Symposium on Impacts of and Alternatives to Systemic Pesticides: A Science-Policy Forum

With Philippine and International Researchers

June 15, 2016

Yuchengco Hall, De La Salle University (DLSU)
Taft, Manila

7:30 AM TO 5:30 PM

Registration Fee: P500.00 (LUNCH INCLUDED)

Salikneta Farm

De La Salle Araneta University

De La Salle University, Taft

IUCN

SSC Species Survival Commission

CEM

Triodos Foundation

Department of Environment and Natural Resources

Family Life and Wellness Institute

WELCOME

It is a great pleasure to welcome you to today's symposium on the Impacts of and Alternatives to Systemic Pesticides, organized by the De La Salle University Taft, De La Salle Araneta University, DLS-Family Life and Wellness Institute, and the Task Force on Systemic Pesticides. In fact, it should have not been me, but Prof. Florencia Claveria, Chair and Organizer of the symposium, standing here. Totally unexpected medical reasons, from which she is now fastly recovering, prevented her to be here today.

On the basis of the Worldwide Integrated Assessment of the Impact of Systemic Pesticides on Biodiversity and Ecosystems, now internationally known and acclaimed as W.I.A., the Governor of the Province of Marinduque, in order to protect its internationally famed butterfly industry, declared as first administrative entity in the world that in future use, import and sale of neonicotinoid pesticides and Fipronil would be banned. Now, after last month's elections, the implementation of this ruling is urgently awaited. Meanwhile the Canadian Provinces of Ontario and Quebec have adopted similar legislation.

New regulations are extremely important, notably in the growing of rice, but also in many other crops. Three are – as far as it is known – are presently registered in the Philippines. Further knowledge is needed is needed on their effects (especially on soil and aquatic biodiversity, but also on public health) and on the further development of alternatives, such as biological control in Integrated Pest Management.

Today's symposium brings together scientists from the Philippines, Australia, Asia and Europe, as well as policy-makers, members of the agriculture communities, and non-governmental organizations. Scientists speaking today include visiting members of the International Task Force on Systemic Pesticides (TFSP), whose groundbreaking research on neonicotinoid insecticides is helping educate policy-makers on the impacts of systemic pesticides and the need for alternatives.

I would like to thank my co-chair Dr.Patricia C. Sison, Dr. Florencia Claveria, Dr. Mary-Jane Cruz-Flores and all staff of the Biology Science Dept. of the De La Salle University Taft and DLS-Family Life and Wellness Institute. I also thank Dr. Maarten Bijleveld van Lexmond of the TFSP. Funding and in-kind support have been provided by the De La Salle University , DLS Family Life and Wellness

Institute, the Triodos Foundation of The Netherlands, and Department of Environment and Natural Resources(DENR).

Thank you for attending our symposium today!

Elizabeth Lumawig-Heitzmann

Symposium on Impacts of and Alternatives to Systemic Pesticides:

A Science –Policy Forum

with Philippine and International Researchers

15th June 2016

De La Salle University, Taft Avenue, Manila, Philippines

7:30 **Registration**

8:45 **Opening Ceremony**

Singing of the Philippine National Anthem

Message from Symposium Chair:
Ms. Elizabeth Lumawig-Heitzmann, Hon. Sec. of TFSP Public Health Working Group

9:00 **Welcome Message**
Dr. Jose Santos Carandang VI,
Dean, College of Sciences, De La Salle University, Taft Avenue, Manila, Philippines

Guest and Inspirational Speaker
Dr. Mina Ramirez
President, Asian Social Institute, Philippines.

Session 1: Scientific knowledge available

Moderators: Dr. Noel F. Alfonso, Faculty, Biology Department, De La Salle University, Philippines
Dr. Theresa Mundita Lim, Director, Biodiversity Management Bureau, DENR, Philippines
Dr. Rodel D. Lasco, Senior NRM Scientist, World Agroforestry Centre, ICRAF, Philippines

9:30 **Systemic Pesticides and TFSP, a historical perspective**
Dr. Maarten Bijleveld van Lexmond, Chairman Task Force on Systemic Pesticides – TFSP, Neuchâtel, Switzerland.

9:45 **Biodiversity and food production are threatened by neonicotinoids: The Worldwide Integrated assessment on systemic pesticides**
Dr. Jean-Marc Bonmatin, Deputy Chairman TFSP, Centre National de la Recherche Scientifique, Center for Molecular Biophysics, Orléans, France.

10:10 **Systemic Pesticides in aquatic environments and implications for the large ecosystems**
Dr. Francisco Sanchez-Bayo, Faculty of Agriculture & Environment,
The University of Sydney, Australia.

Coffee break
11.35 – 11.00

11:00 **Ecosystem Approach in Mitigating Bee Decline in the Philippines**
Dr. Cleofas R. Cervancia, Pr. Emeritus, President Apimondia Regional Commission for Asia,
Institute of Biological Sciences, University of the Philippines, Los Banos, Philippines.

11:25 **Usage of Systemic Pesticides in the Philippines (with Video Film)**
Ms. Elizabeth Lumawig-Heitzmann, Hon.Secretary TFSP Public Health Working Group
Marinduque Biological Field Station, Philippines.

11:45 **Human Health Impacts of Exposure to Neonicotinoid Insecticides: Recent Memory Loss and Human Neonicotinoid Symptoms**
Dr. Kumiko Taira, Chair TFSP Public Health Working Group
Tokyo Women's Medical University, Japan.

12:15 **Open Forum**

Lunch Break
12:45 – 13:45

Session 2: Post-Neonicotinoids: The Alternatives

Moderators: Dr. Cleofas Cervancia, University of the Philippines, Los Banos, Laguna, Philippines.
Dr. Patricia Sison, President, DLS-Family Life Wellness Institute, Ayala Alabang Muntinlupa City, Philippines. Symposium-Co-chair

13:45 **European Academies Science Advisory Council (EASAC) Work on Neonicotinoids**
Dr. Michael Norton, EASAC Environment Program Director
Tokyo Institute of Technology, Tokyo, Japan

14:05 **IPM and protection of growers by a Mutual Insurance against pitfalls: Powerful alternatives to neonicotinoids in Arable Crops**
Dr. Lorenzo Furlan, Chairman TFSP Working group on alternatives, Veneto Agricultura, Centre for Agricultural Research in Cooperation with the University of Padua, Italy.

14:30 **Ecological engineering - a strategy for rice production without neonicotinoids in Asia**
Dr. Kong Luen Heong, Qiushi Chair Professor, Zhejiang University, Hangzhou, China; Former Principal Scientist, International Rice Research Institute, Los Banos, Philippines.

14:55 **New avenues for neonicotinoid-free agriculture in the Philippines through Organic Agriculture in the Philippines through Organic Agriculture and IPM**
Dr. Raymundo Lucero, University of the Philippines Open University, Los Banos.
Dr. Charito Medina, MASIPAG (NGO), Organic Agriculture Council of the Philippines, Biology Department, De La Salle University, Taft, Manila.

Tea break

15:20 -15:50

15:50 **Use or non-use of systemic pesticides in the framework of IPM and in general.**
Dr. Jean-Marc Bonmatin, Deputy Chairman TFSP, Centre National de la Recherche Scientifique, Center for Molecular Biophysics, Orléans, France.

16:05 **Conservation of *Comperiella calauanica*, a parasitoid of coconut scale insect, *Aspidiotus rigidus***
Dr. Divina Amalin, Dr. Jose Santos Carandang VI, Mr. Billy Almarinez, MS
Biology Department, College of Science, De La Salle University, Taft, Manila, Philippines.

16:30 **Open Forum**

17:15 Dr. Maarten Bijleveld van Lexmond. Closing remarks

Closure of the symposium

Master of Ceremony: **Dr. Patricia Sison,** President, DLS-Famiy Life and Wellness Institute
Symposium Co-Chair

AN INTRODUCTION
TO THE TASK FORCE ON SYSTEMIC PESTICIDES (TFSP)

www.tfsp.info

The Task Force on Systemic Pesticides is an independent group of scientists from all over the globe, who came together to work on the Worldwide Integrated Assessment of the Impact of Systemic Pesticides on Biodiversity and Ecosystems.

The mandate of the Task Force on Systemic Pesticides (TFSP) has been "*to carry out a comprehensive, objective, scientific review and assessment of the impact of systemic pesticides on biodiversity, and on the basis of the results of this review to make any recommendations that might be needed with regard to risk management procedures, governmental approval of new pesticides, and any other relevant issues that should be brought to the attention of decision makers, policy developers and society in general.*"

The Task Force has adopted a science-based approach and aims to promote better informed, evidence-based, decision-making. The method followed is Integrated Assessment (IA) which aims to provide policy-relevant but not policy-prescriptive information on key aspects of the issue at hand. To this end a highly multidisciplinary team of 30 scientists from all over the globe jointly made a synthesis of 1,121 published peer-reviewed studies spanning the last five years, including industry-sponsored ones. All publications of the TFSP have been subject to the standard scientific peer review procedures of the journal (http://www.springer.com/environment/journal/11356).

Key findings of the Task Force have been presented in a special issue of the peer reviewed Springer journal "Environmental Science and Pollution Research" entitled "Worldwide Integrated Assessment of the Impacts of Systemic Pesticides on Biodiversity and Ecosystems" and consists of eight scientific papers, reproduced here with permission of Springer.

In summary the TFSP's scientific assessment indicates that the current large-scale prophylactic use of systemic insecticides is having significant unintended negative ecological consequences. The evidence indicates that levels of systemic pesticides that have been documented in the environment are sufficient to cause adverse impacts on a wide range of non-target organisms in terrestrial, aquatic, wetland, marine and benthic habitats. There is also a growing body of evidence that these effects pose risks to ecosystem functioning, resilience and services such as for example pollination and nutrient cycling.

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EDITORIAL

Worldwide integrated assessment on systemic pesticides

Global collapse of the entomofauna: exploring the role of systemic insecticides

Maarten Bijleveld van Lexmond · Jean-Marc Bonmatin · Dave Goulson · Dominique A. Noome

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The appeal of Notre Dame de Londres

In July 2009, a group of entomologists and ornithologists met at Notre Dame de Londres, a small village in the French department of Hérault, as a result of an international enquiry amongst entomologists on the catastrophic decline of insects (and arthropods in general) all over Europe.

