclysta camptozonale Lepidoptera: Pyralidae	Australia (Queensland)	*L. microphyllum* *L. reticulatum*
Musotima sp. Lepidoptera: Pyralidae	Malaysia, Singapore, Thailand	*L. microphyllum* *L. flexuosum*
Pyraustine sp. Lepidoptera: Pyralidae	New Caledonia	*L. microphyllum*
Neomusotima fuscolinealis Lepidoptera: Pyralidae	Japan	*L. japonicum*
Callopistria sp. A Lepidoptera: Noctuidae	Australia (Queensland), China	*L. microphyllum*
Callopistria sp. B Lepidoptera: Noctuidae	Australia (Northern Territory)	*L. microphyllum*
Callopistria sp. C. Lepidoptera: Noctuidae	Thailand	*L. microphyllum*
Lepidoptera: Limacodidae	Thailand	*L. microphyllum*
Archips machlopis Meyrick Lepidoptera: Tortricidae	Thailand	*L. microphyllum*
Lepidoptera: Tortricidae	Malaysia, Singapore	*L. microphyllum*
Stem-borer Lepidoptera: Pyralidae	Singapore	*L. microphyllum* *L. flexuosum*
Neostromboceros albicomus Hymenoptera: Tenthridinidae	Malaysia, Singapore, Thailand, Vietnam	*L. flexuosum*
Neostromboceros nr. *albicomus* Hymenoptera: Tenthridinidae	Thailand, Vietnam	*L. microphyllum*
Metriona sp. Coleoptera: Chrysomelidae	Australia (Northern Territory)	*L. microphyllum*
Endelus bakerianus Coleoptera: Buprestidae	Singapore, Thailand	*L. microphyllum*
Manobia sp. Coleoptera: Chrysomelidae	Thailand	*L. flexuosum*
Lophothetes sp. Coleoptera: Apionidae	Palau (Arakabesang Is.)	*L. microphyllum*
Hemiptera: Miridae	Australia (Northern Territory)	*L. microphyllum*
Acanthuchus trispinifer Homoptera: Membracidae	Australia (Queensland, Northern Territory)	*L. microphyllum*
Pseudococcus longispinus Homoptera: Pseudococcidae	Australia (Queensland)	*L. microphyllum*
Thrips: Thysanoptera	China, Malaysia, Thailand	*L. microphyllum* *L. japonicum*

***Lygodium* Exploration in Australia and New Caledonia**

Exploration for natural enemies of *L. microphyllum* continued in 2001 with trips within Queensland (12), New South Wales (1), the Northern Territory (2), Western Australia (2) and New Caledonia (2). New survey methods were employed including night searches and visits to sites during the tropical monsoon season. Both methods proved to be successful and will be continued in 2002.

French New Caledonia was surveyed for the first time this year. This island lies 900 miles east of Australia but has an ancient Gondwanan connection to north Queensland. New Caledonia split from Australia over 30 million years ago and took with it the rainforest species that were common during this time period, including *L. microphyllum*. The soils of New Caledonia are nickel rich, which makes colonization of exotic non-adapted species difficult. As a result much of the flora and fauna of the island is endemic. With this understanding of the biogeography we predicted that the herbivore complex on *Lygodium* would represent a combination of species, those with an ancient Gondwanan association to the fern and unique new species that have evolved there in isolation. Two field surveys were conducted, one in the fall and a second in early spring. *Lygodium microphyllum* occurs on the wet eastern half of the island, with *L. reticulatum* most common in the wet highlands. On the second trip we visited one of the offshore islands. These islands are much younger and are underlaid with limestone. The *L. microphyllum* in this environment is quite robust with unusual black stems. As predicted, the *Floracarus* mite, with its ancient association to the fern, was commonly collected on both surveys. A new pyralid species was discovered on the second trip. The identity of the moth is unknown but it is expected to be a new species and endemic to New Caledonia.

Field surveys were conducted during the monsoon season in the Northern Territory and in the Kimberly Region of Western Australia. Access to field sites during this time of year is limited, due to flooding and movement inland of crocodiles. John Goolsby and Ryan Zonneveld liaised with John Moulden of Western Australia Agriculture to visit field sites in the Kimberley by helicopter. In the Northern Territory, Graham Schultz of Northern Territory Department of Primary Industries arranged a boat and quad cycles to enter areas flooded by the monsoon rains. Insects flourish during the warm, humid, rainy weather. Insects such as the noctuid moth, *Callopistria* sp., which are normally rare, become abundant. Localized defoliation of *L. microphyllum* by *N. conspurcatalis* was also common. It was useful to see the herbivore complex at peak levels. We concluded that the insects, especially the leaf-defoliating Lepidoptera, play an important role in regulating *L. microphyllum* in its environment. Conditions in the monsoon season of northern Australia are similar to those in southern Florida during the summer months.

Field surveys in the Pilbara region of WA were unsuccessful in locating *L. microphyllum*. Botanist Dr. Steve Van Leeuwin of WA Conservation and Land Management (CALM) indicated that reports of *L. microphyllum* in the Pilbara might be in error. Mr. Kevin Cameron and Mr. Maitland Parker, CALM park rangers and aboriginal elders in the Karijini tribe concurred, since they were not familiar with the plant.

Australian/New Caledonian Exploratory Trips

- Southeast Queensland - Monthly visits to five field sites to determine phenology of *C. camptozonale* and *Floracarus* sp.
- Western Australia and Northern Territory (Feb. 25 – Mar. 3) - Surveyed during monsoon season.
- Western Australia (May 1-11) - Surveyed the Pilbara and Gascoyne Regions.
- New Caledonia (May 21-26) - Obtained collection permits and surveyed Province Nord and Sud.
- New Caledonia (Sept. 9-14) - Surveyed Province Nord, Sud and Isle de Pins.

Lygodium Exploration in Southeast Asia

Thirty-two site visits were made in three countries, with many additional observational stops made within these countries during travel between collecting sites (Fig 6, a&b). Visits resulted in 51 collections of plant or herbivore specimens. Although unusual weather conditions continued during 2001, which deleteriously affected many populations of *L. microphyllum* and its herbivores, the year was notable for some very interesting and positive developments, summarized below. Other plant species, known to be invasive in the USA, were noted in Southeast Asia during the year, including: *Ardisia elliptica*, *Arundo donax, Rhodomyrtus tomentosa, Scaevola taccada*, *Thespesia populnea*, *Ipomoea aquatica* and *Paederia foetida*.

Southeast Asian Exploratory Trips: Tony Wright

- Thailand (Feb 19-Mar 1) (Jointly with A. Winotai, DOA). In Bangkok, meetings to formalize arrangements with the Department of Agriculture (DOA) were held with head of the Biological Control Group (Khun Pimolporn Nanta) and the Director of the Division of Entomology and Zoology (Khun Auranj Kongkanjana). At the Bangkok Herbarium, specimens of *Lygodium* spp. and *R. tomentosa* were inspected with botanist Khun Winai Somprasong. Exploratory work in the south of Thailand included the provinces of Surat Thani, Nakhon Si Thammarat, Narathiwat (on the eastern peninsular coast) and Trang on the west coast, where contact was made with staff of the Trang Horticultural Research Center.
- New Caledonia (May 19-26) (jointly with J. Goolsby, M. Purcell - details in separate section).
- Hong Kong (Jun 7-13). Discussions aimed at developing collaborative arrangements to cover work in Hong Kong and southern China were held with Drs R. Corlett and D. Dudgeon (both of Hong Kong University) and P. Lam and D. O'Toole (both of City University). At the Hong Kong Herbarium, information and advice was obtained from P. Lai and C.K. Cheung.
- Thailand (Jun 13-20) (jointly with A. Winotai, DOA). In Chiang Mai met with Dr R. Beaver, an entomologist with experience with fern-boring insects, but he had not encountered lepidopteran borers. Also met with Dr Sawai Buranapanichpan (Chiang Mai University) and Khun Usanee Chattrakuk (Royal Projects entomologist). Fieldwork in Chiang Mai province included the discovery of a borer hole in *L. flexuosum*, from which (at DOA laboratories, Bangkok) emerged one adult moth. Traveled to the southeast (Trat province) near Cambodia where sawfly larvae were collected feeding on *L. microphyllum*. *Callopistria sp.* larvae (Lep: Noct.) were collected at Ongkharak, near Bangkok.
- Singapore (Aug 12- 13) (jointly with M. Purcell, CSIRO). Eriophyid mites on Ne*phrolepis biserrata* were collected but are probably not the same as the *Floracarus sp*. of widespread occurrence on *L. microphyllum*. Saw little activity by leaf-miner *Endelus bakerianus* on *L. microphyllum*.
- Malaysia (Aug 13-19). Attended the 4th Asian Pacific Conference of Entomology in Kuala Lumpur. (*Hydrilla verticillata* sampling – details in separate section).

- Thailand (Aug 19-23) (jointly with A. Winotai, DOA). Fieldwork in Surat Thani and Nakhon Si Thammarat provinces. Few insects at this time of year (dry), but obtained *Endelus* and *Callopistria*.
- Indonesia (Aug 24-27) (jointly with R. Desmier de Chenon, CIRAD, and M. Purcell, CSIRO - hydrilla details in separate section). Traveled in Sumatra from Medan to Pematang Siantar to Pulau Samosir. Dry conditions resulted in some mites but few insects on *L. microphyllum*.
- Singapore (Aug 27-29) (jointly with M. Purcell, CSIRO). Met with Mrs. Yang Chang Man (Raffles Zoological Collection). Few insects at field sites apart from several specimens of *Endelus*.
- Singapore (Oct 6-10) (jointly with R. Pemberton, USDA). This visit included Pulau Ubin where the mite *Tenuipalpus sp*. was also found on *L. microphyllum*.
- Thailand (Oct 10-20) (jointly with R. Pemberton, USDA, and A. Winotai, DOA). In Chiang Mai province in the north, stem-borer moth larvae were collected on *L. flexuosum*. In the south, visited the provinces of Surat Thani, Songkhla, Nakhon Si Thammarat and Narathiwat. Collected the sawfly (variant of *Neostromboceros albicomus*, on *L. microphyllum*), larvae of *E. bakerianus* (for Prague Museum) and adults for culture in Brisbane, larvae of *Neomusotima conspurcatalis* and *Musotima* sp. (for morphological taxonomic studies), and *Callopistria sp*. larvae for DNA studies.
- Singapore (Oct 20-22). *Endelus* adults were collected for rearing in quarantine.

Leaf Curling Mite - *Floracarus* sp. (Acari: Eriophyidae)

Floracarus sp. (inset left) has excellent potential as a biological control agent of *L. microphyllum*. It appears to have a strong regulatory effect on the fern in its native habitat despite heavy predation by natural enemies. In addition, the mite is likely to be very host specific. Working with the mite has required specialized equipment, techniques, and the input of experienced acarologists. We are fortunate at ABCL to have had the support this year from OIRP to purchase new equipment, from CSIRO horticultural staff to develop suitable host plants, and from Dr. Ozman, an eriophyid acarologist, to help us study the mite. Dr. Ozman, from Trakya University (Turkey), is on sabbatical at the University of Queensland, studying with Dr. Dave Walters of the Department of Entomology and Zoology.
The combination of people and laboratory facilities has resulted in excellent progress towards our goal of delivering an effective new agent for *L. microphyllum*.

Taxonomy and Distribution. *Floracarus* sp. is being described as a new species by Dr. Danuta Knihinicki of NSW Agriculture. Dr. Knihinicki, an eriophyid taxonomist, has described several new eriophyoid species from Australia. The description of the new species from *L. microphyllum* has been submitted for publication. *Floracarus* sp. is the most widespread arthropod associated with *L. microphyllum*. It has been collected from locations in Australia, China, Indonesia, Malaysia, Thailand, Singapore, and most recently from New Caledonia. *Floracarus* sp. appears to be tolerant of the wide range of climates found in the tropics and subtropics of the region.

Molecular Studies. Populations of the mite, from five locations in Australia, were compared by sequencing the nuclear rRNA D2 gene. We found a consistent gene sequence in all the Australian specimens. *Floracarus* sp. from China and New Caledonia showed ten and two base pair changes respectively. This level of difference is not indicative of separate species, but does show considerable temporal isolation from the Australian population.

Biological Studies. Intensive studies of *Floracarus* sp. continued through 2001. Specialized techniques were developed for the mite to investigate its biology and begin host-range testing experiments. Dr.

Sebahat Ozman is collaborating with ABCL on these studies. *Floracarus* sp. has a simple life cycle, consisting of an egg, larva, nymph and adult. Eggs hatch within 5.0 days at 21 °C and 3.9 days at 26 °C and 70% RH. A quiescent or resting stage occurs between the larva and nymph, and again between the nymph and adult. Development time from first instar to adult takes 4.0 days at 21 °C and 3.1 days at 26 °C. The mean fecundity is 59.0 and 35.4 progeny at 21 and 26 °C respectively. Adult longevity is 35.3 and 19.6 days at 21 and 26 °C respectively. Immatures are similar to adults in appearance, but smaller in size. Males are similar to females, but slightly smaller. Fertilization occurs in the leaf curl, and we have observed the male spermatophores (note red arrows inset left). The sex ratio of the mite colony is female biased. Eggs are laid in the leaf curling where the adult females feed. Eggs are very small, spherical and translucent and difficult to see when first laid. They change color within a few days of being laid, becoming more visible.

Mature females prefer the new sterile pinnae on actively growing plant tips for oviposition. A single gravid female is able to cause the development of the deformation for itself and later for all its progeny. With the start of feeding (and probable secretion of chitonase), deformation in the leaf tissue occurs. The tissues become swollen and have a watery appearance; formation of a complete leaf curl takes 4 days. Attack on the leaf margin induces rolling, and on some pinnae, the whole margin may be affected. The leaf curls over downwards or upwards and turns on itself 2-3 times. The leaf curling eventually dries and falls. When the leaf curling begins to dry, adults leave and go to another young pinnule for feeding.

