**WHITE** PAPER

# POLLINATORS, PESTICIDES AND PARASITES

## Background

Pollinating insects play a key role in agricultural productivity [1] [2] and maintenance of ecosystems [3] [4]. They therefore significantly contribute in maintaining both food security and biodiversity. In ecological terms, 80% of wild plant species around the world need pollinating insects in order to achieve their sexual reproduction [5]. Overall, pollinating insects are involved in 75% of the crop production directly intended for human consumption [2] and out of the 57 leading crops in food production, about 42% are pollinated by wild bees [2]. Unfortunately, the last decades have presented some concerning challenges. Indeed, many recent alarming reports reveal global pollinator decline [5] [6] [7] while the demand for pollination services is continuously increasing [2] [8].

Many theories have emerged to try to explain this decline, but the ones attracting the most attention are pesticide use and parasitisation. The correlation between the increase in use of pesticides and the decrease of pollinators around the world has aroused the curiosity of scientists around the world. Whereas, in theory, only specific pests should be targeted, in the field it seems that non-target organisms such as pollinators can also be exposed to these compounds by foraging pollen and nectar on treated crops. Co-evolution is driving insect host-parasite systems and to defend against the parasite, hosts activate their immune system. This outcome is costly and may not be supported at the same time as other necessary and demanding activities (e.g. foraging, nursing, comb building).

www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.
Pub 04/17

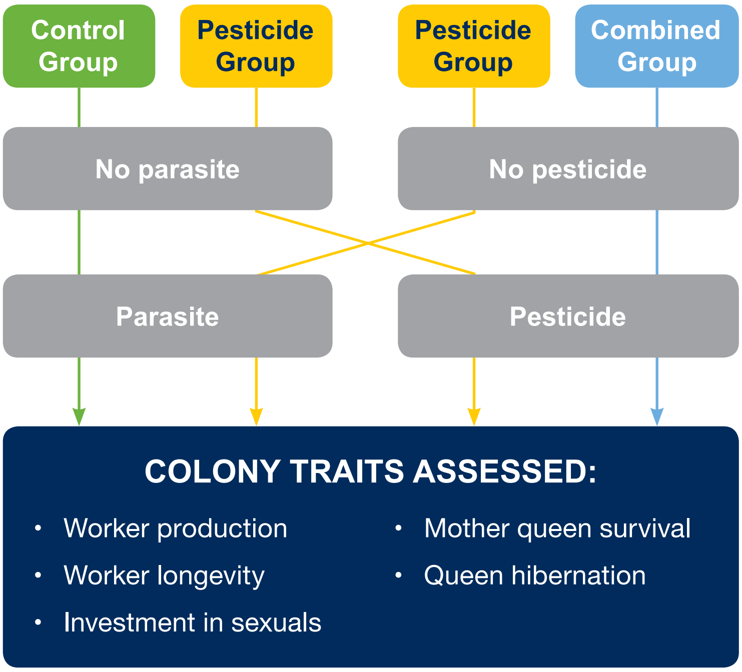
## Challenges

Most of the recent research concerning pollinator decline only assess one environmental stress factor at a time. This is highly unrealistic, as in the field, insects must deal with a combination of two or more stressors. There is a lack of knowledge on combined effects of different environmental stressors on pollinating insects and particularly on wild pollinators. Therefore, in order to better understand wild pollinator and general pollinator decline mechanisms and to help halt biodiversity losses, this research aims to identify the effects that parasites alone, pesticides alone or a combination of both factors could have on different important bumblebee traits.

## Assay

The *Bombus terrestris-Crithidia bombi*-Neonicotinoids model was used in fully crossed experimental designs in order to fill in the gaps concerning the effects of different stressors on pollinator decline. *Crithidia bombi* is a trypanosome infecting the gut cells. This organism is highly prevalent and occurs in 47.5% of the spring queens and in up to 80% of workers. The neonicotinoids used in these assays are systemic in the plant and generally co-occur in nectar and pollen of treated crops.

Because they are non-dissociable, it was decided to use them simultaneously with applied concentrations corresponding to environmentally relevant residue levels. The impact of these two stressors was assessed on various crucial traits: weekly worker production, workers' longevity, investment in sexual individuals, mother queens' survival and queen hibernation.




www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.

