New and Effective Plant Protection Product & Mode of Delivery to Control Tree Pests & Diseases

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Trees - Why We need Them - Why We Like Them - Why We Value Them

Trees are integral to our lives;

Trees are keystone organisms that play a fundamental role in the terrestrial ecosystem upon which humans depend,

In short humans could not survive without trees.

"What we are doing to the forests is but a mirror reflection of what we are doing to ourselves". (Mahatma Ghandi)

When the trees are attacked by Pests & Diseases we need to find solutions!

What Has Come Into the UK

Invasive / Introduced

* Ash decline (*Chalara fraxinea*)
* **Oak processionary moth, (*Thaumetopoea processionea*), [OPM]**
* Great Spruce bark beetle (*Dendroctonus micans*),;
* **Horse chestnut leaf miner (*Cameraria ohridella*), [HCLM]**
* Sweet chestnut blight (*Cryphonectria parasitica*)
* European gypsy moth (*Lymantria dispar*)
* Pitch pine canker (*Gibberella circinata)*
* Asian longhorn beetle (*Anoplophora glabripennis*), [ALB]
* Brown spot needle blight of pine

Existing Threats

Possible future introductions

* Emerald ash borer (*Agrilus planipennis*) [EAB]
* Spruce bark beetle (*Ips typographus*)
* Citrus longhorn beetle (*Anoplophora chinensis*) [CLB]
* Plane wilt disease, (*Ceratocystsis platani*)
* Pine processionary moth (*Thaumetopoea pityocampa*) [PPM]
* Pine Wood Nematode (*Bursaphelencus xylophilus*) [PWN]

What has come into Europe

Pine Wood Nematode (*Bursaphelencus xylophilus*)

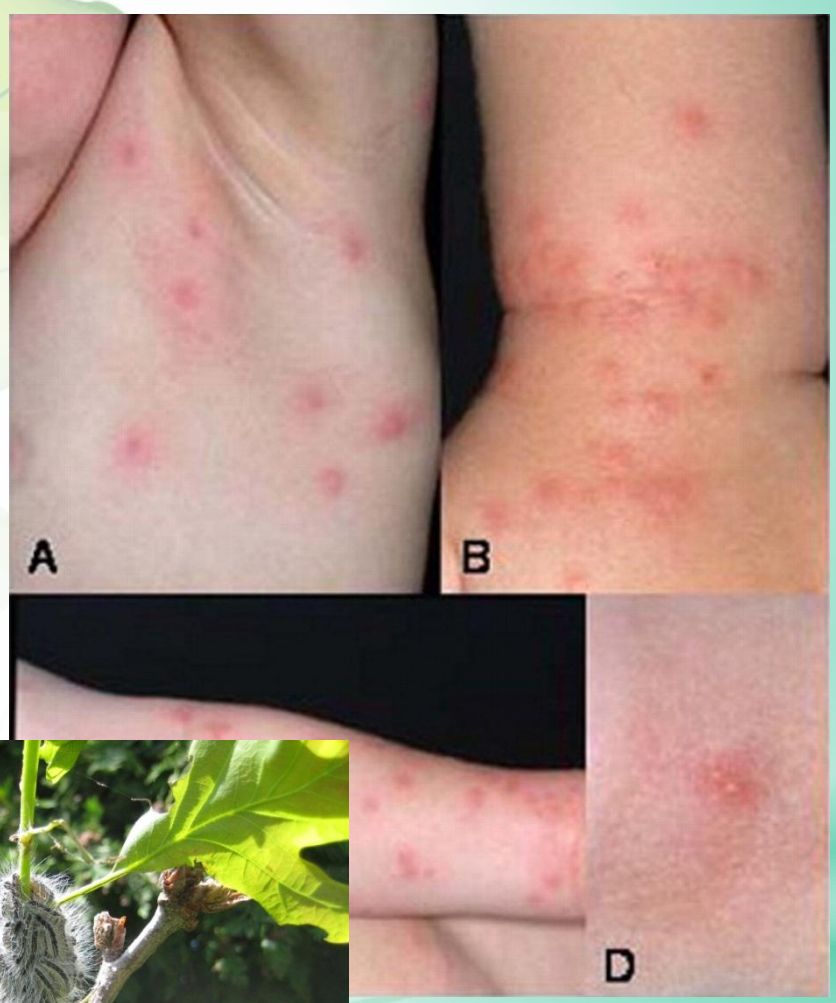
Red Palm Weevil (*Rynchophorus ferrugineus*) [RPW]

Palm Borer Moth (*Paysandisia archon*) [PBM]

Oak Processionary Moth - OPM

Found in Britain in 2007 – Richmond, West London;
Also confirmed in Pangbourne, Hertfordshire.

