“Neonicotinoids and their Impact on Ecosystem Services for Agriculture and Biodiversity in Africa”

Working Group Meeting

Proceedings Report

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International Centre of Insect Physiology and Ecology (*icipe*), Nairobi

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List of Acronyms

AAIS	African Association of Insect Scientists
AASSA	Association of Academies and Societies of Sciences in Asia
ACIA	Agricultural Chemicals Industry Association
ADAPPT	African Dryland Alliance for Pesticidal Plant Technology
AHS	Animal Health Services
APC	Agricultural Pesticides Committee
ASRIC	African Scientific Research Council
ASSAf	Academy of Science of South Africa
AU	African Union
AVCASA	Association of Veterinary and Crop Associations of South Africa
BMBF	German Federal Ministry of Education and Research
CAR	Central African Republic
CCD	Colony Collapse Disorder
CEMAC	Central African Economic and Monetary Community
CERES-Locustox	*Centre Régional de Recherche en Écotoxicologie et de Sécurité Environnementale*
CILSS	Permanent Interstate Committee for Drought Control in the Sahel
COCOBOD	Ghana Cocoa Board
CODAPEC	Cocoa Disease and Pest Control Program
CPAC	Committee of Pesticides in Central Africa
CSP	Sahelian Committee of Pesticides
DAAD	German Academic Exchange Service
DFG	German Research Foundation
DGs	Director Generals
EASAC	European Academies' Science Advisory Council
EC	European Commission
ECCAS	Economic Community of Central African States
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organisation

FFR	Fertiliser, Farm Feeds, and Remedies
GDP	Gross Domestic Product
GEO BON	Group on Earth Observations Biodiversity Observation Network
GTZ	German Technical Cooperation Agency
IANAS	InterAmerican Network of Academies of Sciences
IAP	InterAcademy Partnership
IAPSC	Inter-African Phytosanitary Council
ICCO	International Cocoa Organisation
ICIPE	International Centre of Insect Physiology and Ecology
IKS	Indigenous Knowledge Systems
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IPPM	Integrated Pests and Pollinator Management
IRS	Indoor Residual Spraying
ISRA	*Institut Sénégalais de Recherches Agricole*
ITK	Indigenous Technical Knowledge
LANADA	*Laboratoire National d'Appui au Dévelopement Agricole*
MAWF	Ministry of Agriculture, Water, and Forestry
MSDS	Material Safety Data Sheets
NASAC	Network of African Science Academies
NGOs	Non-Governmental Organisations
PRO	Pesticides Registration Office
PPPs	Plant Protection Products
RECs	Regional Economic Communities
SABS	South African Bureau of Standards
SADC	Southern African Development Community
TPRI	Tropical Pesticides Research Institute
US/USA	United States (of America)
WG	Working Group
WHO	World Health Organisation
ZEMA	Zambia Environmental Agency

1. Pre-meeting session

1.1 Welcome and Presentations

Professor Volker ter Meulen, former President of the German National Academy of Sciences Leopoldina, welcomed workshop participants and thanked them for traveling to join the workshop and for contributing to the upcoming discussions. He introduced the institutions involved in this meeting, namely the Academy of Science of South Africa (ASSAf), the Leopoldina, the Network of African Science Academies (NASAC), the European Academies' Science Advisory Council (EASAC), the InterAcademy Partnership (IAP), and the International Centre of Insect Physiology and Ecology (*icipe)*, and thanked *icipe* for hosting this meeting. All involved networks are engaged in providing scientific advice to policy makers. IAP has just completed a project on 'Food and Nutrition Security and Agriculture' with 280 participating scientists worldwide. The knowledge and commitment combined in the academy networks and their working groups are very valuable to policy makers. The present project on neonicotinoids is very important for Africa and the resultant report will surely be a wake-up call for African policy makers.

Dr Michael Lattorff, Senior Scientist Bee Research in the Environmental Health Theme at *icipe*, welcomed participants to *icipe* and thanked the workshop organisers for inviting him. His talk entitled 'Neonicotinoids, bees and bee products in Africa: what we know and what we don't know' summarised knowledge, and the lack thereof, of bees and their pollination services on the African continent. In addition to food security resulting from pollination services, honeybees are tools for rural development as farmers can keep bees as a side business and increase their income through sales of honey and wax. Bees are also used in wildlife fencing as a defence against elephant intrusion into cultivated areas, thus reducing human-wildlife conflict. 75% of crop plants require pollination and pollination services are worth at least 163 billion EUR per year worldwide. From an economic perspective, honeybees can be considered the third-most important domestic animal in the world, ranking third after cattle and pigs and followed by chickens. Pollination dependence worldwide continues to grow steadily, and particularly in the developing world, which depends more heavily on pollination-dependent crops than developed countries (see Fig SPM.4 in IPBES 2016a). The value of pollination of cash crops differs worldwide, with peak areas, e.g. in West Africa, India, eastern China, and Asia (see Fig. SPM.3B in IPBES 2016a), as does the proportion of agricultural production that is dependent on pollination for vitamin A, iron, and folate. Most areas of sub-Saharan Africa are to some extent dependent on pollination for supply with these micronutrients (see Fig. SPM.3A in PBES 2016a), and it is important to emphasise that food security alone is not enough, micronutrients are also important, particularly in Africa.

Bee declines are due to environmental stressors, pests and pathogens, and genetic diversity and vitality. The use of pesticides in agriculture interacts with all these factors. Scientific publications on neonicotinoids are increasing steadily, with most published in the United States (US) and Europe, and very few papers published in Africa and Australia. Papers concerned with neonicotinoid effects on bees represent around 50% of all papers published on neonicotinoids. Neonicotinoids are nicotinic acetylcholine receptor agonists and kill insects by causing hyper-excitation of the nervous system. However, neonicotinoids are not selective and kill or negatively affect all insects. Pollinators are non-target organisms; their exposure varies depending on their foraging activities and options. Most assessments of neonicotinoid toxicity assess acute toxicity of topical application (LD50), however, since bees are not target organisms of neonicotinoid applications, their exposure is more long-term and low-level. Therefore, acute toxicity tests are not always meaningful when assessing toxicity in pollinators (Blacquière *et al*., 2012). The oral and contact lethality of the different neonicotinoids differs greatly (Blacquière *et al.*, 2012). The most toxic neonicotinoids, namely imidacloprid, clothianidin, and thiamethoxam, were banned for outdoor use in the European Union (EU) in 2018. Contamination of nectar and pollen with neonicotinoids can come from spray applications, drifting neonicotinoid dust when nearby fields are planted with neonic-coated seeds, neonicotinoids from seed coating of the crop itself, and from neonic-contaminated soils. Examination of several crops planted as seeds coated with imidacloprid or thiamethoxam showed that neonicotinoids were present in pollen and nectar in most crops, with higher concentrations (ng/g) in pollen than nectar (Jiang *et al*., 2018). Pollen and nectar are the larval food of bees, and larval food contaminated with neonicotinoids results in exposure from the earliest ages onwards, not only as adult foragers.

Compared to Europe, Kenya and Brazil use a much higher fraction of known toxic pesticides than the EU: In Kenya, 43% of pesticides registered or used are categorised as highly toxic to bees, compared to 33% in Brazil and 15% in the Netherlands (van der Valk *et al*., 2013). However, data for Africa overall is lacking.

A comparison of LD50 of dimethoate (an organophosphate) and deltamethrin (a pyrethroid) of European, South American, and African bees showed considerable differences among bee species in sensitivity to specific pesticides. The African honeybee and the small African stingless bee, *Melliponula ferruginea,* respond most sensitively to dimethoate. Both African and Brazilian solitary bees are highly sensitive to deltamethrin, to which African honeybees are less sensitive. Bumblebees are least sensitive to both pesticides, suggesting that body size matters and that smaller bees are more susceptible than bigger ones (Blacquière 2010). However, it is overall unknown how African pollinators are affected by neonicotinoids, and knowledge is particularly lacking with regard to stingless bees.

Sublethal effects of pesticides can also be observed at the level of pollinator communities: In South African mango plantations, the distance from natural habitat negatively affects pollinator diversity, and pesticide use increases this negative relationship (Carvalheiro *et al*., 2012). It is unknown which pollinators are most affected by the combined lack of natural habitat and effects of pesticides.

Field-realistic doses are very different from the direct topical application used in LD50 tests, but they still negatively affect bee immunity, brood production and offspring sex ratio (skew towards male), adult longevity, mobility, learning and navigation ability, defence against predators, foraging activity at colony level, and colony growth rate, queen production, and swarming propensity. Thus, negative effects affect not only individual functions but also overall colony function and performance (full list of documented effects in Table 2.3.3. in IPBES 2016b). The sub-lethal effects in African pollinators, especially stingless bees, are unknown. African bees are less affected by breeding than European bees, they are more resistant to certain pests and pathogens – are they also more resistant to neonicotinoids? Most sublethal effects are found at colony level in field- and semi-field studies (Fig. 2.3.6. in IPBES 2016b).

A study of pesticide residues in bee products from Uganda (honey, beeswax, royal jelly, pollen for human consumption) by Amulen *et al*. (2019) found the neonicotinoids acetamiprid, thiacloprid, imidacloprid, and thiamethoxam in beeswax but not in the bees themselves and not in honey. This may be in part attributable to the chemical properties of the different neonicotinoids, which make them more soluble in aqueous solution (thus found in honey) or give them greater affinity to lipids (thus found in pollen). The findings of the Ugandan study contrast with a study of Kenyan bee products by *icipe* (Irungu *et al* 2019, in prep) in Kiambu County, where agriculture (including coffee production) is the predominant economic activity: Here, neonicotinoids were found in both honey and pollen taken from the same hives, though at very different levels. On a landscape scale, usage of pesticides is very heterogeneous, thus sample concentrations vary widely. Good data linking pesticide usage (amount, frequency, crop, etc.) with neonicotinoid presence and concentrations in bee products is lacking.

Question and Answer Session for this Talk:

Question: To what extent can data and findings from studies outside Africa be used to better understand the African situation? Which data gaps can only be filled through research in Africa?

Response: Recommendations for policymakers should be based on solid evidence. Extrapolation is a good tool but leaves some uncertainty. Empirical studies with real data will be more valuable and convincing to policymakers.

Question: Cotton varieties differ in pollinator dependence for seed set as cotton is generally considered to be partially self-compatible, so perhaps observation of few bees in cotton fields reflects more the properties of the crop than the amount and toxicity of the pesticides used?

Response: Seeing very few pollinators in a crop doesn't necessarily mean that the crop doesn't require pollinators – it might mean that pollinators are rare due to pesticide use, lack of nesting habitat, lack of permanent food availability.

Question: Were there pollinator declines already before the introduction of neonicotinoids?

Response: Pollinator declines are also a consequence of ongoing agricultural intensification and increase in use of pesticides. It is hard to assign pollinator declines unequivocally only to pesticides or particularly neonicotinoids.

Question: Other pesticides have dual action (contact plus systemic toxicity), so neonicotinoids are less toxic than other alternatives. What should be more important to the farmer – increasing yields or protecting the environment?

Response: Sustainable increase of yields requires environmental protection as a prerequisite. Even precision agriculture in Europe and the US are limited in their efficiency because ecosystem services cannot be replaced through mechanical and/or chemical measures. Integrated Pest Management (IPM) enables sustainable production while high-level precision agriculture will always be limited in yields and duration.

Professor Baldwyn Torto, Principal Scientist and Head of Behavioural and Chemical Ecology Unit, *icipe*, and Extraordinary Professor, Department of Zoology and Entomology, University of Pretoria, South Africa thanked the organisers for the invitation to contribute to this workshop and presented a talk on 'Neonicotinoids in Freshwater Systems of Western Kenya'. Agricultural runoff potentially results in pollution of surface waters, and this can influence the prevalence of some neglected tropical diseases like schistosomiasis (Halstead *et al*., 2018). Unusually heavy rainfall, which will become more common due to climate change, could affect surface water quality through massive washouts of pesticides. Western Kenya is mainly characterised by agricultural activities (tea, fishing industry, sugar cane, irrigated rice, etc.). A study conducted by an International consortium comprised of *icipe*, Helmholtz Centre for Environmental Research-UFZ Leipzig, Germany, RWTH Aachen University, Germany, and funded by the German Research Foundation (DFG) sampled 48 surface water bodies distributed within western Kenya. The study area is characterised by commercial agricultural plantations mainly tea, rice and sugarcane. These crops are sprayed with pesticides to ensure good yields.

