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Green growth and improving preparedness to adapt to pollinator decline in Nigeria – Communicating results for policy and action

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Abstract
Insect pollinators contribute to agricultural crop yield and beekeeping provides a major source of livelihoods for farmers in Nigeria. This study developed two survey questionnaires and collected data from beekeepers, researchers and government officials to generate quantitative indicators for the purpose of description as a guide to action. Evaluation and characterization of colony bee loses by beekeepers were assessed and surveys conducted in Osun State, Southern Nigeria, consisting of questions related to: the importance of pollinators, including managed honeybees (*Apis mellifera*), in agriculture and observations on factors associated with pollinator declines; and management of bee mortality. A majority of beekeepers were ignorant of the cause of the death of their colonies. Information from policy makers indicate that population abundance trends in honey bee and other pollinator populations have largely not been documented in Nigeria. This study emphasizes pollination and insect pollinators as drivers of agricultural crop production with a view to providing guidance for sustainable management of pollinators and achievement of green growth objectives.

Keywords bee mortality; crop yield; insect pollinators; sustainable pollinator management.

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1 Introduction

Insect pollination is vitally important to terrestrial ecosystems and to crop production (Dormann, 2011; Kamel et al, 2013). It has been determined that 75% of our crop species benefit from insect pollinators (Klein et al, 2003), which provide a global service worth $215 billion to food production (Gallai et al, 2009). Hence the potential that we may be facing a "pollination crisis" (Holden, 2009; Gross, 2008) in which crop yields begin to fall because of inadequate pollination has generated understandable debate and concern and stimulated much research in recent decades. Nonetheless, knowledge gaps remain substantial, both with regard to the extent and causes of pollinator declines (Goulson et al, 2015).

Bees serve humanity indirectly by contributing to the healthy functioning of unmanaged terrestrial ecosystems. The decline of pollinating species, which has grown over the last decades (Goulson et al, 2008), can lead to a parallel decrease of plant species (Biesmeijer et al, 2006). More specifically, there is a great deal of concern about the decline of the honey bee (*Apis mellifera* L.) across the world that has been termed colony collapse disorder (Committee on the Status of Pollinators in North America, 2006). Pollinator declines are a consequence of multiple environmental pressures, e.g. habitat transformation and fragmentation, loss of floral resources, pesticides, pests and diseases, and climate change (Potts et al, 2010; Vanbergen, 2013). Similar environmental pressures are faced in Nigeria where there is a high demand for pollination services.

Overall, these suggest that numbers of managed honey bee colonies have decreased in Europe with 25% loss of colonies in central Europe between 1985 and 2005 (Potts et al, 2010), and markedly in North America with 59% loss of colonies between 1947 and 2005 (NRC, 2007; van Engelsdorp, 2008). However, overall global stocks actually increased by ~45% between 1961 and 2008, due to a major increase in numbers of hives in countries such as China and Argentina (Aizen and Harder, 2009). Conversely, there are widespread reports of unusually high rates of honey bee colony loss from many parts of the world, sometimes ascribed to a syndrome known as Colony Collapse Disorder (CCD) (van Engelsdorp et al, 2009). It seems that socioeconomic factors (such as increasing demand for pollination or honey (Smith et al, 2013), are at present sufficient to incentivize beekeepers to overcome problems with bee health, when examined at a global scale. Another way to examine the likelihood or proximity of a pollination crisis is to examine delivery of pollination services. Although global honey bee stocks have increased by ~45%, demand has risen more than supply, for the fraction of global crops that require animal pollination has tripled over the same time period (Smith et al, 2013), making food production more dependent on pollinators than before. It has also emerged that the majority of crop pollination, at a global scale, is delivered by wild pollinators rather than honey bees. Yields correlate better with wild pollinator's abundance than with abundance of honey bees (Breeze et al, 2011; Garibaldi et al, 2013; Mallinger and Gratton, 2014), hence increasing honey bee numbers alone is unlikely to provide a complete solution to the increasing demand for pollination. Reliance on a single species is also a risky strategy (Kearns, et al, 1998). While Aizen et al. 2008, concluded from a global analysis of changing crop yields over time that there was not yet any clear evidence that a shortage of pollinators was reducing yield, a subsequent analysis of the same data set by Garibaldi et al. (2011), shows that yields of pollinator-dependent crops are more variable, and have increased less, than crops that do not benefit from pollinators, to the extent that a shortage of pollinators is reducing the stability of agricultural food production. In a meta-analysis of 29 studies on diverse crops and contrasting biomes, Garibaldi et al. (2011), found that wild pollinator visitation and yields generally drop with increasing distance from natural areas, suggesting that yields on some farms are already impacted by inadequate pollination.