They noted that a perceptible and gradual decline of insects, as part of the general impoverishment of the natural environment, had set in from the 1950s onwards. Amongst many others, they recognized as root causes of this decline the intensification of agriculture with its accompanying loss of natural habitats and massive use of pesticides and herbicides, the manifold increase in roads and motorized traffic as well as a continent-wide nocturnal light pollution and nitrogen deposition.

They equally agreed that a further degradation of the situation, a steeper decline in insect populations, had started in the decade 1990–2000. This first began in western Europe, followed by eastern and southern Europe, is nowadays apparent in the scarcity of insects splattered on windscreens of motorcars and squashed against their radiators and is best documented in the decline of butterflies and the global disorders amongst honey bees. They concluded that these phenomena reflected the now general collapse of Europe's entomofauna.

They also noted that the massive collapse of different species, genera and families of arthropods coincided with the severe decline of populations of different insectivorous bird species up to now considered as "common" such as swallows and starlings.

On the basis of existing studies and numerous observations in the field as well as overwhelming circumstantial evidence, they came to the hypothesis that the new generation of pesticides, the persistent, systemic and neurotoxic neonicotinoids and fipronil, introduced in the early 1990s, are likely to be responsible at least in part for these declines.

They, therefore, issued the Appeal of Notre Dame de Londres under the heading "No Silent Spring again" referring to Rachel Carson's book "Silent Spring" then published almost half a century ago:

> The disappearance of honey bees is only the most visible part of a phenomenon now generalized in all of Western Europe. The brutal and recent collapse of insect populations is the prelude of a massive loss in biodiversity with foreseeable dramatic consequences for natural ecosytems, the human environment and public health.
> The systematic use of persistent neurotoxic insecticides in intensive agriculture and horticulture (neonicotinoids such as imidacloprid and thiamethoxam, and fipronil as

Responsible editor: Philippe Garrigues

M. B. van Lexmond · D. A. Noome
Task Force on Systemic Pesticides, Pertuis-du-Sault, 2000 Neuchâtel, Switzerland

M. B. van Lexmond
e-mail: mbvl@club-internet.fr

D. A. Noome
e-mail: dominiquenoome@gmail.com

J.-M. Bonmatin (✉)
Centre National de la Recherche Scientifique, Centre de Biophysique Moléculaire, rue Charles Sadron, 45071 Orléans Cedex 02, France
e-mail: bonmatin@cnrs-orleans.fr

D. Goulson
School of Life Sciences, University of Sussex, Brighton BN1 9QG, UK
e-mail: d.goulson@sussex.ac.uk

D. A. Noome
Kasungu National Park, c/o Lifupa Conservation Lodge, Private Bag 151, Lilongwe, Malawi

a phenylpyrazole), which now form an invisible, widespread, toxic haze on land, in water and in the air, is regarded as a principal cause of this collapse observed by entomologists beginning in the middle of the 1990's and followed by the decline of insectivorous and other bird species by the ornithologists.

For this reason the undersigned raise an alarm and demand a much stricter adherence to the « Precautionary Principle » as enshrined in the E.U. Commission's Directive 91/414, and defined by UNESCO in 2005 as « When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm ».

The international scientific Task Force on Systemic Pesticides (TFSP)

In response, an international scientific Task Force on Systemic Pesticides of independent scientists was set up shortly afterwards by a Steering Committee of which Maarten Bijleveld van Lexmond (Switzerland), Pierre Goeldlin de Tiefenau (Switzerland), François Ramade (France) and Jeroen van der Sluijs (The Nederlands) were the first members. Over the years, membership grew and today counts 15 nationalities in four continents. The Task Force on Systemic Pesticides (TFSP) advises as a specialist group two IUCN Commissions, the *Commission on Ecosystem Management* and the *Species Survival Commission*. Its work has been noted by the *Subsidiary Body on Scientific, Technical and Technological Advice* under the Convention on Biodiversity (CBD) and was brought to the attention of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in the context of the fast-track thematic assessment of pollinators, pollination and food production.

In undertaking the Worldwide Integrated Assessment (WIA), over the course of the last 4 years, the TFSP has examined over 800 scientific peer-reviewed papers published over the past two decades. The TFSP areas of expertise span diverse disciplines, including chemistry, physics, biology, entomology, agronomy, zoology, risk assessment and (eco) toxicology, and this has enabled a truly interdisciplinary evaluation of the evidence, necessary to understand the diverse ramifications of the global use of systemic pesticides on individual organisms, on ecosystems and on ecosystem processes and services.

The findings of the TFSP-WIA

Neonicotinoids were introduced in the early 1990s and are now the most widely used insecticides in the world. They are neurotoxins, binding to nicotinic acetylcholine receptors (nAChRs) in the central nervous system and causing nervous stimulation at low concentrations but receptor blockage, paralysis and death at higher concentrations. Fipronil is another widely used systemic insecticide that shares many of the properties of neonicotinoids and was introduced around the same time; hence, this compound is also included here. Both neonicotinoids and fipronil exhibit extremely high toxicity to most arthropods and a lower toxicity to vertebrates (although fipronil exhibits high acute toxicity to fish and some bird species). They are relatively water soluble and are readily taken up by plant roots or leaves, so they can be applied in a variety of ways (e.g. foliar spray, soil drench and seed dressing). The predominant use of these chemicals, in terms of the area of land over which they are used, is as a seed dressing, whereby the active ingredient is applied prophylactically to seeds before sowing and is then absorbed by the growing plant and spreads throughout the plant tissues, hence protecting all parts of the crop (Simon-Delso et al. 2014).

A range of concerns have emerged as to the impacts of neonicotinoids and fipronil on the environment (Bonmatin et al. 2014; Pisa et al. 2014; Gibbons et al. 2014; Chagnon et al. 2014; Furlan and Kreutzweiser 2014):

- It has become apparent that neonicotinoids can persist for years in soils and so cause environmental concentrations to build up if regularly used. This is likely to be impacting substantially on soil invertebrates, which as a group perform a vital service in maintaining soil structure and in cycling nutrients. Being water soluble, neonicotinoids leach into ponds, ditches and streams and contaminate groundwater. Contamination of marine environments has been observed but as yet has not been monitored systematically. Concentrations exceeding the LC_{50} for aquatic insects frequently occur in waterways, and much higher concentrations have been found in surface water in arable fields and in adjacent ditches. Waterways with higher neonicotinoid concentrations have been found to have depleted insect abundance and diversity.
- Dust created during drilling of treated seeds is lethal to flying insects and has caused large-scale acute losses of honeybee colonies. When applied as foliar sprays, drift is likely to be highly toxic to non-target insects. Non-crop plants, such as those growing in field margins, hedgerows and near contaminated waterways can become contaminated with neonicotinoids either via dust created during drilling, spray drift or contaminated water. This provides the potential for major impacts on a broad range of non-target herbivorous invertebrates living in farmland.
- Neonicotinoids and fipronil are found in nectar and pollen of treated crops such as maize, oilseed rape and sunflower and also in flowers of wild plants growing in farmland. They have also been detected at much higher concentrations in

guttation drops exuded by many crops. In bees, consumption of such contaminated food leads to impaired learning and navigation, raised mortality, increased susceptibility to disease via impaired immune system function and reduced fecundity, and in bumblebees, there is clear evidence for colony-level effects. Studies of other pollinators are lacking. Bees in farmland are simultaneously exposed to some dozens of different agrochemicals, and some act synergistically. The impact of chronic exposure of non-target insects to these chemical cocktails is not addressed by regulatory tests and is very poorly understood.

- Although vertebrates are less susceptible than arthropods, consumption of small numbers of dressed seeds offers a potential route for direct mortality in granivorous birds and mammals, for such birds need to eat only a few spilt seeds to receive a lethal dose. Lower doses lead to a range of symptoms including lethargy, reduced fecundity and impaired immune function. In addition, depletion of invertebrate food supplies is likely to indirectly impact on a broad range of predatory organisms, from arthropods to vertebrates.
- The prophylactic use of broad-spectrum pesticides (as seed dressings) goes against the long-established principles of Integrated Pest Management (IPM) and against new EU directives which make adoption of IPM compulsory. Continual exposure of pests to low concentrations of neonicotinoids is very likely to lead to the evolution of resistance, as has already occurred in several important pest species. Although systemic pesticides can be highly effective at killing pests, there is clear evidence from some farming systems that current neonicotinoid use is unnecessary, providing little or no yield benefit. Agrochemical companies are at present the main source of agronomic advice available for farmers, a situation likely to lead to overuse and inappropriate use of pesticides.

Overall, a compelling body of evidence has accumulated that clearly demonstrates that the wide-scale use of these persistent, water-soluble chemicals is having widespread, chronic impacts upon global biodiversity and is likely to be having major negative effects on ecosystem services such as pollination that are vital to food security and sustainable development. There is an urgent need to reduce the use of these chemicals and to switch to sustainable methods of food production and pest control that do not further reduce global biodiversity and that do not undermine the ecosystem services upon which we all depend (van der Sluijs et al. 2014).

The systemic insecticides, neonicotinoids and fipronil, represent a new chapter in the apparent shortcomings of the regulatory pesticide review and approval process that do not fully consider the risks posed by large-scale applications of broad-spectrum insecticides to ecosystem functioning and services. Our inability to learn from past mistakes is remarkable.

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The authors are listed in alphabetic order.