The objective of the study was to identify the potential effects of organic micropollutants on the distribution and vector competence of the snail hosts of *Schistosoma* flatworms by examining water and sediment samples, as well as samples from *Schistosoma* host snails, their predators, and competitors. Imidacloprid and acetamiprid were found in water, snails, and sediment. The degradation product imidacloprid-guanidine, resulting from photolysis in water and with higher mammalian toxicity than the parent (Sharma 2012), was found only in water while thiacloprid was detected only in sediments. All examined snails contained imidacloprid and acetamiprid. Five sites had extremely high toxic unit values for crustacean community. Depending on the site, the risk stems mostly from acetamiprid or imidacloprid. In conclusion, neonicotinoids were detected in aquatic systems of western Kenya. Snails and sediments act as passive samplers that allow for the detection of compounds that are not detectable in water. It is important to monitor aquatic ecosystems to prevent potential (eco)toxicological effects. Since some metabolites have been shown to be more toxic than the parent substance, their presence in the environment should be included in chemical analyses of future environmental studies. Additional studies are also needed in the potential primary sources (e.g. agricultural crops, soil) and impact on other fauna (e.g. pollinators, other beneficial organisms).

Question and Answer session for this talk:

Question: Can you link the magnitude of toxicity with specific crops?

Response: We are busy with establishing this knowledge. There is some link between crop and toxicity.

Question: Are the observed levels high enough to affect humans as well?

Response: We will look at that in the future

Question: Are there baseline values or pollution thresholds for water in Kenya?

Response: Baseline values are not known. There are no guidelines or thresholds for maximum residue concentrations in water. These need to be established and communicated to policy makers.

Question: Do neonicotinoids go into the brains of the snails?

Response: Not yet examined

Question: Have you done upstream-downstream comparisons of the aquatic fauna relative to fields that use pesticide?

Response: Data on concentrations upstream and downstream have been collected but have not been analysed yet.

Comment: Neonicotinoids are much more effective in killing the predators of snails than snails themselves in studies in the US. *Daphnia* very resistant to pesticides in general.

Response: The *Schistosoma* host snails are more resistant to neonicotinoids than their predators in our studies, too. This will influence levels of schistosomiasis in that area. If we lose the predators of the host snails, then schistosomiasis will become an even worse problem in that area.

Close of Pre-meeting Session:

Professor Mike Norton, Scientific Director of the EASAC Environment Programme, thanked the speakers and *icipe* for hosting the meeting. *icipe* speakers have nicely introduced problems caused by neonicotinoids in both bees and the ecosystem services provided by snails and aquatic organisms. He thanked the participants for traveling to Nairobi and explained that this is the second and last meeting for this project.

Day 1: 14 May 2019

2. Session 1: Welcome and Introductory Remarks

Professor Volker ter Meulen, former President of the German National Academy of Sciences Leopoldina, welcomed participants and reiterated the key points from yesterday's talks by Michael Lattorff and Baldwyn Torto. He outlined the programme for the workshop and emphasised the main purpose of this workshop, namely discussing and finalising the main messages for policy makers. He explained the collaboration between Leopoldina and EASAC on topics like biodiversity and pesticides and thanked the German Federal Ministry of Education and Research (BMBF) for funding this project.

Mr Stanley Maphosa, International and National Liaison Manager at ASSAf, thanked Professor ter Meulen, EASAC, NASAC, *icipe*, and the workshop participants for bringing together, and contributing to, this project. ASSAf has a long-standing collaboration with EASAC in bringing science to policy, where it is needed to create evidence-based policies. ASSAf honours and brings together South Africa's most excellent scientists (currently 550 members) to bring science to policy making. ASSAf signed a Memorandum of Understanding with the Pan-African Parliament that enables ASSAf to bring their evidence into Parliament, thus creating a direct connection between the scientific community and Parliament. Stanley thanked his colleagues at ASSAf and EASAC for preparing and organising this meeting.

Mrs Jackie Olang-Kado, Executive Director of NASAC, welcomed workshop participants and explained that ASSAf is a member of NASAC, whose mission it is to bring together African scientists from all over the continent, to give them a voice in policy making, and to enable the establishment of new academies in countries that do not have academies yet. NASAC communicates with Regional Economic Communities (RECs) and other pan-African and regional African organisations. NASAC has excellent convening power and conducts both science-for-science and science-for-policy projects. Science advice is critical for NASAC and brings NASAC together with like-minded organisations like EASAC and IAP, which also provide valuable feedback loops for NASAC to ensure that their work is aligned globally and advises sustainable policies for Africa. Science cannot save Africa, but Africa cannot be saved without science. Jackie thanked *icipe*, which is a very important institution for Africa, for hosting this meeting.

Dr Peter McGrath, Coordinator of IAP for Science, introduced the InterAcademy Partnership, which brings together the four regional networks from Europe (EASAC), Africa (NASAC), Asia (Association of Academies and Societies of Sciences in Asia (AASSA)) and the Americas (InterAmerican Network of Academies of Sciences (IANAS)). IAP can call on approx. 30 000 scientists in their policy advisory work. A good example for IAP's work is the recent project on 'Food and Nutrition Security and Agriculture', which started with four regional reports that were summarised in a global synthesis report published in November 2018. A second example is the current project 'Neonicotinoids and their Impact on Ecosystem Services for Agriculture and Biodiversity in Africa', which started with the European project 'Ecosystem services, agriculture and neonicotinoids' by EASAC (published 2015) and has now been extended to the African content. He thanked *icipe* for hosting this meeting.

Dr Sunday Ekesi, Director of Research and Partnerships at *icipe*, thanked the participants for choosing *icipe* as a meeting place. *icipe* and NASAC share the same founding father, Professor Thomas Risley Odhiambo. *icipe's* work and the present workshop focus on insects, whereby the primary concern about their wellbeing extends to food and nutrition security and biodiversity. Ecosystem services and animal, plant, and human health are also key foci of *icipe's* work. African agriculture is thought to be still safe from neonicotinoids, but this is not correct. The resilience of African bees and insects to neonicotinoids has been overestimated and there is increasing evidence of the damage caused by neonicotinoids to African insects and ecosystem services. The present project on neonicotinoids is therefore very valuable and will provide crucial advice to African policymakers. He wished the workshop participants an enjoyable workshop and thanked them again for coming to *icipe*.

Dr Christiane Diehl, Executive Director of EASAC, introduced EASAC and thanked the co-organisers for their help and *icipe* for hosting this meeting. Over the past years, the structures of the European institutions have become more and more important, and the value of the European academies has increased tremendously in providing evidence for science-based policy making. A similar trend can be observed in Africa, and this project provides a good example of bringing Africa's best science to policy makers to help protect African agriculture from the devastating effects of neonicotinoid pesticides.

Dr Mike Norton, Scientific Director of the EASAC Environment Programme, welcomed the workshop participants, and particularly the new participants that had not attended the Pretoria workshop. As a reminder to all, and an introduction to the new participants, Mike summarised project progress and recapped the Pretoria Workshop key outcomes. EASAC started its project on neonicotinoids in response to discussions around the toxicity of neonicotinoids and ongoing mass fatalities of bees in Europe. The EASAC report considers not only pollination but also other ecosystem services and quantified their economic value. Neonicotinoids are water-soluble and mostly used in seed coatings, but only 5% of the neonicotinoids are taken up by the plant. The rest mostly leaks into the soil where it affects soil fauna, leaks into water bodies, and is taken up by other (non-target) plants. Due to their systemic nature, neonicotinoids also get into pollen and nectar and thus negatively affect pollinators. Due to their special characteristics, the toxicity of neonicotinoids differs from that of many other chemicals: neural blockage is cumulative and non-reversible, so even very low doses accumulate over time. Neonicotinoids are also very persistent pesticides; thus they accumulate over subsequent cropping cycles in many soils, and leach into watercourses. The conclusions of the EASAC reports were that there was an increasing body of evidence that the widespread prophylactic use of neonicotinoids has severe negative effects on non-target organisms, which provide ecosystem services, incl. pollination and natural pest control; that there is clear evidence for sub-lethal effects of neonicotinoids; that even very low levels can have severe effects on bee health, e.g. through interactive and synergistic effect with latent viruses in bees and other stressors; and that the large-scale preventive pesticide usage against occasional or secondary pests is of questionable sustainability. With regards to EU policy, the EASAC report concluded that the sublethal effects of neonicotinoids are not sufficiently addressed in the present EU approval procedures, and that the prophylactic use of neonicotinoids is inconsistent with basic principles of IPM as expressed in the EU's Sustainable Pesticides Directive (2009/128/EC).

Till the publication of the EASAC report, the focus of research and concerns in the EU had been on honeybees, which have a significant buffer to external negative influences from their colony structure. Following EASAC's recommendations, the debate in the EU was extended to ecosystem services more generally, further research on ecosystem services was conducted, and the three main neonicotinoids (clothianidin, imidacloprid and thia-methoxam) were banned for outdoor use in 2018.

Following this regulatory response, EASAC and IAP became concerned that the neonicotinoids ban in Europe will have negative consequences on African agriculture due to pesticides producers seeking alternative markets and started the current project. As a first step, a workshop was held in Pretoria in November 2018 to discuss the existing evidence base for neonicotinoid usage and effects in Africa. A questionnaire was sent to all workshop participants, a literature survey on published literature on neonicotinoids in Africa was conducted, and a provisional report/position paper was drafted. The current workshop is the second and last workshop planned in this project and serves to expand the consultation process with African experts that was started in November 2018. Thanks to NASAC, eight additional African countries are represented in the current workshop. Furthermore, the workshop serves to update and review the paper on the use and effects of neonicotinoids in Africa, to discuss and agree on key messages, to discuss future research needs and coordination, and to exchange opinions on improvements in extension services and regulation. The planned timeline involves updating of the position paper after the meeting with new material provided by workshop participants (next 6 weeks), to have the report peer-reviewed, and to get endorsement from EASAC and NASAC. Target publication date is in September/October 2019. In parallel, the key messages will be disseminated to policy makers in Africa, international aid organisations, and through IAP to the regional member academies.

Question and Answer session for this talk:

Question: Will we also communicate key messages to producers and the public?

Response: Yes, absolutely.

Question: How to deal with multinational pesticide producers?

Response: The European political process managed to balance scientific evidence and pressure from chemicals companies and from farmers clamouring for easy access to pesticides. EASAC does not get involved in such debates, but the provision of scientific evidence has resulted in a majority vote for a ban of several neonicotinoids at EU level. One of the points of this workshop is to find ways to enable African policymakers to make evidence-based decisions with the help of the workshop participants.

3. Session 2: New Information from Academies' representatives

3.1 Professor Salah A. Soliman, Department of Pesticide Chemistry and Technology, Alexandria University, and past Chairman of the Agricultural Pesticide Committee of Egypt, introduced several unknown facts about neonicotinoids in Egypt. How much of these chemicals are used in Africa? What is the impact of these chemicals on ecosystem services, particularly pollinators – and what about birds and other animals? How much colony collapse disorder (CCD) is taking place in Africa?

In 2007, Egypt used a total of 5.9 kilotons of pesticide active ingredients (18% herbicides, 58% insecticides, and 24% fungicides), which represents 0.25% of worldwide pesticide usage. In comparison, in 2007, worldwide pesticide (active ingredient) usage was 2 372 kilotons, of which 22% were used in the US. China is a major pesticide exporter to the US and has increased exports more than tenfold between 1999 and 2005 (from $12 million to $162 million).

Table 1: Pesticide use in some African countries (metric tons of active ingredient)

Country	Quantity	Year	Country	Quantity	Year	Country	Quantity	Year
Burkina Faso	1,044	2009	Kenya	1,998	2000	Niger	7	2009
Burundi	304	2005	Madagascar	144	2009	Rwanda	1,188	2009
Cameroon	6,492	2009	Malawi	517	2009	Senegal	491	2000
Egypt	8,091	2011	Mali	24	2009	South Africa	26,857	2000
Ethiopia	602	2000	Mauritius	2,324	2009	Sudan (former)	266	2009
Gambia	813	2005	Morocco	13,966	2005	Tunisia	2,136	2009
Guinea	449	2009	Mozambique	915	2009	**Total**	**68,576**	

The documented pesticide use of the countries in Table 1 amounts to approx. 68,600 metric tons. Assuming that the countries not featured in Table 1 use similar amounts of pesticide, the total assumed use of pesticides in Africa is approximately 137,000 to 170,000 metric tons or 5.5 – 6.8% of global pesticide use. Table 1 also shows that South Africa is the largest pesticide user in the continent, followed by Egypt. In Egypt, pesticide use has increased from approximately 3,600 metric tons in 2005 to approximately 8,000 metric tons in 2011 and is currently estimated at approximately 10,000 tons of active ingredient, mostly insecticides.