Seasonal Phenology. Regular sampling at four sites in SQ has begun in order to determine the seasonal phenology of *Floracarus* sp. on *L. microphyllum*. Fifty pinnae (leaflets) (approximately 300 pinnules) were collected at each site. The numbers of curled sterile and fertile pinnules were counted to estimate the level of infestation at each field site. We also dissected pinnules and counted the numbers and stages of mites. From this count we could determine the actual numbers of mites responsible for the damaged pinnules and look for the occurrence of predator mites. The purpose of this field research was to develop an understanding of what influences the population dynamics of *Floracarus* sp., in its native habitat to assess its potential as a biological control agent. This information will be used to predict its impact in Florida.

Mite populations at the four sites were steady during 2000 and then reached the highest recorded levels during the winter months of 2001. The mean number of adults and nymphs was 9.4 +/- 1.1 per infested pinnule. The higher population levels could be influenced by the drought conditions in 2001. Average rainfall for the Brisbane area is 1200 mm per year (47 inches) with 600 mm (23 inches) recorded from January to October 2001. This is considered to be a -300 mm anomaly by the Australian Bureau of Meteorology. Lower rainfall levels could be negatively influencing predator mite populations that normally keep *Floracarus* sp. populations at lower levels.

Natural enemies, primarily predator mites, were collected and identified from the field studies. Predator mites were found feeding on the *Floracarus* adults, nymphs and eggs. The first four, of the following six species, were commonly encountered: *Tarsonemus* sp., *Tydeid* sp. 1, *Tydeid* sp. 2, *Agistemus* sp., Cheyletidae sp., and Ascidae sp. A pathogenic fungus, *Hirsutellea thompsonii* (?), was common in the winter months at some locations as well as syrphid larvae. We can conclude that *Floracarus* populations are stable throughout the year despite considerable mortality from predators and pathogens.

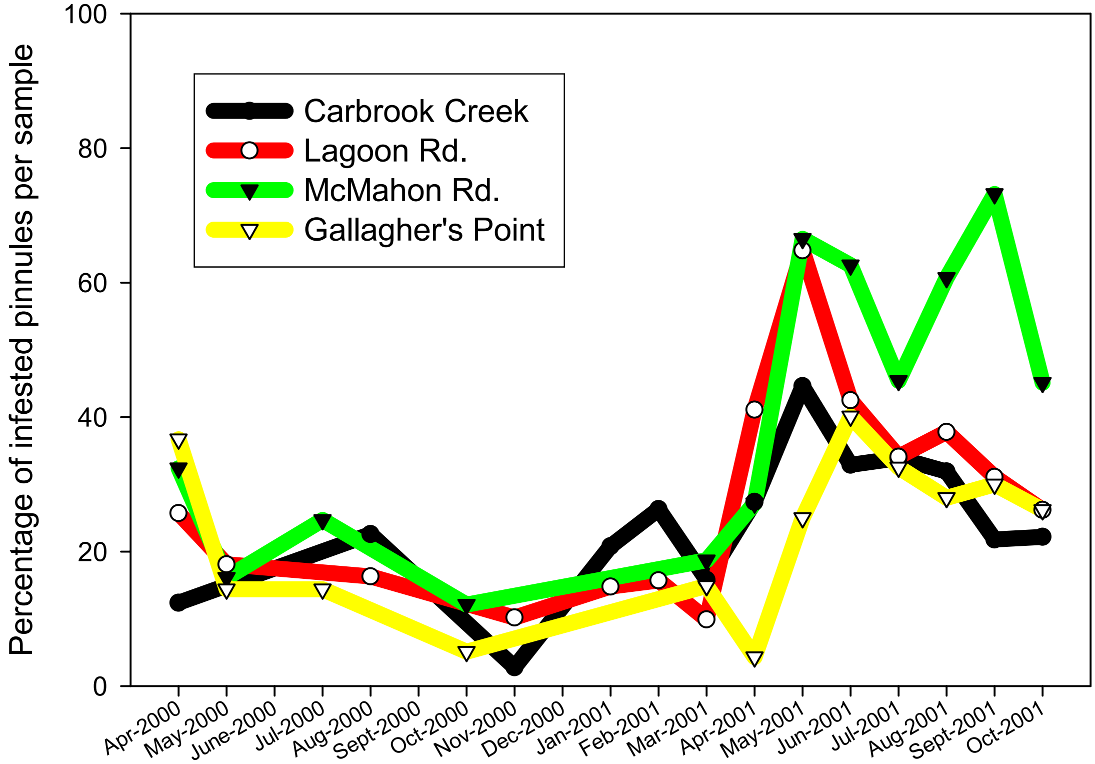

Fig 8. Seasonal population levels of *Floracarus* sp. at four locations in Southeast Queensland expressed as a percentage of pinnules infested (curled).

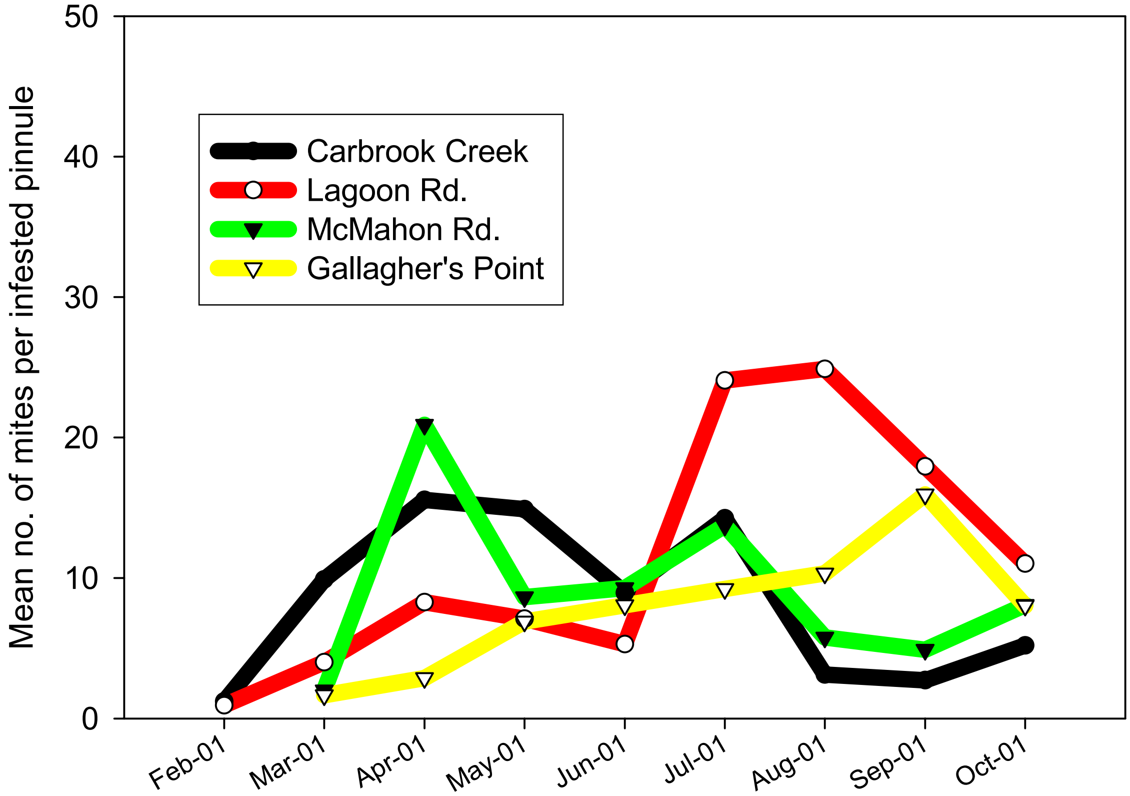

Fig 9. Mean number of *Floracarus* adults and nymphs per infested pinnule collected from four locations in southeast Queensland.

***Floracarus* Impact Studies.**

Field populations of *Floracarus* appear to cause considerable damage to *L. microphyllum*. However, in field settings it is difficult to quantify the effect of the mite. Damage caused by the mite, which includes galling of the pinnules and growing tips, leads to necrosis and early senescence of pinnules, and a reduction in photosynthetic ability. This subtle debilitation of the plant over time could be measured in terms of biomass production.

A field experiment was designed and implemented to measure the impact of the *Floracarus* mite on *L. microphyllum* biomass production. In the experiment, one half of the plants are treated with Vertimec® miticide to control the *Floracarus* mites. The other half are untreated, allowing mites to reach natural densities. By measuring the difference in biomass production between the two treatments it is possible to measure the impact of the mite. Each quarter, four pairs of plants are removed, washed clean of soil, dried, and weighed (Fig 12). The plot has 64 plants, allowing us to harvest four pairs of plants each quarter, for two years. On a monthly basis, we are measuring other indicators of plant health, including the longevity of pinnae and numbers of infested pinnules.

The first two harvests of plants from the impact study have shown significant differences in biomass production (Fig 13). After six months the untreated plants with *Floracarus* have 60% less biomass than the treated mite-free plants. This dramatic effect is likely due to higher than normal mite populations in the test plot than occurs in natural field settings. One explanation may be that predator mite populations in the test plot have remained at low levels. In addition, the test plot currently lacks the full complement of these predator species. Over time we predict that predator mite populations will reach normal levels. This will help us determine if *Floracarus* is still effective, even under heavy pressure from its natural enemies. This question is also relevant to the release of *Floracarus* in Florida. If *Floracarus* can effectively suppress *L. microphyllum* in Australia, even with its full complement of natural enemies, then it would be likely that non-coevolved predator mites in Florida would have less of a negative effect.

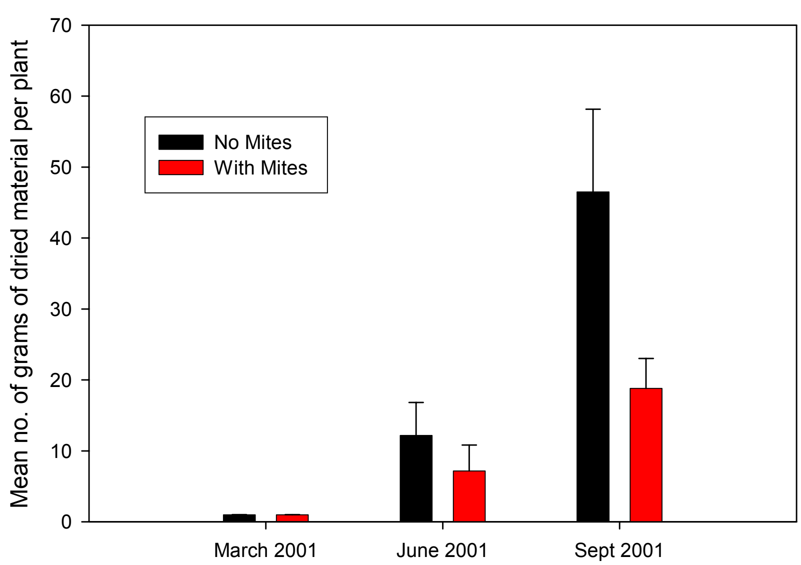

Fig 13. Biomass accumulation of *Lygodium microphyllum* plants with and without *Floracarus* sp.

Host-Range Testing. *Floracarus* sp. appears to have a very narrow host-range. Field surveys have detected the mite on one other species, *Lygodium reticulatum,* which is sympatric with *L. microphyllum* in north Queensland and New Caledonia (north Queensland and New Caledonia shared an ancient Gondwanan connection, >30 million years ago). We have not observed the mite on other species, including: *L. japonicum, L. circinatum*, or *L. flexuosum*.

Laboratory host-range testing of *Floracarus* sp. is underway. Through discussion with Dr. Robert Pemberton (ARS Ft. Lauderdale) a host test list for *Floracarus* has been developed (Table 5). We will concentrate upon *Lygodium* species, close relatives in the environment where *L. microphyllum* is invasive, horticultural ferns, and known hosts of other *Floracarus* spp. Micro-cultured spore grown ferns will be used for the majority of the testing. A no-choice test design will be used. Gravid females will be transferred to the test plants and held until death. Plants will be observed twice weekly to assess feeding, oviposition and leaf deformation.

Fern species grown from spores have proven to be ideal for studying *Floracarus* sp. Individual mites can be transferred to the tiny plants and their biology observed. Spore grown plants provide the type of plant tissue necessary for the female to feed and oviposit. Mr. Gio Fichera (CSIRO Entomology) has developed the spore grown micro-culture technique. Many ferns including all the *Lygodium* species have now been successfully grown from spores. Dr. Robert Pemberton (ARS-Ft. Lauderdale) plans to collect spores from additional Florida native species for shipment to ABCL.

Table 5. Host test list for *Floracarus* sp.

Family	Species	Comments
Schizaeaceae	*Lygodium microphyllum* from Australia	Native host plant
Schizaeaceae	*Lygodium microphyllum* from Florida	Invasive phenotype
Schizaeaceae	*Lygodium reticulatum*	Related host from Australia
Schizaeaceae	*Lygodium japonicum*	Related invasive species from SE Asia
Schizaeaceae	*Lygodium flexuosum*	Closely related from Australia & SE Asia
Schizaeaceae	*Lygodium palmatum*	Closely related Caribbean endemic
Schizaeaceae	*Lygodium oligostachyum*	Closely related Caribbean endemic
Schizaeaceae	*Lygodium venuustrum*	Closely related Caribbean endemic
Schizaeaceae	*Lygodium cubense*	Closely related Cuban endemic
Schizaeaceae	*Lygodium volubile*	Closely related South American endemic
Schizaeaceae	*Actinostachys pennula*	Same family, in Florida where L.m. is invasive
Schizaeaceae	*Anemia adiantifolia*	Same family, in Florida where L.m. is invasive
Schizaeaceae	*Schizaea bifida*	Family representative, grows with Lm in Australia
Pteridaceae	*Acrostichum speciosum*	Family representative
Pteridaceae	*Adiantum capillus-veneris*	Family representative
Blechnaceae	*Blechnum serrulatum*	Family representative
Parkeriaceae	*Ceratopteris thalictroides*	Family representative
Cyathaceae	*Cyathea cooperi*	Family representative, horticultural plant
Dennstaedtiaceae	*Hypolepis muelleri*	Family representative, grows with Lm in Australia
Marsilaceae	*Marsilea vestita*	Family representative
Dryopteridaceae	*Nephrolepis biserrata*	Family representative
Ophioglossum	*Ophioglossum petiolatum*	Family representative
Osmundaceae	*Osmunda regalis*	Family representative, horticultural plant

Polypodiaceae	*Platycerium hillii*	Family representative, horticultural plant
Dryopteridaceae	*Rumohra adiantifolis*	Family representative, horticultural plant
Gleicheniaceae	*Sticherus flabellatus*	Family representative, horticultural plant
Sterculiaceae	*Theobroma cacao*	Known host of related *Floracarus* sp.
Convolvulaceae	*Ipomoea alba*	Known host of related *Floracarus* sp.
Rutaceae	*Citrus paradisi*	Economic species
Poaceae	*Saccharum officinarum* (sugarcane)	Economic species

<u>Leaf Feeding Moth - *Cataclysta camptozonale* (Hampson) (Lepidoptera: Pyralidae)</u>

Taxonomy. Dr. Alma Solis (ARS SEL, Washington, D.C.) and Dr. Shen-Horn Yen (British Museum of Natural History, London, UK) have recently revised the genera in the subfamily of Musotominae. *C. camptozonale* will be moved into a new genus created for Australian fern feeding Musotominae. The new genus name should be published in 2002.