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Dr Maarten Bijleveld van Lexmond is a biologist and conservationist by training. He studied at Leiden and Amsterdam Universities obtaining his PhD. in 1974 with the publication of his first book: Birds of Prey in Europe. As one of the founders of the World Wildlife Fund in the Netherlands he joined the WWF international secretariat in Switzerland and later led the Commission on Ecology of the International Union for the Conservation of Nature (IUCN). In the mid-eighties he founded the Swiss Tropical Gardens in Neuchâtel, now in Kerzers (Switzerland), in parallel with the Shipstern Nature Reserve in Belize, Central America. For many years he also served as President of the Foundation for the Conservation of the Bearded Vulture which succeeded in reintroducing the species into the Alps and other parts of Europe. At present, dividing his time between Switzerland and the south of France most of it since 2009 is taken up by his function as Chairman of the international Task Force on Systemic Pesticides (TFSP) which now looks into the worldwide impact of these chemicals on biodiversity and ecosystems, and in particular on pollinators such as honey bees, bumble bees, butterflies, but also at suspected consequences for public health.

Dr Jean-Marc Bonmatin is researcher for the Centre National de la Recherche Scientifique (CNRS, France). He completed his thesis in 1987 at the University of Bordeaux (Chemistry and Physics) by studying interaction mechanisms between biological membranes and peptides by various spectroscopic techniques. This was his first scientific contact with the fascinating world of bees because these peptides have included bee venom. Just after, he worked for the National Research Council of Canada (Ottawa, Canada) until 1989. Here he was interested in dynamics of cholesterol in membranes by solid state NMR. He joined the Centre de Biophysique Moléculaire late 1989 (CBM, CNRS, Orléans, France) where he started his researches on structure-activity relationships of various biomolecules by high resolution NMR. These biomolecules have in common to be toxic to their target (antibacterial, antifungal, neurotoxins from arthropods, etc.). He shares the idea that 'knowing how it kills, gives clues on biological mechanisms and may allow saving'. From 2008 he was involved during twelve years in European programs on what is called the Colony Collapse Disorder (CCD), especially concerning analytics of pesticides in soil, water, pollen and honey, as well as concerning the finding of a virus of bee mites (Varroa destructor). He joined the Task Force on Systemic Pesticides very early and he is a member of its Steering Committee. He is also involved in risk assessments for pollinators for several public organisms, at national and international levels, such as ITSAP (French Institute of Bee and Pollination), ANSES (French Agency of Environmental and Food Safety) and the Organisation for Economic Co-operation and Development (OECD).

Dave Goulson is Professor of Biology at the University of Sussex. He received his bachelor's degree in biology from Oxford University, followed by a doctorate on butterfly ecology at Oxford Brookes University. Subsequently, he lectured in biology for 11 years at the University of Southampton, before moving to Stirling in 2006, and then to Sussex in 2013. Goulson works mainly on the ecology and conservation of bumble bees. He has published more than 200 scientific articles on the ecology and conservation of insects, with a particular focus on bumblebees. He is the author of Bumblebees; Their Behaviour, Ecology and Conservation, published in 2010 by Oxford University Press, and of A Sting in the Tale, a popular science book about bumble bees, published in 2013 by Jonathan Cape. Goulson founded the Bumblebee Conservation Trust in 2006, a UK-based charity which has grown to 8,000 members. For his work on bumblebee conservation he was made BBSRC Social Innovator of the year in 2010, and received the Zoological Society of London's Marsh Award for Conservation Biology in 2013. He was also elected a Fellow of the Royal Society of Edinburgh in 2013.

Dominique Noome MSc is currently project coordinator for the Task Force on Systemic Pesticides and conservation manager in Kasungu National Park, Malawi. Originally a veterinary epidemiologist, she studied the hematology of Kenyan cattle and economic impacts of emerging infectious diseases on livestock in the Netherlands during her MSc. After graduating as an animal health specialist at Wageningen University, she continued as an independent conservation scientist, being involved with the IUCN Commission on Ecosystem Management, and Foundation Chimbo. During this period she first got acquainted with the Task Force on Systemic Pesticides, starting with field work in 2011 which evolved into project coordinator over the years. In Malawi, where she has just concluded writing the general management plan for Kasungu National Park, she is now focused on coordination of research projects identified in the management plan. Her main areas of interest are protected areas management, more specifically wildlife health, law enforcement and strategies for ecosystem restoration. This also extends to systemic pesticide use in African countries, such as Malawi, where many knowledge gaps about the scale of use and associated impact of these substances still exist.

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EDITORIAL

Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning

J. P. van der Sluijs · V. Amaral-Rogers · L. P. Belzunces · M. F. I. J. Bijleveld van Lexmond · J-M. Bonmatin · M. Chagnon · C. A. Downs · L. Furlan · D. W. Gibbons · C. Giorio · V. Girolami · D. Goulson · D. P. Kreutzweiser · C. Krupke · M. Liess · E. Long · M. McField · P. Mineau · E. A. D. Mitchell · C. A. Morrissey · D. A. Noome · L. Pisa · J. Settele · N. Simon-Delso · J. D. Stark · A. Tapparo · H. Van Dyck · J. van Praagh · P. R. Whitehorn · M. Wiemers

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Introduction

The side effects of the current global use of pesticides on wildlife, particularly at higher levels of biological organization: populations, communities and ecosystems, are poorly understood (Köhler and Triebskorn 2013). Here, we focus on one of the problematic groups of agrochemicals, the systemic insecticides fipronil and those of the neonicotinoid family. The increasing global reliance on the partly prophylactic use of these persistent and potent neurotoxic systemic insecticides has raised concerns about their impacts on biodiversity, ecosystem functioning and ecosystem services provided by a wide range of affected species and environments. The present scale of use, combined with the properties of these compounds, has resulted in widespread contamination of agricultural soils, freshwater resources, wetlands, non-target

Responsible editor: Philippe Garrigues

J. P. van der Sluijs (✉) · L. Pisa · N. Simon-Delso
Department of Environmental Sciences, Copernicus Institute, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands
e-mail: jeroen@jvds.nl

V. Amaral-Rogers
Buglife, Bug House, Ham Lane, Orton Waterville, Peterborough PE2 5UU, UK

L. P. Belzunces
INRA, UR 406 Abeilles and Environnement, Laboratoire de Toxicologie Environnementale, Site Agroparc, 84000 Avignon, France

M. F. I. J. Bijleveld van Lexmond
46 Pertuis-du-Sault, 2000 Neuchâtel, Switzerland

J.-M. Bonmatin
Centre National de la Recherche Scientifique, Centre de Biophysique Moléculaire, Rue Charles Sadron, 45071 Orléans Cedex 02, France

M. Chagnon
Département des Sciences Biologiques, Université du Québec À Montréal, Case Postale 8888, Succursale Centre-Ville, Montreal, Québec, Canada H3C 3P8

C. A. Downs
Haereticus Environmental Laboratory, P.O. Box 92, Clifford, VA 24533, USA

L. Furlan
Veneto Agricoltura, Legnaro, PD, Italy

D. W. Gibbons
RSPB Centre for Conservation Science, RSPB, The Lodge, Sandy, Bedfordshire SG19 2DL, UK

C. Giorio
Department of Chemistry, University of Cambridge, Lensfield Road, CB2 1EW Cambridge, UK

V. Girolami
Dipartimento di Agronomia Animali Alimenti Risorse Naturali e Ambiente, Università degli Studi di Padova, Agripolis, viale dell'Università 16, 35020 Legnaro, Padova, Italy

D. Goulson
School of Life Sciences, University of Sussex, Brighton BN1 9RH, UK

vegetation and estuarine and coastal marine systems, which means that many organisms inhabiting these habitats are being repeatedly and chronically exposed to effective concentrations of these insecticides.

Neonicotinoids and fipronil currently account for approximately one third (in monetary terms in 2010) of the world insecticide market (Simon-Delso et al. 2014). They are applied in many ways, including seed coating, bathing, foliar spray applications, soil drench applications and trunk injection. These compounds are used for insect pest management across hundreds of crops in agriculture, horticulture and forestry. They are also widely used to control insect pests and disease vectors of companion animals, livestock and aquaculture and for urban and household insect pest control and timber conservation (Simon-Delso et al. 2014).

Although the market authorization of these systemic insecticides did undergo routine ecological risk assessments, the regulatory framework has failed to assess the individual and joint ecological risks resulting from the widespread and simultaneous use of multiple products with multiple formulations and multiple modes of action. These applications co-occur across hundreds of cropping systems including all of our major agricultural commodities worldwide and on numerous cattle species, companion animals, etc. Also, the ecological risk assessment did not consider the various interactions with other environmental stressors. Once a market authorization is granted, the authorization poses limits to the dose and frequency per allowed application, but no limits are set to the total scale of use of the active ingredients leading to a reduced potential for the recovery of impacted ecosystems from effects. In addition, there has been no assessment of successive neonicotinoid exposure typical in watersheds and resulting in culmination of exposure and effects over time (Liess et al. 2013). The potential interactions between neonicotinoids and fipronil and other pesticide active substances have not been considered either, although additivity and synergisms of toxic mechanisms of action have been documented (Satchivi and Schmitzer 2011; Gewehr 2012; Iwasa et al. 2004).

The Worldwide Integrated Assessment (WIA) presented in the papers in this special issue is the first attempt to synthesize the state of knowledge on the risks to biodiversity and ecosystem functioning posed by the widespread global use of neonicotinoids and fipronil. The WIA is based on the results of over 800 peer-reviewed journal articles published over the past two decades. We assessed respectively the trends, uses, mode of action and metabolites (Simon-Delso et al. 2014); the environmental fate and exposure (Bonmatin et al. 2014); effects on non-target invertebrates (Pisa et al. 2014); direct and indirect effects on vertebrate wildlife (Gibbons et al. 2014); and risks to ecosystem functioning and services (Chagnon et al. 2014) and finally explored sustainable pest management practices that can serve as alternatives to the use of neonicotinoids and fipronil (Furlan and Kreutzweiser 2014).