Pesticide registration in Egypt is controlled by the Ministry of Agriculture and Land Reclamation (Agricultural Pesticides Committee and Veterinary Services) and the Ministry of Health. The basis of registration is harmonisation with other national, regional, and international agencies, and assessments of risks and efficacy. Some of the pesticides currently in use in Egypt have been already banned elsewhere. Suggestions to ban active ingredients in Egypt generally use international agreements and conventions, decisions by the European Commission (EC) or US Environmental Protection Agency (EPA), and World

Health Organisation (WHO) and Food and Agriculture Organisation (FAO) classification of toxicity and lists of obsolete pesticides as guidance. Similarly, registration of pesticides follows guidance from EC or US EPA decisions, but there are no specific reasons for looking at these institutions for guidance.

Currently 113 neonicotinoid pesticides are registered in Egypt, of these 14 are technical and 99 are formulated pesticides. For authorised quantities (tons) of neonicotinoids in Egypt in 2012-2015 and use of neonicotinoid active ingredient in 2017, see Table 2. The 48 metric tons of neonicotinoids in use in Egypt in 2017 represent 0.48% of the estimated current pesticide usage of 10,000 metric tons per year.

Table 2: Neonicotinoids authorised for use in Egypt in 2012-2015, and neonicotinoid active ingredient used in Egypt in 2017 (tons)

Neonicotinoid	**2012**	**2013**	**2014**	**2015**	**2017**
Acetamiprid	4.84	8.32	13.32	5.26	27.72
Clothianidin					2.40
Dinotefuran	2.02	1.01	1.01	----	0.61
Imidacloprid	33.04	15.47	30.12	46.34	1.73
Sulfoxaflor					0.84
Thiacloprid	1.94	2.43	1.92	2.40	2.64
Thiamethoxam	0.37	0.83	5.64	4.37	12.17
Total	**42.21**	**28.06**	**52.01**	**58.37**	**48.11**

Following the EPA's decision to change pesticide labels to better protect pollinators, e.g. by adding directions like 'Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen', the Agricultural Pesticides Committee (APC) has restricted use of neonicotinoids to outside the flowering season and times of bee activity (amendment of June 17, 2015). On May 15, 2018, the APC decided that Plant protection products (PPPs) containing clothianidin, imidacloprid, and thiamethoxam shall be used only under Greenhouse conditions; that the quantities of these neonicotinoids registered shall be reduced by 20% per year; and that there shall be continuous follow up on relevant decisions taken by the EC. Good alternative pest management to neonicotinoids usage must offer efficacious control of target pests, availability (particularly in developing countries, includes affordability), durability (low risk of resistance development in target pests), and practicability (ease of use by farmers).

Question and Answer session for this talk:

Question: How should farmers avoid application of neonicotinoids during crop flowering period and bee foraging?

Response: This recommendation focuses on kept beehives and means that people should move kept beehives out of harm's way before spraying.

Question: Neonicotinoids bind insect receptors more strongly to insect than to mammal receptors. Do neonicotinoids bind to human receptors and impact human health?

Response: At the time of initial registration, pesticide companies argued that neonicotinoids bind much more strongly to insect than mammalian receptors. Studies in humans are generally lacking. Evidence for harm to humans mostly comes from accidental exposure, where effects on the nervous system were shown. More research is needed, also into permanent/long-term exposure.

Comment: We must also look into food sustainability, particularly the effects of neonicotinoid residues in food and their effects on human health.

3.2 Dr Enock Dankyi, Department of Chemistry, University of Ghana**,** introduced the occurrence and use of neonicotinoids in Ghana. In general, insecticides play a critical role in food production in Ghana. Insecticides comprise the highest number of fully registered pesticide formulations under Ghana's EPA Act 140 (EPA Revised Pesticide Registry, 2015). Neonicotinoid insecticides comprise a significant proportion of insecticides applied and are used in cocoa, cotton, fruits, vegetables, pulses, sweet potatoes and for seed treatment. Currently imidacloprid, thiamethoxam, and acetamiprid are fully registered for various applications in Ghana. They are mainly applied as foliar sprays in which the insecticides are applied to the leaves and branches of trees using backpack manual sprayers or motorised mist blowers. Seed application is limited in Ghana. The overwhelming majority of neonicotinoids are applied in cocoa farming for the control of mirids.

Ghana is the second largest producer of cocoa beans worldwide, with the crop playing an integral role in the economy of the country. The cocoa industry employs about 800 000 farmer families and the crop generates about USD 2 billion in foreign exchange annually. In six of the ten former regions of Ghana, cocoa farming is an important source of revenue (Ghana Cocoa Board; www.cocobod.gh). As such, the cocoa industry is highly regulated and has huge governmental support. To address decline in yields from pests and diseases (up to 40% yield losses[1]; and in particular from insect pests mostly the mirids: *Sahlbergella singularis* and *Distantiella theobroma),* the government of Ghana set up the cocoa disease and pest control program (CODAPEC) in the year 2001. Under the program commonly referred to as "mass spraying", pesticides (amongst them Confidor, containing imidacloprid) are applied on cocoa farms or given to farmers for application at no financial cost. The program does not only ensure the control of pests in cocoa farms, but also ensures the use of approved insecticides on farms. Neonicotinoids are an integral part of this program and are widely applied in cocoa farms multiple times each year. The recommended rate of insecticide application is four times in a year in the months of August, September, October, and December, based on high mirid populations during these months.

[1] https://www.graphic.com.gh/news/general-news/cocobod-introduces-hand-pollination-to-increase-yield.html

Insecticide application is considered the most effective means of insect control (Adu-Acheampong *et al* 2015). Together with other interventions, neonicotinoids have helped contribute to significant increases in cocoa yields. However, the problem is that farmers now rely entirely on insecticides. For instance, the ease of access and approval of Confidor by the Ghana Cocoa Authority has encouraged misuse and abuse resulting in large and widespread exposure in food (cocoa: Dankyi *et al.*, 2015) and soils, where neonicotinoids exhibit high persistence with dissipation half-lives of over 150 days in imidacloprid and thiamethoxam (Dankyi *et al.*, 2014, 2018).

Neonicotinoids usage is showing clear negative effects on ecosystem services in cocoa: The main pollinators of cocoa are midges (Ceratopogonidae), even though flowers are visited by other insects that collect the exposed nectar and pollen. Currently there is a general impression of reduction in midge numbers, even though this has not yet been formally quantified, and yield reductions due to lack of pollination are noticeable. In response, the Ghana Cocoa Board (COCOBOD) launched a national hand pollination program in 2017, which employed 30 000 youth to hand-pollinate cocoa trees[1]. This program aims to increase cocoa yields from currently 12 pods to 100 pods per tree, and to elevate overall yields from the current 0.45 tonnes per hectare to the 2 tonnes/hectare harvested in Malaysia, Indonesia, and Ecuador. When launching this program, the Chief Executive of COCOBOD, Mr Joseph Boahen Aidoo, stated that 'hand pollination had become necessary because the natural agents for pollination - insects - had reduced in numbers through the spraying of chemicals on farms to ward off diseases that affected the trees and the pods'[2].

Follow up information: Preliminary results (pers. comm. Enock Dankyi, July 2019) from this program suggest that yields have increased to varying degrees in many farms, with yield improvements between 10% and 100%, although some farms reported no observable increases. Following the first year of hand pollination, yields in subsequent year(s) were constrained by a lack of flower production. The effect of the hand pollination exercise may not have reflected directly in annual cocoa bean production, though, because yields are also limited by diseases, particularly the cocoa swollen shoot virus. However, the wide range of yield improvements from hand pollinations, and the reports of no improvements, suggests that hand-pollination cannot replace natural pollination services in the long term. This may be due to the frail flowers of the cocoa plants, which are easily fatally damaged during hand-pollination attempts. In addition, the costs of the hand-pollination program are considerable: Assuming a payment of approximately US $ 100 a month per pollinator, for a duration of six months per year, the cost of 30 000 pollinators accrues to US $ 18 million per year.

In summary, neonicotinoids are extensively used in Ghana, resulting in high environmental exposure due to widespread usage and high application rates. Mass pesticide application programs are associated with low efficiency (mainly from wastage), higher cost and high environmental burden. Recent research indicates that current application regimes, which are based on studies conducted in the 1950s, are not suitable (Adu-Acheampong et al 2014). Education of farmers may be the most effective means to controlling pests and diseases.

3.3 Dr Elizabeth Bandason, Lilongwe University of Agriculture, and Natural Resources, Malawi, reported on pesticide use in Malawi. In Malawi, the use of pesticides is not regulated and

[2] https://www.graphic.com.gh/news/general-news/cocobod-introduces-hand-pollination-to-increase-yield.html

most farmers employ blanket sprays. The Poisons Board registers pesticides but does not follow up on uses. There is no consideration of flowering periods and pollinator activity in spraying regimes. The linkage between pesticide use in pest- and vector control is very poor. Indoor residual spraying (IRS) to coat the walls and other surfaces of a house with a residual pesticide is very common to control disease vectors like mosquitoes, and clothianidin is now in use for IRS. There are links between insecticides, agriculture, and mosquito control, and there is a need for spatial mapping of pests and vectors to find eco-friendly pest management solutions. Plant-based pesticides also require toxicity testing to ensure safety. Current research focuses on *Tephrosia vogelii* (Fabaceae) and neem (*Azadirachta indica*, Meliaceae), in particular on toxicity testing for topical application, identification of mode of action, selectivity of toxic action, and safety to bees. Pyrethroids can scare away insects even in minute amounts, so olfactory repellents can be an efficient means of pest control that requires minimal use of chemicals. Current research also focuses on control of agricultural pests with garlic extracts, combining botanical extracts with pyrethroids, and ensuring bee safety of products.

3.4 Dr Penny Hiwilepo-van Hal, University of Namibia**,** reported on types and uses of neonicotinoids in Namibia. Pesticides are regulated by the Namibian Ministry of Agriculture, Water, and Forestry (MAWF) under Act No. 36 of 1947, which was last amended in 1977. This act includes registration of fertilisers, farm feeds, and agricultural remedies (pesticides). Stock remedies have been incorporated in the Medicine Act administered by the Ministry of Health and Social Services. Pesticide laws were enacted to protect users, consumers of treated products, water, domestic animals, and the environment in general. Water is a particularly valuable resource in Namibia, whose water usage often exceeds rainfall so that groundwater is used, and pesticide leaching into groundwater is a major concern in Namibia. MAWF is now reviewing the pesticides act to make provision for the registration of pesticides and pest-control operators. Existing pesticides registration procedures in Namibia are cumbersome. In registration decisions, MAWF uses international guidance from FAO, the South African Bureau of Standards (SABS), WHO, CODEX, etc. to recommend or reject pesticide registration. Registration requirement include a dossier containing a) plant/pest specific research findings, b) human and animal health finds, c) environmental effects in semi-arid conditions, and d) toxicology profile. Regular inspections of agrochemical dealers and distributors are conducted to ensure registration compliance and safe storage, handling, and distribution. All pesticide registrations are renewed annually. In 2014, Namibia introduced an Import Permit system for pesticides, farm feed, and fertilisers. For successful import into Namibia, such goods need to be registered and issued with import permits first. Inspections are conducted at port of entry for verification of products to be imported.

Neonicotinoids registered in Namibia are imidacloprid, thiamethoxam, clothianidin, acetamiprid, thiacloprid, dinotefuran, and nitenpyram. Imidacloprid is available under the tradenames (e.g.) Blattanex Cockroach Gel, Confidor 70 WG, Gaucho 350 FS, Premise 200 SC, Merit 200 SC, Aphicide Plus, and Kohinor 350 SC, and is used to control sucking insects, termites, some soil insects, and fleas on pets. Thiamethoxam is available under the tradenames (e.g.) Agita WG 10 Fly Bait, Agita IGB Granular Fly bait, Kombat Molecricks, Aphi Free, Dyfly Sprinkle Bait. Acetamiprid is available under the tradenames (e.g.) Mulan 20 SP and Acata Star 48 EC, and is generally used to protect plants against sucking insects such as aphids, and to control household pests such as bed bugs and ticks. Some neonicotinoids are also used to treat livestock, which makes major contribution to Namibian Gross domestic product (GDP). The MAWF is already in process of deregistering pesticides found to have negative effects on environment and other living organisms. Registration of alternative pesticides to neonicotinoids will hopefully be possible. Technical and financial support is required to conduct an inventory of neonicotinoids in Namibia, and for implementation of IPM in the country.