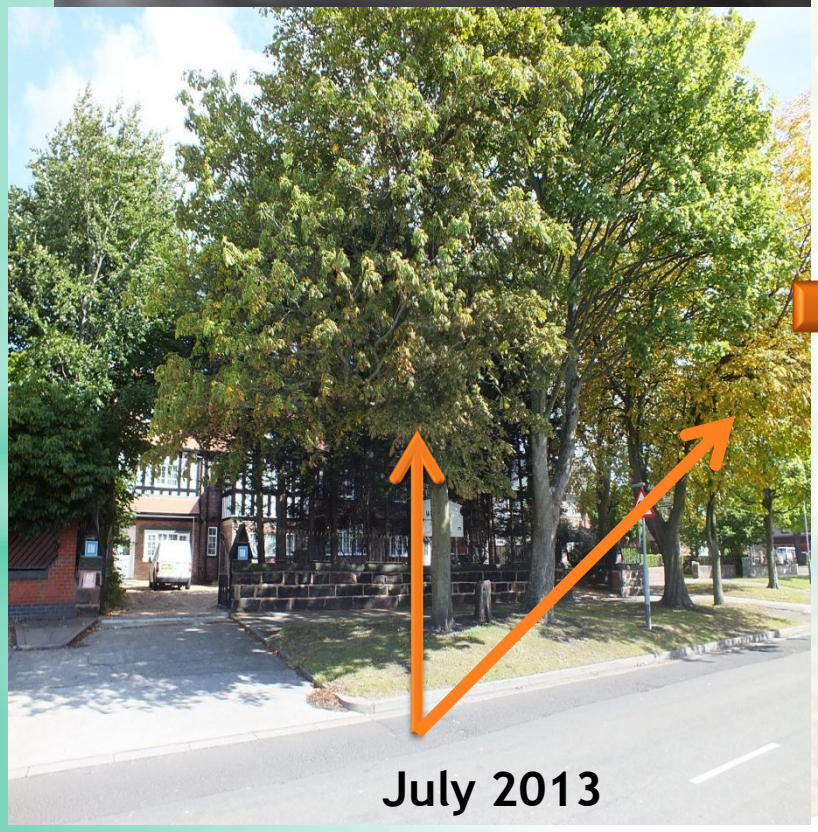
OPM is a Risk to Human Health



Full PPE is essential as exposure to the OPM toxin is sensitising i.e. the more exposure the worse the effect.

Nests and larvae should be treated with extreme caution!

Horse Chestnut Leaf Miner - HCLM



Horse Chestnut Leaf Miner - HCLM

Severe Leaf Damage
(Not just a cosmetic issue!)

Early Leaf Fall – July

Reduced number of seeds

Seeds smaller than average

Up to 25% of seed not viable

Reduced Energy Reserves

Trees less able to deal with other infections such as *Phytophthora* or *Armillaria*.

Controls – Tree Protection

What have we got? What is Available?