Distribution. *Cataclysta camptozonale* is distributed from subtropical SQ and nNSW to tropical NQ.

Biology. Eggs are yellow and laid singly or in clusters, mostly on the new growth. Larvae skeletonize *L. microphyllum* leaves; with fourth instar larvae consuming entire leaves. The developmental period from egg to adult at 27 C^{o} is 21 days.

Seasonal Phenology. Populations of *C. camptozonale* were monitored monthly at four locations near Brisbane. The numbers of larvae collected per hour was recorded as a measure of density. Populations remained at very low levels throughout 2001.

Host-Range. In order to expedite the host-range testing of *C. camptozonale* the test plant list was split between ABCL and quarantine facilities in Gainesville. ABCL screened species of ferns that were more readily available in Australia. An additional *Lygodium* species from the Caribbean was shipped to ABCL for the no-choice tests (Table 6). Two pairs of newly emerged moths were placed inside a moistened plastic bag that enclosed a single fern leaf, or small group of pinnae. Adults were left in the bags until death or five days, if eggs were visible.

Table 6. List of species to be tested in Australia

Family	Plant Species	Comments
Schizaeceae	*Lygodium microphyllum*	Australian form
Schizaeceae	*L. microphyllum*	Florida form
Schizaeceae	*L. japonicum*	Related species in Australia/SEA
Schizaeceae	*L. palmatum*	Closest relative in N. America
Schizaeceae	*L. reticulatum*	Related species from Australia
Schizaeceae	*L. oligostachyum*	Related species from West Indies
Schizaeceae	*Anemia adiantifolia*	Related species from Florida
Schizaeceae	*Schizaea bifida*	Related species from Australia
Aspleniaceae	*Asplenium nidus*	Rare in Florida, in same habitat
Aspleniaceae	*Phyllitis scolopendrium*	Ornamental
Cyathaceae	*Cyathea cooperi*	Ornamental
Dennstaediaceae	*Hypolepis muelleri*	Ornamental
Dennstaediaceae	*Pteridium aquilinum*	Wide-spread fern
Dryopteridaceae	*Nephrolepis biserrata*	Ornamental
Dryopteridaceae	*Polystichum acrostichoides*	Ornamental
Dryopteridaceae	*Rumohra adiantifolis*	Ornamental
Gleicheniaceae	*Sticherus flabellatus*	In same habitat in Australia
Lycopodiaceae	*Lycopodiella cernuum*	Ornamental
Ophioglossum	*Ophioglossum petiolatum*	Ornamental
Osmundaceae	*Osmunda regalis*	Common in Australia
Parkeriaceace	*Ceratopteris thalictroides*	In same habitat in Australia
Polypodiaceae	*Phlebodium aureum*	Common in Australia
Polypodiaceae	*Platycerium hillii*	Ornamental
Psilotaceae	*Psilotum nudum*	Ornamental
Pteridaceae	*Acrostichum speciosum*	Related species in West Indies
Pteridaceae	*Adiantum capillus-veneris*	Related species from Hispanola

Salviniaceae	*Salvinia molesta*	Ornamental
Selaginellaceae	*Selaginella emmelliana*	Primitive fern ally
Thelypteridaceae	*Thelypteris patens*	Ornamental

Host-range data indicates that *C. camptozonale* is a specialist below the genus level (Table 7). *Lygodium microphyllum* (Florida & Australia) and *L. palmatum* had the highest mean number of eggs deposited. It appeared that these two species were preferred over *L. japonicum* and *L. reticulatum*.

Females were induced to lay eggs on nine fern species outside the *Lygodium* genus (Table 7). In all cases the naïve first-instar larvae died shortly after hatching. In most instances we observed that the larvae attempted to feed on the test plant but did not find it suitable. Unfortunately, we were not able to move naïve first-instars onto all the plant species in the test list due to difficulties in removing eggs from leaves. Tests to determine the physiological host-range of experienced third-instar larvae were also conducted in 2001. Third-instar larvae completed development only upon *L. microphyllum* and *L. reticulatum*.

In 2001, additional neotropical *Lygodium* species from the West Indies were tested because of the proximity of this region to southern Florida. *Lygodium volubile*, which occurs in Cuba and other areas of the West Indies, belongs to the same subgenus, Volubilia, as *L. microphyllum*. *Lygodium cubense* a Cuban endemic, *L. venustum* in the West Indies, and *L. oligostachyum* endemic to Hispaniola (the Dominican Republic and Haiti), belong to a separate subgenus, Flexuosa. With the addition of the neotropical species, we will be testing eight *Lygodium* species. At ABCL we tested *L. oligostachyum* from the Dominican Republic. Although females would readily lay eggs on the plant, none of the larvae survived past the first instar.

Table 7. Host-range Testing Results for *Cataclysta camptozonale.*

Family	Plant Species	No. Reps	Total Eggs	Mean No. Eggs ± SE	Mean No. Adults Reared ± SE
Schizaeceae	*Lygodium microphyllum*- (AU)	13	385	29.6 ± 8.6	20.3 ± 5.9
Schizaeceae	*L. microphyllum* – (FL)	9	183	20.3 ± 7.6	12.8 ± 7.0
Schizaeceae	*L. japonicum*	9	25	2.8 ± 2.1	1.9 ± 1.6
Schizaeceae	*L. palmatum*	4	117	29.3 ± 1.4	13.8 ± 4.8
Schizaeceae	*L. reticulatum*	1	2	2.0	0.0
Schizaeceae	*L. oligostachyum*	4	103	34.3	0.0
Schizaeceae	*Anemia adiantifolia*	12	90	7.5 ± 6.9	0.0
Schizaeceae	*Schizaea bifida*	7	0	0.0	-
Aspleniaceae	*Asplenium nidus*	11	5	0.5 ± 0.3	0.0
Aspleniaceae	*Phyllitis scolopendrium*	4	0	0.0	-
Cyathaceae	*Cyathea cooperi*	10	3	0.3 ± 0.3	0.0
Dennstaediaceae	*Hypolepis muelleri*	7	0	0.0	-
Dennstaediaceae	*Pteridium aquilinum*	10	0	0.0	-
Dryopteridaceae	*Nephrolepis biserrata*	9	5	0.6 ± 0.5	0.0
Dryopteridaceae	*Polystichum acrostichoides*	7	0	0.0	-
Dryopteridaceae	*Rumohra adiantifolis*	11	15	1.4 ± 1.1	0.0
Gleicheniaceae	*Sticherus flabellatus*	4	5	1.3 ± 0.7	0.0
Lycopodiaceae	*Lycopodiella cernuum*	4	0	0.0	-
Ophioglossum	*Ophioglossum petiolatum*	0	0	0.0	-
Osmundaceae	*Osmunda regalis*	8	15	1.9 ± 1.1	0.0

Parkeriaceace	*Ceratopteris thalictroides*	4	0	0.0	-
Polypodiaceae	*Phlebodium aureum*	10	21	2.1 ± 1.8	0.0
Polypodiaceae	*Platycerium hillii*	4	0	0.0	-
Psilotaceae	*Psilotum nudum*	4	0	0.0	-
Pteridaceae	*Acrostichum speciosum*	7	0	0.0	-
Pteridaceae	*Adiantum capillus-veneris*	11	13	1.2 ± 1.1	0.0
Salviniaceae	*Salvinia molesta*	7	0	0.0	-
Selaginellaceae	*Selaginella emmelliana*	7	0	0.0	-
Thelypteridaceae	*Thelypteris patens*	7	0	0.0	-

Cold Temperature Tests.

Cold temperature tests were conducted on four species of Lepidoptera under consideration as biological control agents of *L. microphyllum*. Two populations of *C. camptozonale* were tested to determine if there was a difference in cold tolerance between populations from tropical north and subtropical Queensland. The tests are designed to determine the thermal limits of these species, so that we can predict their eventual range in the Southeastern US if released. One of the critical non-target species, *L. palmatum*, occurs in cool temperate parts of the Appalachian Mountains of the eastern US (Zone 7a and northward, Fig 14). Establishing the minimum thermal limits of the candidate agents will help us better assess the potential risk these agents may pose to this non-target species of *Lygodium*.

Minimum temperatures and hours below freezing for a typical cold outbreak in Florida were used to develop the testing protocols. Temperatures as low as 7° C were experienced in the Florida Panhandle for 15 hours. In the area north of Lake Okechobee temperatures were slightly below freezing, at – 1° C for four hours. Our tests are designed to measure the effects of a short duration mild freeze, down the scale to progressively colder temperatures.

The temperature tests were conducted using a refrigerated water bath with an attached heater. The water bath was filled with clean water for temperatures above zero and an anti-freeze solution for temperatures below zero. Cultures of live insects were maintained on *L. microphyllum* plants in insect-proof cages or on cut *L. microphyllum* material in plastic containers. When pupation was observed, pupae were placed into 6mL glass tubes, sealed with plastic screw caps. The glass tubes were held firmly in a plastic rack so that they could be totally submerged in the water bath for two hours at a constant temperature. The tubes were removed and the pupae were held loosely in containers for adult emergence. The number of newly emerged adults was recorded daily.

Results of the tests are shown in Table 8. The three pyralid species: *C. camptozonale, N. conspurcatalis* and *Mustotima* sp., experienced 100 percent mortality at –5° C (23° F). The noctuid moth from China, *Callopistria* sp. A, shows slightly more cold tolerance. This indicates that these moths would not be able to establish beyond the expected distribution of *L microphyllum* in Zone 9a, that experiences temperatures in the range of -3.9 to -6.6° C (20 to 25° F). Zone 9a is approximately 500 miles south of Zone 7a where *L. palmatum* is known to occur. We conclude that Lepidoptera species under consideration for *L. microphyllum* would pose an insignificant risk to native *L. palmatum* populations.

Table 8. Percent emergence of adults after exposure as pupae at selected temperatures for two hours.

Temp °F	Temp °C	*Cataclysta camptozonale* tropical N. QLD 2000273	*Cataclysta camptozonale* subtropical S. QLD 2000216	*Neomusotima conspurcatalis* Northern Territory 2000280	*Musotima* sp. Thailand 2000708	*Callopistria* sp. China 2000686
Control	Control	97	93	87	83	97
55	13				70	
50	10				40	
45	7	97	90	97	83	100
41	5	97	93	97	93	90
38	3	97	93	87	70	90
32	0	50	23	77	30	87
27	-3	7	17	63	33	83
23	-5	0	0	0	0	37
19	-7	0	0	0	0	0

N = 30 pupae per temperature

Leaf Feeding Moth – *Neomusotima conspurcatalis* (Lepidoptera: Pyralidae)

EXPORTED TO FLORIDA. *Neomusotima conspurcatalis* was shipped to quarantine facilities in Gainesville in August. Colonies have been established and final host-range testing is underway. Preliminary host-range testing at ABCL indicated that it was a genus level specialist. Dr. Gary Buckingham and Chris Bennett will test additional Florida native ferns and *Lygodium* species collected in the Caribbean and South America. The population of the moth shipped to Florida was originally collected in Litchfield National Park in the Northern Territory, Australia. We are also attempting to collect and ship *N. conspurcatalis* from Hong Kong, China near the northern end of its distribution. This population could prove to be more cold-hardy and thus better adapted to survive in southern Florida.

Leaf Feeding Moth – *Musotima* sp. (Lepidoptera: Pyralidae)

Taxonomy. Dr. Alma Solis (ARS SEL, Washington , D.C.) and Dr. Shen-Horn Yen (British Museum of Natural History, London, UK) have recently revised the genera in the subfamily of Musotominae and described this moth as a new species. The new name should be published in 2002. *Musotima* sp. has been collected in the lowland tropical parts of Malaysia and Thailand. Colonies of this moth have been terminated in order to shift resources to higher priority agents.

Leaf Feeding Moth – (Lepidoptera: Pyralidae)

Distribution. Drs John Goolsby and Robert Pemberton collected this moth (inset left) on *L. microphyllum* in New Caledonia, in Province Sud near the capital, Noumea. New Caledonia is an island 900 miles to the east of Brisbane and an overseas territory of France.

Taxonomy. The identity of this species is unknown. Specimens have been forwarded to Dr. Alma Solis (SEL) for identification and description. Dr. Solis has identified this species as a member of the Pyraustinae subfamily of Pyralidae. The pyralid species listed above are in the Musotominae subfamily.

Biology. The larvae feed on *L. microphyllum,* skeletonizing foliage as early instars and consuming entire pinnules as they mature. Larvae are nocturnal, pupating on the foliage. We did not observe the larvae on any other fern species in the *Melaleuca quinquenervia* swamp in which it was found, which may indicate that it is a specialist. At one location near Plum the entire patch of *L. microphyllum* (1 square kilometer) was heavily damaged. This may have been the largest single defoliation event we have observed in all of the exploration efforts.

Host-Range Testing. We plan to conduct preliminary host-range tests on this species in 2002. Methods will be identical to those used for *Cataclysta camptozonale* and the other pyralid species.