Questions and Answer session for this talk:

Question: On what base do Namibian farmers select a pesticide – because it works elsewhere or because of proof of efficacy in Namibia?

Response: Most pesticide use is informed by efficacy in other countries.

Question: What are Namibia's most important crops?

Response: In addition to crops grown for domestic consumption (millet, maize etc.) Namibia's has important export crops such as black currants, dates, grapes and asparagus.

3.5 Professor Papa Ibra Samb, Department of Plant Biology, Université Cheick Anta Diop de Dakar, Senegal, summarised the very limited knowledge about neonicotinoid use in Senegal. Neonicotinoid regulation is subject to general pesticide legislation, which is under the control of the Sahelian Committee of Pesticides (*Comité Sahélien des Pesticides*) under supervision of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS)[3]. In November 2018, the Committee authorised 59 pesticide formulations, amongst them three formulations containing imidacloprid or acetamiprid for use against sucking insects, also in cotton. However, national guidelines for pesticide usage are very limited and control of actual usage is practically non-existent. Better understanding of neonicotinoids and their role in agriculture and ecosystem services is needed, and it is crucial that African scientists are involved in advancing research and identifying solutions.

3.6 Professor Samir Abbes, Institut Superieur de Biotechnologie de Beja, University of Jendouba, Tunisia**,** reported on the current situation in Tunisia with regards to neonicotinoids. Ten years after their discovery, neonicotinoids have become the most widely used class of insecticides in Tunisia, with large-scale applications ranging from plant protection (crops, vegetables, fruits), veterinary products, and biocides, to invertebrate pest control in fish farming. The citrus and olive agro-industry are the two pillars of the Tunisian economy, and both extensively use neonicotinoids. Neonicotinoids are also used on vegetable crops and rapeseed. Foliar application of neonicotinoids has become routine for controlling aphids, whiteflies, leaf miners and mites. Neonicotinoid resistance is appearing in some insects, particularly in economically important species of aphids (*Myzus persicae* (Charaabi *et al.*, 2017)), whitefly and plant hoppers. This loss of efficacy of neonicotinoids presents a serious threat to the continued success of aphid control.

The latest list of approved pesticides in Tunisia, revised and updated on 18 October 2019 by the Ministry of Agriculture, Water Resources, and Fisheries, contains imidacloprid. An article

[3] The Permanent Interstate Committee for Drought Control in the Sahel (French: Comité permanent inter-État de lutte contre la sécheresse au Sahel, CILSS) is an international organisation consisting of countries in the Sahel region of Africa. The organisation's mandate is to invest in research for food security and the fight against the effects of drought and desertification for a new ecological balance in the Sahel. CILSS member states are Benin, Burkina Faso, Cape Verde, Chad, Gambia, Guinea, Guinea-Bissau, Ivory Coast, Mali, Mauritania, Niger, Senegal, and Togo.

in the Tunisian LaPresse.tn[4] criticises the continued approval of imidacloprid given its recent ban in the EU, and reports that imidacloprid is distributed by eight companies in Tunisia. Even today, the Tunisian government authorises the importation, use, and marketing of imidacloprid on its territory despite well-established negative effects particularly on bees.

There is no Tunisian research that establishes a causal link between neonicotinoid products and declines in biodiversity. However, a study by Feki *et al*. (2018) examines the cardiotoxicity of thiamethoxam in vertebrates and suggests that a polysaccharide derived from fenugreek seeds could provide protection from the toxic effects of thiamethoxam.

Question and Answer session for this talk:

Question: Does the French ban of neonicotinoids have consequences for Tunisia? Will Tunisia rethink its authorisation of neonicotinoids?

Response: Farmers oppose the bans, particularly after the revolution. Farmers protest against neonicotinoid bans and thus oppose any attempts to follow the French example.

Question: Did France suggest alternatives when they banned neonicotinoids?

Response: Not really. Alternatives include changing the crop cycles, particularly when planting rapeseed. There are alternative techniques, a ban of one pesticide does not necessarily mean that farmers must change to another pesticide. In addition, there are other neonicotinoids that have not yet been restricted. The Ministry of Agriculture and Water Resources approved imidacloprid only in 2018.

Question: Are there publications documenting bee declines in Tunisia?

Response: I will check. (Follow-up: There are no published papers on disturbance of bee homing flight by neonicotinoids)

Comment: African regulatory authorities generally follow guidance from other countries (e.g. EU), so poor regulatory decisions elsewhere end up causing problems in Africa, too.

3.7 Professor Phillip Nkunika, Department of Biological Sciences, University of Zambia, reported on the use of neonicotinoids in the Zambian agriculture sector. Zambia has 42 million hectares, about 58% of this land is classified as medium to high potential for agricultural production. The country is divided into three agro-ecological regions, which are primarily based on rainfall and soil characteristics. The agricultural sector is the backbone of the Zambian economy. 70% of the farming community in Zambia are small-scale farmers.

Maize is one of Zambia's most important cereal crops, its high genetic diversity and broad usage account for its cultivation in all agro-ecological regions. It is a staple food for a large proportion of the population. However, many factors limit maize production, with insect pests infesting fields and stored grain being the key limiting factor. Due to climate change, Lepidopteran and termite pests have become the most damaging insects on maize. Fall armyworm (*Spodoptera frugiperda*) is the most serious pest, followed by African stalk borer (*Busseola fusca*), African armyworm (*S. exempta*), and several stem- and grain borers and termites.

[4] https://lapresse.tn/3492/enquete-sur-le-danger-des-pesticides-en-tunisie-interdits-en-europe-utilises-en-tunisie/

Farmers use various pesticides to combat pests, including neonicotinoids. Imidacloprid has been widely used to control termites in maize fields in most parts of Zambia. Fortenza Duo (Syngenta) is a new seed treatment technology, it contains thiamethoxam and protects plants for at least 4 weeks after germination against fall armyworm. The differences in plant growth and health between treated and untreated plants are remarkable. Fortenza duo protects against wide range of above-and belowground insects but is highly toxic to both insect pests and non-target organisms. Fortenza duo was registered in Zambia in January 2018 by the Zambia Environmental Agency (ZEMA), which is an independent environmental regulator and coordinating agency. Zambia's position on neonicotinoids has not been clearly stated.

Regardless of their successful use for pest control, research has shown that neonicotinoids pose danger to non-target organisms and their ecological functions. The current practice of prophylactic use of neonicotinoids is inconsistent with basic principles of IPM. In Africa, Indigenous Knowledge Systems (IKS) have played a significant role in the management of crop insect pests among small-scale farmers (Nkunika *et al*., 2013; Mihale *et al*., 2010). For example, Muswishi farmers in the central province of Zambia who employed Indigenous Technical Knowledge (ITK) under IPM had 37% maize yield increase compared to non-IPM farmers who did not use ITK (Nkunika 2002). ITK uses botanical insecticides that are compatible with IPM.

The present workshop can leverage on work done by the African Dryland Alliance for Pesticidal Plant Technology (ADAPPT)[5], which is a network for optimising and promoting the use of indigenous botanical knowledge for food security and poverty. Continued research into alternatives to neonicotinoids is essential. The increasing population in most African countries and greater demand for improved food security will result in increasing neonicotinoids usage as crop production increases. Research on the use of neonicotinoids in agriculture and ecosystems in Africa will be critical as their use increases, and correspondingly the need for more research on alternative control options. Small-scale farmers must be included in searches for alternatives to neonicotinoids.

3.8 Professor Charles Nhachi, Department of Clinical Pharmacology, University of Zimbabwe, introduced governance, use, and regulation of neonicotinoids in Zimbabwe. All pesticides used in Zimbabwe are regulated by the Fertilisers, Farm Feeds, and Remedies Act. Pesticides regulation is implemented by Statutory Instrument 144 of 2012. This legislation provides for registration of pesticides and regulates and restricts their importation and sale.

Pesticide governance in Zimbabwe is in the hands of the Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement and in the Specialised Services Division for Fertiliser, Farm Feeds, and Remedies (FFR)[6] of the Department of Research and Specialist Services. The FFR conducts research on pesticides and acts as the Pesticides Registration Office (PRO). Core functions of the PRO are registration of pesticides; registration of Pesticide Distributors, Retailers and Pest Control Operators; issuing of Pesticides Import and Export Permits, providing advisory services on various issues pertaining to pesticides, and post-registration surveillance. The PRO also has the mandate to enforce provisions of the pesticides legislation.

Neonicotinoids are used quite widely and liberally in Zimbabwe, there are no restrictions. Most pesticides are imported, almost none are produced in Zimbabwe. Registered

[5] http://projects.nri.org/adappt/
[6] http://www.drss.gov.zw/index.php/library/library-services/fertiliser-farm-feeds-and-remedies

neonicotinoids in Zimbabwe are imidacloprid, clothianidin, acetamiprid, thiacloprid, and thiamethoxam. Previously used pesticides (e.g. organophosphates) are very toxic to humans, currently the evidence base for human toxicity of neonicotinoids is very limited. Neonicotinoids are very efficient due to the specific sensitivity of insects. However, a metabolite of imidacloprid, desnitro-imidacloprid, is highly toxic to humans but not to insects[7]. In Zimbabwe, neonicotinoids are used for grain protection, to combat cotton aphids, in horticulture, and IRS. However, pesticide use is prohibited in tobacco. Fludora Fusion, a combination of clothianidin and deltamethrin, currently going through registration for IRS.

In the absence of own data and guidelines, Zimbabwe follows the Rotterdam, Stockholm, and Montreal conventions, and FAO code of conduct in use of pesticides (though not binding). However, with regards to neonicotinoids regulation, Zimbabwe is not (yet) listening to Europe's example.

General discussion:

Dr Katambo (Tanzania): In Tanzania we are advising beekeeping policy and some of the statements are very clear on bee protection. However, agricultural policy in Tanzania does not mention bee health, and bee health is also not mentioned in agricultural policies in other African countries. Policies are government documents and form the basis of laws. If policy makers are not aware of the need for pollinator protection, then the laws and regulations will also be silent on the matter. The beekeeping sector in Tanzania is in trouble because agricultural policy does not make provisions for pollinator protection. Bee populations in Africa are largely wild, but wild populations, too, will die from neonicotinoid exposure.

Prof Nhachi (Zimbabwe): Agricultural policies and regulations are not evidence-based because of lack of research. Policies are also silent because of lack of scientific evidence to change this.

Prof Paraiso (Benin): More and more people are aware of the importance of pollination and are aware of the relation between pollination and productivity. FAO has declared 20 May as World Bee Day[8], this will increase awareness of the importance of bees. Small-scale farmers who have only a few hives on their plot are particularly hard hit by declines in pollination services and therefore agricultural productivity.

Prof ter Meulen (Germany): Which African countries are we still missing that might have good data/information on neonicotinoids?

Prof Nhachi (Zimbabwe): Is the impact of neonicotinoids on insects in Africa the same as in Europe? African insect diversity is much higher.

Prof Pirk (South Africa): Given that Africa has more insects, the impact is expected to be higher. Research from South Africa shows similar sensitivity of insects to neonicotinoids as reported from elsewhere. To feed the continent, we need to have reliable pollination services, this includes a good knowledge base about bee numbers, health, etc.

Dr Assad (Sudan): What is the cause of observed decline in agricultural production, what should be prioritised – protecting the bees or combatting the pests?

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[7] Tomizawa and Casida (1999), Tomizawa *et al.*, 2000, 2001

[8] https://www.un.org/en/events/beeday/

Prof Pirk (South Africa): Pollinator diversity increases yield and yield quality.

Prof Soliman (Egypt): It is important to better understand the impact of neonicotinoids on ecosystem services and insects in Africa. Data is needed on the type of neonicotinoids used in each country (different neonicotinoids act differently and have different persistence in soil), when authorised in which country, annual use in each country, types of crop protected by neonicotinoids, application method, and we need to have solid information on annual production of honey as one measure of pollinator availability/health. It would also be useful to know the availability of equivalent alternatives in each country. For example, Egypt uses 10 000 tons of active ingredients per year, of these only 50 metric tons are neonicotinoids.

