Integrated pest management: control, or out of control?

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Pests can be a major problem in plant collections, especially in glasshouses. With the rich plant diversity of a botanic garden, pest management can be a challenge, even for the most experienced horticulturalists. The use of toxic chemicals in areas open to the public is not always possible. It is therefore common sense that integrated pest management should be employed whenever possible. Chemical pest controls also have the potential to damage plants and promote resistance within pests.

Integrating chemical and biological controls can be complex and time consuming, but worthwhile for the perspective of safety, long term sustainability and reducing pollutants. With proper administration, monitoring and feedback from horticultural staff chemical warfare is now a last resort.

On the other hand, beneficial insects can occasionally escape into the wild, out-competing and feeding on native fauna. This poster details the use of biological control at the National Botanic Garden of Belgium (NBGB) and highlights one example where beneficial insects have become out of control with negative effects on native species.

PEST scientific name	PEST common name	BIOLOGICAL CONTROL	BIOLOGICAL (B), CULTURAL (C) or CHEMICAL (Ch) TREATMENTS
Planococcus citri *Pseudococcus longispinus* *Planococcus affinis*	**mealybug** **wolluizen** **cochenilles laineuses** **Schmierläuse**	*Cryptolaemus montrouzieri* *Leptomastix dactylopii* *Leptomastidea abnormis*	imidacloprid (Ch) thiacloprid (Ch) pyrethrine + horticultural turnip oil (Ch + B)
Coccus hesperidum *Saissetia coffeae* *Saissetia oleae*	**soft scale** **schildluizen** **cochenilles à bouclier** **Napfschildläuse**		horticultural soap (B) + pyrethrine + piperonylbutoxide (Ch) pyrethrine +horticultural turnip oil (Ch + B) fenoxycarb (Ch)
Diaspis bromeliae	**amoured scale** **dopluizen** **cochenilles diaspides** **Deckelschildläuse**		pyrethrine + horticultural turnip oil (Ch + B)
Tetranychus urticae	**red spider mite** **spint** **araignées rouges** **Spinnmilben**	*(Amblyseius cucumeris)* *Amblyseius swirskii* *Phytoseiulus persimilis* *Feltiella acarisuga*	bifenazate (Ch)
Tharsonemidae	**tharsonemid mite** **mijten** **acariens** **Weichhautmilben**	*(Amblyseius cucumeris)* *Amblyseius swirskii*	bifenazate (Ch) fenbutatin oxide (Ch) abamectine (Ch) pyrethrine + turnip oil (Ch + B)
Aphididae	**aphids** **bladluizen** **pucerons** **Blattläuse**	*Aphidius spp.* *Aphidoletes aphidimyza* *Episyrphus balteatus*	pirimicarb (Ch)
Trialeurodes vaporariorum	**whitefly** **witte vlieg** **aleurodes** **weiss Fliege**	*Encarsia formosa* *Amblyseius swirskii*	pyriproxifen (Ch) yellow sticky traps (C)
Echinotrips americanus *Frankliniella occidentalis*	**thrip** **trips** **thrips** **Thripse**	*(Amblyseius cucumeris)* *Amblyseius swirskii*	blue sticky trap (C) abamectine (Ch) spinosad (B)
e.g. *Chrysodeixis chalcites*	**caterpillars** **rupsen** **chenilles** **Raupen**	*Bacillus thuringiensis var. azawai* (spores)	spinosad (B) feromoonvallen (B)
	slug, snail **slakken** **limaces** **Schnecken**		ferri phosphate (B) methiocarb (Ch)
Iridomyrmex humilis	**Argentine ant** **Argentijnse mieren** **fourmis argentines** **Argentinische Ameise**		chlorpyrifos-ethyl (Ch) permethrine (Ch) fipronyl (Ch) siliciumdioxide (B)
Periplaneta australasiae	**Australian cockroache** **kakkerlakken** **cafards** **Kakerlaken**		sticky trap (C) imidacloprid (Ch) fipronyl (Ch)
Otiorhynchus sulcatus	**vine weevil** **taxuskevers** **Otiorrynque** **Dickmaulrüssler**	*Heterorhabditis megidis*	

Table 1: Current major pests on glasshouse plants at the NBGB and their biological (B), cultural (C) and chemical (Ch) control. 'Biological' refers to a range of beneficial parasites and predators such as, mites, midges, wasps, hover flies, ladybirds or nematodes and may be native or non-native to Belgium. 'Cultural' refers to sticky traps while 'Chemical' treatments are pesticides. Note that the active ingredient(s) are listed here, for product names see Table 2.