Pub 04/17

## Results

While parasitization alone did not result in measurable effects, chronic dietary exposure to field-realistic trace residues of the neonicotinoids from an early stage of colony development truncated worker production, decreased worker longevity, and severely reduced investment into sexual offspring, with a population loss of about 43% male and 77% female. A significant interaction between neonicotinoid exposure and parasite infection on mother queen survival was observed. Further, both stressors reduce the hibernation success of bumblebees at different times. While the impact of pesticides occurs at an early stage during hibernation, the effects of the parasite infection only appear later. When both factors are present, the early pesticide effects mask the parasite effects.

The premature death of workers could affect the proper functioning of the entire colony. The decrease of male and gyne (reproducing females expected to be queens) production leads to less choice during mating and a decrease in population for the coming season. More importantly, the colony success relies entirely on the mother queen's fate and new queen's hibernation success, both affected by the two stressors.

The results clearly indicate detrimental long-term impacts of combined exposure to pesticides and parasites on local bumble bee populations by affecting different important traits of the bumblebee life cycle.

More details can be found in following papers:

Fauser-Misslin, A., Sadd, B. M., Neumann, P. And Sandrock, C. (2013) Influence of combined pesticide and parasite exposure on bumblebee colony traits in the laboratory. *Journal of applied ecology*, 51, 450-459.

http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12188/abstract

Fauser, A, Sandrock, C, Neumann, P & Sadd, B.M. (accepted) Neonicotinoids override a parasite exposure impact on hibernation success of a key bumblebee pollinator. Ecological Entomology

http://onlinelibrary.wiley.com/doi/10.1111/een.12385/full

www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

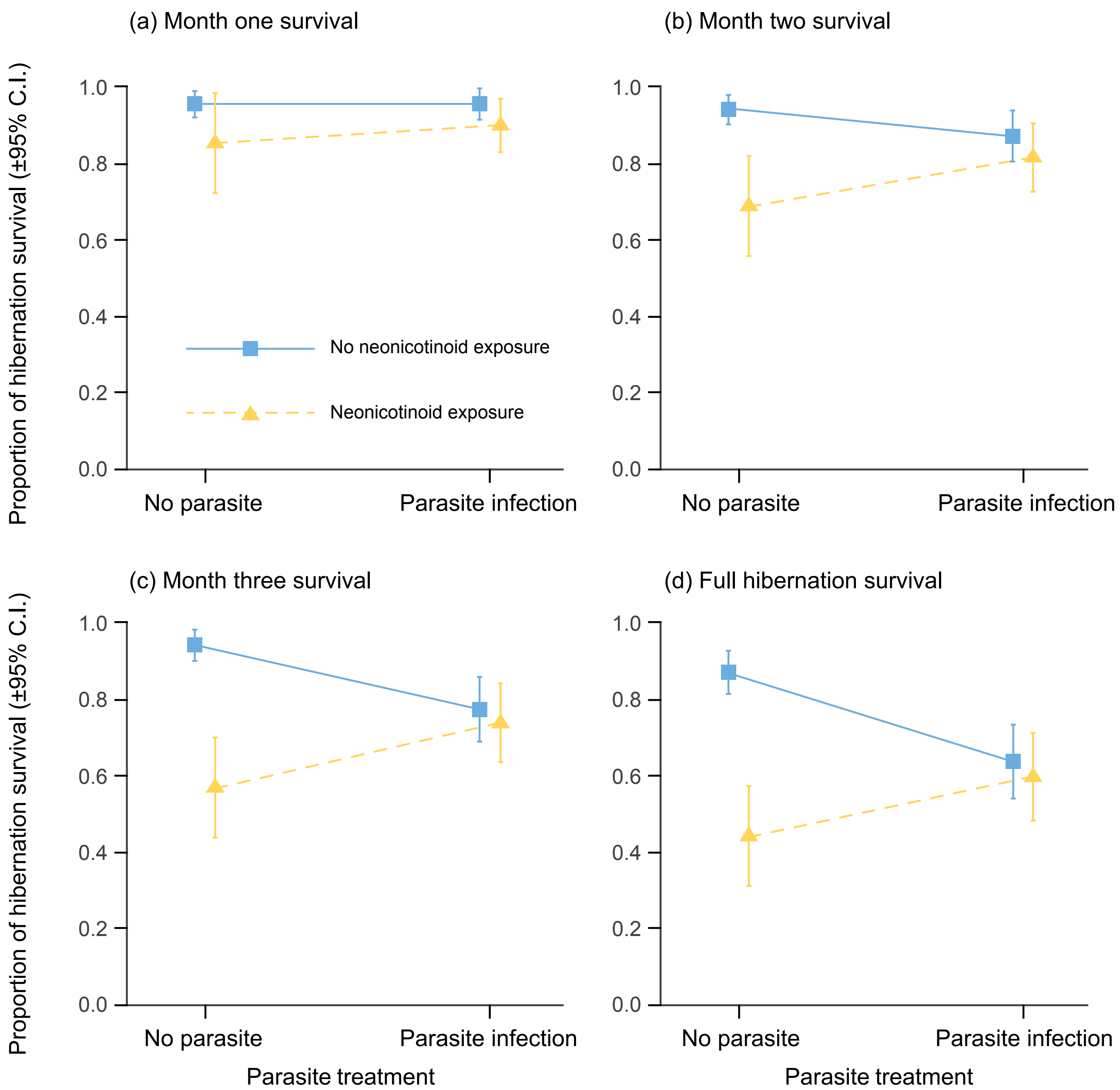
Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.