Dr Mulumba (South Africa): We have all regional communities represented at this workshop, and problems are generally similar within regions. The challenge is to convince policy makers to make decisions. Problems affecting human health have highest priority, followed by economic effects and food security. The articulation of arguments affects priority given by policy makers. The working group (WG) needs to make sure that their recommendations are articulated for maximum impact. Strongly emphasise need for further research. Despite declines in pollination services, food production has not declined, but has also not kept up with population increase. Make sure all arguments are factually correct and do not exaggerate.

Prof Obopile (Botswana): There is need to find crop protection measures that balance destruction of pests with protection of beneficial organisms.

Dr Kasangaki (Uganda): Ugandan policy makers prioritise economic impact, so arguments must specify gains and losses of suggested measures.

Prof Gikungu (Kenya): There is also the aspect of conserving our natural heritage, which includes food, plants, and ecosystems. Consider packaging arguments along natural heritage arguments. Focus on bees because of the clear economic impact of losses but use them to make the case also for the other 3000-odd bee species in Africa. Studies show that bee diversity in Kenyan coffee cultures is positively linked with productivity[9].

Dr Katambo (Tanzania): Synergies between pollinators and pest control will be the only thing that will make sense to policymakers. Trade-offs are unattractive to policy makers. All recommendations should ensure food security and increase pollination and productivity.

Prof Ngamo (Cameroon): Registration of neonicotinoids has increased since the Pretoria meeting (14-16 November 2018). We need to provide basic information: How do neonicotinoids work? How long does it take until all residues are cleared from the environment? Explain that neonicotinoids are not the only group that is killing pollinators, and that honeybees are not the only insects who contribute to food production. There is a problem with resistance of whiteflies, though: If we remove a valuable tool like efficient pesticides such as neonicotinoids, we need to provide alternatives.

Dr Dankyi (Ghana): In IPM, chemical application as a last measure would be an improvement. Reduction of the number of applications would be progress. Emphasise that entire ecosystems are affected by pesticides, not only pollinators.

[9] Kenya: Karanja et al (2013); Indonesia: Klein et al, 2003; Mexico: Vergara and Badono, 2009; Badono and Vergara 2011

4. Session 3: Developing the Draft Statement on the Use and Effects of Neonicotinoids in Africa

Mike Norton introduced the draft statement developed based on the workshop in Pretoria in November 2018. This draft statement cites 105 references and today's workshop has already contributed numerous further references. Mike explained the basic structure of the document, and the detailed information found in the boxes – further information can be added during this workshop. Workshop participants will now be broken up into four discussion groups to discuss priority issues related to research and field studies. Discussion groups are based roughly geographical and on ecological similarities.

4.1 Feedback from West African countries:

Available studies and scientific resources

- Some countries already have labs working on neonicotinoids, but others do not.
- Ghana's data are limited to Enock Dankyi's studies, but no study on target organisms available.
- Senegal has the '*Centre Régional de Recherche en Écotoxicologie et de Sécurité Environnementale* (CERES-Locustox)' [10], which does ecotoxicological work but lacks permanent funding. Dakar University has several groups working on ecotoxicology in biology and chemistry.
- Ivory Coast has labs and research centres, amongst them the *Laboratoire National d'Appui au Dévelopement Agricole* (LANADA)[11], which works, amongst others, in quality control of agrochemicals and feeds, conducts research on pesticide and mycotoxin residues in agri-food products, and provides development research and consulting. There has been considerable work on mosquitoes and their resistance to pesticides and study of neonicotinoids effects in freshwater fish, and a study evaluating cocoa farmers' phytosanitary practices (Martin *et al*, 2018).

On regulatory/authorisation processes:

- Authorisation processes are often not implemented correctly, bribery is common.
- In West Africa, the Sahelian Committee of Pesticides (CSP) is the body in charge of the implementation of the CILSS members states' Common Regulations for pesticides registration [12]. The CSP reviews registration dossiers submitted by firms dealing with pesticides to be granted authorisation for sale in the CILSS Member States.
- At the level of regional communities, West Africa (CILSS) has the CSP, which makes lists of product preparations that can be used. Each country can decide whether they use these preparations or not. In Central Africa the Economic Community of Central African States (ECCAS), the Interstate Committee of Pesticides in Central Africa (CPAC) is a sub-regional inter-state body in charge of pesticide regulation for some member states. Cameroon has its own regulatory body. There are intentions to harmonise regulation amongst countries. Authorisation decisions often rely on prior informed consent procedure.
- Authorisation processes are driven and sponsored by chemical companies
- In Cameroon, staff working in the institutions registering pesticides are not aware of their toxicity to non-target organisms.

[10] http://cereslocustox.sn/
[11] http://www.lanada.ci/index.html
[12] www.insah.org/doc/pdf/GUIDE_CSP_FINAL_nov_2017_anglais.pdf

- Syngenta pays for emergency registrations of Fortenza Duo against fall army worm
- *icipe* has a project on 'integrated pests and pollinator management' (IPPM) strategies in avocado-cucurbit production systems in East Africa.
- In Cameroon, regulation is very tricky, private sectors finance and drive registration process.

Research/scientific resources needed:

- Studies needed on the effects of neonicotinoids in plants and soils. Studies available were looking at effectiveness of neonicotinoids, alternative pesticides, and resistance. Lack of permanent ecotoxicology labs, institutes dedicated to research on neonicotinoids. Ghana Standards authority is not a research body, they apply the same standards to several crops.
- Needed: an independent laboratory that follows international standards in assessment and makes independent recommendations.
- Following EU rules in African climate may not be adequate. Research is needed on pesticide (side) effects, persistence, efficiency, etc. under African conditions.
- Cameroon: Many laboratories working on pollinator biodiversity, but research is lacking on pollinators and pesticides. There is a lack of research providing evidence that bees are dying following application of pesticides, but the University of Ngaoundéré is planning research on this.
- More independent research institutes on pesticides are needed, more research on neonicotinoids is necessary to develop relevant standards for African climate and soils.
- Laboratory capacity to detect neonicotinoid residues is very important and should be integrated into all regional groupings.
- There is need for socioeconomic studies on the perception of neonicotinoids. Farmers want maximum toxicity and feel upset if they do not get sick after applying pesticides as they interpret lack of sickness as lack of pesticide efficacy.

On communication, outreach, and education:

- The scientific community must be more vocal and proactive in communicating the dangers of (neonicotinoids) pesticides and help train the next generation of communicators. Information needs to filter from the scientific community to the farmers.
- Better education of farmers and pesticide operators with regards to effectiveness of insecticides. Instant death of insect is not the only, or relevant, measure of success.
- There is a lack of awareness of farmers and the public in general – research institutes need to do education and outreach to increase awareness that insects can also be beneficial, e.g. by providing pollination services.
- Preventive application of pesticides is a waste of money. Come back to the principle of IPM, organise surveys to assess level of pest infestation, establish meaningful thresholds for pesticide treatment. More education is needed.

Other comments:

- International Plant Protection Convention (IPPC) of FAO will make a list of active ingredients that can be used, based on existing treaties, conventions, etc.
- Some African countries inherited old pesticides stock from FAO, some of which are now banned elsewhere but are still being used in Africa.
- Farmers know about toxicity of old pesticides and are keen for new alternatives.

- If there are pest outbreaks in Senegal, pesticides are donated by other countries, amongst them banned pesticides. The government then distributes the donated pesticides to the people at no cost. Farmers tend to overdose those pesticides because they were free.
- In Sudan and Mali, pesticides are sprayed against tree locusts. Locusts are commonly eaten in these countries, particularly by children, and there have been child deaths due to pesticide poisoning from locusts. The FAO recommendation to Africans to eat more insects can be very dangerous unless insects are specifically farmed for human consumption. Insect farming is essentially non-existent in Africa.
- Spray application is a very common method of application in Ghana, so neonicotinoids spread widely through drift.
- Senegal: In the past, vegetables had to be banned from human consumption due to excessive pesticide residues.

4.2 Feedback from North African countries:

No representative from Morocco, Algeria, Libya.

What volumes of neonicotinoids are used?
TUNISIA: Not aware of exact totals.
SUDAN: No figures on hand, Sudan uses 4 types of neonicotinoids in differing concentrations on cotton, vegetables etc.
EGYPT: 42 and 50 tons of just neonicotinoids (Egypt is 3rd highest user on continent, Morocco 2nd and South Africa 1st). National Agricultural Pesticide Committee has data on import, mixing and use.

When did neonicotinoid use commence?
TUNISIA: 2000
SUDAN: Late 90s
EGYPT: Late 90s

On what crops are neonicotinoids used?
TUNISIA: Olive, citrus, wheat (seed treatment), barley, palm
SUDAN: Cotton, palm (soil and tree injection), vegetables, particularly tomatoes, okra, eggplant
EGYPT: Authorisation of use on all important crops, essentially all crops

Which active ingredients are used?
TUNISIA: Imidacloprid
SUDAN: Imidacloprid, thiamethoxam, acetamiprid, thiacloprid
EGYPT: Clothianidin (but stopped recently), all 6 neonicotinoids

How are neonicotinoids applied?
SUDAN: Soil, seed or foliar spray and injection

How is honey production organised, how much honey is produced?
TUNISIA: Family farmers, no exact amounts known
SUDAN: Commercial beekeeping, but no data on hand, depend mainly on wild honey hunters
EGYPT: Will look for data on pesticide use and honey production and correlation data

Are there observations/studies on honeybee losses in your country?

TUNISIA: Bees are mostly in Eucalyptus plantations, so minimal loss etc., observed possibly due to insect deterrent

EGYPT: Representative has personal observation of honeybee losses

Switching from neonicotinoids to other pesticides? What consequences do EU decisions on pesticides have for your country?

SUDAN: Switching means going back to organophosphates and pyrethroids, so that would affect especially vegetables and resistant pests

EGYPT: All export foods will be affected because the detectable levels of residues must be especially low to continue exports. Currently levels are low. It will be easier to reduce usage: legislation is in place to allow for immediate banning of products once the EU bans them. This is similar in the Sudan and most likely Tunisia will also be forced to do so eventually.

General discussion:

- To make recommendations for change, one must acknowledge that these products are important for agriculture but must show that these chemicals are proven to affect pollinators, and that pollinators are important for farming success. The question is how to get farmers to live with restrictions and compromises.
- There is a lack of studies on bioaccumulation of neonicotinoids in the systems in which they are used. Water and soil especially are affected by presence and accumulation of neonicotinoids.
- Little or no information is provided on the effects neonicotinoids have on birds, which are an important factor in biological pest control.
- Acute toxicity testing of neonicotinoids relies on the amount of active ingredient per bee at one instant. However, bee foraging results in accumulation of doses, so the moderately toxic effect observed in acute toxicity testing is meaningless.
- Toxicity testing also suggests that neonicotinoids are practically non-toxic for fish and practically non-toxic to moderately toxic for birds.
- Are neonicotinoids the only factors linked to the loss of the pollinators? Do we need many more parallel laboratory and field studies in Africa to assimilate more data?
- Africa has many more pollinator species and differing climatic regions, so more research is needed. Much of the EU decisions were based on research on a single pollinator species in a temperate region.
- Perhaps honeybees could develop resistance and fortify the populations through selective pressure?
- There is a clear dichotomy between protecting honeybees and protecting the crops from pests. Perhaps it would be good to rely on seed treatments to ensure that crops reach a certain growth stage – by doing so, less spray cycles would be needed, and this would be beneficial for the pollinators.
- New alternatives are usually more expensive because they come from Europe. Why not come up with local alternatives, natural alternatives?
- It is always better to look for alternatives coming from the people on the ground. However, if no alternatives are forthcoming, then go for pesticides developed elsewhere.

4.3 Feedback from East African countries

East Africa (Kenya, Malawi, Tanzania, Uganda, Zambia)

Country-specific comments

- In Uganda, there is generally limited research on neonicotinoids, including residues (e.g. in honey). Need to quantify effects and put in economic terms.
- Malawi has no data on current status of neonicotinoid residues in the environment or food, which would yield important baselines for later comparison. Also needed are studies on insect abundance and diversity, which could be used to quantify their economic value and to assess neonicotinoid effects on ecosystem services.
- Zambia has lucrative honey industry/export (managed and wild honeybees) but little is known about pollinators. Beekeepers rely on feral colonies.
- Termites are important in recycling dead biomass and are also eaten. They are found on Zambian markets but are difficult to rear.
- In Tanzania, the size of bee colonies is getting smaller and colonies are becoming fewer. In the past, baits would draw hives. Today, 50 bait stations will only draw 10 hives. What is the cause - is it related to pesticides, neonicotinoids, other threats?
- In Tanzania, studies look at residues but not at pollinators, particularly not their behaviour.
- In Kenya, application of miticides to beehives resulted in significant bee deaths.