D. P. Kreutzweiser
Canadian Forest Service, Natural Resources Canada, 1219 Queen Street East, Sault Ste Marie, ON, Canada P6A 2E5

C. Krupke · E. Long
Department of Entomology, Purdue University, West Lafayette, IN 47907-2089, USA

M. Liess
Department of System Ecotoxicology, Helmholtz Centre for Environmental Research - UFZ, 04318 Leipzig, Germany

M. McField
Healthy Reefs for Healthy People Initiative, Smithsonian Institution, Belize City, Belize

P. Mineau
Pierre Mineau Consulting, 124 Creekside Drive, Salt Spring Island V8K 2E4, Canada

E. A. D. Mitchell
Laboratory of Soil Biology, University of Neuchatel, Rue Emile Argand 11, 2000 Neuchatel, Switzerland

E. A. D. Mitchell
Jardin Botanique de Neuchâtel, Chemin du Perthuis-du-Sault 58, 2000 Neuchâtel, Switzerland

C. A. Morrissey
Department of Biology and School of Environment and Sustainability, University of Saskatchewan, 112 Science Place, Saskatoon, SK S7N 5E2, Canada

D. A. Noome
Task Force on Systemic Pesticides, Pertuis-du-Sault, 2000 Neuchâtel, Switzerland

D. A. Noome
Kijani, Kasungu National Park, Private Bag 151, Lilongwe, Malawi

J. Settele · M. Wiemers
Department of Community Ecology, Helmholtz Centre for Environmental Research - UFZ, Theodor-Lieser-Str. 4, 06120 Halle, Germany

J. Settele
iDiv, German Centre for Integrative Biodiversity Research, Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany

N. Simon-Delso
Beekeeping Research and Information Centre (CARI), Place Croix du Sud 4, 1348 Louvain la Neuve, Belgium

Mode of action, environmental fate and exposure

Due to their systemic nature, neonicotinoids and, to a lesser extent, fipronil as well as several of their toxic metabolites are taken up by the roots or leaves and translocated to all parts of the plant, which, in turn, makes the treated plant effectively toxic to insects that are known to have the potential to cause crop damage. Neonicotinoids and fipronil operate by disrupting neural transmission in the central nervous system of organisms. Neonicotinoids bind to the nicotinic acetylcholine receptor, whereas fipronil inhibits the GABA receptor. Both pesticides produce lethal and a wide range of sublethal adverse impacts on invertebrates but also some vertebrates (Simon-Delso et al. 2014 and Gibbons et al. 2014). Most notable is the very high affinity with which neonicotinoid insecticides agonistically bind to the nicotinic acetylcholine receptor (nAChR) such that even low-dose exposure over extended periods of time can culminate into substantial effects (see the literature reviewed by Pisa et al. 2014).

As a result of their extensive use, these substances are found in all environmental media including soil, water and air. Environmental contamination occurs via a number of disparate routes including dust generated during drilling of dressed seeds; contamination and build-up of environmental concentrations after repeated application in arable soils and soil water; run-off into surface and ground waters; uptake of pesticides by non-target plants via their roots followed by translocation to pollen, nectar, guttation fluids, etc.; dust and spray drift deposition on leaves; and wind- and animal-mediated dispersal of contaminated pollen and nectar from treated plants. Persistence in soils, waterways and non-target plants is variable but can be long; for example, the half-lives of neonicotinoids in soils can exceed 1,000 days. Similarly, they can persist in woody plants for periods exceeding 1 year. Breakdown results in toxic metabolites, though concentrations of these in the environment are rarely measured (Bonmatin et al. 2014).

This combination of persistence (over months or years) and solubility in water has led to large-scale contamination of, and the potential for build-up in, soils and sediments (ppb-ppm range), waterways (ground and surface waters in the ppt-ppb range) and treated and non-treated vegetation (ppb-ppm range). Screening of these matrices for pesticides and their metabolites has not been done in a systematic and appropriate way in order to identify both the long-term exposure to low concentrations and the short-term erratic exposure to high concentrations.

However, where environmental samples have been screened, they were commonly found to contain mixtures of pesticides, including neonicotinoids or fipronil (with their toxic metabolites). In addition, samples taken in ground and surface waters have been found to exceed limits based on regulatory ecological threshold values set in different countries in North America and Europe. Overall, there is strong evidence that soils, waterways and plants in agricultural and urban environments and draining areas are contaminated with highly variable environmental concentrations of mixtures of neonicotinoids or fipronil and their metabolites (Bonmatin et al. 2014).

This fate profile provides multiple routes for chronic and multiple acute exposure of non-target organisms. For example, pollinators (including bees) are exposed through at least direct contact with dust during drilling; consumption of pollen, nectar, guttation drops, extra-floral nectaries and honeydew from seed-treated crops; water; and consumption of contaminated pollen and nectar from wild flowers and trees growing near treated crops or contaminated water bodies. Studies of food stores in honeybee colonies from a range of environments worldwide demonstrate that colonies are routinely and chronically exposed to neonicotinoids, fipronil and their metabolites (generally in the 1–100 ppb range), often in combination with other pesticides in which some are known to act synergistically with neonicotinoids. Other non-target organisms, particularly those inhabiting soils and aquatic habitats or herbivorous insects feeding on non-crop plants in farmland, will also inevitably be exposed, although exposure data are generally lacking for these groups (Bonmatin et al. 2014).

Impacts on non-target organisms

Impacts of systemic pesticides on pollinators are of particular concern, as reflected by the large number of studies in this area. In bees, field-realistic exposures in controlled settings have been shown to adversely affect individual navigation, learning, food collection, longevity, resistance to disease and fecundity. For bumblebees, colony-level effects have been clearly demonstrated, with exposed colonies growing more slowly and producing significantly fewer queens (Whitehorn

J. D. Stark
Puyallup Research and Extension Centre, Washington State University, Puyallup, WA 98371, USA

A. Tapparo
Dipartimento di Scienze Chimiche, Università degli Studi di Padova, via Marzolo 1, 35131 Padova, Italy

H. Van Dyck
Behavioural Ecology and Conservation Group, Biodiversity Research Centre, Université Catholique de Louvain (UCL), Croix du Sud 4-5 bte L7.07.04, 1348 Louvain-la-Neuve, Belgium

J. van Praagh
Scientific Advisor, Hassellstr. 23, 29223 Celle, Germany

P. R. Whitehorn
School of Natural Sciences, University of Stirling, Stirling FK9 4LA, UK

J. P. van der Sluijs
Centre for the Study of the Sciences and the Humanities, University of Bergen, Postboks 7805, N-5020 Bergen, Norway

et al. 2012). Limited field studies with free-living bee colonies have largely been inconsistent and proved difficult to perform, often because control colonies invariably become contaminated with neonicotinoids, or there is a lack of replication in the study design, all of which demonstrates the challenges of conducting such a study in the natural environment (Maxim and Van der Sluijs 2013; Pisa et al. 2014).

Other invertebrate groups have received less attention. For almost all insects, the toxicity of these insecticides is very high including many species that are important in biological control of pests. The sensitivity to the toxic effect is less clear with non-insect species. For annelids such as earthworms, the LC_{50} is in the lower ppm range for many neonicotinoids (LOEC at 10 ppb). Crustaceans are generally less sensitive, although sensitivity is highly dependent on species and developmental stage. For example, blue crab megalopae are an order of magnitude more sensitive than juveniles.

At field-realistic environmental concentrations, neonicotinoids and fipronil can have negative effects on physiology and survival for a wide range of non-target invertebrates in terrestrial, aquatic, wetland, marine and benthic habitats (see the literature reviewed by Pisa et al. 2014). Effects are predominantly reported from laboratory toxicity testing, using a limited number of test species. Such tests typically examine only lethal effects over short time frames (i.e. 48 or 96 h tests), whereas ecologically relevant sublethal effects such as impairment of flight, navigation or foraging ability and growth are less frequently described. It has become clear that many of the tests use insensitive test species (e.g. *Daphnia magna*) and are not sufficiently long to represent chronic exposure and therefore lack environmental relevance. Laboratory testing to establish safe environmental concentration thresholds is hindered by the fact that most pesticide toxicity tests are based on older protocols. Although these systemic pesticide classes possess many novel characteristics, testing methodologies have remained largely unchanged, resulting in flawed conclusions on their ecological safety (Maxim and Van der Sluijs 2013). New and improved methodologies are needed to specifically address the unique toxicology profiles of chemicals, including their possible cumulative and delayed lethal and non-lethal effects for a variety of terrestrial, aquatic and marine organisms. Nevertheless, our review shows a growing body of published evidence that these systemic insecticides pose a serious risk of harm to a broad range of non-target invertebrate taxa often below the expected environmental concentrations. As a result, an impact on the many food chains they support is expected.

We reviewed nearly 150 studies of the direct (toxic) and indirect (e.g. food chain) effects of fipronil and the neonicotinoids imidacloprid and clothianidin on vertebrate wildlife—mammals, birds, fish, amphibians and reptiles. Overall, at concentrations relevant to field exposure scenarios in fields sown with coated seeds, imidacloprid and clothianidin pose risks to small birds, and ingestion of even a few treated seeds could cause mortality or reproductive impairment to sensitive bird species (see the studies reviewed by Gibbons et al. 2014). Some recorded environmental concentrations of fipronil have been sufficiently high to potentially harm fish (Gibbons et al. 2014). All three insecticides exert sublethal effects, ranging from genotoxic and cytotoxic effects to impaired immune function, reduced growth or reduced reproductive success. Conclusive evidence was described recently, that neonicotinoids impair the immune response at the molecular level, thus enabling damages by covert diseases and parasites (Di Prisco et al. 2013). All these effects often occur at concentrations well below those associated with direct mortality (Gibbons et al. 2014). This is a trend in many taxa reported throughout the reviewed literature: short-term survival is not a relevant predictor neither of mortality measured over the long term nor of an impairment of ecosystem functions and services performed by the impacted organisms.

With the exception of the most extreme cases, the concentrations of imidacloprid and clothianidin that fish and amphibians are exposed to appear to be substantially below thresholds to cause mortality, although sublethal effects have not been sufficiently studied. Despite the lack of research and the difficulty in assigning causation, indirect effects may be as important as direct toxic effects on vertebrates and possibly more important. Neonicotinoids and fipronil are substantially more effective at killing the invertebrate prey of vertebrates than the vertebrates themselves. Indirect effects are rarely considered in risk assessment processes, and there is a paucity of data, despite the potential to exert population-level effects. Two field case studies with reported indirect effects were found in the published literature. In one, reductions in invertebrate prey from both imidacloprid and fipronil uses led to impaired growth in a fish species, and in another, reductions in populations of two lizard species were linked to effects of fipronil on termite prey (see the studies reviewed by Gibbons et al. 2014).