Pub 04/17




## Hibernation survival:

Proportion of surviving *Bombus terrestris* queens after 1 (a), 2 (b), 3 (c) and 4 months (d) of experimental hibernation depending on infection with the trypanosome parasite *Crithidia bombi* and/or exposure to neonicotinoid pesticides prior to hibernation. Plotted values are from the raw data (controls, n = 140; parasite-exposed, n = 95; neonicotinoid-exposed, n = 55; double-exposed, n = 71), although average marginal predicted probabilities from the fitted models (see text) show close agreement. Error bars represent 95% confidence intervals (CIs) based on a binomial distribution.

www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

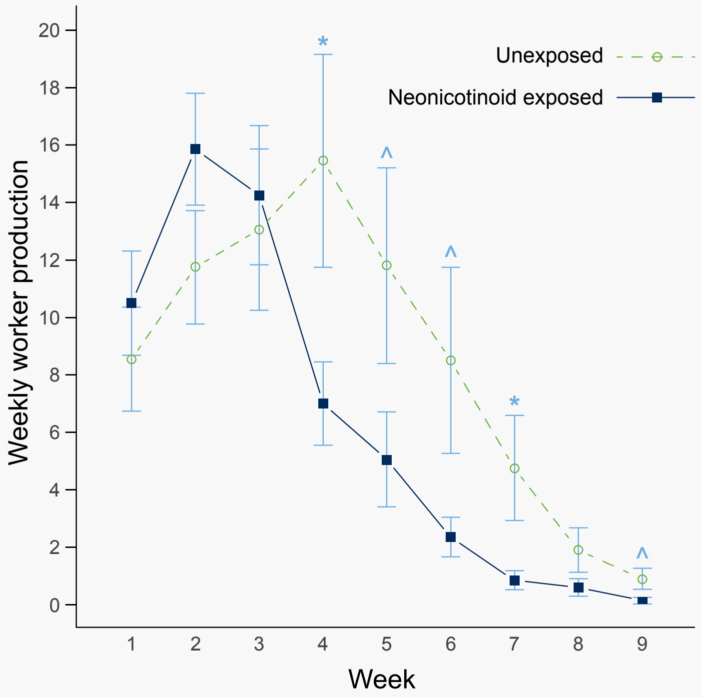
Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.

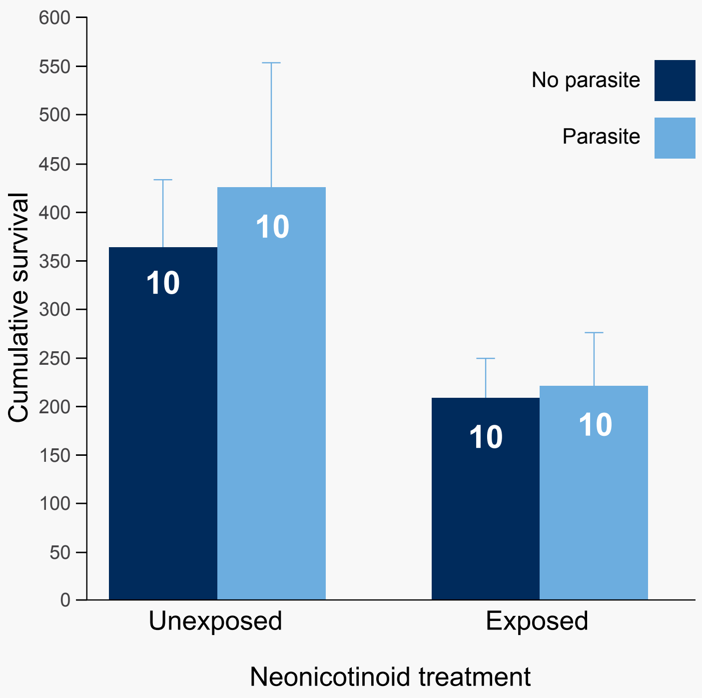
## Weekly worker production:

