This chapter is part of
"A Manual of Integrated Pest Management for Urban Landscapes for British Columbia"
prepared in 1993 by Mario Lanthier and Linda Edwards
Integrated Crop Management Inc., Okanagan Centre, British Columbia
and submitted to the B.C. Ministry of Environment, Lands and Parks, Victoria B.C.

CHAPTER 7
INTERIOR PLANTSCAPES:
THE APPLICATION OF INTEGRATED PEST MANAGEMENT

TABLE OF CONTENTS

CHAPTER 7
INTERIOR PLANTSCAPES: THE APPLICATION OF IPM

INTRODUCTION

Plants are grown and enjoyed in a variety of indoor settings across British Columbia. These include shopping malls, office buildings, hotels, large restaurants, conservatories and tourist sites displaying exotic plants. Plants are also grown for commercial sales in greenhouses. These areas are confined spaces, with regulated climates and limited interaction with the exterior.

Biological control is the use of living organisms to control other, less desirable organisms. This pest management approach has a long and successful history in greenhouses and interior plantscapes across Europe and North America since the 1960's. In British Columbia, it has been used since 1980 at Crystal Gardens in Victoria, since 1986 in Bloedel Conservatory in Vancouver and in many commercial vegetable greenhouses.

Biological controls are not simply a substitute for pesticides. To be effective, they must be used within an integrated pest management program that includes regular insect monitoring, planting resistant cultivars, screening out pests, eliminating residual pesticides while occasionally using short residue or non-residual pesticides.

The experience of IPM practitioners in B.C. is summarized in a 19-page brochure prepared in 1992 by R.A. Costello, D.P. Elliot. L.A. Gilkeson and D.R. Gillespie. Titled "Integrated Control of Greenhouse Pests", the document was published by the B.C. Ministry of Agriculture, Fisheries and Food and is available from 808 Douglas Street, Victoria, B.C.

This chapter summarizes the information for specific pest problems and their biological control.

Box 7-1: Guidelines to start with biocontrols

Eliminate broad spectrum and residual pesticides.

Substitute to pesticides with targeted activity and little residual action.

Being in a separate greenhouse

Select an area where pesticides applied to other plants will not interfere.

Start small and learn as much about the biocontrols as you can.

Find an extension agent to help set up a monitoring program.

Locate and contact suppliers.

Plan with a local delivery service and have insulated coolers ready.

Make a release plan for greenhouse staff to follow.

Train your staff how and where to distribute the biocontrols, when and where they cannot spray, and what to look for while they are handling the crop.

Be patient.

Give the predators and parasites time to act.

Keep good records and use them to improve the program next year.

It takes one or two years for most people to learn a biocontrol program.

Source: Gilkeson, Linda A., "How to use beneficial insects and mites: A Pest-By-Pest Primer", *Greenhouse Grower*, February 1992.

A) MONITORING

Successful IPM programs utilizing biological agents are based on early detection of pest populations and ongoing monitoring of pests and biological agents. This allows the manager to act on the first appearance of pests, to determine if control agents are establishing, and to assess whether pest populations are being controlled. Biological controls are generally most economical and successful when they are released while the target pest population is small.

i) Sticky traps

Yellow sticky traps detect and monitor populations of greenhouse whitefly, sweet potato whitefly and fungus gnats. Whiteflies are usually found on yellow traps before they are noticed on the plants and well before they cause crop damage. Blue sticky traps detect and monitor populations of thrips.

Different type of sticky traps are available. They are usually made of a rectangular piece of cardboard, about 10 cm X 20 cm. The cardboard is sturdy but not too thick. Yellow paint is applied on both sides, as this color attracts adult insects of different species. A thin layer of adhesive glue (Tanglefoot or vaseline / mineral oil mix) is applied to the complete surface to trap the insects landing on the trap. The trap is stapled or tied to wooden posts or large branches close to the plants.