Impacts on ecosystem functioning and ecosystem services

The concept of ecosystem services is widely used in decision-making in the context of valuing the service potentials, benefits and use values that well-functioning ecosystems provide to humans and the biosphere (e.g. Spangenberg et al. 2014) and as an end point (value to be protected) in ecological risk assessment of chemicals. Neonicotinoid insecticides and fipronil are frequently detected in environmental media (soil, water, air) at locations where no pest management benefit is provided or expected. Yet, these media provide essential resources to support biodiversity and are known to be threatened by long-term or repeated contamination. The literature synthesized in this integrated assessment demonstrates the large-scale bioavailability of these insecticides in the global environment at levels that are known to cause lethal and sublethal effects on a wide range of terrestrial (including soil) and aquatic microorganisms, invertebrates and vertebrates. Population-level impacts have been demonstrated to be likely at observed environmental concentrations in the field for insect pollinators, soil invertebrates and aquatic invertebrates. There is a growing body of evidence that these effects pose risks to ecosystem functioning, resilience and the services and functions provided by terrestrial and aquatic ecosystems. Such services and functions can be provisioning, regulating, cultural or supporting and include amongst others soil formation, soil quality, nutrient cycling, waste treatment and remediation, pollination, food web support, water purification, pest and disease regulation, seed dispersal, herbivory and weed control, food provision (including fish), aesthetics and recreation.

Knowledge gaps

While this assessment is based on a growing body of published evidence, some knowledge gaps remain. These compounds have been subject to regulatory safety tests in a number of countries. However, several potential risks associated with the present global scale of use are still poorly understood. We highlight key knowledge gaps.

- For most countries, there are few or no publicly available data sources on the quantities of systemic pesticides being applied, nor on the locations where these are being applied. Reliable data on the amounts used are a necessary condition for realistic assessments of ecological impacts and risks.
- Screening of neonicotinoid and fipronil residues in environmental media (soils, water, crop tissues, non-target vegetation, sediments, riparian plants, coastal waters and sediments) is extremely limited. Although their water solubility and propensity for movement are known, also, only very scarce data for marine systems exist.
- An even bigger knowledge gap is the environmental fate of a wide range of ecotoxic and persistent metabolites of neonicotinoids and fipronil. Hence, we cannot evaluate with accuracy the likely joint exposure of the vast majority of organisms.
- There is a poor understanding of the environmental fate of these compounds, and how, for example, soil properties affect persistence and whether they accumulate in (usually flowering) woody plants following repeated treatments with the parent compound. The behaviour of degradation products (which can be highly toxic and persistent) in different media (plants, soils, sediments, water, food chains, etc.) is poorly known.
- Long-term toxicity to most susceptible organisms has not been investigated. For instance, toxicity tests have only been carried out on four of the approximately 25,000 globally known species of bees, and there are very few studies of toxicity to other pollinator groups such as hoverflies or butterflies and moths. Similarly, soil organisms (beyond earthworms) have received little attention. Soil organisms play multiple roles in the formation of soil and in the maintenance of soil fertility. Toxicity to vertebrates (such as granivorous mammals and birds which are likely to consume treated seeds) has only been examined in a handful of species.
- Those toxicological studies that have been performed are predominantly focused on acute toxicity tests, whereas the effects of long-term, acute and chronic exposure is less well known, despite being the most environmentally relevant scenario for all organisms in agricultural and aquatic environments. The long-term consequences of exposure under environmentally realistic conditions have not been studied.
- All neonicotinoids bind to the same nAChRs in the nervous system such that cumulative toxicity is expected. At present, no studies have addressed the additive or synergistic effects of simultaneous exposure to multiple compounds of the neonicotinoid family, i.e. imidacloprid, clothianidin, thiamethoxam, dinotefuran, thiacloprid, acetamiprid, sulfoxaflor, nitenpyram, imidaclothiz, paichongding and cycloxaprid, into an aggregated dose of e.g. "imidacloprid equivalents". Currently, risk assessments are done for each chemical separately, while many non-target species, such as pollinators, are simultaneously being exposed to multiple neonicotinoids as well as other pesticides and stressors. As a consequence, the risks have been systematically underestimated. While quantifying the suite of co-occurring pesticides is largely an intractable problem, a single metric that incorporates all neonicotinoid exposures to representative taxa would be an invaluable starting point.
- Cumulative toxicity of successive and simultaneous exposure has not been studied in the regulatory assessment and governance of chemical risks.
- Sublethal effects that often have lethal consequences in a realistic environmental setting have not been studied in most organisms. However, they are known to be profound in bees, and for those few other species where studies have been performed, sublethal doses of these neurotoxic chemicals have been reported to have adverse impacts on behaviour at doses well below those that cause immediate death.
- Interactions between systemic insecticides and other stressors, such as other pesticides, disease and food stress, have been explored in only a handful of studies (on bees), and these studies have revealed important synergistic

effects. For example, in honeybees, low doses of neonicotinoids greatly increase susceptibility to viral diseases. Interactions between systemic insecticides and other stressors in organisms other than bees are almost entirely unstudied. In field situations, organisms will almost invariably be simultaneously exposed to multiple pesticides as well as other stressors, so our failure to understand the consequences of these interactions (or even to devise suitable means to conduct future studies in this area) is a major knowledge gap.

- Impacts of these systemic insecticides on the delivery of a wide range of ecosystem services are still uncertain. The accumulation in soil and sediments might lead us to predict impacts on soil fauna such as earthworms and springtails (Collembola), which may in turn have consequences for soil health, soil structure and permeability and nutrient cycling. Contamination of field margin vegetation via dust or ground or surface water might lead us to expect impacts on fauna valued for aesthetic reasons (e.g. butterflies) and is likely to impact populations of important beneficial insects that deliver pollination or pest control services (e.g. hoverflies, predatory beetles). The general depletion of farmland and aquatic insect populations is likely to impact insectivorous species such as birds and bats. Contamination of freshwater is hypothesized to reduce invertebrate food for fish and so impact fisheries. The same might apply to coastal marine systems, potentially posing serious threats to coral reefs and salt marsh estuaries. None of these scenarios have been investigated.
- The short- and long-term agronomic benefits provided by neonicotinoids and fipronil are unclear. Given their use rates, the low number of published studies evaluating their benefit for yield or their cost-effectiveness is striking, and some recent studies (see Furlan and Kreutzweiser 2014) suggest that their use provides no net gain or even a net economic loss on some crops. It is not currently known what the impact on farming would be if these systemic pesticides were not applied or applied less (though their recent partial withdrawal in the EU provides an opportunity for this to be examined).

Given these knowledge gaps, it is impossible to properly evaluate the full extent of risks associated with the ongoing use of systemic insecticides, but the evidence reviewed in this special issue suggests that while the risks affect many taxa, the benefits have not been clearly demonstrated in the cropping systems where these compounds are most intensively used.

Conclusions

Overall, the existing literature clearly shows that present-day levels of pollution with neonicotinoids and fipronil caused by authorized uses (i.e. following label rates and applying compounds as intended) frequently exceed the lowest observed adverse effect concentrations for a wide range of non-target species and are thus likely to have a wide range of negative biological and ecological impacts. The combination of prophylactic use, persistence, mobility, systemic properties and chronic toxicity is predicted to result in substantial impacts on biodiversity and ecosystem functioning. The body of evidence reviewed in this Worldwide Integrated Assessment indicates that the present scale of use of neonicotinoids and fipronil is not a sustainable pest management approach and compromises the actions of numerous stakeholders in maintaining and supporting biodiversity and subsequently the ecological functions and services the diverse organisms perform.

In modern agricultural settings, it is increasingly clear that insecticide treatments with neonicotinoids and fipronil—and most prominently its prophylactic applications—are incompatible with the original mindset that led to the development of the principles of integrated pest management (IPM). Although IPM approaches have always included insecticide tools, there are other approaches that can be effectively incorporated with IPM giving chemicals the position of the last resort in the chain of preferred options that need be applied first. Note that the current practice of seed treatment is the opposite: it applies chemicals as the first applied option instead of the last resort. The preferred options include organic farming, diversifying and altering crops and their rotations, inter-row planting, planting timing, tillage and irrigation, using less sensitive crop species in infested areas, using trap crops, applying biological control agents, and selective use of alternative reduced-risk insecticides. Because of the persistent and systemic nature of fipronil and neonicotinoids (and the legacy effects and environmental loading that come with these properties), these compounds are incompatible with IPM. We accept that IPM approaches are imperfect and constantly being refined. However, there is a rich knowledge base and history of success stories to work from in many systems where pest management is required. In fact, in Europe, the IPM approach has become compulsory for all crops as of the 1st of January 2014 in accordance with EU Directive 2009/128/EC, but most member states still need to operationalize and implement this new regulation, and IPM is sometimes poorly defined.

Recommendations

The authors suggest that regulatory agencies consider applying the principles of prevention and precaution to further tighten regulations on neonicotinoids and fipronil and consider formulating plans for a substantial reduction of the global scale of use. Continued research into alternatives is warranted, but equally pressing is the need for education for farmers and other practitioners and the need for policies and regulations to encourage the adoption of alternate agricultural strategies to manage pests (e.g. IPM, organic, etc.). In addition, there is a need for research to obtain a better understanding of the institutional and other barriers that hamper large-scale adoption of proven sustainable agricultural practices that can serve as alternatives to the use of neonicotinoids and fipronil—as of many other pesticides as well.

The adequacy of the regulatory process in multiple countries for pesticide approval must be closely considered and be cognizant of past errors. For example, other organochloride insecticides such as DDT were used all over the world before their persistence, bioaccumulation and disruptive impacts on ecosystem functioning were recognized, and they were subsequently banned in most countries. Organophosphates have been largely withdrawn because of belated realization that they posed great risks to human and wildlife health. The systemic insecticides, neonicotinoids and fipronil, represent a new chapter in the apparent shortcomings of the regulatory pesticide review and approval process that do not fully consider the risks posed by large-scale applications of broad-spectrum insecticides.