Chronic dietary neonicotinoid exposure and weekly production of workers of all colonies across the 9 weeks of worker production after initiation of the experiment. Independent of parasite infection (see Results), dashed lines and open symbols represent non-exposed colonies (n = 20), while solid lines and filled symbols represent exposed colonies (n = 20). Points show mean numbers (±SE) of produced workers. Symbols above bars represent the results of individual post hoc t-tests for each time point (*P < 0·05; ^0·05 < P < 0·1).




## Investment in sexuals:

Colony investment into sexual offspring in relation to corresponding neonicotinoid and parasite (*Crithidia bombi*) treatments. To account for the greater cost of producing gynes, colony reproductive investment was calculated as the number of male offspring plus two times the number of gynes. Bars represent treatment means (+SE). Numbers inside the bars represent the number of colonies within each treatment group.






**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

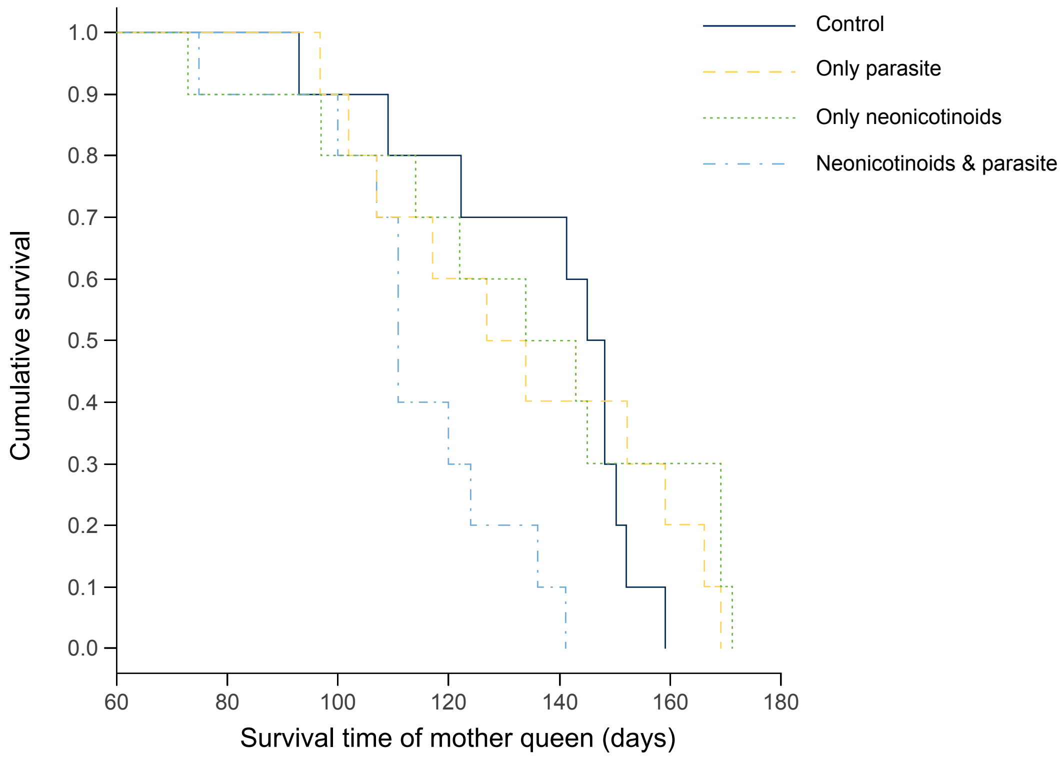
Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.

Pub 04/17




## Mother queen survival:

Cumulative survivorship of mother queens across the different treatment groups

(n = 10 for each line). The x-axis is truncated as all mother queens survived the first 60-day period following the initiation of the experiment.