Information gaps and needed research

- Good data is usually lacking, so problem is often only poorly defined. Who collects data, what is collected, how is data collected (comparative manner)? Standardisation of procedures is needed.
- Need standardised protocols to enable comparison across countries (e.g. Group on Earth Observations' Biodiversity Observation Network (GEO BON)[13], the Bee Informed Partnership[14] collects data across US and Europe to monitor CCD, *icipe* can provide leadership on standard protocols).
- There is a general need for rapid assessments/baseline data in soils, water (including sediments), and food products.
- Most countries in Africa (maybe except Kenya) have little data on presence, abundance, distribution, endemicity, and ecological requirements of insect species.
- Conduct surveys: Active ingredients and trade names in each country, recommendations for crop/pest combination. This info is available for Tanzania and Malawi.
- Also look at other ecosystem providers – e.g. biodegradation/decomposers; soil aeration – below ground biodiversity; natural enemies; water quality; insects as food.
- Also consider accumulating effect on human health.
- What are the fates of neonicotinoids in the environment? Malawi has malaria in villages with mud houses close to water bodies, so there are many sprays to combat mosquitoes. However, there are no studies on anti-mosquito pesticides, particularly where they drift/flow during and after application. What about effects on pregnant mothers and bioaccumulation?
- The microclimate can affect degradation rate and provide unknown opportunities for accumulation.
- Does climate change affect the microclimate within hives?

[13] https://www.earthobservations.org/activity.php?id=128
[14] https://beeinformed.org/

- How to mitigate threats – which methods to use for mitigation, how to replace specific pesticides?
- Prices of replacement technologies/chemicals – economic valuation of ecosystem services is needed.

Lack of entomologists and taxonomists, lack of scientific networks

- There are very few entomologists in many African countries, even fewer look at pollination. Therefore, many African countries fail to see any trends in pollinator decline since 1990s. However, Africa has some pristine habitats left that could provide baselines for comparative analyses.
- There is a lack of taxonomists in Africa, and a need for training and capacity development in this area.
- Existing taxonomists are often poorly connected. There is a need for a survey of taxonomic expertise available in Africa. The same also applies to related relevant disciplines, e.g. chemical analysis, chemical ecology, etc. The African Association of Insect Scientists[15] (AAIS) could provide a platform for networking within/between these groups. Regional groups mirrored on RECs could be set up. Zambia used to have such a network, perhaps that could be restarted.

Other points

- To create awareness, it is important to involve grassroots organisations and small-scale farmers. Social sciences studies should explore how best to reach these audiences. Explore how technology (mobile phones) can help with awareness creation.
- Focus on IPM – Participatory integrated pest management.
- Arguments should be clustered as follows: Economic aspect / Food security as an issue (rather than human health) / Lack of data – sound scientific evidence to back recommendations / Prioritise which generalities/case studies rather than country-by-country data.
- The main problem is lack of follow-up on regulations, e.g. by poison control boards.
- There is a lack of awareness of the FAO code of conduct for use of pesticides, so it is not followed.

4.4 Feedback from Southern African countries:

Differences between Africa and Europe

- The main differences between the Europe/America region and Africa are that farming systems are different – reliance on wild rather than cultivated bees, different cropping systems within regions, 60 – 70% of farming is done by smallholding farmers.
- Are there differences between what has been found in comparative studies between Europe and North America? What matters more – farming system or ecosystem? Comparisons of sunflower pollinators in California and Africa suggest that the type of farming system plays a major role, not the ecosystem.

[15] http://aais-africa.com/

Information gaps and needed research

- How about the basic crops, such as maize sorghum etc.: How much pollination services do they receive? (Note: maize, sorghum, and all grains are pollinated by wind and do not require animal pollinators).
- How does the pollinator composition etc. change with the farming system?
- Clear local data on yield declines due to lack of pollination services is needed.
- Would alternative pesticides not also harm or repel pollinators?
- The most important research need in Africa is: Which pollinators are there? And how many of them? And what are they doing? Once this data is available, one can accurately compare the different farming systems.
- We do not necessarily need new data or research: Some of what we are discussing and what will be relevant for our message is already there (esp. at the Southern African Development Community (SADC) and other organisations).
- A key research question should be: "Resilience and resistance of cropping systems in Africa" (large-scale, small-scale, tropical) to answer the question which insects are responsible for pollination in which system.
- Is there a way to demonstrate the utility and economic contribution of natural enemies?
- Need to look at the entire ecosystem and the long-term effects on the ecosystem.
- What are the persistence level differences between neonicotinoids and other (older) pesticides?
- The Botswana Ministry of Agriculture has sent out a questionnaire to scientists to monitor insect numbers but has not supplied any funding to deliver this monitoring.

Communication, outreach, education:

- Needed urgently: research about how best to inform (and influence) the smallholder farmers.
- Issue of trust: The farmers tend to trust the company representatives and their neighbours more than the government extension officers.
- Basic education about ecosystem services needed for farmers: Some farmers look at all insects as pests.
- The ratio of extension workers to farmers is important - sometimes there are just too few to cover the ground. South Africa has so few extension workers that there is effectively no extension system.
- Communication with farmers, demonstration of effects: One should take a leave out of the book of the pesticides companies themselves. They normally pick one example farmer (lead farmer) and ask him to plant on an easily visible strip of land to show how much better the treated crops are performing. To demonstrate the value of pollination and natural pest control, one could set up demonstration plots with and without pollinators and natural pest control.
- Communication: The message coming out of the workshop should be couched in terms of "Health" / "Economic impact" / "Food security", as messages connected to these topics are being heard.

Other points:

- Degrees of toxicity: neonicotinoids are in principle less toxic to humans than 'old' insecticides, but they are used more widely and indiscriminately, and effect builds up.

- One should not completely ignore that there are other pesticides (non-neonicotinoids) which are still widely used, and which are also toxic to bees.
- Material Safety Data Sheets (MSDS) for pesticides do not contain accurate/up-to-date information: MSDS for a neonicotinoid specified that the pesticide will remain in soils for ca. 30 days. Current data indicates that it is several years.
- The industry is normally picking their "lead farmers" – and those then get also management support for organising their farm, planning the planting etc. which results in better harvest etc. But the additional support is not being openly acknowledged so attribution of success is only to use of neonicotinoids.
- The impact of neonicotinoids on smallholding farmers may be more severe than on big scale farming, but this is not noticed because smallholding farmers do not have a common voice. Some big farmers in South Africa do not care about the impact on bees, but simply buy new colonies after having used the neonicotinoids, as this is easiest/cheapest for them.
- The impact of neonicotinoids on European bees is only so obviously visible because European agriculture has killed so many pollinators that only honeybees are left.
- In Ghana the government buys up the neonicotinoids and distributes them, which makes it very cheap for farmers.
- Pesticides companies often withdraw previous pesticides as new ones become available, so farmers are pushed to use neonicotinoids.

General discussion:

- Also consider the landscape in which agriculture takes place, not all landscapes are equally suitable for pollinators.
- Biological control takes longer to take effect than pesticides.
- Pesticide is a quick fix but investment in long-term biological control would be beneficial. Biological control systems can be self-sustaining once established.

The socioeconomic aspect is very important: Farmers should be informed about alternatives.

Discussion of draft statement and key messages:

The Working Group discussed the proposed key messages and Mike Norton produced revised key messages based on WG inputs overnight.

Day 2: 15 May 2019

5. Session 1: Recap from Day One and Objectives for Day Two

Prof Mike Norton thanked the presenters for their excellent presentations and the information they provided. With the eight new countries represented in this workshop, a total of 20 countries are represented in this project, which is a good representation of the African continent. The discussion groups have yielded a tremendous amount of new information, as did the discussion about the key messages, which have been revised for further WG discussion today. This report is not a scientific paper with individual authorship, but instead the final product is a product of the organisations, in this case of IAP and NASAC. All participants in the two workshops will be listed as contributors.

Discussion of perspectives and possible ideas for improvement of pesticide authorisation, regulation, and extension services in Africa:

Dr Peter McGrath suggested the following questions for discussion:

- Some countries are looking at other countries/organisations for standards. Which countries/organisations are they looking at, and is that helpful?
- What is the role of RECs and similar groupings?
- What harmonisation efforts for standards exist, and where are they lacking and desirable?
- Where does the data in dossiers for national approval come from?
- Do individual countries do their own testing?
- How can extension services be improved?

Dr McGrath (IAP): In a case study from Ghana (Northern Presbyterian Agricultural Services and Partners, 2012), the government controlled the release of pesticides to farmers but then changed pesticide supply to a market economy, sadly without setting standards or providing information. Chemicals companies thus became providers not only of pesticides but also of information to farmers, instead of extension services.

Dr Katambo (Tanzania): The Tanzanian Plant Protection Act is from 1997[16] and plant protection regulations are from 1998[17]. Section 17 of the Act sets out that producers, marketers, and importers of PPPs can apply for registration of PPPs and lists the documentation required for PPP registration. Section 18 describes the conditions under which PPPs may be registered, amongst them proven efficacy and that the PPP under consideration, when used for its intended purposes and in the correct manner, or as a result of such use, does not have any harmful effects on human and animal health, ground water and the natural environment which are not justifiable in the light of the present state of scientific knowledge. There are some field trials for efficacy and for effect on environment and human health before registration. The Tropical Pesticides Research Institute Act of 1979[18] established the Tanzanian Tropical Pesticides Research Institute (TPRI), which, amongst others, carries out research on pesticide efficacy, application, and safety; supervises and regulates the manufacture, importation, distribution, sale and use of pesticides; and administers regulations. In March 2018, the Controller and Auditor General of the Tanzanian National Audit Office conducted a performance audit to determine whether the Ministry of Agriculture through the Crop Development Division and the TPRI efficiently manage the quality of pesticides to safeguard against human health risks and environmental degradation in order to ensure sustainability of land productivity[19]. The main findings of the audit were:

- Presence of un-registered and un-certified pesticides in the market
- Illegal importation of pesticides
- Weak implementation of pesticides registration activities
- Inadequate assessment on health and environmental effects from pesticides uses
- Inadequate implementation of the mechanism that ensures that only registered pesticides are sold in the market
- Insufficient updating of the list of registered pesticides

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[16] http://extwprlegs1.fao.org/docs/pdf/tan19688.pdf
[17] http://extwprlegs1.fao.org/docs/pdf/tan19459.pdf
[18] http://www.ilo.org/dyn/natlex/docs/ELECTRONIC/95004/111675/F-423246688/TZA95004.pdf
[19] http://www.nao.go.tz/management-of-pesticides-in-agriculture/

- Inadequate dissemination of knowledge about pesticides management
- Insufficient inspection of pesticides sellers and ports of entry
- Inadequate coordination and monitoring of pesticides training, registration and inspection activities

The audit report made several recommendations to the Ministry of Agriculture and the TPRI to improve the situation.

Prof Obopile (Botswana): The National Agrochemical Committee is responsible for registration of agrochemicals including fertilisers. If a pesticide is imported from a country where it is not registered, then it is not registered in Botswana, essentially a prior informed consent procedure. If necessary, additional trials are conducted. Existing conventions (Rotterdam, Stockholm, and Montreal) are considered in regulatory decisions. So far, there are no considerations of banning neonicotinoids. Botswana has quite a trained extension service, but they often cannot get to the farmers living in the rural areas because they do not have sufficient transport. Overall extension services are effective, but less so in rural areas.

Dr Kasangaki (Uganda): The Department of Crop Protection of the Ministry of Agriculture, Animal Industry, and Fisheries, together with the Agricultural Chemicals Board, authorises and regulates pesticides. The National Bureau of Standards ensures meeting of national standards. Police staff are trained in following up on agro-input dealers and in looking for fake and counterfeit agrochemicals. The extension service systems have limited capacity and requires strengthening.

Prof Soliman (Egypt): The decisions of the Agricultural Pesticides Committee since 2006 are available at http://www.apc.gov.eg/en/.