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SPEAKERS' BIOGRAPHIES AND ABSTRACTS

DR. MAARTEN BIJLEVELD van LEXMOND, PHD

Chairman, Task Force on Systemic Pesticides.
46, Pertuis-du-Sault, 2000 Neuchâtel, Switzerland
mbvl@club-internet.fr

Maarten **BIJLEVELD VAN LEXMOND** is a biologist and conservationist by training. He studied at Leiden and Amsterdam Universities obtaining his PhD in 1974 with the publication of his first book: Birds of Prey in Europe. As one of the founders of the World Wildlife Fund in the Netherlands he joined the WWF international secretariat in Switzerland and later led the Commission on Ecology of the International Union for the Conservation of Nature (IUCN). In the mid-eighties he founded the Swiss Tropical Gardens in Neuchâtel, now in Kerzers (Switzerland), in parallel with the Shipstern Nature Reserve in Belize, Central America. For many years he also served as President of the Foundation for the Conservation of the Bearded Vulture which succeeded in reintroducing the species into the Alps and other parts of Europe. At present, dividing his time between Switzerland and the south of France most of it since 2009 is taken up by his function as Chairman of the International Task Force on Systemic Pesticides (TFSP) which now looks into the worldwide impact of these chemicals on biodiversity and ecosystems, and in particular on pollinators such as honey bees, bumble bees, butterflies, but also at suspected consequences for public health.

Abstract: In July 2009, a group of entomologists and ornthologists met at Notre Dame de Londres, a small village in the French Department of Hérault, as a result of an international enquiry amongst entomologists on the catastrophic decline of insects (and arthropods in general) all over Europe. They issued the Appeal of Notre Dame de Londres under the heading "No Silent Spring again"referring to Rachel Carson's book "Silent Spring" then published almost half a century ago. In response, an international Task Force on Systemic Pesticides was set up at the end of 2009. Over the years, membership grew and today counts 17 nationalities in four continents. In undertaking the Worldwide Integrated Assessment (WIA), over the course of the last four years, the TFSP has examined over 1,100 scientific peer-reviewed papers published over the last two decades. The WIA was almost simultaneously launched in June 2014, and published in a special issue of the peer-reviewed Springer journal "Environmental Science and Pollution Research" in January 2015.

DR. JEAN-MARC BONMATIN, PHD

Deputy Chairman Task Force on Systemic Pesticides. Centre National de la Recherche Scientifique (CNRS).

Centre de Biophysique Moléculaire, CS 80054, 45071 Orléans, France

bonmatin@cnrs-orleans.fr

Jean-Marc **BONMATIN** is researcher for the Centre National de la Recherche Scientifique (CNRS, France). He completed his thesis in 1987 (Chemistry and Physics) by studying biological membranes in interactions with various peptides, especially a bee venom. Just after, he worked for the National Research Council of Canada (Ottawa, Canada) until 1989. Here, he was interested in dynamics of cholesterol in membranes. He joined the Centre de Biophysique Moléculaire late 1989 (CBM, CNRS, Orléans, France) where he started his researches on structure-activity relationships of various natural toxicants (antibacterial, antifungal, neurotoxins, etc.). From 2008 he was involved during twelve years in coordination of European research programs on the Colony Collapse Disorder (CCD). This concerned analytics of insecticides in soil, water, pollen and honey, as well as the finding of the first virus of bee mites (Varroa destructor). From 2009 he also joined the Task Force on Systemic Pesticides, being now the vice-chairman. He is also involved in risk assessments for pollinators for several public organisms such as ITSAP (French Institute of Bee and Pollination), ANSES (French Agency of Environmental and Food Safety) and OECD.

Abstract: Bee disorders are accompanied by a general collapse of entomofauna (www.iucn.org/) while biodiversity has probably never faced so many threats at a global scale because of human activities. A Worldwide integrated assessment on systemic pesticides (www.tfsp.info) was carried out to explore the role of neonicotinoids (DOI: 10.1007/s11356-014-3220-1).Our meta-analysis has described the uses and metabolism in soil, plants, water and air (DOI: 10.1007/s11356-014-3470-y). The environmental fate and exposures via these compartments (DOI: 10.1007/s11356-014-3332-7) have been linked to large effects on non target invertebrates (aquatic, terrestrial, including bees, DOI: 10.1007/s11356-014-3471-x), and on vertebrates such as fishes and birds, to a lesser extent (DOI: 10.1007/s11356-014-3180-5).Some uses of three neonicotinoids have been restricted (Italy: 2009, Europe: 2013), but because they also threaten agricultural productivity through impacts on ecosystem functioning and services (DOI: 10.1007/s11356-014-3277-x), our conclusions support further restrictions of their prophylactic uses in favor of integrated pest managements (IPM) practices or organic farming, which minimize pesticide use (DOI: 10.1007/s11356-014-3628-7, DOI: 10.1007/s11356-014-3229-5).Our findings on neonicotinoids have been confirmed by EASAC (http://www.easac.eu/) and incorporated in part by IBBES (www.ipbes.net/).

DR. FRANCISCO SANCHEZ-BAYO, PHD

University of Sydney, Eveleigh, NSW, Australia

sanchezbayo@mac.com

Dr. Francisco SANCHEZ-BAYO, born in Spain, studied at the University of Madrid, where he obtained his 'cum laude' doctorate in Ecolgy. In 1989 he immigrated to Australia where he is now working at the Faculty of Agriculture & Environment of the University of Sydney, Eveleigh, NSW, Australia. He authored and co-authored over a hundred scientific articles on the risk of pesticides, ecology and many other subjects. In the article "The trouble with Neonicotinoids" published in *Science* in November 2014, he largely confirmed the findings of the "Worldwide Integrated Assessment of the Impact of Systemic Pesticides on Biodiversity and Ecosystems" published earlier that year.

Abstract:

The use ofsystemic insecticides in agriculture has produced widespread contamination of the soil in the treated crops. This soil acts as a reservoir ofresiduesthat arelater transferred to the aquatic environment.

The high toxicity [illegible]nicotinoid insecticides to aquatic insects and other arthropods [illegible]umented, but there is little awareness of the impacts these che[illegible] on aquatic environments and the ecosystem at large. Recent monitoring studies throughout the worldhave revealed a larger than expected contamination of creeks, rivers and lakes with these insecticides, with residue levels in the low ppb range; as a result, somequestion the relevance of such low concentrations for the health of aquatic ecosystems.In order to evaluate the environmental risks of water-borne residues of such chemicals, the monitoring data will be contrasted with the known acute and chronic toxicity of fipronil and neonicotinoids to various aquatic organisms. However, predictions of risk based on toxicological and residue data alone aren't sufficient for understanding the real impacts that chemicals have on ecosystems. The latter impacts have been studied using mesocosms. A comparison of the findings of mesocosm studies with known toxicological data help sort out the aquatic communities most at risk from those that undergo little or no change.

The relevance of these community impacts for the large environment is not evident, as the indirect effects of pesticides on ecosystems are elusive and may pass unnoticed. However, the ecological links between aquatic and terrestrial organisms explain that populations of birds that depend largely on aquatic food sources have been severely affected in the Netherlands over a two-decade period, mostly due to food depletion byimidacloprid. Gaps in knowledge and difficulties in obtaining experimental data that relates the effects on individual organisms to impacts on populations and ecosystems will be pointed out. I will conclude with a summary of findings and the implications they have for ecosystems.

ELIZABETH LUMAWIG-HEITZMANN
Secretary of Task Force on Systemic Pesticides Public Health Working Group.
Marinduque Biological Field Station. Cawit, Marinduque, Philippines
beth_heitzmann@yahoo.com

Elizabeth **LUMAWIG-HEITZMANN** was born in Manila, Philippines, where grew up in a household immersed in entomology. Her parents collected and discovered Philippine butterflies and other insects, some of which have been named after members of her family. In 1986, she received a BS in Secondary Education with a major in Biology and a minor in Earth Science. In 1996, she established the first butterfly house in the Philippines in Quezon City. She has been the owner of Flora Farm (Butterfly House) since 1991, and serves as the director of the Philippine Exotic Butterfly Fund and as Director of the Subic Bay Freeport Zone Butterfly Garden & Breeding Centre since 2004. During her professional career, she routinely conducted seminars on butterfly farming and watershed management, served as an expert for the Department of Environment and Natural Resources (DENR), advised or managed butterfly houses and trails for provincial governments in the Philippines, and served as a consultant on the Livelihood Project on Butterfly Breeding. She previously served as the honorary secretary of IABES External Liaison Committee in 2009, and as a member of the IUCN Task Force on Systemic Pesticides representing the Philippine Protected Ares and Wildlife Bureau in 2011. She is currently the Hon.Sec of TFSP Public Health Working Group. She now heads the Marinduque Biological Field Station.

Abstract: Like in other Asian countries use of neonicotinoid pesticides is wide-spread in the Philippines. Given the virtual absence of marketing regulations these products can be sold under multiple trade names at the lowest retailer levels with the well-entrenched agro-chemical industry strengthening its marketing networks, penetrating into local villages. In addition, the pesticide regulatory process appears to be far too pro-industry to play an effective role. From 2011 statistics it appears that the three principle neonicotinoid pestides, clothianidin, imidacloprid, and thiamethoxam, are being sold under 13 different brand names and imported by four major chemical manufacturers. No information on the quantities imported, however, is available and an early survey of usage of neonicotinoid pesticides around nature reserves was discontinued. The Worldwide Integrated Assessment on the Impact of Systemic Pesticides on Biodiversity (WIA) initiated by the Task Force on Systemic Pesticides (TFSP) was first launched in Manila in June 2014 to be followed in hours by press conferences in Brussels, Ottawa and Tokyo. In response to the WIA the Governor of the Province of Marinduque in order to protect the island's famous butterfly breeding industry, declared to ban all usage, sale and importation of Neonicotinoid pesticides and Fipronil, an initiative that awaits its implementation.