At regular intervals, a count is made of the number of insects trapped on the sticky surface. The insects are removed or circled to prevent counting them at the next monitoring session. When too many insects are caught, or the trap is dusty, the glue is scraped and renewed.

ii) Visual inspection

Visual inspection of the plants detects the presence of various insects. For example, check plants for two-spotted mite feeding at least once a week. This can be done in conjunction with normal maintenance activities such as pruning and watering. Aphids can also be monitored by direct observation of lower leaves and growing tips. Whiteflies, thrips and fungus gnats can also be detected and monitored with visual inspection.

Early detection allows timely initiation of control procedures, and ongoing monitoring determines the success of the control. For example, once predators are introduced to control western flower thrips, weekly counts of immature thrips and predator mites are required.

Box 7-2: Pest management at Crystal Garden

Crystal Garden, located in Victoria, is a tropical conservatory devoted to raise awareness about endangered animals and plants. Over 400 species of plants are grown in 2,700 square meters under glass. It is a popular stop among tourists and locals with aviaries, primates, nocturnal displays and a seasonal tropical butterfly display.

The pest control program has evolved considerably since the opening days in 1980. The original chemical spray program gave way to a complete reliance on biological control agents. In 1992, only 70 grams (active ingredient) of pesticides were used, mostly to kill pest infestations on purchased plants. The recipe for success is good soil, healthy plants, permanent monitoring and continuous release of predator agents.

According to Bruce Tanner, the chief horticulturist, the most important change over the years was to modify the soil mixture. Insects tend to attack weak and unhealthy plants, while healthy plants growing in good soil have minimal pest problems. Today, the potting and bedding soil is a mixture of 40% professional growers peat moss, 40% pumice soil amendment (3/8") and 20% sterilized garden loam. The soil has excellent porosity and drainage for plant growth. The fertilizer program is based on an accurate, bi-annual soil analysis. Plants respond with rapid growth, vibrant green foliage and robust health.

Another important change was to stop the common reflex of spraying-on-sight. Earlier, for example, an aphid problem was immediately knocked down with a chemical insecticide. Killing the aphids starved the predator populations, and the aphid population soon rebuilt. This created a teeter-totter effect where predator populations built up then droped off as sprays were applied.

The goal of eradicating the aphid population was replaced with a balanced approach as found in nature. Low aphid numbers are tolerated on plants to allow the biological control populations to do their job. Predators and parasites are released to keep the aphid population under control. No sprays have been applied against aphids since 1983.

Activities such as watering and bed cleaning are done manually. It allows the personnel to look at the plant health, identify where problems are occurring and what pest is causing the problem. This monitoring activity is based on years of experience, a good understanding of the susceptible plants and a tolerance of low pest numbers.

Finally, biocontrol agents bought in British Columbia are released on a weekly basis according to the needs. Outbreaks of mites, mealy bugs, whiteflies, aphids and thrips are controlled in this fashion. The annual purchase cost is about $14,000 for the predators and parasites. According to Tanner, using pesticides would cost as much without providing better pest control, and would expose the livestock and public to more possible dangers.

For example, for plants growing along water streams where Koi and Flamingos live, plastic coverings would be installed to prevent spray drift and contamination. The spraying would be done at night to prevent exposure to the visiting public. These factors would increase the labor cost of spraying.

Crystal Garden is a demonstration that under proper conditions, the use of biocontrol agents can be part of an effective pest management program.

Source: Tanner, Bruce. Chief Horticulturist (Victoria, B.C.). Personal Interview. December 13, 1993.

B) BIOLOGICAL CONTROL OF PESTS

i) Mites

The two-spotted mites, *Tetranychus urticae*, is a pest of a wide variety of ornamental plants, including roses, chrysanthemums and gerbera and is the pest most frequently encountered in indoor plant environments.

The problem is particularly severe in hot, dry conditions and under high intensity lights because these conditions speed up the rate of reproduction.

Monitoring

Monitoring is done by visual inspection of the leaves. Adult mites are very small, oval-shaped and yellowish or greenish except for two dark spots on the back. Young mites are similar but smaller. Hand lens are necessary to identify spider mites and predator mites.