Leaf Feeding Moths - *Callopistria* spp. A (QLD & China), B (NT & WA), & C (Thailand)

Callopistria sp. A was collected from *L. microphyllum* near Cairns in tropical NQ. As the larvae mature they consume whole leaves. *Callopistria* sp. B has been collected from the Kimberly Region near Kununurra in WA and from Litchfield National Park in NT. *Callopistria* sp. C has been collected in southern Thailand. Colonies of *Callopistria* spp. have been terminated in order to shift resources to higher priority agents. Representatives of all three species have been forwarded to The British Museum of Natural History for identification.

Lygodium Sawfly – *Neostrombocerus albicomus* (Hymenoptera: Pergidae)

Lygodium sawfly larvae have been collected on *L. microphyllum* from just three sites in Thailand and Vietnam. Adult wasps lay conspicuous yellow eggs, singly and in clusters, on the new growth. Larvae defoliate the plant and pupate in the soil. This habit may make them adapted to survival from fire.

Collections of *Neostrombocerus albicomus* from *L. flexuosum* and *L. microphyllum* may represent two separate species. Specimens apparently identical to the *L. flexuosum* sawfly (*N. albicomus*), but collected from *L. microphyllum*, were shown by DNA comparisons to be slightly different. Sequencing of the D2 gene revealed a two base pair difference. It is not known if this amount of genetic difference indicates that the two types are separate species. However, each type develops more readily on their original host species: *N. albicomus* A on *L. flexuosum* and *N. albicomus* B on *L. microphyllum*. Adult specimens of type B were sent to Dr. David Smith at SEL for additional morphological comparisons.

Several rearing methods have been investigated in quarantine without success. Larvae collected in the wild readily complete development on *L. microphyllum* and pupate. Larvae pack sand or debris around them before pupation. Pupae were then placed in sand trays until emergence as adults (inset right). Emergence of adults is not synchronized, with emergence staggered over several weeks. Low numbers of adults has limited the chances for successful mating. Future rearing research needs to investigate methods for breaking the quiescent pupal period. This would ensure large numbers of adult wasps at one time, which would allow for mating and colony initiation.

Stem-Borer – (Lepidoptera: Pyralidae)

The stem-borer has been collected from *L. microphyllum* in Singapore. The wing patterns of the adult appear to mimic spiders. The larvae can cause considerable damage to *L. microphyllum* as they tunnel in stems, eventually causing death of the shoot distal to the larval feeding. Although uncommon in the field, the sight of a long dead shoot amongst undamaged healthy foliage is impressive and indicates the potential damage that could be caused by a large population. Larvae have a terminal, sclerotized plate, presumably to block the tunnel or the entry/exit hole in the stem (Fig 15). Much effort was put into re-collecting larvae of this rare stem-boring moth. Stem damage has also been observed on *L. flexuosum* in Singapore. Unfortunately, there was no sign of its presence in Singapore during this year, but very similar and perhaps identical larvae were collected in northern Thailand on *L. flexuosum*. A single adult was obtained and this was forwarded to Dr. Alma Solis at SEL for study. The moth is not represented in the Thailand DOA insect collection.

Buprestid Leaf-Miner – *Endelus bakerianus* (Coleoptera: Buprestidae)

This leaf-mining beetle, *Endelus bakerianus,* has been collected in Singapore and Thailand from *L. microphyllum*. Females oviposit on the leaf margins of new growth and the larvae tunnel between leaf surfaces, completing development in one subpinnae. Pupation occurs in the leaf tissue. The length of the life cycle is not known. There is some evidence of parasitism in the field by microhymenoptera. This may account for the low density of this species on *L. microphyllum*.

Although we have only collected this species from *L. microphyllum,* its field host range is not known. Similar leaf-mining damage has been seen on swordfern, *Nephrolepis biserrata,* but this turned out to be a Lepidopteran larva. Low numbers of adults in the field have not helped with efforts to establish rearing colonies. Adults from Thailand and Singapore died in quarantine without reproducing. Collections of larvae were made and supplied to buprestid expert Dr Svatopluk Bílý (National Museum, Prague) who identified the species for us, to assist with taxonomic research using immature stages. We continue to collect, and attempt to rear, this species in quarantine.

Voucher Specimens

Plant voucher specimens of *Lygodium microphyllum* from Australia, New Caledonia and Thailand were deposited with Dr. Alan Whittemore and Kevin Conrad at the US National Arboretum in Washington D.C (Appendix 2). All specimens were identified by Dr. Peter Bostock, fern specialist and Senior Botanist, at the Queensland Herbarium, Brisbane. Selected specimens from New Caledonia were also lodged with Queensland Herbarium.

Voucher specimens of *L. microphyllum* and *L. reticulatum* collected in New Caledonia, France were deposited with Dr. Tongi Faman, (IRD, Noumea). Insect voucher specimens were deposited with Dr. Jean Chazeau, (IRD, Noumea) (Appendix 2).

Research Plans for 2002

Our research plans for 2002 include additional foreign exploration, biological studies of agents, and host-range testing. Exploration in South Asia will focus on Sabah (Malaysian Borneo), Sri Lanka and India. We will also revisit Singapore and Thailand to recover and culture the stem-boring moth, sawfly, and leaf-mining buprestid. Additional methods will be tested and developed for culturing these agents. In

Australia, new parts of the range of *L. microphyllum* in NQ, near the Iron Range, will be explored. The fauna of Iron Range, at the tip of Cape York, is similar to New Guinea. Field studies will focus on the host-range and seasonal phenology of the eriophyid mite, *Floracarus* sp. To determine the impact of the mite on *L. microphyllum*, a chemical exclusion experiment will continue on the grounds of ABCL. We will be attempting to measure the impact on biomass production caused by *Floracarus* sp. We will also conduct host-range testing of *Floracarus* sp. and the new pyralid from New Caledonia.

Biological Control of Giant Salvinia, *Salvinia molesta*

Release of Biological Control Agent. The noxious aquatic weed, *Salvinia molesta,* has recently invaded Texas and Louisiana. Biological control programs conducted by CSIRO in Australia have been very successful using the weevil, *Cyrtobagous salviniae,* originally imported from South America. ABCL staff collected, reared and shipped over 860 *C. salviniae* weevils from locations in Australia to Phil Tipping and Ted Center (ARS-Invasive Plant Research Lab, Ft. Lauderdale, FL). *Cyrtobagous salvinae* is being reared in Ft. Lauderdale for release in Texas. Phil Tipping will be monitoring the establishment and impact of the weevil.

Prospects for Biological Control of Downy Rose Myrtle, *Rhodomyrtus tomentosa*

The evergreen shrub *Rhodomyrtus tomentosa* is listed as noxious by the Florida Department of Agriculture and Consumer Services and is a Category 1 in the EPPC List of Invasive Species. It occurs in the central and southern regions of Florida. Following the introduction of *R. tomentosa* prior to 1924, the plant has spread to many regions forming dense thickets that displace native vegetation. *R. tomentosa* is widespread in Southeast Asia and often encountered during exploratory efforts for *L. microphyllum*.

At the request of ABCL, staff of the Thai Department of Agriculture commenced a survey of the distribution of the plant in Thailand. *R. tomentosa* occurs in coastal sandy soils on both coasts of the southern peninsula, around to Trat Province in the east. Herbivores of potential biological control interest are being collected and reared for identification. So far all work has focused on rearing specimens to adults but if the project continues, breeding colonies will be established for further study. So far 23 formal site visits have been completed resulting in nearly 30 collections, however most non-collection sites were not formally recorded. Soil from two of the sites was tested and showed a very low pH of around 4.5. Further pH testing is planned covering the Thailand distribution of the plant.

The most common herbivore on *R. tomentosa*, and not yet found on any other plant species, is a small moth whose striped larvae tunnel and destroy flower buds and fruit. A second slightly larger moth, whose larvae also tunnel in fruit, was also reared to adult. Neither species appears to be represented in Thai insect collections so they have been forwarded to SEL, Washington.

So far, attempts to obtain adults of a third caterpillar, that causes shoot death by boring into stems and tips have not been successful. Because the damage is so impressive, further research efforts are planned.

Larvae of a large leaf-feeding noctuid similar to, but not the same, as *Careades plana* found on *Melaleuca spp*. were collected and an adult reared for identification (inset below). Although leaf damage is moderately severe and the species was seen in widely separated regions of Thailand, these big, obvious caterpillars are not common, perhaps because of predation or parasitism.

An unknown leaf-miner and an interesting ant-mimic caterpillar have been observed, however damage appears minor and consequently the insects have been given low-priority status regarding further work. Many flower-feeding beetles and thrips have been collected, but (although not yet confirmed) it appears that these also use flowers of another plant species, *Melastoma malabathricum*, often found growing with *R. tomentosa*. Other presumed non-specific herbivores include mealybugs, whitefly, and an unidentified tortricid moth.

Prospects for Biological Control of Hydrilla, *Hydrilla verticillata*

Hydrilla, *Hydrilla verticillata* (Hydrocharitaceae), was first introduced into the United States through the aquarium trade in the early 1950's and since that time it has greatly expanded its range from Florida to Delaware on the East Coast and westward to Texas and California (Steward and Van 1987). Current control measures are very expensive and economic losses are excessive. In south Texas during drought, hydrilla infestations clog the Rio Grande River impeding water flow and distribution to cities and farms. Hydrilla is present in the U.S. in both the monoecious and dioecious biotypes, probably as a result of two separate introductions. The dioecious biotype has been found in 13 states (Steward et al. 1984).

The origin of hydrilla is unclear, but genetic evidence indicates that monoecious hydrilla closely matches material from Korea, and the more prevalent dioecious type is closely related to material from Bangalore, India, however literature records indicate Sri Lanka as the origin (Madeira et al. 2000)

Management of hydrilla through chemical and mechanical control is ineffective in the long term, environmentally damaging, and costly. Biological control using aquatic invertebrates is considered to be the safest, most cost-effective and sustainable long-term solution to controlling hydrilla. However, biological control of hydrilla has not yet been realized with the existing agents that have been found during extensive worldwide surveys. Global surveys were undertaken to compile lists of the natural enemies of hydrilla throughout its native range. Foreign scientists were contracted to conduct most searches in conjunction with overseas trips by US scientists. Surveys of northern and eastern Australia (1984-1988), China (1989 and early 1990's), eastern Africa (1976, 1981-1984), India (late 1960's, 1982) and Pakistan (1971-1976) were extensive, though trips to Panama (late 1970's, 1980), the Philippines (1982) and south-east Asia - including Indonesia (1982), Malaysia (early 1970's and 1982), Thailand (1982 and 1996) and Vietnam (1996) - involved only brief surveys. Many phytophagous insects were found during these surveys, though few were selected as potential agents due to their specificity, availability and impact. Two *Bagous* weevils (Coleoptera: Curculionidae) and two *Hydrellia* flies (Diptera: Ephydridae) were released in the U.S. but have either not established or have had limited impact on the growth of hydrilla. New agents are needed.

Additional foreign exploration is needed to find new agents that are adapted to the range of environments where hydrilla is invasive, in particular, constant level rivers and lakes. After small surveys in southern Thailand in 1999, ABCL intended to canvas co-operators across the US to develop new support for exploration in Southeast Asia. In July of this year, a meeting (phone link) was held between parties interested in the further control of hydrilla. Representatives from the USDA-ARS in Beltsville, Tuscon, Fort Lauderdale and Brisbane, as well as from the US Army Corps of Engineers, U.S. Bureau of Reclamation and the Lower Rio Grande Valley Development Council, participated in the meeting. After an update by all participants about the current status of hydrilla and its biocontrol agents, it was generally agreed that more research was needed and the go-ahead was given for ABCL to conduct preliminary exploration in the poorly surveyed areas of southeast Asia and Western Australia.

As part of this plan, a brief preliminary survey was conducted by ABCL scientists in Singapore, Malaysia, Thailand and Indonesia in August 2001. The purpose of the trip was primarily to make contact with possible collaborators in these countries, and this was successful. Hydrilla was surveyed and insects were collected and preserved from each location. These insects are yet to be identified. A brief verview of the regions, sites and insects collected are given in Table 9. Of most interest were three weevil species collected from Lam Poa Dam in Kalasin Province, northeast of Bangkok. The site was flooded and only a small amount of hydrilla (approx 500g) could be found and searched. These and other insects collected will be sent to taxonomists for identification. The sparse nature of hydrilla at several sites suggests that natural enemies are controlling this plant. Additionally, insects collected from these habitats would be adapted to permanently flooded sites, such as lakes, irrigation canals and reservoirs in the USA. Regular collections at these and other sites in southeast Asia is recommended. In 2002 we also plan to visit sites in Western Australia.

Table 9. Sites and insects collected during exploratory surveys of *Hydrilla verticillata* in southeast Asia during August 2001.

Country	Site	Nymphuline Moths	Aquatic Weevils	*Hydrellia* Flies	Chironomidae Midges
Malaysia	Putra Jaya	x		x	x
Thailand	Royal Irrigation Dept.	x			
	Lam Takong Dam	x	x		
	Kaeng Loeng Reservoir	x			x
	Lam Pao Dam		x (3 spp)		x
Indonesia (Sumatra)	Lake Toba - Toledo				
	Lake Toba - Tomok				
	Marihut	x		x	
Singapore	Sungai Buloh	x			x
	Botanic Gardens				

Prospects for Biological Control of Carrotwood, *Cupaniopsis anacardioides*

Cupaniopsis anacardioides is a serious weed in localized areas in the United States, particularly Florida where it has invaded 14 southern and central counties (Lockhart et al. 1999). It was first recognized as a serious weed in 1989 about ten years after it became popular as an ornamental (Lockhart et al. 1999). In the late 1980's seed production was observed and it spread into natural areas, replacing native vegetation in a variety of habitats (Oliver 1992). Birds spread the seed and are responsible for its rapid invasion.

This year, two moth species collected in 2000 were taken to the ANIC in Canberra for identification. One species, whose larvae feed on the fruits of *C. anacardioides,* was identified as *Crytophlebia ombrodelta* (Lepidoptera: Tortricidae), a known pest of Macadamia trees. The second species was identified as *Octasphales eubrocha* (Lepidoptera: Oecophoridae). The larvae of this moth tunneled through the stems of young branches of *C. anacardioides* on Stradbroke Island, near Brisbane, in 2000. There were 16 specimens held in the ANIC, 14 of which were collected before 1937. They were collected from both QLD and NSW. However, no host records were given on the specimen labels.