DR. CLEOFAS RODRIGUEZ CERVANCIA, PHD

Institute of Biological Sciences, College of Arts and Sciences
University of the Philippines Los Banos, College, Laguna
crcervancia@uplb.edu.ph

Dr. Cleofas RODRIGUEZ CERVANCIA studied Entomology at the University of the Philippines where she obtained her PhD. Her Post Doctoral studies in Apiculture and Pollination Ecology were carried out at the University of Wales, U.K. At present, as Professor Emeritus, she handles thesis students (graduate and undergraduate) doing bee related studies and served before as faculty member of the University of the Philippines for 38 years; taught General Education Courses (Biology, Ecology, Environmental Science, Botany), major courses in Ecology and Entomology, while supervising 30 students and helping in the curriculum development of the University. She is also serving as President of the Apimondia Regional Commission for Asia and Vice-President of the Asian Apicultural Association.

Abstract: The Philippines is home to diverse bee species because of the abundance of floral resources. There are numerous native species of solitary and social bees that are excellent pollinators of native plants. The European bees, introduced species, are commonly used in commercial beekeeping because of its high production of honey and gentle behaviour. However, this species could hardly be sustained in the country. During the past decade, there is an observable decline in the population of both managed and wild bees. The identified causes are exposure to agro and industrial chemicals, loss of bee pasture, monoculture, pests and diseases, mismanagement, habitat fragmentation and natural calamities. This presentation documents several cases of pollinator losses in various areas in the Philippines and their specific causes. Ecosystem approach in conserving the bee populations will be discussed.

DR. KUMIKO TAIRA, MD

Chair of Task Force on Systemic Pesticides. Public Health Working Group.
Tokyo Women's Medical University, Japan
tfsp.phwg@gmail.com

Kumiko **TAIRA** received her medical degree from Kobe University in 1982. Since 2001, she has been involved in studying the effects of environmental exposure of organophosphates and neonicotinoids on human health in collaboration with Dr. Yoshiko Aoyama in Gunma. Together, they have published eleven academic articles. She received the Japanese Society of Environmental Ecology President's awards in 2004 and 2006, an incentive award from the Japanese Society of Environmental Ecology in 2007, and an award for excellence from the Japanese Society for Clinical Toxicology in 2009. Dr. Taira is a part-time lecturer at the Department of Anesthesiology at Tokyo Women's Medical University Medical Center East, a part-time lecturer at the Department of Environmental Education at Tokyo Kasei University, a board member of the Japanese Society of Clinical Ecology, and the chairman of the Public Health working group of IUCN Task Force on Systemic Pesticides.

Abstract: Neonicotinoid (neonic) pollution in the human body is ubiquitous and increasing in Japan. Eight neonics are now registered in Japan. Flupyradifurone is newly registered. Dinotefuran is the most commonly used neonic, followed by clothianidin, imidacloprid, acetamiprid, and thiamethoxam; while thiacloprid and nitenpyram are also used in small amounts. Last year, a small-scale epidemiological study revealed that 7 neonics were detected in the urine of Japanese women (approximately 300) at nM levels. We speculated that neonics are retained in the human body in spite of their water solubility and that continuous use of neonics may pollute human tissues.

Continuous exposure to neonics, especially acetamiprid and thiamethoxam, may cause typical symptoms, e.g. recent memory loss. In the summer of 2006, we met a large-scale pandemic of patients with typical symptoms. All of them were nonsmokers, original healthy, and became ill after consecutive intake of tea beverages and/or conventional domestic fruits. We started chemical analysis of patients' urine from 2007. We detected some neonicotinoid metabolites in their urine. We then conducted a prevalence case control study prospectively, and analyzed urinary neonics and an acetamiprid metabolite, N-desmethyl-acetamiprid (DMAP), by LC-MS/MS. 35 patients were divided into two groups, typical symptomatic group (TSG) and atypical symptomatic group (ASG) by symptoms. Typical symptoms are named neo-nicotinic symptoms including 6 subjective symptoms, i.e. headache, general fatigue, chest pain or palpitation, stomach ache, muscle pain or weakness or spasm and

cough, and 3 objective symptoms, e.g. postural tremor, recent memory loss, and fever. 50 sex- and age-matched volunteers without any symptoms were recruited as non-symptomatic group (NSG). DMAP and thiamethoxam were more detected from TSG group significantly. Odds ratio of neo-nicotinic symptoms for urinary DMAP detection was 14. The details of the patient's symptoms are as follows: In addition to neo-nicotinic symptoms, ECG abnormality, such as sinus tachycardia, sinus bradycardia, supraventricular or ventricular arrhythmia, was consistently found from TSG patients. They also complained of neuropsychiatric symptoms, such as sleepless, depression, aggressiveness, auditory and sensory hallucination, and hypersensitivity. Dermal symptoms, Kaposi varicelliform eruption, or diffused ringworm disease were observed sometimes. Edema with oliguria was also found. (Marfo et al. 2015).

DR. MICHAEL G. NORTON, PHD

EASAC Environment Programme Director

Tokyo Institute of Technology

norton.m.aa@m.titech.ac.jp

Dr. Michael NORTON obtained his BSc and PhD degrees in chemistry at Bristol University. He was a research chemist at Imperial Chemical Industries (1970-74), and then joined the UK government science service. After 8 years working on environmental pollution, he spent 4 years in the USA as Science Attache, specialising in environment and biosciences. He returned to the UK in 1986 to direct a biotechnology research group in a National Laboratory but was then chosen to lead a new S&T Office for the National Parliament. As founding Director of the Parliamentary Office of Science and Technology, he set up the new organisation, developed its advisory services and oversaw its adoption as a formal part of the UK Parliament (1989-1998). From 1998 to 2004, he was Counsellor Science and Innovation at the British embassy in Tokyo and promoted UK-Japan collaboration in S&T – particularly in environmental sciences and sustainability. He then took up a position as Professor at Tokyo Institute of Technology in the fields of innovation, management of technology, and sustainable development (2004-6). From April 2006 he became a Professor at the Management Innovation Institute at Shinshu University specializing in innovation clusters, and environmental sustainability. From 2012-15 he was Professor at the Environmental Leader Program at Tohoku University, before returning as Adjunct Professor to Tokyo Institute of Technology from June 2015.
Since 2013 he has also supported the European Academies Science Advisory Council (EASAC) as Environment programme Director.

Abstract: The European Academies Science Advisory Council (EASAC) brings together the combined expertise of Europe's academies of science to address science-based policy issues. Over the period 2013-14, it established an expert working group to examine the role of neonicotinoids from an ecosystem perspective and published the report "Ecosystem services, agriculture and neonicotinoids" in April 2014.

The report looked at the ecosystem services of pollination, natural predator control, soil ecosystems and biodiversity, the relation between agriculture and ecosystem services, and what we know of their economic value, and examined trends. These showed that trends in the most

publicly-discussed honeybees were difficult to establish because of the confounding socio-economic factors which influence colony numbers. However, trend data on wild bee species, other pollinators, on insect species with natural pest control functions and on biodiversity indicators such as farmland birds **all showed major declines** in recent decades.

Against this background, EASAC examined the role of neonicotinoids and their 'systemic' mode of action in the plant and conducted a detailed review of the literature with particular focus on the many papers which have emerged since 2012. EASAC concluded that:

i. There is an increasing body of evidence that the widespread prophylactic use of neonicotinoids has severe negative effects on non-target organisms which provide ecosystem services including pollination and natural pest control.
ii. There is clear scientific evidence for sublethal effects of very low level of neonicotinoids over extended periods on non-target beneficial organisms. These should be addressed in EU approval procedures
iii. Current practice of prophylactic usage of neonicotinoids is inconsistent with the basic principles of Integrated Pest Management as expressed in the EU's Sustainable Pesticides Directive
iv. Widespread use of neonicotinoids (as well as other pesticides) constrains the potential for restoring biodiversity in farmland under the EU's Agri-environment Regulation 1993.
v. Finally, some intensive food production has become reliant on neonicotinoids and industry studies argue that their withdrawal would have serious economic and food security implications. On the other hand, some recent research has questioned the benefits of routine use as seed dressing against the occasional or secondary pests targeted. When combined with our strengthened and broadened understanding of risks to non-target organisms, and concerns over iatrogenic effects as a result of reduction in natural pest control services, the balance between risks and benefits for neonicotinoids requires reassessment.

DR. LORENZO FURLAN, PHD

Chairman of the Task Force on Systemic Pesticides Working Group on Alternatives.

Veneto Agricultura, center for Agricultural research in co-operation with the University of Padua, Italy

lorenzo.furlan@venetoagricoltura.org

Dr. Lorenzo FURLAN, graduated in Agricultural Sciences at the University of Padua, has been working on soil insects (wireworms, blackcutworms, *Diabrotica virgìfera virgifera*) and on implementation of sustainable agriculture since 1981. He is currently the Manager of the Agricultural Research Department at Veneto Agricoltura (an extension Service for regional agricultural activities) where he is in charge of running the pilot farms and the research activity. Significant part of his research is devoted to IPM strategies against pests of arable crops. He is reviewer and the author or co-author of more than 200 papers in national and international Journals; among them the description of practical IPM strategies suitable for a dramatic reduction of soil insecticide usage in Europe.

Abstract: An extensive survey of fields and numerous trials conducted over the last 30 years in Italy made possible a reliable risk assessment of maize damage by soil pests and the implementation of IPM. Strong risk factors include organic matter content >5%, rotations including meadows and alfalfa, double crops one year or two years before maize is sown and landscape around the maize fields including meadows and/or natural grass, alfalfa and double crops. Weaker risk factors include a poor field drainage, late sowing date, a warm spring and clay or loam clay soils. The statistical models also showed how the simultaneous occurrence of two or more of the aforementioned risk factors can conspicuously increase the risk of wireworm damage to maize crop, while the probability of damage for a field with no risk factors is always low (<1%). IPM includes two steps:

1) "area-wide" risk assessment including click-beetle population monitoring with pheromone traps;
2) "complementary field monitoring" where risk assessment has identified the presence of risk factors.