1. Chemical & Biological Controls

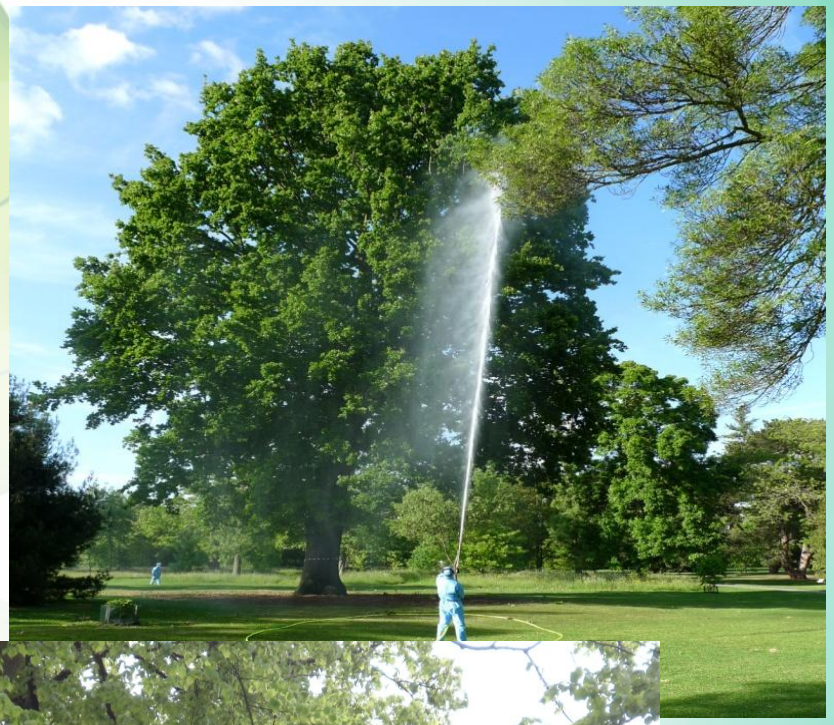
2. Integrated Pest Management (IPM)
   (a) Attract & Kill
   (b) Allee Approach

Chemical Controls in IPM programmes is the best way for trees in the short to medium term.

Very long term – Tree Breeding

Tree Protection - Soil Injection

Rainbow Treecare Soil Injection System® - a Completely Closed System for Soil Injection



Tree Protection - Foliar Spray

Tree Protection – Systemic Injection

Pressurised Capsules

Tree Protection – Systemic Injection

ArborJet® System

Syngenta Tree Micro-Injection (TMI) System®

Tree Protection – Systemic Injection

There are many other systems available and these include, but are not limited to:

Pressurised Capsules;

Mauget®; Tree-Tech Capsule System ®

Pressure Injection:

ArborJet®; Viper®; Wedgle Direct Injection System®; Rainbow Q-Gun®, Q-Connect ®& IQ Infuser® and Syngenta TMI®.

For a Review of Available Systems See:
Tree Care Industry (TCI) Volume XXV, No. 5, May 2014, Pages 8 to 14

New Plant Production Product - Revive ®

Revive is Emamectin Benzoate. Derived from the naturally occurring avermectin insecticide.

Refined into a highly effective targeted option.

Revive is a formulation specifically developed for Tree Micro Injection allowing for: -

- Low pressure injection;
- Very small volumes of product; applied;
- Very small injection holes required
- Very fast injection.

Revive moves rapidly into the leaf and crown and targets pest activity.

New Plant Protection Product - Revive®

Approved for use in Switzerland for *C. ohridella* (HCLM)

Recently (April 2014) Approved in France and Emergency Approval in Spain for Red Palm Weevil and Full Approval in Portugal for Pine Wood Nematode

Currently with CRD for Approval for use in the UK for control of OPM and HCLM – Target date Q1 of 2015

Research trials of its efficacy against OPM and HCLM in Britain have been ongoing for 3 years.

Thaumetopoea processionea (OPM) Trials at Barnes Common in London 2012, 2013 & are Ongoing in 2014

Trials undertaken by the Bartlett Tree Research Lab at Reading University

Trees injected with Revive at various doses & formulations.

OPM Trials at Barnes Common in London

Two formulations of EM tested at 4 different levels of active ingredient, (ai);

Untreated control
Water treated control

16297A 0.02 gai/cm DBH
16297A 0.04 gai/cm DBH
16297A 0.08 gai/cm DBH
16297A 0.16 gai/cm DBH

19308A 0.02 gai/cm DBH
19308A 0.04 gai/cm DBH
19308A 0.08 gai/cm DBH
19308A 0.16 gai/cm DBH

Each individual plot (treatment) consisted of 1 tree. Trial consisted of 4 replicates (40 trees in total).

Barnes Common OPM Trials

Influence of insecticide formulations A16297A and A19308A applied by ArborJet trunk injection on *T. processionea* nest number and viability over two years.