Mites are often found along midribs on the underside of the leaf. The visual inspection can target the plants or leaves showing feeding damage. It first appears as yellow stippling on leaves, then leaves turn brown and silken webs mat the underside of the leaves and the growing tips. The presence of webbing is a good sign of mite activity.

Monitoring is also done with limb taps on larger, woody plants. A standard size white sheet of paper, secured to a pad, is held under a branch with one hand. With the other hand, the branch is lightly tapped three times on the pad. If mites are present on the foliage, they fall down on the sheet of paper. Their yellowish or greenish color contrast with the white paper. With a magnifying glass, a count can be made of spider mites and predator mites.

Biological control

The voracious predatory mite *Phytoseiulus persimillis* has been used since the late 1960s to control spider mites. They reproduce best at temperatures between 21 - 27^{o}C and humidities above 60%. They are usually shipped in containers of moist vermiculite or other granular carriers that are easy to sprinkle onto plants.

As soon as spider mites are found, release one predator per plant for the entire range, plus one more for every infested leaf. Continue releases weekly until at least one predator is on every infested leaf. On mums, a total release of 10 predators per plant has successfully controlled spider mites. On ornamental and tropical plants, apply two predators to each leaf showing signs of mite feeding, and six predators to each undamaged plant.

The predatory mites are about the same size as the prey but are a bright orange-red color, do not have spots and move rapidly. They are harmless to people or plants but feed heavily on two-spotted spider mites, killing 5 to 20 per day.

Cultural and chemical control

A key management practice in suppressing spider mites is to raise the relative humidity of the air. Spider mites dislike high humidity, whereas the predator *P. persimilis* does better at 60 to 80% relative humidity. Plants can be frequently misted or, in areas of hot, dry summers, an overhead mist system can be installed.

During prolonged periods of hot, dry, summer weather, predatory mites tend to avoid the upper-most leaves and consequently two-spotted spider mite infestations may develop there. If this occurs, the tops of plants can be treated with a selective miticide and the lower parts left untreated to preserve the predators.

ii) Whiteflies

Whiteflies are among the most common pests on ornamental plants found in conservatories. In ornamental plantings this pest can breed year round, and success with biological control has been variable (Steiner and Elliott, 1987).

Two species of whitefly infest British Columbia crops. The "greenhouse whitefly" *Trialeurodes vaporariorum* is most common, while the "sweet potato whitefly" *Bemesia tabaci* has recently been introduced in Canada. Plants heavily infested with whiteflies are generally lacking in vigor and may wilt, turn yellow and die.

Monitoring

Monitoring is done by visual inspection of the leaves. The adults are easy to see and frequent the under surface of the top leaves of actively growing shoots. Adult whiteflies are powdery white and about 1.5 mm long. The pale yellow eggs, laid on the under-surface of leaves, hatch to oval, flat, pale green nymphs or "scales" that, after a brief period of mobility, remain in one place and feed on sap from the leaves.

Monitoring is also done with yellow sticky traps. According to laboratory testing, whiteflies are attracted to a specific shade of yellow, available commercially as Rustoleum Yellow No. 659 (Olkowski et al, 1991). When the population is high, the traps help catch and reduce the whitefly numbers. The traps are distributed evenly through the area, with extra traps located in areas of previous early infestations.

Monitoring is also done with indicator plants. Some plants highly attractive to the whitefly include *Lantana*, Jerusalem cherry and *Fuchsia* (Steiner and Elliott, 1987). These can be used as indicator plants to detect infestations.

Biological control

Adult *Encarsia formosa*, the parasite sold commercially to control whiteflies, is about 0.6 mm long, with a black head and thorax and yellow abdomen. Almost all adults are females, each laying an egg in 50 to 100 whitefly scales. The parasite develops inside the scale, turning it brown to black; the new adult emerges by chewing a small, round, exit hole in the dead pupa.