Prof Ngamo (Cameroon): Phytosanitary law of 2003 established a National Phytosanitary Council as a consultative body on phytosanitary protection policy in Cameroon. This Council meets annually, though extraordinary meetings (e.g. in case of fall armyworm) can be convened to discuss additional registrations. The list of pesticides authorised by the *Comité Sahélien des Pesticides* (last updated May 2018) is available online[20]. The Cameroonian Minister of Agriculture can authorise removal of pesticides from this list. For example, Paraquat products were removed from this list. Cameroon is a member of the Inter-African Phytosanitary Council (IAPSC)[21] and has joined the FAO International Plant Protection Convention in 2006. Cameroon is also a member of the Central Africa Inter-State Pesticides Committee (CPAC) of the Central African Economic and Monetary Community (CEMAC), which includes Gabon, Cameroon, the Central African Republic (CAR), Chad, the Republic of the Congo and Equatorial Guinea. Products approved in Cameroon easily move in the CEMAC. Cameroon has very good phytosanitary laws but they are poorly implemented. Phytosanitary controllers can take people to court for mismanagement of pesticides. There is a general process of dematerialisation of pesticides used. For export purposes, it would be helpful if all pesticides used on a given batch of crops were registered online to reduce market rejection in Europe.

Dr Dankyi (Ghana): There is a pesticide registration manual that is similar amongst west-African countries. There is comprehensive assessment before registration and post-registration surveillance. The Ghanaian EPA undertakes registration of chemicals, usually taking 90 days from application to decision, and ensures that labelling and formulation are

[20] http://www.egypttoday.com/Article/1/70310/Egypt-introduces-pesticide-applicator-training-program
[21] https://www.ippc.int/ru/external-cooperation/regional-plant-protection-organisations/interafricanphytosanitarycouncil/

right. Pesticides registered for cocoa are given to the Ghana Cocoa Board, which conducts field trials focussed on efficacy but not necessarily on environmental effects - despite regulations specifically requesting trials for environmental effects.

Dr Diehl (EASAC): Are there examples of newly implemented laws or new initiatives that would improve implementation of laws?

Prof Soliman (Egypt): There should be a certification system for people involved in the process of approving and regulating pesticides. Distributors must also be certified, including small shops. In 2018, Egypt established certification for applicators (farmers) based on training courses[22], with mandatory recertification every 3 years. The Ministry of Agriculture and Land Reclamation selected the institutions that conduct training for certifications.

Dr Masehela (South Africa): There is a general problem with oversight of pesticide use and reinforcement of regulations. In South Africa, CropLife SA[23] currently oversees compliance by companies. Most problematic is the use of pesticides that are registered on certain crops but are used on other crops. This is because the registration process takes time, and because of the costs of registration, so minor crops fall through the cracks. There is a lack of repercussions even for consultants – if consultants give bad advice to farmers, their license is not revoked, and they are not fined. Consultations are trained and certified.

Prof Pirk (South Africa): But isn't CropLife SA a lobbyist group?

Dr Masehela: CropLife SA is aligned with Association of Veterinary and Crop Associations of South Africa[24] (AVCASA) and has the endorsement of Registrar Act 36 (Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act of 1947[25]) with the Department of Agriculture, Forestry, and Fisheries. CropLife SA also runs the website Agri-Intel[26], which hosts information on pesticide label information, residue management, etc. In 2001, thousands of bees were killed by aerial spraying of canola near the town of Tulbagh[27], and CropLife SA took the responsible consultant to court. Overall, CropLife SA has been very helpful in following up on cases of pesticide mismanagement.

Dr Mulumba (South Africa): What is the magnitude of penalties and fines when farmers are found in contravention of conventions? Most legislation is archaic, and fines are very low so people are prepared to break the law.

Prof Obopile (Botswana): Fines are low and big farmers are rich. If farmers are found in possession of illegal pesticides, then pesticides are confiscated, and the farmers have to pay for the export of the pesticides back to the country where they got them. If farmers are found not in compliance with pesticide regulations, the inspector can report them to relevant authorities. There has been a recent review of the legislation governing agrochemicals, lawyers are still trying to work out the practical consequences of the changes.

Dr Assad (Sudan): There are many steps to be followed before registration. The Pesticide Act (1974/amended 1994) also regulates how pesticides are to be handled by farmers. The

[22] http://www.egypttoday.com/Article/1/70310/Egypt-introduces-pesticide-applicator-training-program
[23] https://croplife.co.za/
[24] https://www.avcasa.co.za/
[25] https://www.nda.agric.za/doaDev/sideMenu/ActNo36_1947/act36.htm
[26] https://www.agri-intel.com/
[27] https://www.iol.co.za/news/south-africa/western-cape/aerial-crop-sprayer-kills-tulbagh-bees-2057152

General Directorate of Extension, Technology Transfer, and Pastoralists' Development[28] of the Federal Ministry of Animal Resources and Fisheries trains farmers in the correct use of pesticides, including when to spray relative to harvest times.

Prof Paraiso (Benin): In Benin, pesticide registration is approximately the same: in 2018, a National Pesticide management Committee was created[29], which is responsible for accreditation and certification of pesticides. Farmers need to be informed not only via official channels but also by other ways. Official channels are very political, suppliers sell only those products for which they are accredited. The European ban on organochlorines is also effective in Benin, but even after the ban, organochlorines were used for 15-20 years because they are very efficient. Farmers like their efficiency because they kills all insects. The Benin government was obliged to ban it because of high pressure from the outside (Non-governmental organisations (NGOs), embassies, etc.). Roundup was also only very recently banned, following the recent court decision in the US. There is need for more engagement by civil society and NGOs, and farmers need more information from other sources, otherwise they remain unaware of changes, decisions, and new findings.

Prof Ngamo (Cameroon): CropLife Cameroon is an association of 10 major pesticides companies, and part of CropLife Africa Middle East, a non-for-profit industry association representing the leading global manufacturers of pesticides, seeds, and biotechnology products[30]. CropLife Cameroon offers pesticide management courses[31] in partnership with the Ministry of Agriculture and Rural Development[32]. CropLife Cameroon is not a member of Board of Registration in Cameroon.

Dr Abbes (Tunisia): The National Committee of Pesticides in the Ministry of Agriculture, Water Resources regulates the use of pesticides, there is a code of good practice. Many agricultural manufacturers give chemicals and sell agricultural technology to farmers. The farmers, in turn, sell their products to those companies.

<u>Discussion:</u> There is often a dichotomy in the information provided to farmers, end users, and extension services by companies/agents marketing products and by independent advisory bodies. How can this problem be resolved?

Dr Bandason (Malawi): Poorly trained agents provide advice and general pesticides, but they are the only resource farmers have. In collaboration with the Bunda College of Agriculture, the Farm Radio Trust[33] fosters rural and agricultural development, amongst others through a 'farm radio' programme where farmers can ask questions, however, the efficacy of the radio programme is unclear. The programme also provides farmer advisory services based on expert inputs.

Prof Nkunika (Zambia): Zambian extension services used to be fairly strong, but they are not now.

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[28] http://www.g-fras.org/en/world-wide-extension-study/africa/northern-africa/sudan.html#extension-providers
[29] https://juriafrique.com/eng/2018/10/17/benin-equips-itself-with-a-national-pesticide-management-committee/
[30] https://croplifeafrica.org/#
[31] https://croplife.org/case-study/croplife-cameroon-offers-pesticide-management-course/
[32] https://allafrica.com/stories/201904030976.html
[33] https://www.farmradiomw.org/

Dr Dankyi (Ghana): In Ghana, you can see huge billboards advertising chemicals, chemicals companies advertise on television and sponsor e.g. weather forecasts. Pesticides labelling has become very pretty, with pictures of bees, birds, etc., to attract consumers. There are training schools for agricultural extension officers although these extension services are largely focussed on the cocoa industry with less attention paid to other crops . Here, the chemicals industry remains the main information provider. Shops provide advice on pesticides, and farmers exchange experiences. Once a farmer has identified an effective pesticide, he will use it very regularly, thus encouraging resistance. The government supports cocoa production but there is debate on whether free mass spraying of cocoa plantations or handing out free pesticides to farmers is the better solution. Both have their disadvantages: the first approach treats all farms as the same, in the second approach, all farmers receive the same volume of pesticides regardless of farm size. For every district where cocoa is grown, there are a number of trained agents that work with specific groups of farmers. They advise on how much fertiliser to use, pruning, etc., and check for diseases. In general, the extension services for cocoa are very good.

Prof Nhachi (Zimbabwe): The Specialised Services Division for Fertiliser, Farm Feeds, and Remedies, which conducts research on pesticides and acts as Pesticides Registration Office, is quite active and follows up on pesticide regulation. There are lots of illegally imported pesticides in Zimbabwe. The industries and companies involved in pesticide importation are organised in the Agricultural Chemicals Industry Association (ACIA), which also provides some aspects of extension services, such as advice on proper use of pesticides and incineration of obsolete and illegal pesticides (Nhachi and Kasilo, 1996).

Prof Paraiso (Benin): In all countries there is obviously lots of spraying of pesticides, and extension service staff are undertrained civil servants. Is this what we call ‘working well’? We need to find a better way of doing this better.

Dr McGrath (IAP): The case study from Ghana (Northern Presbyterian Agricultural Services and Partners, 2012) suggested putting levy on chemical companies that would finance extension services.

Prof Paraiso (Benin): We need to refresh knowledge and use of IPM, emphasise economic thresholds for pesticide application, and ban the term ‘preventive control’ from the vocabulary. A service is needed that assesses infestation severity and advises on thresholds for pesticide application. The provision of free insecticides to farmers is a very bad idea. The widespread practice of ‘calendar protection’, which involves regular sprays without assessment of pest load, is a huge waste of money and results in environmental pollution and harm to applicators from high exposure.

Dr Masehela (South Africa): Governmental extension services have been downgraded over time, but this differs amongst provinces. Extension officers are supposed to know everything about everything, specialisation would be better. The relationship between company consultants and extension officers needs to be regulated to ensure independence. Useful initiatives include mentorship classes and tutorials for emerging farmers, farmers’ days, etc.

Dr Mulumba (South Africa): Extension services used to work in the past: When you worked in government, you could see and feel extension services at work. The Zimbabwean government was not prepared for land reforms. Before the land reforms, there was one extension officer per farmer. This ratio could not be kept up after land was handed over to up to 200 farmers where there was previously only one. Extension services today are not what they used to be. To get our messages to the farmers, we need to be clear on what resources are available on the ground.

Prof Nhachi (Zimbabwe): Zimbabwe's land redistribution was followed by a transitionary period also for extension services. The available resources are stretched out too thinly, but the impact of extension services is also related to the kind of farming that is done. There are better and more exhaustive extension services when farmers practice commercial farming than for subsistence farming. The picture of extension services will change given the transitions implemented in Zimbabwe and South Africa.

Dr Diehl (EASAC): If extension services are not working and are not a natural partner for the messages we want to give, where else must we look for alternatives? Who are the key multipliers given that extension services are not working?

Dr Bandason (Malawi): What do we say when we mean 'extension workers are not working' – do we refer only to their knowledge about pesticides? Or their knowledge about economy? Or Insects? Extension servers are insufficiently specialised to deal with the problems they are faced with.

Prof Paraiso (Benin): Extension services are working in several fields: some extension officers are working on 5-6 cultures or areas of plant protection, and very few staff have to serve a large number of farmers. University researchers connect with government extension services, but not with NGOs and other organisations. NGO workers do not know the field well enough and it is hard to find the right people to do the work.

Prof Samb (Senegal): In Senegal, the Department of Plant Protection (*Direction de la Protection des Végétaux*) and the Senegalese Institute for Agricultural Research (*Institut Sénégalais de Recherches Agricole*, ISRA), both under the Ministry of Agriculture and Rural Infrastructure, provide extension services[34], with different specialisations. Information on regulatory matters is available on the internet[35].

Prof Nkunika (Zambia): Scientists need to team up with farmers and farming schools. A paradigm shift on where extension services are (re-)trained is needed.

Dr Mulumba (South Africa): If we need to reach farmers, we need to identify a clear and suitable pathway. Extension service staff needs to be crosscutting because specialisation is very expensive. This is something we should discuss – farmer training schools, who implements them? We need to define our expectations of an extension service that works well.

6. Breakaway discussions: Discussion of Possible New Coordination Mechanisms between Research

Groups Across African Countries

Prof Pirk introduced 'Future Africa' located in Pretoria, South Africa. The Future Africa campus has conference facilities, meeting rooms, etc. Located in the administrative and research hub of South Africa, with numerous embassies and ASSAf nearby, it is an attractive new centre to identify interdisciplinary solutions for Africa. www.futureafrica.science.