	Year 1		Year 2	
Treatment	Mean No OPM nests per tree	Percent mortality of OPM larvae	Mean No OPM nests per tree	Percent mortality of OPM larvae
Control (no injection)	0.5b	0	6.0c	0
Water injected	1.0c	0	6.8c	0
A16297A 0.02g	0.0a	-	0.0a	-
A16297A 0.04g	0.0a	-	0.0a	-
A16297A 0.08g	0.0a	-	0.0a	-
A16297A 0.16g	0.0a	-	0.0a	-
A19308A 0.02g	0.5b	0	1.0b	0
A19308A 0.04g	0.0a	-	0.0a	-
A19308A 0.08g	0.0a	-	0.0a	-
A19308A 0.16g	0.0a	-	0.0a	-

Barnes Common OPM Trials

Cameraria Trials at Greenwich
2011 -2013 & ongoing

Two formulations injected at various doses using the ArborJet® system.

Cameraria Trials at Greenwich

Untreated Control
Water injected control

A16297A (0.02 gai cm DBH)
A16297A (0.04 gai cm DBH)
A16297A (0.08 gai cm DBH)
A16297A (0.16 gai cm DBH)

A19308B (0.02 gai cm DBH)
A19308B (0.04 gai cm DBH)
A19308B (0.08 gai cm DBH)
A19308B (0.16 gai cm DBH)

The treatments, 1 non-injected tree, 1 water injected control, 4 A16297A, 4 A19308B were applied in 4 randomized complete blocks with a single tree as the experimental unit i.e. 10 trees per block, 40 trees in total.

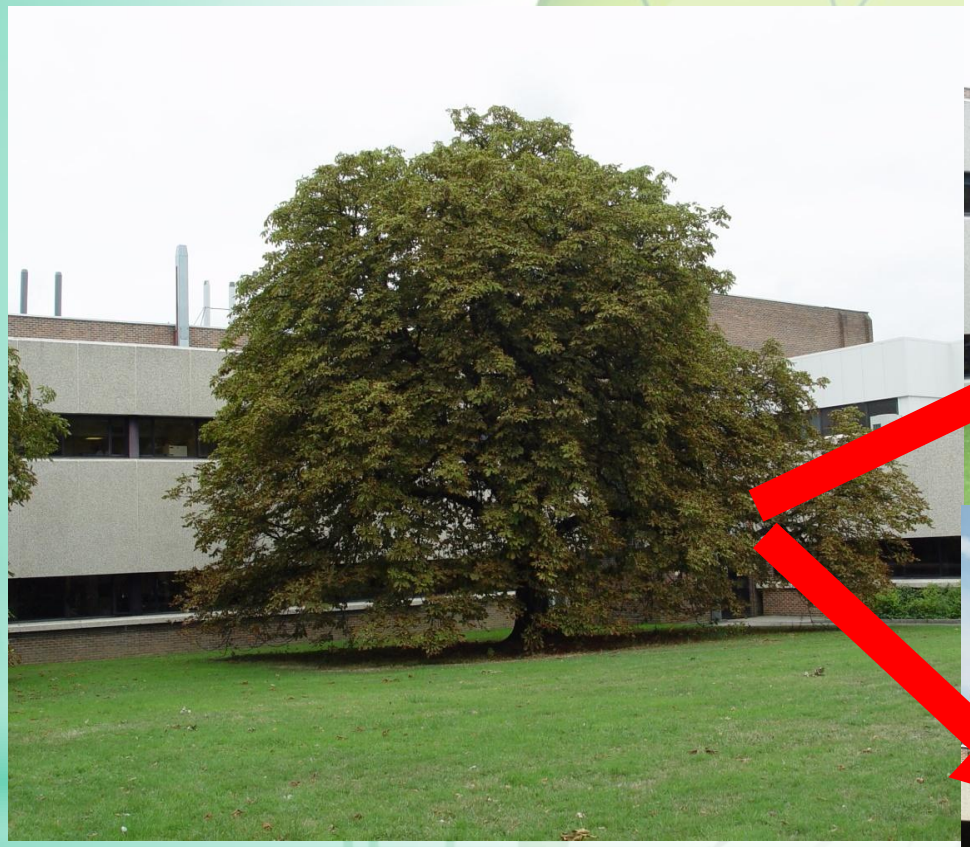
Cameraria Trials at Greenwich

Influence of Revive® applied by ArborJet trunk injection on HCLM infection severity. **(* = Significant at <0.5%)**