In B.C., a low rate of introduction over a long period has proven more successful than larger releases over a shorter time. Thus, to succeed against whitefly the parasite must be introduced when the first whiteflies are recorded. If whitefly populations are high before they are detected, then non-residual sprays can be used to reduce whitefly levels before releasing *Encarsia*.

To reduce the cost and number of shipments, double or triple numbers of parasites could be released bi-weekly. On ornamentals such as poinsettias, releases of 1-4 pupae per square yard of bench are recommended (Gilkeson, 1992).

Cultural and chemical control

Light and temperature play an important role in the use of parasites for whitefly control. Optimum conditions for *Encarsia* reproduction are 21 to 27^{o}C and bright light. During pruning operations, it is important to retain the lower leaves long enough to ensure that the *Encarsia* pupae, which are on the lower leaves, have had time to emerge. If a spray is needed, a careful application to the tops of plants will reduce the pest population with minimal effect on the parasite.

iii) Thrips

Several species of thrips are troublesome in indoor plantings, particularly during the summer months. The western flower thrips, *Frankliniella occidentalis*, is a serious pest as insecticide resistant races are common. The greenhouse thrips, *Heliothrips haemorrhoidalis*, is a problem inside conservatories.

The adults and immatures feed by puncturing the leaf cells and sucking plant sap from the broken cells under epidermis. This causes a characteristic silvery shine on the surface of the leaf.

Monitoring

Thrips are tiny, slender insects difficult to identify without hand lens. Adults have two pairs of fringed wings, which normally are held back over and parallel to the body. The flower thrips are yellowish or yellowish brown species which attack flowers and foliage. The greenhouse thrips are larger, slow-moving, dark-brown thrips with yellow legs which attack the foliage. Nymphs resemble adults, except they are wingless and generally paler in color.

Monitoring is best done with blue sticky traps. Agriculture Canada researchers have found this color to be most attractive to thrips. They recommend hanging the traps so the top is about 60 cm above the plant and the bottom is about 2 cm above the plants. This recommendation is based on adult thrips flying within a 60 cm zone above the plants.

Monitoring is also done by visual inspection. Nymphs are seen on the underside of the leaves. Heavy infestations are noticed from black spots (fecal matter) on leaves.

Biological control

Predatory mites, *Amblysieus cucumeris* and *A. barkeri*, are used widely in western Canada to control thrips in greenhouse crops. The mites are reared in a bran mixture and are shipped in plastic or cardboard containers to the grower. Success depends on releasing these predators as soon as, or before, the first thrips are detected on sticky traps or plants.

In ornamentals, mites are applied at rates of 10-50 per 900 cm^2 before thrips are present. Researchers have had good results using *A. cucumeris* on cut chrysanthemums at rates of 100 predators per individual cutting.

The commercial predatory mites do not kill adult thrips, so feeding damage continues to be apparent for several months. Research is currently underway with other predators to assist the predatory mites. Minute pirate bugs, *Orius* species, have reduced thrips populations by killing the adult pest. A soil-dwelling predatory mite, *Hypoaspis miles*, attacks the pupae around the roots of the plant. Thrips predators should be used together for best results.

Cultural and chemical control

Managers practicing thorough sanitation between crops, including fumigation and complete removal and disposal of plant material, have had the best results using biological control. High humidity around the plant is detrimental to many thrips species. A soil surface insecticide treatment can be used for thrips pupating in the soil. Insecticidal soil is recommended for thrips found on leaves in areas of high infestation.

iv) Aphids

The green peach aphid, *Myzus persicae*, is a problem on roses, chrysanthemums and many greenhouse crops. This, and other species of aphids found on indoor plants, reproduce quickly and are difficult to control with conventional insecticides.

Severe aphid infestations distort and suppress plant growth. They damage plants by secreting honeydew onto the leaves below, allowing a black fungus to grow on the surface. Pesticide resistant races of aphids occur, and some aphids may spread virus diseases from outdoor fields.