During 2001, we only made three collections of carrotwood in SQ, though multiple sites were casually observed for herbivore activity. A Lepidoptera larva that fed on the epidermis of leaves and bound leaves together was collected from Point Arkwright on the Sunshine Coast north of Brisbane, but it died in rearing. Mirids were collected feeding on *C. anacardioides* flowers at Hervey Bay north of Brisbane and preserved for identification. Moth larvae feeding on flowers at Flinders Beach Swamp on Stradbroke Island east of Brisbane were reared and two species have been preserved for identification.

We are maintaining seedlings of *C. anacardioides* at the ABCL to colonize any field-collected insects that have potential as biological control agents. The project is low priority and opportunistic collecting will continue during 2002. Insect specimens reared during 2001 will be sent to the ANIC for identification.

Prospects for Biological Control of Chinese Tallow, *Triadica sebifera*

Chinese tallow, *Triadica sebifera* (= *Sapium sebiferum*) (Euphorbiaceae), is a serious environmental and agricultural weed in the southeastern U.S. In Texas, pasturelands along the Gulf Coast are invaded by this weed, changing the grass prairies to woodland thicket. In the eastern states it is invading riparian and coastal marshland habitats. Five-year-old trees can produce in excess of 100,000 seeds per year. The seeds are dispersed by birds, further enhancing the plant's invasive characteristics. Researchers at Washington State University predict that its eventual distribution could include most of the eastern US.

The tree is a popular ornamental in the southern states, favored for its Fall color. Biological control programs could target seed production, which could potentially reduce the invasiveness of this species. A limited program of this kind would still preserve the tree as an ornamental species.

Chinese tallow is native to southern China including Hong Kong and the adjacent provinces of Guanghzou, Guanxi, and Hainan. John Goolsby and Tony Wright were in southern China in November of 2000 collecting agents for *L. microphyllum*. Many sites with Chinese tallow were noted; it was often growing with *L. microphyllum*. Several insect species were observed feeding on the leaves, flowers and seeds. We found very little seed production on most trees, which should be investigated further. Overall, the potential for biological control of this species is promising. The ABCL and the Sino-American Biological Control Lab in Beijing could conduct foreign exploration in southern China.

Chinese tallow is naturalized and is becoming weedy in Australia. In the Brisbane area, *T. sebifera* is invading wetland areas, often in the same habitat with Lygodium and Melaleuca. The pictur shows a stand of Chinese tallow growing in a wetland near Dayboro, QLD. We have also noted seedlings of the tree on Bribie Island. It is likely that this plant will be a serious weed in Australia. A recent model by Pattison and Mack of Washington State University confirms this threat (Mlot 2001).

Survey of Australian Parasitoids of Pink Bollworm, *Pectinophora gossypiella*

Pink Bollworm, *Pectinophora gossypiella,* is a key pest of cotton in Northeastern Mexico, Arizona, and California. Pink Bollworm feeds on cotton bolls, reducing both yield and quality of the lint. The introduction of transgenic Bt cotton varieties has resulted in more effective control of pink bollworm, while simultaneously reducing broad-spectrum insectide use. As a result, classical biological control agents for control of pink bollworm are more likely to establish and be effective. Recent studies by Gordh (University of Queensland) indicate that *P. gossypiella* is native to northern Australia.

Several *Gossypium* spp. are native to northern and western Australia (Table 10). Upland cotton, *Gossypium hirsutum,* is not native but naturalized over much of this area. Many new species of cotton have recently been discovered in the Kimberley in Western Australia. Many of these new species are located in Mitchell Plateau of the Kimberley. It is likely that many of these plant species are suitable hosts for *P. gossypiella*. Pink Bollworm could have a suite of undiscovered natural enemies that are associated with native *Gossypium* spp.

Table 10. *Gossypium* species in Australia

Preliminary field surveys of the parasitoid complex attacking *P. gossypiella* were conducted in northern Australia. Four surveys were conducted in 2000-01. In October 2000, John Goolsby and Don Sands (CSIRO) collected from feral cotton and wild hosts and in the Darwin and Kimberley regions (Fig 19). Dr. Sands had conducted a similar study in the 1970's for the University of California. Mr. Graham Schultz (NT DPI, Darwin) traveled with us to several known sites of feral cotton. Mr. Schultz has continued to collect from the feral cotton and makes shipments of infested cotton bolls to ABCL for evaluation. In July 2000 John Goolsby and Alan Kirk (EBCL) surveyed sites in Darwin and Kimberley and across to Broome in northwest Australia. This survey focused on wild hosts, including many of the indigenous *Gossypium* species. We were aided by Roweena Eastick (CSIRO Cotton CRC, Kununurra, WA) who monitors the indigenous *Gossypium* spp. for potential hybrids with transgenic cotton. In February 2001, John Goolsby and Ryan Zonneveld surveyed the Kimberley and Darwin regions during the monsoon season. *Pectinophora gossypiella* populations peak during this time, as many of the wild host plants are flowering. In Kununurra, WA we collected hundreds of *P. gossypiella* from cotton being grown through the summer as a green mulch. It is unusual to find cotton during this time of year because commercial cotton production has shifted to a winter growing season to avoid pest pressure. Cotton grown in the summer monsoon season represents an excellent opportunity to survey and recover parasitoids of *P. gossypiella.* We were aided in Kununurra by John Moulden, Kimberley Entomologist with Western Australia Agriculture. Mr. Moulden and his colleague, Amanda Annells, provide research and extension services to local growers and are interested in future collaboration that involves cotton pests. In May 2001, John Goolsby and Alan Kirk surveyed the Pilbara region. Several *Gossypium* species occur in this area, including several native species such as *G. australe, G. rotundifolia,* and *G. sturtiantum*. Each species flowers at different times of the year providing a succession of suitable hosts for *P. gossypiella*. In summary, *Gossypium hirsutum* and its native congeners occur across a wide range of habitats and climates in Australia. Quarterly sampling would be needed to target flowering and boll set for each species.

The target, *P. gossypiella,* occurs over this entire range moving between wild and feral hosts, but reaching highest densities on *G. hirsutum*. Several species of parasitoids are associated with *P. gossypiella,* with a wide range of biologies (Table 11). It is likely that some species attack early larval instars and emerge from late larvae or pupae. Many larvae fall to the ground and pupate. We did not sample pupae in the soil, but expect there would be another suite of parasitoids that attack this stage of the pest. Host exposures at or below the soil surface would be best for sampling parasitoids with this type of biology.

Table 11. Parasitoids reared from pink bollworm in Australia

Host Plant	Host Insect	Parasitoid	Location
Gossypium hirsutum	*Pectinophora gossypiella*	*Apantales* nr. *oenone*	Kununurra, WA
Gossypium australe	*Pectinophora gossypiella*		
Gossypium hirsutum	*Pectinophora gossypiella*	*Apantales* sp. *novum*	Darwin, NT
Gossypium hirsutum	*Pectinophora gossypiella*	*Brachymeria* sp.	Woolner Station, NT

Understanding the biology of the parasitoids is critical to predicting their impact in the cotton agro-ecosystem. Another aspect of biology that should be investigated is host range. Only parasitoids with a narrow field host range should be considered in a biological control program. A unique opportunity is available to study field host range of the parasitoids attacking *P. gossypiella*. A related gelechiid moth, *Evippe* sp., originally collected from Mesquite, *Propospis* sp., in Argentina has been released in northern Australia in the same habitat as *P. gossypiella*. By surveying the parasitoids on both the native and introduced gelechiid moths we can learn a great deal about their host ranges. *Evippe* species in North America would be a critical non-target species if an Australian parasitoid was released in the southwestern U.S. 'mesquite belt'.

Dr. Steve Naranjo and John Goolsby met in August at the Practice of Biological Control Symposium to discuss future prospects for the research program. It was proposed that future research should entail both field and laboratory studies. Fieldwork would involve continued exploration for *Pectinophora* parasitoids in the Darwin, Kimberley and Pilbara regions. Field research would also include an assessment of field host range for the common parasitoids. Laboratory research would focus on the biology of the key parasitoid species. Standard artificial diets would be used to rear the *P. scutigera* and/or *P. gossypiella* used in the biological studies of the parasitoids. Evaluation would focus on the ability of *Apantales* sp. and other candidate parasitoid species to parasitize both early instars of *P. gossypiella* on the surface of the boll and/or latter instars that have tunneled inside. (Parasitoids with this type of biology would be most suited to the cotton agro-ecosystem in southwestern U.S.) Parasitoid species that target the correct host stage, and have a sufficiently narrow host range, would be forwarded to collaborators in the US for final quarantine screening and field release. Further research is contingent upon funding.

Biological Control of Pink Hibiscus Mealybug

The Pink Hibiscus Mealybug (PHMB), *Maconellicoccus hirsutus* (Green) (Homoptera: Pseudococcidae), has recently entered California and poses a serious threat to the forestry, agricultural, horticultural and tourist industries of the southern USA. It attacks 215 genera of economically useful plants worldwide. Chemical control is ineffective; Encyrtidae (Hymenoptera) parasitoids have been successfully used in biological control of PHMB elsewhere. ABCL, in co-operation with the ARS European Biological Control Laboratory, is carrying out foreign exploration for PHMB natural enemies. During 2001 exploration continued in Western Australia. Several parasitoid and predator species have been discovered (Table 12).

Table 12. Natural enemies recovered from Pink Hibiscus Mealybug in Australia.

Species	ABCL #	Location	Date	Comments
Gyranusoidea indica Hym: Encyrtidae	2000809	Brisbane, QLD	28-II-2000	D2 sequences identical to colony in Brawly, CA
Cacoxenus perspicax Diptera: Drosophilidae	2000809	Brisbane, QLD	28-II-2000	Common predator of high density PHMB
Ophelosia bifasciata Hym: Pteromalidae	2000803	Brisbane, QLD	28-II-2000	Not commonly recovered may be parasitoid of *Cryptolaemus*
Cryptolaemus montrouzierri Coleoptera: Coccinellidae	2000809	Brisbane, QLD	28-II-2000	Very common predator
Encyrtidae: Hymenoptera *Coccidoctonus* sp.?	2000892	Kununurra, WA	8-X-2000	Collected from wild Malvaceous host plant, may be a hyperparasite
Coccophagus sp. Hymenoptera: Aphelinidae	2000892	Kununurra, WA	8-X-2000	Collected from wild Malvaceous host plant
Mataeomera sp. Lepidoptera: Noctuidae	2000892	Kununurra, WA	8-X-2000	Collected from wild Malvaceous host plant

Field Studies. Little is known about the biology of *M. hirsutus* in its native range where it is not a pest. Studies of *M. hirsutus* in its native range may be useful as a benchmark for biological control programs where mealybug is an exotic pest. With this in mind we set-up field studies in the Brisbane area to record the seasonal phenology of PHMB and its associated natural enemies. Six sites with *Hibiscus rosa-sinensis* were chosen in Sherwood, a suburb of Brisbane, for the study. Cardboard bands (6) were placed on the limbs of the hibiscus plants and collected monthly. The numbers of mealybugs and emerged parasitoids were recorded. This technique has been used by numerous mealybug researchers, and provides a standard measure of density across field sites.

Population levels of PHMB peaked in the Fall of 2000 and then stayed at extremely low levels through October 2001 (Fig 20). We expected to see an increase in PHMB during the Fall of 2001 (Mar-May), but drought conditions may have had an influence. However, even at sustained low densities, we commonly collected the predator, *Cryptolaemus montrouzierri*. This suggests that natural enemies play an important role in regulating PHMB populations in its native range. We will continue the study through 2002.

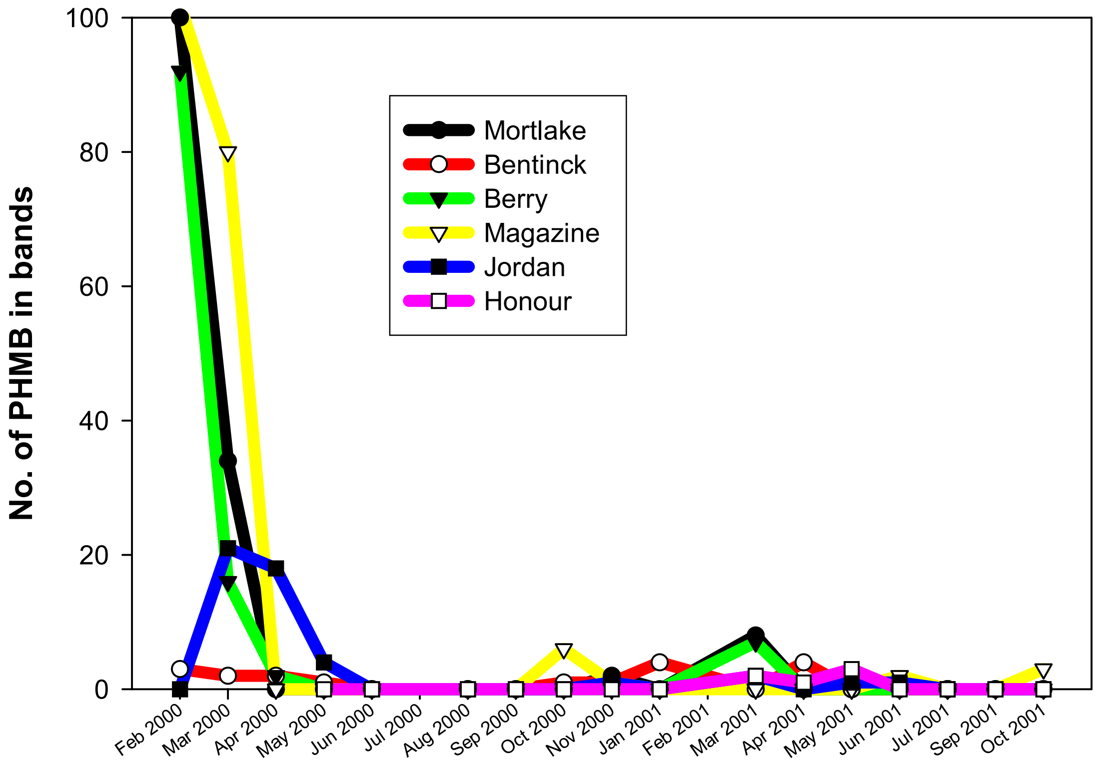

Fig 20. Seasonal population levels of PHMB at six locations in Queensland, Australia.