Problems in ensuring persistance of beneficial insects

It is preferable for biological control agents to be self-reproducing within the glasshouses, thus giving continuous control of pests. Yet, this idea situation is not always easy to achieve. For example, the larvae and adults of the Mealybug Destroyer Beetle (Cryptolaemus montrouzieri) predate mealybugs of the species Pseudococcus longispinus and Planococcus citri. The beetle lays its eggs on the cottony egg sack of mealybugs so that its larvae can feed on the eggs and young. However, only one of the mealybugs (Planococcus citri) produces such egg sacks as the other (Pseudococcus longispinus) is viviparous. For some reason, or perhaps because of predation by the beetle, the egg laying P. citri has become rarer in our glasshouses while Pseudococcus longispinus has increased.

Case study of the Phaseoleae collection

The NBGB holds an important collection of wild Phaseoleae (Beans) recognised by Biodiversity International as a base collection for wild Phaseolus and Vigna. Integrated pest management began in the collection in 2002. The amount of pesticide administed has (with two exceptions) been reduced by over half, while in 2006 this figure was 8 times lower than the amount given in the last year of wholly chemical control (Table. 2). The two exceptions to this treand were in 2002 and 2004. In 2002, a thrip outbreak had to be controlled with chemical treatments more than it would be in recent years. In 2004, a serious outbreak of red spider mite (Tetranychus urticae) occurred causing major damage in glasshouse crops across Belgium and surrounding countries. This was caused by resistance against all the then used acaricides. That year more chemical applications were used than usual as we tried to manage the infestation. Eventually, the use of bifenazate was admitted for use in Belgium to which red spider mites are not currently resistant. This product gives good results and is harmless for beneficial creatures such as Amblyseius cucumeris, A. swirskii and Phytoseiulus persimilis. However, while it controls spider mites at present it is likely that resistance will also manifest itself in populations in the near future.

The main pests requiring control in the collection are thrips, followed then by red spider mites and mealybugs (See Table 1 from details). Many different products were used for control but by the time IPM was started many of the most toxic products used had been withdrawn from the market (Table 3). It is now our policy to use only a small number of the less toxic pesticides.

	Applications of pesticides prior to IPM						Pesticides use with IPM				
Year	1996	1997	1998	1999	2000	2001	2002	2003	2004*	2005	2006
Amount in L	1390	1272	1447	1647	2156	1722	1610	492	1925	820	210
Applications	34	44	37	34	36	41	27	16	27	15	6

Table 2. The amount of pesticide use in litres and the number of applications on a single research collection of wild Phaseolinae plants between 1996 and 2006. '*' = the figures from 2004 highlight a necessary chemical response to large populations of red spider mite (*Tetranychus urticae*). These could not be controlled to a satisfactory level using biologicalor chemical control.

	Active ingredient	Trade name	LD_{50} mg/kg
■	mevinfos	Phosdrin	4
	oxamyl	Vydate	6
■	sulfotep	Bladafum	10
	abamectine	Vertimec	10
	methomyl	Lannate	17
■	formetanaat	Dicarzol	21
■	methamidofos	Tamaron	30
■	omethoaat	Folimat	50
■	permethrin	Ambush	50
	bifenthrin	Talstar	55
	mercaptodimethur	Mesurol	100
	furathiocarb	Deltanet	137
✓	pirimicarb	Pirimor	147
✓	imidacloprid	Confidor	450
	tebufenpirad	Masai	595
✓	tebufenpirad	Pyranica	595
■	dicofol	Kelthane	690
■	amitraz	Mitac	800
■	amitraz	Byebye	800
■	acefaat	Orthene	945
✓	bifenazate	Floramite	>2000
■	pirimifos-methyl	Actellic	2018
✓	fenbutatin oxide	Torque	2630
	clofentezin	Apollo	>3200
✓	spinosad	Tracer	>3738
	pyriproxifen	Admiral	>5000
	broompropylaat	Neoron	>5000
✓	hexythiazox	Nissorun	>5000