Monitoring

Monitoring is done by visual inspection of the plants. Green peach aphids are 1 to 3 mm long, usually green but sometimes pink or pale yellow. The insects are either wingless unfertilized females, giving birth to living young, or winged adults that are produced when the colony is overcrowded. They thrive over a wide temperature range and in moderate humidity. Aphids are usually found on undersides of leaves and in growing tips.

Aphid colonies are usually in localized infestations. Mark infested plants for follow-up inspections.

Biological control

The aphid midge, *Aphidoletes aphidimyza*, has been sold commercially in Canada since 1986. It is a good control for many aphid species. Female midges lay their eggs among aphid colonies, where the larvae feed on aphids until they are ready to drop and pupate in the soil.

Midges are shipped in the pupa stage, usually in moist vermiculite, which is sprinkled on the soil or kept in the opened container until the adults have emerged. One week after the adults have emerged, the bright orange larvae is visible among the aphids. For most plants, release 1-2 midge cocoons per plant or 3-5 cocoons per square meter. The midges are released weekly or biweekly until the aphids are controlled, usually after 2 to 4 applications.

An important management detail is the type of material at the base of the plant. The midge pupates in soil, in the pots or beneath the plants. Exposed soil is required to allow the complete insect development. For soils without exposed soil, a light sprinkling of sawdust, peat or straw, or openings cut in the plastic to expose a strip of bare soil, have been used with success.

Convergent lady beetles, *Hippodamia convergens*, are commercially available for the control of aphids and other pests. They are most reliable if exit points are screened to keep them in the area. They are not efficient predators at low pest levels but are used to reduce high aphid populations.

Cultural and chemical control

Research has shown that using spot sprays to control aphids in localized areas is not compatible with the use of aphid midges. Spot sprays tend to disperse the aphid populations, leaving the midge larvae, which are not very mobile, without food. Heavily infested branches can be pruned or sprayed with water to remove the aphids, unless predators and parasites are present. An insecticidal product or soap can be applied as spot-treatment when predators are not present.

v) Fungus gnats

Fungus gnats, *Bradysia* spp., cause aesthetic damage to bedding plants and potted ornamentals and spread various diseases in greenhouse crops. This insect usually feed on natural fungi and decaying organic matter in the soil Occasionally, the larvae feed on roots and root hairs, reducing growth and providing access for root pathogens.

Plants attacked by the larvae include poinsettias, gerberas, daisies, most bulb crops, cyclamens, hybrid impatiens, geraniums and others. Serious larvae feeding on the roots results in wilting of the plant and occurrence of root diseases.

Monitoring

Monitoring is done with sticky traps. The traps catch the adult flies, indicate their presence and provide some control. The adults are slender dark flies, about 3 mm in length with long thread-like antennae. They run rapidly over the soil and pots and require wet conditions to lay the eggs.

Monitoring is also done from inspection of affected plants. The larvae found around the roots are legless white maggots with a prominent black head. They grow to 6 mm long.

Biological control

There are two promising biological controls for fungus gnats. One is the native predatory mite *Hypoaspis miles*, which attacks the larvae and to some extent the eggs. It lives in the top layers of soil and thrives in sawdust growing bags, soil cultures and even on the surface of rock-wool root media. *Hypoaspis* are shipped in containers of vermiculite or other carriers. About 500 ml treats 300 m^2 of growing area.

The other biological control is the insect parasitic nematode *Steinernema carpocapsae*, a microscopically small threadworm that enters the fungus gnat larvae through body openings. The nematodes are applied at 7 to 10 day intervals through the watering system at rates of about 1 billion per hectare of actual growing area.

Current recommendations are to start with an early season release of *Hypoaspis* to get them established, then apply nematodes through the watering system later in the season.

Cultural and chemical control

The first step in controlling fungus gnats is removing breedings sites where larvae develop on algae. Drain wet areas on floors or under benches, repair leaking irrigation pipes, improve drainage and check that automatic systems do not overwater some areas.