Green growth is a concept that recognizes environmental protection as a driver of global and national economic development. It refocuses society on achieving qualitative growth rather than simply increasing GDP. This project will identify appropriate actions needed to adapt to pollination decline, especially given the uncertainty posed by gaps in scientific knowledge and effective policy interventions, as well as helping to demonstrate how an essential service contributes to the post-2015 developmental agenda.

The Future We Want, the outcome of the Rio+20 Sustainable Development Summit, recognizes the vital role for green growth strategies, which "should contribute to eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the earth's ecosystems" (UNCSD, 2012).

At the visionary level, the Green Economy is considered as: "An economy that results in improved human Well-being and social equity, while significantly reducing environmental risks and ecological scarcities"

(UNEP, 2011). At the operational level, the green economy is seen as one whose growth in income and employment is driven by investments that: (1) reduce carbon emissions and pollution; (2) enhance energy and resource efficiency; and (3) prevent the loss of biodiversity and ecosystem services (UNEP, 2011). These include investments in human and social capital, and recognize the central position of human well-being and social equity as core goals promoted by growth in income and employment.

2 Methods

Evaluation and characterization of colony bee loses by beekeepers in Osun State, Nigeria, using a detailed questionnaire and a survey on insect pollination management was conducted among researchers and policy makers. Osun State is an inland State in South-Western Nigeria with capital is Osogbo. It situated in the tropical rainforest zone. It covers an area of approximately 14,875sq km and lies between latitude $7^0$30' N and longitude $4^0$30'E.

Beekeeper assessments were based on production colony information between October 2014 and September 2015. The survey consisted of 22 major questions with some questions further divided into subparts. Although the majority of questions were intended to generate yes/no responses, several questions were multiple-choice or were open-ended to provide respondents with an opportunity to enter their own responses and supporting references. Thirty one (31) participating beekeepers returned their completed surveys to the authors out of a total of thirty five beekeepers indicating 89% response rate. Data were excluded from the loss rate analysis if the essential questions about colony losses were not answered. Where necessary, translation was required in the indigenous language. Participant knowledge, expectations, experience through spoken or written forms were obtained. Transcripts were analyzed to provide salient information, including potential trends in responses. Key informants for the pollination management survey included researchers, agricultural scientists, and government officials.

3 Results

Bees are the predominant and most economically important group of pollinators worldwide. Thirty five per cent of world crop production depends on pollinators. Bees serve humanity indirectly by contributing to the healthy functioning of unmanaged terrestrial ecosystems. The decline of pollinating species, which have grown over the last decades, can lead to a parallel decrease of plant species. More specifically, there is a great deal of concern about the decline of the honey bee (*Apis mellifera* L.) across the world that has been termed colony collapse disorder. The abundance of pollinators in the environment is influenced by biotic factors (predators, pathogens, parasites, competitors, availability of resources) and abiotic factors (climate, pollutants). In Nigeria, *Apis mellifera adansonii* is the most common specie, which is characterized by aggressiveness, high temperament, low honey yield as a result of defensive nature and frequent swarming behavior. Information was collected using interviews and two survey questionnaires for beekeepers and policy makers. Osun State was selected due to the beekeeper's being well organized under the Federation of Beekeepers Association in Nigeria (FEBKAN), Osun State branch. In this study, 31 beekeepers (89% of the total number of beekeepers) participated out of a total number of 35 beekeepers. A majority of policy respondents (90%) were not aware or uncertain of active in-country pollination research on various native and non-native pollinators.