Table 3. The array of pesticides used in the Phaseoleae collection between 1996 and 2006. Black boxes refer to the chemical having been recently withdrawn from sale, whereas '✓' refers pesticides in use during 2005 and 2006. LD_{50} refers to 'Lethal Dose 50' a lower number indicates higher toxicity.

Various biological control agents have been used in the Phaseoleae collection (Table 4). Thrips used to be controlled by the predatory mite Amblyseius cucumeris, but we now use A. swirskii. The latter was found to be more effective and has the added benefit of also controlling whitefly (Aleyrodidae). Mealybugs are controlled with a preventive watering of the systemic pesticide imidacloprid.

The gardeners and curation staff are pleased with the reduced use of toxic chemicals in the garden. We are constantly trying to improve our pest management through observation and experimentation. So that we can keep ahead of our war on pests.

	Year				
Biological control agent	2002	2003	2004	2005	2006
Amblyseius cucumeris	9	19	5	20	
Amblyseius swirskii				4	13
Phytoseiulus persimilis				2	6

Table 4. The number of releases of beneficial insects against thrips and spider mites in the Phaseoleae collection between 2002 and 2006.

Exotic and invasive fauna

Half of the predatory and parasitic insects and mites used in Europe for pest management are exotic (1). Occasionally, they can become a problem themselves when they escape and compete with native fauna.

The Harlequin ladybird (Harmonia axyridis) comes from central and eastern Asia. Since the 1960s they have been used in Europe for integrated pest management (IPM). Introduced as an aphid control for glasshouse crops, they were first recorded in the wild in Western-Europe in the 1990s. They are winter hardy and it was quickly discovered that they successfully compete with native ladybirds. Harlequin ladybirds prefer to eat aphids (Aphidoidea) and scale insects (Coccoidea), yet, if these are not available, they prey on caterpillars, butterfly eggs, lacewing larvae and even native ladybirds (2). They can potentially devastate native species and are highly invasive. In addition, they can cause problems when they hibernate en masse in houses.

The effects of the spread of H. axyridis in Europe are not easy to predict. Much of what we expect to happen in Europe is based on the North American experience. There the ladybird has been naturalised since the 1980s. In addition to their impacts impacts on native ladybirds, North American populations of the Harvester butterfly (Feniseca tarquinius) are being threatened because the butterfly's carnivorous caterpillars feed exclusively on one species of alder aphid (Paraprociphilus tesselatus) also predated by H. axyridis.

Harmonia axyridis has now been withdrawn from the market by the breeders and replaced by the European native Adalia bipunctata (two-spot ladybird). H. axyridis was used a few times at NBGB, but currently aphids are controlled using other native species such as the predatory aphid midge (Aphidoletes aphidimyza), the parasitic wasp (Aphidius sp.) and the predatory hoverfly (Episyrphus balteatus). The native predatory midge (Feltiella acarisuga) provides control of red spider mites (Tetranychus urticae).

Nowadays, the importance of managing the release of biological control agents is clear and the European Union have a program for the regulation of biological control agents called REBECA, which develops guidelines to implement risk assessment on release of biocontrol agents. Globally, the International Organization for Biological Control of Noxious Animals and Plants (IOBC) take the lead.

Although the impacts of H. axyridis on native wildlife in Europe is yet to be known it is likely that it will have to be added to the list of biological controls that went wrong, along with the South American Cane Toad in Australia and the Asian Mongoose in Hawaii.

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