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ABCL Staff Publications

The following is a list of publications, authored or co-authored by ABCL staff members, which are in press or were published during 2001.

Giblin-Davis, R.M., J. Makinson, B. J. Center, K. A. Davies, M.F. Purcell, G. S. Taylor, S. Scheffer, J. Goolsby and T. D. Center. *Fergusobia/Fergusonina*-induced shoot bud gall development on *Melaleuca quinquenervia.* Journal of Nematology (submitted).

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Appendix 1: 2001 ABCL Field Explorations

HOST CODES

ABlp	*Abutilon lepidum*	LPsp	*Leptospermum sp.*
ADsp	*Adiantum sp.*	Mar	*Melaleuca argentea*
		Mcj	*Melaleuca cajuputi*
ANON	No host searched	Mdl	*Melaleuca dealbata*
		Mfl	*Melaleuca fluviatilis*
ARdo	*Arundo donax*	Mlb	*Melaleuca leucadendra*
		Mnv	*Melaleuca nervosa*
Csp	*Callistemon sp.*	Mqn	*Melaleuca quinquenervia*
		Mvr	*Melaleuca viridiflora*
CPan	*Cupaniopsis anacardioides*		
		MALV	Undet Malvaceae
dung	Cow dung - termites		
		MLma	*Melastoma malabathricum*
Ets	*Eucalyptus tessellaris*	MLsp	*Melastoma sp.*
EHcr	*Eichhornia crassipes*	mound	soil mound - termites
fruit	mixed fruits - for DOA	Nbi	*Nephrolepis biserrata*
		Nsp	*Nephrolepis sp.*
Gau	*Gossypium australe*		
Ghr	*Gossypium hirsutum*	Pfo	*Paederia foetida*
Grb	*Gossypium robinsoni*		
Gst	*Gossypium stuartiantum*	PRvi	*Pteris vittata*
GDst	*Goodenia stobbsiana*	RHto	*Rhodomyrtus tomentosa*
Hpn	*Hibiscus panduriformis*	SLmo	*Salvinia molesta*
Hrs	*Hibiscus rosa-sinensis*		
Hsp	*Hibiscus sp.*	SVta	*Scaevola taccada*
HTsu	*Hyptis suaveolens*	TAap	*Tamarix aphylla*
HYvr	*Hydrilla verticillata*	THpo	*Thespesia populnea*
Lfl	*Lygodium flexuosum*	Torch	Torch Ginger - for DOA
Ljp	*Lygodium japonicum*		
Lmc	*Lygodium microphyllum*	UNDET	Undet. aquatic plant
Lrt	*Lygodium reticulatum*		
Lsp	*Lygodium sp.*	Undet fern	Undet. fern

Collection #	Date	Host	Site	State/Province	Country
2001001	10-Jan-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001002	10-Jan-01	Mqn	Marcoola	QLD	AUSTRALIA
2001003	4-Apr-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001004	4-Apr-01	Mqn	Peregian Environmental Park	QLD	AUSTRALIA
2001005	4-Apr-01	CPan	Yinneburra Bushland Park, Point Arkwright	QLD	AUSTRALIA
2001006	4-Apr-01	Mqn	Dunlop Tce	QLD	AUSTRALIA
2001007	2-May-01	Mqn	Morayfield	QLD	AUSTRALIA
2001008	2-May-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA

2001009	2-May-01	Mqn	Peregian Environmental Park	QLD	AUSTRALIA
2001010	2-May-01	Mfl	Ross River Dam	QLD	AUSTRALIA
2001011	2-May-01	Mqn	Pacific HWY	QLD	AUSTRALIA
2001012	3-May-01	Mvr	Leumann Rd, 5km S Gordonvale	QLD	AUSTRALIA
2001013	3-May-01	Mlb	Centenary Lakes	QLD	AUSTRALIA
2001014	3-May-01	Mnv	Gilmore Rd.	QLD	AUSTRALIA
2001015	4-May-01	Mqn	Pacific HWY	QLD	AUSTRALIA
2001016	3-May-01	Lmc	Edmund Kennedy National Park	QLD	AUSTRALIA
2001017	3-May-01	Lmc	Refuse Transfer Facility, Cairns	QLD	AUSTRALIA
2001018	4-May-01	Lmc	Martyville	QLD	AUSTRALIA
2001019	20-May-01	Mqn	West of Plum turnoff, off RP3		NEW CALEDONIA
2001020	20-May-01	Mqn	~5km North of Yate		NEW CALEDONIA
2001021	21-May-01	Mqn	RT1, South of Bouloupari		NEW CALEDONIA
2001022	21-May-01	Mqn	Fort Tremba Road off RT1		NEW CALEDONIA
2001023	24-May-01	Mqn	RPN3, South of Poindimie		NEW CALEDONIA
2001024	24-May-01	Mqn	RPN3 South of Poindimie		NEW CALEDONIA
2001025	26-May-01	Mqn	near Nondoue		NEW CALEDONIA
2001026	22-May-01	Mqn	West of Plum turnoff, off RP3		NEW CALEDONIA
2001027	25-May-01	Mqn	West of Plum turnoff, off RP3		NEW CALEDONIA
2001028	26-May-01	Mqn	outskirts of Plum		NEW CALEDONIA
2001029	18-May-01	Mqn	McMahon Rd	QLD	AUSTRALIA
2001030	5-Jun-01	Mqn	Marks Rd, Woongoolba	QLD	AUSTRALIA
2001031	5-Jun-01	Mqn	Jacobs Well, North	QLD	AUSTRALIA
2001032	5-Jun-01	Mqn	Jacobs Well, South	QLD	AUSTRALIA
2001033	24-May-01	Mqn	Carbrook Creek	QLD	AUSTRALIA
2001034	7-Jun-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001035	7-Jun-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001036	7-Jun-01	Mqn	Peregian Springs, Hauana Rd	QLD	AUSTRALIA
2001037	7-Jun-01	Mqn	Lorikeet Dv, Peregian Environmental Park	QLD	AUSTRALIA
2001038	7-Jun-01	Mqn	Peregian Environmental Park	QLD	AUSTRALIA
2001039	7-Jun-01	Csp	Peregian Environmental Park	QLD	AUSTRALIA
2001040	13-Jun-01	Mqn	McMahon Rd	QLD	AUSTRALIA
2001041	14-Jun-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001042	14-Jun-01	LPsp	Racecourse Rd	QLD	AUSTRALIA
2001043	19-Jun-01	Mqn	Pottsville	NSW	AUSTRALIA
2001044	19-Jun-01	Mqn	Woodburn	NSW	AUSTRALIA
2001045	20-Jun-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001046	20-Jun-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001047	4-Jul-01	Mqn	Nudgee	QLD	AUSTRALIA
2001048	4-Jul-01	Mqn	opposite Nudgee Golf Course	QLD	AUSTRALIA
2001049	4-Jul-01	Mqn	opposite Bracken Ridge Plaza	QLD	AUSTRALIA
2001050	18-Jun-01	Mfl	Main Street	QLD	AUSTRALIA
2001051	18-Jun-01	Mfl	Pacific HWY, North end of town	QLD	AUSTRALIA
2001052	18-Jun-01	Mfl	Ross River Dam	QLD	AUSTRALIA
2001053	19-Jun-01	Lmc	Refuse Transfer Facility, Cairns	QLD	AUSTRALIA
2001054	19-Jun-01	Mqn	Refuse Transfer Facility, Cairns	QLD	AUSTRALIA
2001055	19-Jun-01	Mar	Saltbag Creek, Mt Malloy-Mt Carbine Rd	QLD	AUSTRALIA
2001056	19-Jun-01	Mnv	Agricultural College turnoff	QLD	AUSTRALIA
2001057	19-Jun-01	Mvr	Leumann Rd, 5km S Gordonvale	QLD	AUSTRALIA
2001058	20-Jun-01	Lmc	Martyville	QLD	AUSTRALIA
2001059	20-Jun-01	Mqn	Pacific HWY	QLD	AUSTRALIA
2001060	27-Jun-01	Ets	The Esplanade	QLD	AUSTRALIA
2001061	27-Jun-01	CPan	The Esplanade	QLD	AUSTRALIA
2001062	27-Jun-01	Ets	The Esplanade	QLD	AUSTRALIA
2001063	27-Jun-01	Mdl	The Esplanade	QLD	AUSTRALIA
2001064	27-Jun-01	Mvr	Poona National Park	QLD	AUSTRALIA
2001065	27-Jun-01	Mqn	Cooloola Way	QLD	AUSTRALIA
2001066	27-Jun-01	Mqn	Harrys Hut Rd	QLD	AUSTRALIA
2001067	10-Jul-01	Mqn	McMahon Rd	QLD	AUSTRALIA

2001068	10-Jul-01	Mqn	Bribie Island Rd	QLD	AUSTRALIA
2001069	10-Jul-01	Mqn	Nudgee	QLD	AUSTRALIA
2001070	18-Jul-01	Mqn	Brown Lake	QLD	AUSTRALIA
2001071	18-Jul-01	Mqn	18 Mile Swamp	QLD	AUSTRALIA
2001072	18-Jul-01	Mqn	Blue Lake Beach	QLD	AUSTRALIA
2001073	18-Jul-01	Mqn	Adder Rock	QLD	AUSTRALIA
2001074	18-Jul-01	Mqn	Flinders Beach Rd	QLD	AUSTRALIA
2001075	25-Jul-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001076	25-Jul-01	Mqn	Maroochydore Airport	QLD	AUSTRALIA
2001077	25-Jul-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001078	25-Jul-01	Mqn	Surf Air	QLD	AUSTRALIA
2001079	25-Jul-01	Mqn	Peregian Springs, Hauana Rd	QLD	AUSTRALIA
2001080	18-Jul-01	CPan	Flinders Beach Rd	QLD	AUSTRALIA
2001081	30-Jul-01	Mqn	Lake Innes Nature Reserve	NSW	AUSTRALIA
2001082	30-Jul-01	Mqn	Queen's Lake Nature Reserve	NSW	AUSTRALIA
2001083	31-Jul-01	Mqn	Sandy Point, Mungo Brush Rd	NSW	AUSTRALIA
2001084	31-Jul-01	Mqn	Seal Rocks Rd Swamp	NSW	AUSTRALIA
2001085	31-Jul-01	Mqn	Boomerang Drive	NSW	AUSTRALIA
2001086	1-Aug-01	Mqn	Perch Hole, Lake Innes Nature Reserve	NSW	AUSTRALIA
2001087	1-Aug-01	Mqn	Hat HEad National Park	NSW	AUSTRALIA
2001088	2-Aug-01	Mqn	Airport	NSW	AUSTRALIA
2001089	2-Aug-01	Mqn	Double Crossing Ck, Coffs-Woolgoolga Rd	NSW	AUSTRALIA
2001090	2-Aug-01	Mqn	Upper Corindi turnoff	NSW	AUSTRALIA
2001091	2-Aug-01	Mqn	Casuarina Beach	NSW	AUSTRALIA
2001092	30-Aug-01	Mqn	Roy's Road	QLD	AUSTRALIA
2001093	30-Aug-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001094	30-Aug-01	Mqn	Peregian Environmental Park	QLD	AUSTRALIA
2001095	5-Sep-01	Mqn	200m S Illoura Place turnoff	QLD	AUSTRALIA
2001096	5-Sep-01	Mqn	Cooloola Way	QLD	AUSTRALIA
2001097	5-Sep-01	Mqn	Eumundi - Noosa Road	QLD	AUSTRALIA
2001098	11-Sep-01	Mqn	Nudgee	QLD	AUSTRALIA
2001099	11-Sep-01	Mqn	Morayfield	QLD	AUSTRALIA
2001100	17-Aug-01	HYvr	Putra Jaya Wetland		MALAYSIA
2001101	17-Aug-01	Mcj	Putra Jaya Wetland		MALAYSIA
2001102	20-Aug-01	HYvr	Royal Irrigation Dept		THAILAND
2001103	20-Aug-01	HYvr	Lam Takong Dam	Nakhon Ratchasima	THAILAND
2001104	21-Aug-01	HYvr	Kaeng Loeng Chan Reservoir	Maha Sarakham	THAILAND
2001105	21-Aug-01	HYvr	Lam Pao Dam	Kalasin	THAILAND
2001106	26-Aug-01	HYvr	Toledo Hotel, Samosir Island	North Sumatra	INDONESIA
2001107	27-Aug-01	HYvr	Silau Manik	North Sumatra	INDONESIA
2001108	28-Aug-01	HYvr	Sungai Buloh Nature Park		SINGAPORE
2001109	28-Aug-01	HYvr	Singapore Botanic Gardens	Singapore	SINGAPORE
2001110	11-Sep-01	Mqn	Coochin Creek Camping Ground	QLD	AUSTRALIA
2001111	26-Aug-01	HYvr	~500m South of Tomok Village	North Sumatra	INDONESIA
2001112	18-Sep-01	Mqn	Landsborough State Forest	QLD	AUSTRALIA
2001113	18-Sep-01	Mqn	Ewan Maddock Dam	QLD	AUSTRALIA
2001114	25-Sep-01	Mqn	Ewan Maddock Dam	QLD	AUSTRALIA
2001115	25-Sep-01	Mqn	Sunshine Coast Motorway 01 115	QLD	AUSTRALIA
2001116	25-Sep-01	Mqn	roadside	QLD	AUSTRALIA
2001117	25-Sep-01	Mqn	Peregian Springs, Hauana Rd	QLD	AUSTRALIA
2001118	2-Oct-01	Mqn	Pottsville Waters	NSW	AUSTRALIA
2001119	2-Oct-01	Mqn	Tyagarah	NSW	AUSTRALIA
2001120	11-Oct-01	Mqn	Silverwood Dv, intersection of Boreen Pt Rd	QLD	AUSTRALIA
2001121	11-Oct-01	Mqn	Tronson Rd intersection	QLD	AUSTRALIA
2001122	11-Oct-01	Mqn	Little Creek Road	QLD	AUSTRALIA
2001123	18-Oct-01	Mqn	Caboolture Rd	QLD	AUSTRALIA
2001124	18-Oct-01	Mqn	Toorbul	QLD	AUSTRALIA
2001125	18-Oct-01	Mqn	Old Forestry Rd	QLD	AUSTRALIA