Table 7-3: Canadian suppliers of biological control agents

APPLIED BIO-NOMICS LTD.	
	11074 W. Saanich Road
	Sidney, B.C.
	V8L 5P5
	(604) 656-3844
BETTER YIELD INSECTS	
	R.R. 3, Site 4, Box 48
	Belle River, Ont.
	N0R 1A0
	(519) 727-6108
CANADIAN INSECTARIES	
	5 Alderwood Road
	Winnipeg, Man.
	R2J 2K7
	(204) 257-3775
NATURE'S ALTERNATIVE	
	Box 19, Dawson Road
	Nanoose Bay, B.C.
	V0R 2R0
	(604) 468-7912
PHERO TECH INC.	
	7572 Progress Way
	Delta, B.C.
	V4G 1E9
	(604) 940-9944
SAFER LTD.	
	3 Pullman Ct.
	Scarborough, Ont.
	M1X 1E4
	(800) 387-5306

Source: Bio-Integral Resource Center, "1994 Directory of Least-Toxic Pest Control Products", *The IPM Practitioner*, 15(11-12), 1993.

C) SETTING UP A BIOLOGICAL CONTROL PROGRAM

An example of biological control can be found at Bloedel Conservatory in Vancouver. For a number of years, problems have been managed through the release of beneficial insects and narrowly targeted applications of insect growth regulators.

A report prepared in 1987 for the Parks Board in Vancouver outlines some of the initial considerations to set-up a biological control program (Morrow, 1987). Most insects were piercing / sucking feeders: mites, aphids, whiteflies, mealybugs, scales, with thrips becoming an important pest in many indoor facilities. It was recommended to start the biological control program during the winter when pest populations are low, and to release parasites and predators every two weeks until established.

Experience from the United States shows a crucial factor for the successful use of biological controls is an enthusiastic and well-trained staff. Outside expertise can be retained to introduce and establish the beneficial insects, as well as train the personnel in identifying, monitoring, ordering and manipulating the insects. With a successful biocontrol program, chemical treatments are seldom needed but a few compatible products can be used such as insecticidal soap and insect growth regulators.

Other recommended practices included watering the soil and misting the foliage to prevent mite and thrip build-up, fertilizing with the minimum required nitrogen to prevent an increase in sucking insects populations, and examining new plants brought into the Conservatory for the presence of pests.

D) REFERENCES

- Bio-Integral Resource Center, "1994 Directory of Least-Toxic Pest Control Products", *The IPM Practitioner*, 15(11-12), 1993.
- Costello, R.A., D.P. Elliot, L.A. Gilkson, D.R. Gillespie, "Integrated Control of Greenhouse Pests", Ministry of Agriculture, Fisheries and Food (Victoria, B.C.), 1992.
- Environment and Operations Division, "Integrated Pest Management Semi-Annual Report", Board of Parks and Recreation (Vancouver, B.C.), July 16, 1992.
- Gilkeson, L., "Predators and Parasites -- Availability, Use, Quality", Ministry of Environment, Lands and Parks (Victoria, B.C.), undated.
- Gilkeson, Linda A., "How to use beneficial insects and mites: A Pest-By-Pest Primer", *Greenhouse Grower*, February 1992.
- Morrow Engineering Ltd., "Pesticide Use Policy - Integrated Pest Management Program", Board of Parks and Recreation (Vancouver, B.C.), 1987.
- Olkowski, W., S. Daar, H. Olkowski, "Common-Sense Pest Control", The Taunton Press (Newtown, CT), 1991.
- Steiner, M.Y. and D.P. Elliott, "Biological Pest Management For Interior Plantscapes", 2nd edition, Alberta Environmental Centre (Vegreville, AB), Second Edition, 1987.
- Tanner, Bruce. Chief Horticulturist, Crystal Garden (Victoria, B.C.). Personal Interview. December 13, 1993.
- Zilahi, Gabriela. Abbotsford, B.C. Personal Interview, November 18, 1993.