	Year 1	Year1	Year 2	Year 2
Treatment	No. Mines/Leaf	%Mortality of Larvae/Pupae	No. Mines/Leaf	%Mortality of Larvae/Pupae
Control	9.25	10.9	8.0	9.4
Product A 0.02g	5.30*	12.5	4.1*	42.0*
Product A 0.04g	3.65*	13.0	2.3*	33.0*
Product A 0.08g	3.85*	18.9*	0.0*	-
Product A 0.16g	2.05*	14.4*	0.0*	-
Product B 0.02g	3.60*	13.8*	0.0*	-
Product B 0.04g	5.55*	16.0*	0.1*	100*
Product B 0.08g	2.25*	14.9*	0.0*	-
Product B 0.16g	1.45*	22.5*	0.0*	-

Cameraria Trials at Greenwich

Cameraria ohridella Control Tree at Reading University



Revive® Applied by Injection

Trials against *Rhynchophorus ferrugineus* (RPW) – Elche (Alicante), Spain

Results from the Elche trials in Spain (Valencia Region) show that Revive is effective in controlling RPW on Canary Island Palm (*Phoenix canariensis*) and Research is ongoing on Date Palm (*Phoenix dactylifera*). Trials against *Paysandisia archon* are planned.

Revive® - TMI Steps

1. Drill Holes 1 per 5cm dbh

2. Syngenta Plugs (Biodegradable)

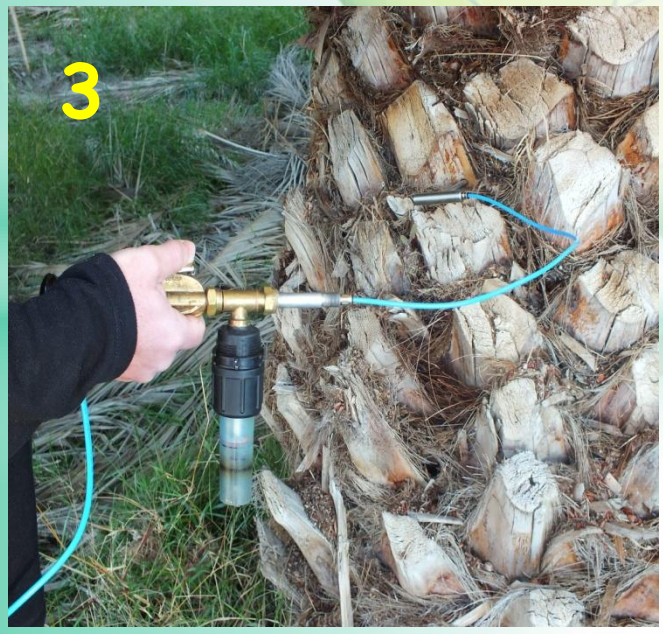
3. Plug Setter

4. View of Set Plug

5. Inject - Revive

Revive® – TMI Steps – Final Injection

TMI of Palm Trees - The Final Delivery is Different



1. Drill 4 holes 20cm-25cm deep but no more than 1/3 of the stem diameter
2. Insert the custom designed injector head
3. Deliver 2 x 6ml doses to each hole
4. Cap the holes when complete

Control / Eradication of OPM & HCLM in the UK?

The Allee Effect is based on population dynamics. It holds where the population density is low.

Newly established populations when detected at low density are most susceptible to eradication.