1) "Area-wide" risk assessment: risk factors evaluation enable each cultivated region to be mapped, and high-risk areas to be pinpointed. The first layer of the risk map includes the main

soil characteristics (organic-matter content, texture, pH); the second includes the key agronomic characteristics (rotation, drainage); and the third, the available entomological information, such as click-beetle population levels for the main *Agriotes* species, or wireworm presence/density assessed with bait traps over the years. A fourth layer reproduces the effects that occur when existing risk factors interact. This system enables areas with different risk levels to be highlighted. Each wireworm-risk category (e.g. low, medium or high, based on the presence of one or more risk factors) will have its own IPM strategy.

2) <u>Complementary field monitoring</u>: where risk factors are present, the suggestion is assessing actual wireworm populations using bait traps and if average number of wireworms does not exceed the thresholds established, maize may be sown without any treatment; if the average number of wireworms exceeds at least one of the thresholds, farmers have the option of moving maize to a no-risk field, as well as of applying organic treatments or chemical treatments.

In this way, control strategies will be implemented only when and where economic thresholds for maize are exceeded.

Assessing the risk of wireworm damage affords a solid basis for estimating the amount of farmland that can be left untreated each season without any risk of yield reduction. Precise targets for IPM of soil pests in maize could be set everywhere. For instance, in no-risk areas, soil insecticides or insecticide-coated seeds may need to be used on no more than 1% of maize-cultivated land, and in areas where organic-matter content is over 5%, soil insecticides could be used on about 15% of maize-cultivated land. For large areas with scattered-risk situations, IPM targets will be a balanced mean of the damage risk caused by various risk factors and the surface area of cultivated land where each risk factor occurs. In order to facilitate IPM, risk insurance coverage may be extremely useful. Insurance may be taken out privately by associated farmers, or with the support of public regulations. With risks below 1%, a few dollars per hectare (ten times less than soil-insecticide costs) would be enough to pay for damaged fields.

As a result, the described IPM strategy may lead to a considerable reduction in the use of soil pesticides and to the immediate containment of the environmental impact of agriculture with no negative repercussions on farmers' income.

DR. K. L. HEONG, QIUSHI CHAIR PROFESSOR

Zhejiang University

Hangzhou, CHINA

kl.heong@gmail.com

Dr Kong Luen HEONG is a fellow of The World Academy of Science (TWAS) and the Malaysian Academy of Science (ASM) and holds both a PhD and a DSc from Imperial College, London. Formerly a Principal Scientist and an insect ecologist in the International Rice Research Institute (IRRI) he is now the Qiushi Chair Professor in Zhejiang University, China and the senior advisor to the Centre for Agricultural BioSciences International (CABI), South East Asia Regional Centre based in Malaysia. His work to develop and communicate innovations in restoring biodiversity, introducing ecological engineering methods and reducing pesticide use in rice production in Asia has been recognized by the US Council for Agricultural Science &Technology (Charles Black Award), The World Academy of Sciences(Agriculture Prize), the International Association of Plant Protection (IAPPS) (Award of Distinction), the Malaysian Plant Protection Society (Excellence Prize) and 2 Gold Medals from the Government of Vietnam. He has also won the St Andrews Prize for Environment, the World Bank Marketplace Award, the COM+ Award and Vietnam's Golden Rice Award. Dr Heong has published more than 200 peer review journal papers, several books and has led several international projects with budgets of more than US$ 7 million.

Abstract: Insecticides introduced with the Green Revolution in Asia have continued to dominate Asian rice production and are applied routinely every season. Farmers' productivity gains from insecticides are generally low or negative and most of the chemical applied do not perform pest management roles. Instead they accumulate in the water and soil. Recently neonicotinoids have been introduced for use as sprays and seed coating to manage early season pests. However most early season pests are managed by naturally occurring biological control services provided by the diversity of predators, parasitoids and aquatic fauna. Moreover early leaf damages have little effects on yields because the crops' high compensatory abilities. The early season insecticide sprays and seed coating (this practice is prohibited in Europe and US) in rice production are thus unnecessary. Such prophylactic practices driven by marketing forces and not pest pressures are misuses of insecticides and are contradictory to IPM principles and the FAO Code of Conduct for Pesticide Distribution and Marketing.

Ecological engineering (EE) is an ecologically based strategy that will increase and conserve biodiversity and biological control services. Started in Jin Hua China with sesame plants grown on the bunds, EE is now practiced in Thailand, Vietnam and China. A multi-country, multi-year field trial showed that the growing of flowers on rice bunds as an EE practice increased profits (by 7.5%), increased yields (by 5%), increased biological control (by 45%) and added aesthetic values to the rural landscape. At the same time the EE practice decreased insecticide use (by 70%), decreased pest densities (by 30%) and farmers' chemical input costs (70%). In Vietnam where 2 TV serials[i] were launched to promote flower growing, farmers that viewed the serials decreased their insecticide use by 24%, had 3.3% increased yields, increased knowledge on parasitoids and gained positive attitudes towards the growing of flowers.

Neonicotinoids are neurotoxins that block the nicotinic acethylcholine (nAChRs) synaptic receptors in the neurons. They are known to be highly toxic to bees, even at very low dosages and are key causes of bee colony collapse disorder (CCD). Since rice insect pest management is dependent on parasitoids in the same insect group hymenoptera as bees, the neonics are detrimental to the biological control services the parasitoids provide. The EE practice of growing flowers on rice bunds provides Shelter, Nectar, Alternative hosts and Pollen (SNAP) and to reduce insecticide use at the crop's early stages and seed coating. Neonics used as seed coating will affect the aquatic fauna that provide pest invasion services.

[i] Heong, K.L., Escalada, M.M., Chien, H.V. and Cuong, L. Q. 2014. Restoration of rice landscape biodiversity by farmers in Vietnam through education and motivation using media. In G. Mainguy (ed) Special issue on large scale restoration of ecosystems. S.A.P.I.E.N.S (online) Vol 7 No. 2. 29 – 35. http://sapiens.revues.org/1578.

RAYMUNDO M. LUCERO, MSC.

Faculty-in-charge, U.P. Open University, Los Baños, Laguna

raymundo.lucero@upou.edu.ph

Raymundo LUCERO studied Entomology and Agriculture at the University of the Philippines. In his long career he served as consultant in the fields of agroforestry, rural development, livelihoods and apiculture throughout the Philippines, while teaching ecology, zoology and entomology at College of Forestry, University of the Philippines at Los Baños (UPLB). He also lectured on basic ecology at the Asian Institute of Management, Makati. The National Association of Beekeepers (BEENET) saw him as their President in Luzon. At present, he has been teaching management of terrestrial protected areas, biodiversity conservation and organic agriculture at the Faculty-in-charge, U.P. Open University, Los Baños, Laguna.

Abstract: Management of pests start even before the crop is planted. It has something to do with the seeds, fertilizer, planting method, and water management. The choice of variety as well as diversification of variety is important in maintaining ecological balance in rice agroecosystem. The result of rice management practices of MASIPAG farmers in the Philippines has made possible the total avoidance of pesticide use in rice. As a result, rice yields are comparable to conventional chemical farming but the net income of those organic farmers, not using pesticides, is significantly higher. The end result is pesticide-free rice farming with healthier ecosystem.

DR. DIVINA M. AMALIN, PHD

Faculty, Biology Department, College of Science

De La Salle University – Manila

divina.amalin@dlsu.edu.ph

Dr. Divina AMALIN studied biology at the University of the Philippines, Los Banos, Laguna, where she obtained her BSc and MSc degrees. Her PhD in Entomology followed at the University of Florida, Gainesville, USA. She authored and co-authored over 60 scientific papers and is now teaching as a Full Professor at the De La Salle University-Manila. In addition, she chairs Technical Working Group on Good Agricultural Practices – ASEAN Cocoa Club, Malaysia. Her main research interests are Taxonomy and Biosystematics of spiders both of agricultural and medical importance species, Biological Control of Invasive Pest Species, Dengue vector control, Biopesticides and Integrated Pest Management (IPM).

Abstract: The Coconut Scale Insect (CSI), *Aspidiotus rigidus* Reyne, was first observed in the Philippines in 2009. It is an invasive species from Indonesia and may have been introduced accidentally to the Philippines. The population of CSI reached outbreak levels in the next few years and was consequently recognized and declared as a national emergency. A new species of a parasitic wasp belonging to genus *Comperiella* Howard (Hymenoptera: Encyrtidae) was discovered in a survey for natural enemies of CSI in Calauan, Laguna in the first quarter of 2014. The parasitic wasp was identified as *Comperiella calauanica* Barrion, Almarinez, Amalin 2015. It was named after the type locality. Field and laboratory observations have confirmed that *C. calaunica* is a parasitoid of *A. rigidus* in all of the surveyed points of Southern Tagalog still infested by the scale insect. Percent parasitisation values ranging from 65 to 92% in the third quarter of 2014 were recorded from field-collected samples. Results of correlation and linear regression analyses point to host density-dependent parasitism by *C. calauanica*. It is confirmed through field studies that *C. calauanica* contributed significantly in the control of CSI. It can now be declared that the pest status of CSI in Southern Tagalog is minor pest. The success of *C. calaunica* in controlling CSI suggests the conservation of the population of this parasitic wasp in the field. The use of insecticide particularly the neonicotinoid (brand name Starkle) for CSI control should be administered with caution since it is known to have negative effect on bees and could have parallel effect on *C. calaunica*. Confirmation on the negative effect of neonicotinoid on *C. calaunica* is underway.

DECLARATION

Those participating in the "Symposium on Impacts of and Alternatives to Systemic Pesticides : A Science-Policy Forum" , held in Manila At the De La Salle University on 15th June 2016, adopted by general acclamation the following declaration of support to further efforts in the Philippines to deal with this now global problem:

" With this declaration of support we pledge further to take an active part in all efforts that will put an end to systemic pesticides use in our Country's Agricultural & Aquaculture practices, as well as in other business or personal undertaking, in order for us to insure protection of our environment, conservation of ecological balance, continued viability of our rich biodiversity, and ultimately to the preservation of human life. "