[34] https://www.g-fras.org/en/world-wide-extension-study/africa/western-africa/senegal.html#developing-local-extension-capacity; https://www.g-fras.org/en/world-wide-extension-study/africa/western-africa/senegal.html#world-wide-extension-study
[35] https://www.ippc.int/en/countries/senegal/

Suggested focus points for break-out groups: bees and pollinators, IPM, insect toxicology.

Report back to plenary from Group 1:

- Consider aligning activities with Future Earth initiative: http://www.futureearth.org/
- There are already numerous established scientific societies, so establish working groups within them or extended regional chapters from them.
- Identifying funding opportunities for joint research, e.g. with EC initiatives and programmes: more dissemination of information regarding joint funding opportunities would be desirable, e.g. through improved communication and coordination between the African Scientific Academies (mailing lists, create a website to link funding). This could be organised by NASAC, perhaps through a liaison officer for scientists.
- Instead of waiting until funding is available, make arrangements and plans and then know whom to approach and secure the funding instead of waiting for funding to become available first.
- Have several smaller working groups responsible for addressing necessary topics by region, for example assessing the economic value of pollination in the North, South etc.
- Must ensure that planning and spearheading is not passed off on to a higher level at which nothing gets done. Bottom-up projects require a champion to drive the project.

IPM

- Need more input from social sciences in conjunction with natural scientists to ensure communication and application/implementation of the proposed methods across the varying socio-economic groups
- Decreasing spray regime on cocoa from four times to twice or once would be a big improvement, this would allow plants to have sufficient protection without need for repeated spraying
- Review of the new research, and update and review of pesticide application regimes and of IPM could include streamlining, improved efficiency, and reduction of pesticide use

Bees & Pollination

- Joint application and joint research proposals
- Setting up of topic-specific research groups, e.g. a dedicated African Society for Bee/Pollinator Research, or working groups within the AAIS, Entomological Society, Chemical Ecology Society, etc.

Toxicology

- Found chapter of toxicologists (possibly with topic-specific sub-chapters) on the African continent
- Establish a website allowing people to register and become more part of the setup and receive more information

Extension Services etc.

- Previously one-on-one but now many avenues of dissemination, e.g. websites, print media, labelling of products, workshops, use of apps/SMS to inform farmers.
- Decentralised extension services more effective
- Dissemination through established social groups and gatherings: get ministries, churches, mosques, clubs involved in information dissemination

- Farmer database

Report back to full group from Group 2:

- Take advantage of existing organisations, e.g. Network of African Scientists/Entomologists
- Need network of toxicologists, none exists yet. Professor Charles Nhachi from Zimbabwe will organise network, as a first step by contacting all workshop participants, a newsletter will be produced.

Report back to full group from Group 3:

- Form a consortium of all specialists in the areas of IPM, bee health, toxicology, etc.
- Need good communication between expert communities, e.g. through social media (Facebook, Twitter, WhatsApp)
- National Associations could be good starting points to build expert communities
- Form working groups on specific issues
- Develop databases and map location of experts
- Bees and pollination: There are not enough taxonomists – need to build capacity
- Limited information on bees – establish baseline data on different bee species
- Access to publication: too often behind paywalls, need to find means to access papers
- IPM: Participatory IPM needed. Involve farmers from the beginning to develop workable solutions
- Employ best practices
- Strengthen research-extension interface
- Toxicology: establish pesticide testing facilities in the individual countries, to conduct pesticide monitoring and evaluation
- When returning to their own countries, working group members should take stock in their own countries – visit ministries, crop protection units, etc. to find out what is available in terms of information on pesticide usage, regulation, etc.

Report back to full group from Group 4:

Discussion of a project proposal for the European H2020/Horizon Europe call: Propose a 5-year project on bees and pollinators, IPM, and toxicology. Such a project could be coordinated by Misheck Mulumba and Elizabeth Bandason and, focussing on bee-pollinated crops, could look broadly into:

- Bee diseases and pesticides (not only neonicotinoids)
- Geographical mapping of bee diseases and their spread
- Quantification of wild bee colonies: Direct reporting of good estimates is very difficult. Collaborate with Animal Health services (AHS), workers can send in data on bee diseases. There are animal health applications that could be adapted to collect a wide range of data on bee occurrence, health, economic impact, etc.
- Climate, and climate-change, effects on distribution of bees and bee diseases: mine climate data available in the South African Agricultural Research Council, particularly the Institute of Soil, Climate, and Water. Such data could be superimposed on other factors affecting bee health (rain, crop availability and type, diseases, fires)
- Broad range of beekeeping practices associated with different bee sizes
- Effects of pesticides used on bee-pollinated plants on bees, the associated consequences for crop yields and corresponding socio-economic consequences
- Valuation of ecosystem services (green economy)

- Establishment of baselines for various parameters and aspects, e.g. animal health, economy, socioeconomic consequences of pollinator losses
- Comparisons of intervention farms with non-intervention farms in terms of yields, farming costs, and ecosystem health. Demonstration farms could not only yield valuable data on economic aspects, but also showcase IPM to farmers and serve to train farmers in alternative methods

The outcomes of such a project would involve new knowledge, clear recommendations for IPM, impact on socio-economy, policy statements, and capacity building through transfer of skills to farmers (learn how to assess bee health, produce more honey) and students (receive training on pesticide management, IPM, and on providing advice to farmers).

A good communication strategy is needed to reach farmers, farmer schools, information centres, etc, and could involve demonstration trials and development of applications.

A separate project on IPM could be coordinated by Leonard Ngamo-Tinkeu and involve development of a set of procedures to protect crops while safeguarding bee health. Toxicology information is needed for this, and Elizabeth Bandason could coordinate toxicological assessments. IKS should be considered while developing IPM.

General discussion:

Tlou Masehela (South Africa): In South Africa, bee products are currently regulated under the Plant Protection and Pesticides Act. Farmers do not own the individual bees themselves, but they own the hives and hive products. A current proposal involves moving bees and bee products into the Agricultural Pests Act (Act 36 of 1983) through amendment of the Control Measures relating to honeybees (of 2013). This would ensure that honeybees are under oversight of veterinary sciences, like any other domestic animal, and makes bees agricultural commodities like in Europe or the US. Therefore: Consider inserting into the report a comment along the lines of 'Placement of bees in the correct legislative framework is essential for the correct provision in terms of accounting for bees and their protection and conservation, and of bee products. This would also enable accounting for beekeeper livelihoods: In Europe and US, bees are agricultural commodities, but e.g. in South Africa they are considered part of the environment'.

7. Session 2: Finalisation of Statement and Key Messages from the Working Group

The Working Group reviewed the revised key messages, provided some more feedback that was incorporated, and finally agreed on the key points of the draft.

The Communications Officer of *icipe*, Liz Ng'ang'a joined the session on communication and dissemination actions.

Discussion of Communication and Dissemination Actions (National Level, Regional Economic Communities, African Union, Relevant Scientific and Regulatory Meetings, etc.)

- Translate to some African languages, e.g. French, Portuguese, Arabic.
- Consider downstream and upstream processes. Who are our partners and conduits to the farmers? Upstream: How do we get this to political principals and decision makers? Handle downstream and upstream processes separately.
- Pesticide registrars of the individual countries are main players of pesticide registration.
- Organise meetings in individual countries, e.g. with registrars.

- Downstream processes require more active participation. NGOs are good to work with but also have their own agenda. Each country would have to look for relevant NGOs that would be useful, also consider existing extension services. The middle ground would be media, social media. Upstream: Develop fact sheets for policy makers.
- Suitable NGOs: Afidep (https://www.afidep.org/)
- The report has to be domesticated: RECs have streams that handle issues like this. Ask RECs to do an audit on a report of this nature every 2 years.
- The academies also have a strong role in disseminating the report. Also use different societies (African Association of Insect Scientists, Entomological Society), German Academic Exchange Service (DAAD), German Technical Cooperation Agency (GTZ), and other developmental agencies busy with capacity building in Africa.
- WG members could present the report to their academy and convince the academy to promote the report, perhaps academies would even endorse the report and present it to the national Minister of Agriculture or similar.
- Each country has slightly different approaches. In Botswana, the first person to convince is the registrar.
- There are opportunities to put items on the agenda of SADC ministerial meetings. Scientists need to contribute to the process at the ministerial meeting. This will be followed by a ministerial decision, which will be recorded and followed up on every 2 years. Approach the secretariat Director Generals (DGs) of the respective politicians.
- Each country participates by submitting agenda items to the Council of Ministers of the African Union (AU). The pathway to this council may differ amongst countries, but when an item gets onto the agenda, a council decision is made. Countries are then bound to act on it and will be audited on it. Even if one country were to fall behind in acting on the ministerial decision, other countries from the same REC would exert pressure on this country to catch up.
- It would be helpful to have press material – films, pictures, etc. - showing the impact of neonicotinoids. Scientific papers are not enough. Summaries for policy makers (policy brief) should show case studies.
- Prepare a slide pack presenting issues and impacts of neonicotinoids, focussing on case studies from Africa. Make sure language is easily accessible – capitalise on terms like biodiversity and conservation, avoid complicated terms like ecosystem services, emphasise use for farmers and food security.
- The communications support available from IAP includes press releases e.g. for the academies, which can be used by the academies to hold their own press conferences.
- National science academies have the power to put this topic on the agenda of the RECs
- Workshop participants should share success stories related to outreach.

Specific communication/dissemination event suggestions:

- Prof Pirk: Will submit session on neonicotinoids for the 36th Annual Meeting of the International Society of Chemical Ecology: September 2020. http://www.isce2020.com/
- Prof Pirk: Offer to hold workshop/meeting around this project at Future Africa Centre (https://www.up.ac.za/future-africa) and will look into possible funding
- Apimondia meeting September 2019 (1-14 September), deadline for paper submissions already passed. http://www.apimondia2019.com/
- 12th International Symposium on Pollination 31 August – 4 September 2020, Cape Town. https://www.icppr.com/events.html
- International Meeting of Science Academies, November 2019, Ghana
- Uganda: National Honey Week, August 2019 (slide set and flyers would be helpful)

- International Plant Protection Congress, 10 – 14 November 2019, Hyderabad. Baldwyn Torto will be keynote speaker for a symposium. Abstract submission deadline 15 August 2019. http://ippc2019.icrisat.org/
- 2nd African Scientific Research Council (ASRIC) Congress 'Freeing Africa from Poverty, hunger and diseases'. 20 – 23 November 2019, Rabat, Morocco. Abstract submission deadline was 1 June 2019. http://www.asric.africa/documents/cfp-2019/Call%20for%20Papers.pdf
- 3rd TYAN International Thematic Workshop "Sustainable Agriculture, Food security and Biotechnology: Best Strategies and Good Practices" 5 – 7 September 2019, Monastir, Tunisia: Samir Abbes on Organising Committee
- Outreach in written form to scientific community: write-up in scientific journals
- Suitable Journals: e.g. Nature. Initiative for short article/commentary: Lattorff, Masehela, Katambo, Torto
- 23rd meeting and conference of the African Association of Insect Scientists (AAIS) with theme 'Biodiversity and sustainable development in Africa: contribution of insect science to the development of agriculture and improvement of human, animal and environmental health', 28 – 22 November, Abidjan, Côte d'Ivoire. Saliou Niassy proposed side event on 'Use of Neonicotinoids on Pests and Pollinators Management and their alternatives'. Abstract submission deadline 30 June 2019.

8. Concluding Remarks and Vote of Thanks

Volker ter Meulen thanked all workshop participants for their excellent inputs into the report and the lively discussions. He thanked Cathy Bester for her excellent work with the literature review, and Mike Norton for his speedy and skilful production of the first draft of the report. Thanks also went to Michael Lattorff and Baldwyn Torto for making it possible to hold this meeting at *icipe* and for their great scientific contributions. He thanked the Leopoldina for their generous support of this project, ASSAf for their support, and Stanley Maphosa and Khutso Phalane-Legoale for their excellent preparation of the meeting. Thanks also went to NASAC for their long-standing and productive collaboration with EASAC, for being a partner in this project, and for handling the endorsement process by the African Academies. He thanked Mike Norton, an essential component to this project, for dedicating so much time and energy to this project. Also Peter McGrath for bringing IAP and his personal support for this project. He thanked Christiane Diehl, Anja Geissler, and Nina Hobbhahn from the Leopoldina for their support in organising and managing this project. He concluded by wishing the participants a safe journey home and all success with promoting the upcoming report in the future.

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10. Appendix A: Online Presentations

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