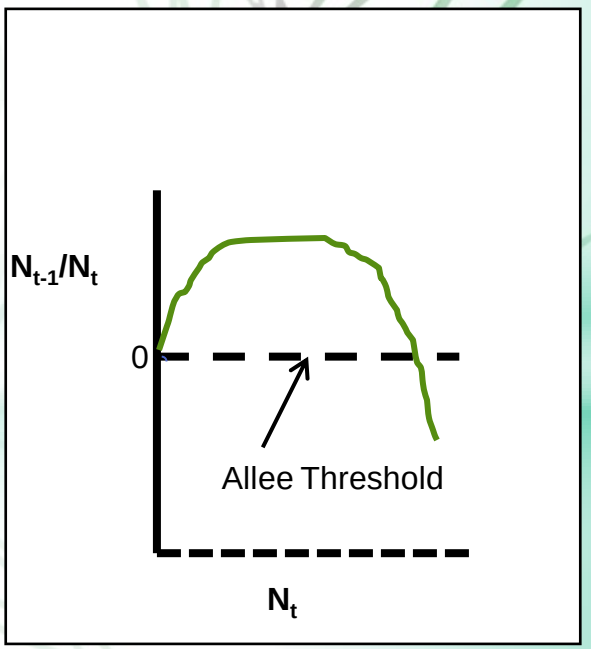
Individuals within a species generally require the assistance of others for more than simple reproductive reasons in order to persist. The level at which this happens is termed the **Allee Threshold**.

Applying the **Allee** population dynamics to pest control, means that not every individual in the pest population has to be killed in order to achieve eradication of the pest population.

Control / Eradication of OPM & HCLM in the UK?

All pest populations require a minimum number of individuals in order to be viable and therefore it follows if a pest control programme can drive the population below this Allee threshold, eradication of the pest is possible without having to track down and kill every last individual.

A strong Allee effect where the change in population density N_{t+1}/N_t is plotted against the initial population N_t. (Source; Suckling *et al*. 2012)



Control / Eradication of OPM & HCLM in the UK?

Given the relatively low OPM population levels in London and Pangbourne it might be possible to eradicate this pest using a process that would drive the population levels below the Allee threshold and effectively eradicate it.

The **Allee effect** can be achieved using an IPM approach and a discussion of these can be found in:

Suckling, D M, Tobin, P C, McCullough, D M and Herms, DA (2012): *Combining Tactics to Exploit Allee Effects for Eradication of Alien Insect Populations*. Journal of Economic Entomology 105 (1): 1-13.

Eradication of HCLM is not really possible given the severity of the outbreak in Britain; but control is possible by treating high value amenity trees and in the longer term combining this with biological controls in the wider environment.

Control / Eradication of OPM & HCLM in the UK?

Allee Implementation in SLAM (Slow Ash Mortality)[1]

An evaluation of the potential of a recently developed systemic insecticide to protect ash trees in the urban population as a component of the SLAM approach. Over a 10 year time period, the simulations showed that the survival of ash was variable and depended on:

(1) how soon the insecticide treatment began after EAB was detected;
(2) the proportion of trees treated; and
(3) the distribution of treated trees relative to the location where EAB was introduced.

It was found that by treating **20%** of ash trees each year, this protected **99%** of the ash trees annually over 10 years. Significantly the cumulative costs of pesticide treatment were significantly lower than the cost of removing dead or declining trees.

The effects of treating 20% of the ash trees with insecticide had the effect of driving the EAB population below the Allee threshold such that it was effectively eradicated

[1]McCullough, D & R Mercader (2012) Int. J. Pest Management 58: 9-23

Control / Eradication of Tree Pests?

<u>Two Success Stories</u>: One in England the Other in the USA

In 2012 a breeding population of *Anoplophora glabripennis* (ALB) was found near Maidstone, Kent, England.

Rapid action by the authorities involved the survey of 4,700 potential host trees and the removal of 2,166 trees

66 trees were infected

No other trees have been detected since then

The discovery was made before the adult ALB emergence period

www.forestry.gov.uk

Control / Eradication of Tree Pests?

Boston, USA

Anoplophora glabripennis (ALB) was recorded in Worcester, Massachusetts in 2008 and 34,000 trees were destroyed

In 2010 ALB was discovered in the grounds of the Faulkner Hospital opposite the Arnold Arboretum in Boston posing a severe threat to the collection and other trees in the area

Using the Allee approach; injecting strategic trees with Revive and selective tree removal; ALB was declared eradicated in May 2014

www.news.harvard.edu/gazette/story/2014/05/beating-the-beetles

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