4 Conclusion

The clear message of this study is that pollination is a key factor in agricultural productivity and pollinators are essential in providing this service. Overall, the Nigerian honeybee populations in the study area have not exhibited significant losses, probably because of the relatively unmanaged state of African honeybees and the

fact that they are indigenous. However, the fairly recent advent of environmental change (Climate change) globally and in Nigeria suggests that our bees are now more vulnerable and stressed than was previously the case. There is need to ensure that we are tackling all the issues that place pressure on honeybees, because in so doing we will hopefully also ensure the survival of some of the other lesser-known pollinators. There is the need to enhance local data for understanding the status and trends of pollinators to sustainably manage pollination services. All stakeholders need to ensure that pollination is well understood as a key limiting factor in agricultural productivity and that steps are taken to manage it in sustainable ways that maintain populations of pollinators and their habitats.

Table 1 Summary policy survey response.

Questions	Yes	No	Uncertain
Are you aware of research that has been conducted on the relative proportions of crops pollinated by various native and non-native pollinators?	2	10	8
Do managed bees pollinate major crops in Nigeria?	5	4	11
Have declines in honey bee populations been documented in Nigeria?	0	3	17
Have declines in other pollinator (non-honey bee) populations been documented in Nigeria?	0	4	16
To the extent of your knowledge, which, if any, Ministries have a formal insect pollination policy, or include insect pollination considerations within their national-level policies and/or programmes?	4	10	6
To the extent of your knowledge, Has the Federal Ministry of Agriculture conducted cross-ministerial work, with any other Ministry, incorporating insect pollination into national policies and programs?	1	8	11

4.1 Recommendation and proposed priority actions

4.1.1 Proposed actions

(a) Pollinators of major crops in Nigeria

- Develop regulations, guidelines and tools for the safe management of insect pollinators

(b) Legislation and policy

- Develop comprehensive policies for an integrated approach to insect pollinator management using a life-cycle approach

(c) Coordination, collaboration and partnership

- Implement inter-sectoral coordination mechanisms for the safe management of insect pollinators
- National multi-sectoral task forces that deal with issues related to crops and the environment to include insect pollinators on their agenda

(d) Human resource capacity

- Develop training packages on pollinators that can be used to upgrade the capacity and capability of farmers

(e) Surveillance capacity

- Enhance surveillance capacity for monitoring insect pollinators that could have impact on agricultural production

(f) Foster inter-sectoral collaboration in the sharing of information and surveillance data

Laboratory capacity

(g) Develop at the minimum capability for laboratory analysis of lethal and sub-lethal pesticide

levels in insect pollinators.

4.1.2 Further scientific research is needed to inform policy decisions that are underpinned by sound scientific basis. These include:

1. Quantifying the abundance of pollinators in Nigeria and the risks associated with the loss of pollination services.
2. Determine the economic value of pollinators for key crops.
3. Establish the conservation status of insect pollinators.
4. Investigate the drivers of pollinator loss.
5. Investigate honeybee forage resources under global change scenarios (land use change or climate change).
6. Detailed research on threats to honeybees in Nigeria.
7. Research alternative species of pollinators (other than the honeybee) for potential managed pollination.
8. More standardized monitoring and documentation of the occurrence and abundance of pollinators are needed to enable comprehensive assessment of pollinator trends.
9. Developing excellence in pollinator taxonomy.
10. Identification of native pollinators for agricultural production.
11. Studying plant-pollinator relationships.
12. Protecting foraging sites and restoring degraded habitats.
13. Studies of pesticide impact and pathogens of wild insect pollinators.
14. Using the honey bee as a bio-indicator.

4.1.3 Priority actions

The Sustainable Development Goal recognizes that biodiversity and ecosystem services can play a role in poverty alleviation, and the need to integrate ecosystem services such as pollination into food production. Priority actions include:

- Dissemination of this report to all relevant stakeholders.
- In-depth on-site evaluation of pollinator numbers and diversity in selected states based on the findings of this report.
- Elaboration of a country 2017–2020 strategy for management of pollinators to address the issues and challenges identified in this report.
- Development where and as necessary on the capacities required for pollinator management.
- Development of a comprehensive training package for public agricultural professionals on pollinator management, working in close collaboration with relevant stakeholders.

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