## About Smithers Viscient:

**Smithers Viscient performs environmental and consumer safety contract research and regulatory services for the crop protection, pharmaceutical, industrial chemical and consumer product industries and has performed standard guideline and higher-tiered environmental studies for over 45 years.**

We conduct studies that satisfy all global regulatory requirements. Smithers Viscient is a leader that delivers trusted testing services. Service offerings include: Environmental fate, Plant metabolism, Aquatic ecotoxicology, Avian toxicology, Honeybee and pollinator testing, Residue, analytical and product chemistry, Endocrine disruptor testing and Toxicology services.

For more information on Pollinator services **click here** or contact us on

**+44 (0) 1423 532 710** or email **info@smithersviscient.com**

linkedin.com/company/smithers-viscient

twitter.com/Viscient

www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172

© 2017 Smithers Viscient. All rights reserved.

Pub 04/17

## References


[1] Garibaldi, L.A., Aizen, M.A., Klein, A.M., Cunningham, S.A., & Harder, L.D. (2011) Global growth and stability of agricultural yield decrease with pollinator dependence. *P Natl Acad Sci USA*, **108**, 5909-5914.

[2] Klein, A.M., Vaissière, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., & Tscharntke, T. (2007) Importance of pollinators in changing landscapes for world crops. *P Roy Soc B-Biol Sci*, **274**, 303-313.

[3] Bascompte, J., Jordano, P., & Olesen, J.M. (2006) Asymmetric coevolutionary networks facilitate biodiversity maintenance. *Science*, **312**, 431-433.

[4] Fontaine, C., Dajoz, I., Meriguet, J., & Loreau, M. (2006) Functional diversity of plant-pollinator interaction webs enhances the persistence of plant communities. *PLoS Biol*, **4**, e1.

[5] Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W.E. (2010) Global pollinator declines: trends, impacts and drivers. *Trends Ecol Evol*, **25**, 345-353.

[6] Biesmeijer, J.C., Roberts, S.P.M., Reemer, M., Ohlemuller, R., Edwards, M., Peeters, T., Schaffers, A.P., Potts, S.G., Kleukers, R., Thomas, C.D., Settele, J., & Kunin, W.E. (2006) Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science*, **313**, 351-354.

[7] Cameron, S.A., Lozier, J.D., Strange, J.P., Koch, J.B., Cordes, N., Solter, L.F., & Griswold, T.L. (2011) Patterns of widespread decline in North American bumble bees. *P Natl Acad Sci USA*, **108**, 662-7.

[8] Aizen, M.A., Garibaldi, L.A., Cunningham, S.A., & Klein, A.M. (2009) How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. *Ann Bot*, **103**, 1579-88.

[9] Moret,Y et Schmid-Hempel,P. (2009) Immune responses of bumblebee workers as a function of individual and colony age: senescence versus plastic adjustment of the immune function. *Oikos*, **118**, 371-378.


### About Dr. Aline Fauser:

Dr. Aline Fauser is an accomplished beekeeper and ecotoxicology study director with specialty expertise in laboratory, field and semi-field studies involving both *Apis* and *non-Apis* bees. Aline has spent several years working in Contract Research Organisations responsible for performing and reporting GLP studies of plant protection products and their impact on beneficial arthropods, soil organisms and non-target plants. Aline at al., have published the articles: Influence of Combined Pesticide and Parasite Exposure on Bumblebee Colony Traits in the Laboratory in the Journal of Applied Ecology – 2013 and Neonicotinoids override a parasite exposure impact on hibernation success of a key bumblebee pollinator in Ecological Entomology -2017. She received her Ph.D. in Ecology and Evolution from the University of Bern in Switzerland.


www.smithersviscient.com
info@smithersviscient.com

**Smithers Viscient Europe**
Harrogate, United Kingdom
Tel: +44 (0) 1423 532 710

**Smithers Viscient North America**
Wareham, Massachusetts, United States
Tel: +1 508 295 2550

Snow Camp, North Carolina, United States
Tel: +1 336 376 0141

Fresno, California, United States
Tel: +1 508 295 2550

**Smithers Viscient Asia**
Tokyo, Japan
Tel: +81 (0) 425 191 172


© 2017 Smithers Viscient. All rights reserved.

Pub 04/17