2001126	18-Oct-01	Mqn	Ewan Maddock Dam	QLD	AUSTRALIA
2001127	18-Oct-01	Mqn	Beerburrum Motel	QLD	AUSTRALIA
2001128	30-Oct-01	Mqn	Silverwood Dv, intersection of Boreen Pt Rd	QLD	AUSTRALIA
2001129	30-Oct-01	Mqn	Silverwood Drive, Site 2	QLD	AUSTRALIA
2001130	30-Oct-01	Mqn	Eumundi - Noosa Road	QLD	AUSTRALIA
2001131	30-Oct-01	Mqn	Ewan Maddock Dam	QLD	AUSTRALIA
2001200	10-Jan-01	Lmc	Peregian 2nd site	QLD	AUSTRALIA
2001201	10-Jan-01	Lmc	Peregian Environmental Park	QLD	AUSTRALIA
2001202	23-Jan-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001203	23-Jan-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001204	31-Jan-01	Lmc	Coolum Park	QLD	AUSTRALIA
2001205	31-Jan-01	Lmc	Peregian Environmental Park	QLD	AUSTRALIA
2001206	22-Feb-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001207	22-Feb-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001208	26-Feb-01	Lmc	Thompson Spring	WA	AUSTRALIA
2001209	26-Feb-01	Lmc	Ivanhoe Falls	WA	AUSTRALIA
2001210	26-Feb-01	ANON	The Grotto	WA	AUSTRALIA
2001211	1-Mar-01	Lmc	Edith Falls	NT	AUSTRALIA
2001212	2-Mar-01	Lmc	Lameroo Beach	NT	AUSTRALIA
2001213	8-Mar-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001214	8-Mar-01	Lmc	Bottoms Creek Crossing	QLD	AUSTRALIA
2001215	8-Mar-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001216	8-Mar-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001217	22-Mar-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001218	22-Mar-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001219	9-Apr-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001220	9-Apr-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001221	9-Apr-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001222	25-Apr-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001223	25-Apr-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001224	27-Apr-01	Lmc	CSIRO Long Pocket Labs, Indooroopilly	QLD	AUSTRALIA
2001225	6-May-01	ADsp	Dales Gorge	WA	AUSTRALIA
2001226	6-May-01	Mar	Dales Gorge	WA	AUSTRALIA
2001227	18-May-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001228	18-May-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001229	18-May-01	Lmc	Bottoms Creek Crossing	QLD	AUSTRALIA
2001230	18-May-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001231	29-May-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001232	24-May-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001233	29-May-01	Lmc	CSIRO Long Pocket Labs, Indooroopilly	QLD	AUSTRALIA
2001234	2-Mar-01	Ljp	Lameroo Beach	NT	AUSTRALIA
2001235	7-Jun-01	Lmc	Peregian Springs, Hauana Rd	QLD	AUSTRALIA
2001236	7-Jun-01	Lmc	Lorikeet Dv, Peregian Environmental Park	QLD	AUSTRALIA
2001237	7-Jun-01	Lmc	Peregian Environmental Park	QLD	AUSTRALIA
2001238	13-Jun-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001239	13-Jun-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001240	13-Jun-01	Lmc	Bottoms Creek Crossing	QLD	AUSTRALIA
2001241	13-Jun-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001242	21-Jun-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001243	21-Jun-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001244	10-Jul-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001245	10-Jul-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001246	10-Jul-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001247	17-Jul-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001248	17-Jul-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001249	28-Jun-01	Lmc	CSIRO Long Pocket Labs, Indooroopilly	QLD	AUSTRALIA
2001250	25-Jul-01	Lmc	CSIRO Long Pocket Labs, Indooroopilly	QLD	AUSTRALIA
2001251	8-Aug-01	Lmc	McMahon Rd	QLD	AUSTRALIA

2001252	8-Aug-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001253	8-Aug-01	Lmc	Bottoms Creek Crossing	QLD	AUSTRALIA
2001254	8-Aug-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001255	17-Aug-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001256	17-Aug-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001257	5-Sep-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001258	5-Sep-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001259	5-Sep-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001260	18-Sep-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001261	18-Sep-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001262	21-Sep-01	Lmc	CSIRO Long Pocket Labs, Indooroopilly	QLD	AUSTRALIA
2001263	19-Sep-01	Lmc	Thompson Spring	WA	AUSTRALIA
2001264	5-Oct-01	Lmc	McMahon Rd	QLD	AUSTRALIA
2001265	5-Oct-01	Lmc	Gallaghers Point	QLD	AUSTRALIA
2001266	5-Oct-01	Lmc	Dux Creek	QLD	AUSTRALIA
2001267	16-Oct-01	Lmc	Carbrook Creek	QLD	AUSTRALIA
2001268	16-Oct-01	Lmc	Native Dog Creek Conservation Park	QLD	AUSTRALIA
2001401	21-Feb-01	RHto	Bo Shaloek	Surat Thani	THAILAND
2001402	21-Feb-01	Lmc	Ban Bk	Surat Thani	THAILAND
2001403	21-Feb-01	Lmc	mushroom site	Surat Thani	THAILAND
2001404	21-Feb-01	Lmc	near Ban Don Sau-Thong Village	Surat Thani	THAILAND
2001405	21-Feb-01	RHto	near Ban Don Sau-Thong Village	Surat Thani	THAILAND
2001407	22-Feb-01	RHto	near Wat Prasit School	NST	THAILAND
2001408	22-Feb-01	fruit	Sa Kaew Village	NST	THAILAND
2001409	22-Feb-01	Lmc	Wat Node, Tambol Photong	NST	THAILAND
2001410	23-Feb-01	THpo	Roadside on Rd # 4013	NST	THAILAND
2001411	23-Feb-01	Lmc	on Road # 408, just E Ban Bo Lo	NST	THAILAND
2001412	23-Feb-01	Lmc	Mae Chao You Hua Village, nr. Ban Bo Lo	NST	THAILAND
2001413	23-Feb-01	Lmc	Ban Tul	NST	THAILAND
2001414	24-Feb-01	Lmc	Luhbohlausa Village	Narathiwat	THAILAND
2001415	25-Feb-01	Lmc	Ga-Looh-Wor-Nua Village	Narathiwat	THAILAND
2001416	25-Feb-01	Lmc	Lipao Demonstration Plot	Narathiwat	THAILAND
2001418	26-Feb-01	SVta	Hat Pak Meng, beachfront	Trang	THAILAND
2001419	26-Feb-01	RHto	nr. Pak Meng	Trang	THAILAND
2001420	26-Feb-01	SVta	road to Marine Nation Park Study Center	Trang	THAILAND
2001421	27-Feb-01	RHto	Trang Horticultural Research Center	Trang	THAILAND
2001422	27-Feb-01	RHto	Trang Horticultural Research Center	Trang	THAILAND
2001423	27-Feb-01	Torch	Trang Horticultural Research Center	Trang	THAILAND
2001424	27-Feb-01	RHto	Trang Horticultural Research Center	Trang	THAILAND
2001425	27-Feb-01	Lmc	Ban Bo Hin	Trang	THAILAND
2001426	14-Jun-01	Lfl	nr. Cherd's site, Ban Pong	Chiang Mai	THAILAND
2001427	14-Jun-01	Lfl	nr. Cherd's site, Ban Pong	Chiang Mai	THAILAND
2001428	15-Jun-01	Lfl	Nr. Cherd's site, Ban Pong	Chiang Mai	THAILAND
2001429	17-Jun-01	Lmc	Ban Huang Som, Tambol Mai Root	Trat	THAILAND
2001430	18-Jun-01	Lmc	Klong Yai 01430	Trat	THAILAND
2001431	18-Jun-01	RHto	Klong Yai 01431	Trat	THAILAND
2001432	18-Jun-01	Lmc	Klong Yai 01432	Trat	THAILAND
2001433	18-Jun-01	RHto	Hat Ban Chuen, Tambol Laem Klad	Trat	THAILAND
2001434	18-Jun-01	RHto	1km from Hat Sai Kaew	Trat	THAILAND
2001435	18-Jun-01	RHto	near Hat Muk Resort	Trat	THAILAND
2001436	18-Jun-01	RHto	North of Hat Muk Resort	Trat	THAILAND
2001437	18-Jun-01	RHto	Muang 01437	Trat	THAILAND
2001438	20-Aug-01	Pfo	Ban Pang Na Chee	Surat Thani	THAILAND
2001439	20-Aug-01	Pfo	Ban Pang Na Chee	Surat Thani	THAILAND
2001440	21-Aug-01	Lmc	Wat Node, Tambol Photong	NST	THAILAND
2001441	21-Aug-01	MLma	Wat Node, Tambol Photong	NST	THAILAND
2001442	21-Aug-01	Lmc	Wat Node, Tambol Photong	NST	THAILAND
2001443	21-Aug-01	RHto	Wat Node, Tambol Photong	NST	THAILAND

2001444	21-Aug-01	Lmc	opposite airport	NST	THAILAND
2001445	21-Aug-01	RHto	Ban Pak Poon School	NST	THAILAND
2001446	11-Oct-01	HTsu	nr Cherds 01446	Chiang Mai	THAILAND
2001447	11-Oct-01	Nsp	Queen Sirikit Botanic Gardens	Chiang Mai	THAILAND
2001448	11-Oct-01	PRvi	Queen Sirikit Botanic Gardens	Chiang Mai	THAILAND
2001449	12-Oct-01	Lfl	Ban Pong Village	Chiang Mai	THAILAND
2001450	15-Oct-01	RHto	Roadside near Ban Sagom	Songkhla	THAILAND
2001451	15-Oct-01	RHto	dirt road near Ban Sagom	Songkhla	THAILAND
2001452	16-Oct-01	Lmc	Lipao Demonstration Plot	Narathiwat	THAILAND
2001453	17-Oct-01	Lmc	Mae Chow Yuhua, West of BoLo	NST	THAILAND
2001454	17-Oct-01	Lmc	Ban Tul	NST	THAILAND
2001455	17-Oct-01	Lmc	Wat Node, Tambol Photong	NST	THAILAND
2001456	18-Oct-01	RHto	RHto soil pH site	NST	THAILAND
2001457	19-Oct-01	RHto	Ban Pang Na Chee	Surat Thani	THAILAND
2001551	20-May-01	Lmc vel. aff.	Lembi RP3, near Plum turnoff		NEW CALEDONIA
2001552	20-May-01	Lsp	near Yate		NEW CALEDONIA
2001553	20-May-01	SVta	~5km North of Yate		NEW CALEDONIA
2001554	24-May-01	MLsp	roadside		NEW CALEDONIA
2001555	24-May-01	Lmc	roadside		NEW CALEDONIA
2001556	24-May-01	Lrt	roadside, small track up hill		NEW CALEDONIA
2001557	24-May-01	ARdo	East Coast, near River inlet and Bridge		NEW CALEDONIA
2001558	24-May-01	Lsp	near Houailou		NEW CALEDONIA
2001559	25-May-01	Lrt	Mt. Dzumac		NEW CALEDONIA
2001560	26-May-01	Lsp	outskirts of Plum		NEW CALEDONIA
2001561	10-Sep-01	Lmc	outskirts of Plum		NEW CALEDONIA
2001562	10-Sep-01	Lmc	near Yate		NEW CALEDONIA
2001563	10-Sep-01	Lmc	outskirts of Plum		NEW CALEDONIA
2001564	11-Sep-01	Lfl	road from Kone to Poindimie		NEW CALEDONIA
2001565	11-Sep-01	Lfl	near Touho		NEW CALEDONIA
2001566	12-Sep-01	Lmc	near Poindimie		NEW CALEDONIA
2001567	12-Sep-01	Lmc	near Houlu		NEW CALEDONIA
2001568	13-Sep-01	Lmc	road to Aerodrome		NEW CALEDONIA
2001569	13-Sep-01	Lmc	Hill to Aerodrome		NEW CALEDONIA
2001570	13-Sep-01	Lmc	near Vad		NEW CALEDONIA
2001601	25-Aug-01	EHcr	Simanindo, Samosir Island	North Sumatra	INDONESIA
2001602	26-Aug-01	Lmc	North of Prapat	North Sumatra	INDONESIA
2001603	26-Aug-01	Nbi	North of Prapat	North Sumatra	INDONESIA
2001701	28-Aug-01	Lmc	Sungai Buloh Nature Park		SINGAPORE
2001702	28-Aug-01	Lmc	Sungai Buloh Nature Park		SINGAPORE
2001703	28-Aug-01	EHcr	Sungai Buloh Nature Park		SINGAPORE
2001704	28-Aug-01	Lmc	Sungai Buloh Nature Park		SINGAPORE
2001705	28-Aug-01	Lmc	Sungai Buloh Nature Park		SINGAPORE
2001706	28-Aug-01	Pfo	Singapore Botanic Gardens	Singapore	SINGAPORE
2001707	28-Aug-01	MLsp	Singapore Botanic Gardens	Singapore	SINGAPORE
2001708	29-Aug-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001709	29-Aug-01	MLsp	Bukit Timah Nature Reserve		SINGAPORE
2001710	29-Aug-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001711	29-Aug-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001712	8-Oct-01	Lfl	Pulau Ubin		SINGAPORE
2001713	8-Oct-01	Lmc	Pulau Ubin		SINGAPORE
2001714	8-Oct-01	Lfl	Pulau Ubin		SINGAPORE
2001715	8-Oct-01	Lmc	Pulau Ubin, roadside NW of 'resort'		SINGAPORE
2001716	9-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001717	9-Oct-01	Undet fern	Bukit Timah Nature Reserve		SINGAPORE
2001718	22-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001719	22-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE

2001720	22-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001721	22-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001722	22-Oct-01	Lmc	Bukit Timah Nature Reserve		SINGAPORE
2001723	22-Oct-01	Lfl	Bukit Timah Nature Reserve		SINGAPORE
2001800	11-Jan-01	Hrs	Graceville	QLD	AUSTRALIA
2001801	11-Jan-01	Hrs	Sherwood	QLD	AUSTRALIA
2001802	11-Jan-01	Hrs	Sherwood	QLD	AUSTRALIA
2001803	11-Jan-01	Hrs	Sherwood	QLD	AUSTRALIA
2001804	11-Jan-01	Hrs	Sherwood	QLD	AUSTRALIA
2001805	11-Jan-01	Hrs	Sherwood	QLD	AUSTRALIA
2001806	26-Feb-01	Hsp	Kununura	WA	AUSTRALIA
2001807	26-Feb-01	Ghr	Packsaddle	WA	AUSTRALIA
2001808	26-Feb-01	MALV	The Grotto	WA	AUSTRALIA
2001809	27-Feb-01	Ghr	Packsaddle	WA	AUSTRALIA
2001810	28-Feb-01	Ghr	Woolner Station	NT	AUSTRALIA
2001811	1-Mar-01	Ghr	Elsey Station	NT	AUSTRALIA
2001812	1-Mar-01	Hpn	Salt Creek	NT	AUSTRALIA
2001813	1-Mar-01	Gau	Salt Creek	NT	AUSTRALIA
2001814	2-Mar-01	Ghr	Lee's Point	NT	AUSTRALIA
2001815	2-Mar-01	Hrs	9 Pinehurst St.	NT	AUSTRALIA
2001816	14-Mar-01	Hrs	Graceville	QLD	AUSTRALIA
2001817	14-Mar-01	Hrs	Sherwood	QLD	AUSTRALIA
2001818	14-Mar-01	Hrs	Sherwood	QLD	AUSTRALIA
2001819	14-Mar-01	Hrs	Sherwood	QLD	AUSTRALIA
2001820	14-Mar-01	Hrs	Sherwood	QLD	AUSTRALIA
2001821	14-Mar-01	Hrs	Sherwood	QLD	AUSTRALIA
2001822	11-Apr-01	Hrs	Graceville	QLD	AUSTRALIA
2001823	11-Apr-01	Hrs	Sherwood	QLD	AUSTRALIA
2001824	11-Apr-01	Hrs	Sherwood	QLD	AUSTRALIA
2001825	11-Apr-01	Hrs	Sherwood	QLD	AUSTRALIA
2001826	11-Apr-01	Hrs	Sherwood	QLD	AUSTRALIA
2001827	11-Apr-01	Hrs	Sherwood	QLD	AUSTRALIA
2001828	2-May-01	TAap	Geraldton	WA	AUSTRALIA
2001829	3-May-01	ARdo	440 Roadhouse	WA	AUSTRALIA
2001830	5-May-01	UNDET	Murchison	WA	AUSTRALIA
2001831	4-May-01	ARdo	Carnarvon Caravan Park	WA	AUSTRALIA
2001832	4-May-01	ABlp	50 km E Carnarvon	WA	AUSTRALIA
2001833	4-May-01	UNDET	Ashburton River	WA	AUSTRALIA
2001834	5-May-01	dung	50km E Nanatarra	WA	AUSTRALIA
2001835	5-May-01	ABlp	60 km E Nanutarra	WA	AUSTRALIA
2001836	5-May-01	Grb	Gum Tree Creek	WA	AUSTRALIA
2001837	5-May-01	ABlp	10km E Gum Tree Creek	WA	AUSTRALIA
2001838	5-May-01	Grb	Beasley River	WA	AUSTRALIA
2001839	5-May-01	Grb	Tom Price	WA	AUSTRALIA
2001840	6-May-01	GDst	Fortescue Campground	WA	AUSTRALIA
2001841	6-May-01	GDst	Weamo Gorge	WA	AUSTRALIA
2001842	7-May-01	GDst	Roebourne Rd	WA	AUSTRALIA
2001843	7-May-01	Hpn	Hooley Station	WA	AUSTRALIA
2001844	7-May-01	Gau	Python Pool	WA	AUSTRALIA
2001845	7-May-01	Gst	on road near Exmouth	WA	AUSTRALIA
2001846	7-May-01	Gst	Shothole Canyon	WA	AUSTRALIA
2001847	9-May-01	dung	Knife Canyon	WA	AUSTRALIA
2001848	9-May-01	dung	100 km N Minilya	WA	AUSTRALIA
2001849	23-May-01	Hrs	Graceville	QLD	AUSTRALIA
2001850	23-May-01	Hrs	Sherwood	QLD	AUSTRALIA
2001851	23-May-01	Hrs	Sherwood	QLD	AUSTRALIA
2001852	23-May-01	Hrs	Sherwood	QLD	AUSTRALIA
2001853	23-May-01	Hrs	Sherwood	QLD	AUSTRALIA
2001854	23-May-01	Hrs	Sherwood	QLD	AUSTRALIA

2001855	27-Jun-01	Hrs	Graceville	QLD	AUSTRALIA
2001856	27-Jun-01	Hrs	Sherwood	QLD	AUSTRALIA
2001857	7-Jul-01	Ghr	St. George	QLD	AUSTRALIA
2001858	27-Jun-01	Hrs	Sherwood	QLD	AUSTRALIA
2001859	27-Jun-01	Hrs	Sherwood	QLD	AUSTRALIA
2001860	27-Jun-01	Hrs	Sherwood	QLD	AUSTRALIA
2001861	27-Jun-01	Hrs	Sherwood	QLD	AUSTRALIA
2001862	27-Jun-01	Hrs	Stamford Rd	QLD	AUSTRALIA
2001863	25-Jul-01	Hrs	Graceville	QLD	AUSTRALIA
2001864	25-Jul-01	Hrs	Sherwood	QLD	AUSTRALIA
2001865	25-Jul-01	Hrs	Sherwood	QLD	AUSTRALIA
2001866	25-Jul-01	Hrs	Sherwood	QLD	AUSTRALIA
2001867	25-Jul-01	Hrs	Sherwood	QLD	AUSTRALIA
2001868	25-Jul-01	Hrs	Sherwood	QLD	AUSTRALIA
2001869	25-Jul-01	Hrs	Stamford Rd	QLD	AUSTRALIA
2001870	21-Aug-01	Hrs	Graceville	QLD	AUSTRALIA
2001871	21-Aug-01	Hrs	Sherwood	QLD	AUSTRALIA
2001872	21-Aug-01	Hrs	Sherwood	QLD	AUSTRALIA
2001873	21-Aug-01	Hrs	Sherwood	QLD	AUSTRALIA
2001874	21-Aug-01	Hrs	Sherwood	QLD	AUSTRALIA
2001875	21-Aug-01	Hrs	Sherwood	QLD	AUSTRALIA
2001876	21-Aug-01	Hrs	Stamford Rd	QLD	AUSTRALIA
2001877	19-Sep-01	Hrs	Graceville	QLD	AUSTRALIA
2001878	19-Sep-01	Hrs	Sherwood	QLD	AUSTRALIA
2001879	19-Sep-01	Hrs	Sherwood	QLD	AUSTRALIA
2001880	19-Sep-01	Hrs	Sherwood	QLD	AUSTRALIA
2001881	19-Sep-01	Hrs	Sherwood	QLD	AUSTRALIA
2001882	19-Sep-01	Hrs	Sherwood	QLD	AUSTRALIA
2001883	19-Sep-01	Hrs	Stamford Rd	QLD	AUSTRALIA
2001884	24-Oct-01	Hrs	Graceville	QLD	AUSTRALIA
2001885	24-Oct-01	Hrs	Sherwood	QLD	AUSTRALIA
2001886	24-Oct-01	Hrs	Sherwood	QLD	AUSTRALIA
2001887	24-Oct-01	Hrs	Sherwood	QLD	AUSTRALIA
2001888	24-Oct-01	Hrs	Sherwood	QLD	AUSTRALIA
2001889	24-Oct-01	Hrs	Sherwood	QLD	AUSTRALIA
2001890	24-Oct-01	Hrs	Stamford Rd	QLD	AUSTRALIA
2001891	29-Oct-01	Ghr	Lee's Point	NT	AUSTRALIA
2001892	1-Nov-01	Ghr	Woolner Station	NT	AUSTRALIA
2001900	9-Apr-01	SLmo	BCC Weed Control Facility	QLD	AUSTRALIA
2001901	2-Mar-01	mound	9 Pinehurst St.	NT	AUSTRALIA
2001902	9-May-01	mound	Knife Canyon	WA	AUSTRALIA

Appendix 2: Voucher Shipments 2001

Date	Institution		Project	#'s Shipped
29-Mar	SEL	<u>*Fergusonina* sp. & parasitoids - relating to paper on gall parasitoids.</u>		
		Fergusonina	2 pins & 2 vials of adults	
		Eurytoma	3 pins of adults	
		Coelocyba	3 pins of adults	
		Neanastatus	3 pins of adults	
		Cirrospilus	2 pins & 1 vial of adults	
		Bracon	2 pins & 1 vial of adults	
		Eupelmus (Macroneura)	2 pins & 1 vial of adults	
		Megastigmus	2 pins & 1 vial of adults	
		Chromeurytoma	1 pin & 2 vials of adults	
		Eupelmus (Eupelmus)	1 pinned adult	
June	SEL	<u>Coleoptera specimens from BioControl of Melaleuca Project</u>		
		F. Anobiidae	*Dryophilodes* sp.	3x
		F. Anthicidae	*Anthicus* sp.	38x
		F. Apionidae	*Apion* sp. B	27x
			Apion sp. C	3x
			Apion sp. J	2
		F. Cerambycidae	*Coptocercus crucigerus*	2
			Platymopsis nr. *obliqua*	2
June	ANIC	<u>Coleoptera specimens from BioControl of Melaleuca Project</u>		
		F. Anobiidae	*Dryophilodes* sp.	3x
		F. Anthicidae	*Anthicus* sp.	39x
		F. Apionidae	*Apion* sp. B	28x
			Apion sp. C	3x
			Apion sp. J	2
		F. Cerambycidae	*Coptocercus crucigerus*	2
			Platymopsis nr. *obliqua*	2
		<u>Pyralidae specimens from the Melaleuca and Hydrilla Projects</u>		
		F. Pyralidae	*Agrotera amathealis*	3
			Cryptoblabes nr. *adoceta*	1
			Poliopaschia lithochlora	7
			Syntonarcha iriastis	6
			Syntonarcha vulnerata	2
			Ambia ptolycusalis	6
			Hygraula nitens	2
			Thelia siennata	3

7-Sep	IRD	New Caledonia & Australian insect specimens sent to IRD, NC		
		F. Miridae	*Eucerocoris suspectus*	2 from NC, 2 from QLD
		F. Curculionidae	*Oxyops vitiosa*	2 from QLD
			Undet curculionid	2 from NC
		F. Psyllidae	Undet psyllid	1 from NC
		New Caledonia & Australian herbarium specimens sent to INRA, NC		
		2001 551	*Lygodium microphyllum* vel. aff.	
		2001 556	*Lygodium reticulatum*	
		2001 559	*Lygodium reticulatum*	
Nov. 01	ANIC	Heteroptera specimens from BioControl of Melaleuca Project		
		F. Acanthosomatidae	*Panaetius lobulatus*	5
		F. Alydidae	*Daclera rufescens*	1
			Undet. sp.	3
		F Anthocoridae	*Orius* sp.	1
		F. Coreidae	*Mictis profana*	1
			Pomponatius typicus	9
		F. Lestoniidae	Undet. sp. A	3
		F. Lygaeidae	*Crompus* sp.	1
			Eurynysius sp.	6
			Germalus humeralis	47
			Graptostethus servus	6
			Oxycarenus luctuosus	4
			Undet Heterogastrinae	2
			Undet Ischnorhynchinae sp. B	6
			Undet. sp. B	1
		F. Miridae	nr. *Calocoris* sp.	10
			Campylomma austrina	4
			Eurystylus sp. A	1
			Hyalopeplus vitripennis	1
			Megacoelum sp. B	1
			Sejanus sp.	2
			Undet Termatophylini sp.	4
			Undet Orthotylini sp. B	2
Nov. 01	SEL	Heteroptera specimens from BioControl of Melaleuca Project		
		F. Acanthosomatidae	*Panaetius lobulatus*	5
		F. Alydidae	*Daclera rufescens*	1
			Undet. sp.	3
		F Anthocoridae	*Orius* sp.	1
		F. Coreidae	*Mictis profana*	1
			Pomponatius typicus	8

		F. Lestoniidae	Undet. sp. A	3
		F. Lygaeidae	*Crompus* sp.	1
			Eurynysius sp.	6
			Germalus humeralis	19
			Graptostethus servus	6
			Oxycarenus luctuosus	4
			Undet Heterogastrinae	2
			Undet Ischnorhynchinae sp. B	6
			Undet. sp. B	1
		F. Miridae	nr. *Calocoris* sp.	10
			Campylomma austrina	4
			Eurystylus sp. A	1
			Hyalopeplus vitripennis	1
			Sejanus sp.	2
			Undet Termatophylini sp.	4
			Undet Orthotylini sp. B	2
Nov. 01	QLD Museum	Heteroptera specimens from BioControl of Melaleuca Project		
		F. Acanthosomatidae	*Panaetius lobulatus*	2
		F. Alydidae	Undet. sp.	2
		F Anthocoridae	*Orius* sp.	2
		F. Coreidae	*Mictis profana*	1
			Pomponatius typicus	3
		F. Lestoniidae	Undet. sp. A	3
		F. Lygaeidae	*Crompus* sp.	1
			Germalus humeralis	9
			Graptostethus servus	3
			Nysius sp.	1
			Oxycarenus luctuosus	3
			Plinthisus sp.	1
			Undet Heterogastrinae	2
			Undet Ischnorhynchinae sp. B	3
			Undet. sp. B	1
		F. Miridae	nr. *Calocoris* sp.	5
			Campylomma austrina	2
			Eurystylus sp. A	1
			Sejanus sp.	1
			Undet Termatophylini sp.	4
			Undet Orthotylini sp. B	2
Nov. 01	SBL	New Caledonia Herbarium specimens from the BioControl of Lygodium Project		
		2001 551	*Lygodium microphyllum* vel. aff.	
		2001 556	*Lygodium reticulatum*	
		2001 559	*Lygodium reticulatum*	