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IMPROVING POLICY TO ADAPT TO POLLINATOR DECLINE IN NIGERIA

Aneni T.I., Aisagbonhi C.I., Adaigbe V.C. and Aghayedo C.O.
Entomology Division, Nigerian Institute for Oil Palm Research, Nigeria
Corresponding author's Email: tomaneni1@yahoo.com
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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. The surveys conducted between October 2015 and March 2016 consisted 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. Evaluation and characterization of colony bee loses by beekeepers in Osun State was conducted. Responses were received from 31 beekeepers and 20 policy makers and researchers. 81% of beekeepers reported a reduction in number of colonies. The results inform policy action on pollinator benefits for increasing crop yield and helping smallholder farmers adapt to a decline in insect pollinators. 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 keepers, Colony bee loses, Crop yield, Insect pollinators, Policy makers.
Postal Address: Entomology Division, Nigerian Institute for Oil Palm Research, Benin, P.M.B. 1030, Nigeria. Mobile: +234-8055514010

INTRODUCTION

Animal pollination, mainly performed by bees, is an important ecosystem service with almost 90% of flowering plants and 75% of the world's most common crops benefiting from animal flower visitation (Klein *et al*., 2007; Ollerton *et al*., 2011). As the majority of the world's staple foods are wind- or passively self-pollinated (wheat, corn, rice), or are vegetatively propagated (potatoes), their production does not depend on and increase with animal pollinators (insects, birds, and bats). These crops account for 65% of global food production, leaving as much as 35% depending on pollinating animals (Klein *et al*., 2007). Habitat loss and fragmentation, pesticides, pathogens, climate change, invasive species, intense management of bees, and decreased interest in beekeeping have all been suggested as threats to bees and pollination services, but the relative importance of these drivers remains uncertain (Potts *et al*., 2010; Vanbergen, 2013). A preliminary survey in Nigeria has indicated that the *Elaeidobius kamerunicus* is a major pollinator of the oil palm inflorescence (Aisagbonhi *et al*., 2004). The *E. Kamerunicus* population trend indicated peak incidence in June and lowest abundance in March (Table 1). In Nigeria, the main strategy at present is to promote pollinators through establishment of protected areas.

Table 1. Estimated Population* of adult *Elaeidobius kamerunicus* per Spikelet (Aisagbonhi *et al*., 2004)

Date/Position	Top	Middle	Bottom	Mean
20 March 2002	37.2	4.2	29.0	23.46
25 April 2002	27.6	32.8	34.4	31.50

05 May 2002	42.8	41.2	30.4	38.13
11 June 2002	53.6	94.2	82.8	76.86
14 June 2002	94.6	116.0	89.4	100.0
01 July 2002	45.6	63.0	59.4	56.00
05 July 2002	98.6	85.2	55.0	79.60
10 July 2002	14.2	12.2	20.6	15.66
15 July 2002	46.2	46.0	31.4	41.20
29 July 2002	51.6	35.8	27.6	38.33
26 August 2002	72.4	54.8	35.6	54.26
05 September 2002	32.4	44.6	58.8	45.26
Mean	51.4	52.5	46.2	50.03
SE	4.36	5.32	4.36	

*Mean of 5 Replicates

Pollination is the transfer of pollen from the stamen, or the male component of a flower, to the pistil, or the female part. The pollen grain reaches the ovary via the stigma to fertilize the ovules which produce the seeds and fruit. Several types of vectors may ensure fertilization of a flower: wind, water, and animals, especially insects. There is increasing evidence of a global decline in insect pollinators that threatens the reproductive cycle of many plants and may reduce the quality and quantity of fruit and seeds, many of which are of nutritional and medicinal importance to humans. Identification of appropriate actions is needed, especially given the uncertainty posed by gaps in both scientific knowledge and effective policy interventions. Insect pollinators, comprising both managed *e.g.* honeybee *Apis mellifera* and wild populations (species that exist as non-managed wild populations including wild *Apis* sp.), have become a focus of global scientific, political and media attention because of their apparent decline and the perceived impact of such declines on crop production (Cameron *et al*., 2011; Kerr *et al*., 2015). Crop pollination by insects (predominantly by bee species) (Kremen *et al*., 2004) is an essential ecosystem service that increases both the yield and quality of an estimated 75% of crop species worldwide (Klein *et al*., 2007). 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. The fact that almost half the data on pollinator decline from recent studies comes from only five countries, with only 4% of the data from the continent of Africa (Archer *et al*., 2014), highlight the lack of information. Despite the perceptions of global honeybee decline, long-term global data indicate an increase in managed honeybees (Aizen *et al*., 2008; Aizen and Harder, 2009), except in the USA. However, agricultural demand could outstrip supply of managed honeybees (Aizen and Harder, 2009) and greater demand for high value fruit and nut crops may further increase demand for pollination services (Gallai *et al*., 2009; Breeze *et al*., 2014). This demand implies that pollination services may experience constraints even without a dramatic decline in honeybees and highlights the need for effective strategies to safeguard reliable pollination services for agriculture. Such strategies could include: improved health of managed honeybees; identifying possible substitutes for managed honeybees (Corbet *et al*., 1991; Potts *et al*., 1991) increasing and diversifying the suite of wild pollinators where possible (Corbet *et al*., 1991) and increasing the effectiveness of wild pollinators (Brittain *et al*., 2013). The latter includes conserving suitable food sources and nesting habitat for wild pollinators within the agricultural matrix and raises the question: 'Is management to secure biodiversity benefits more rewarding for crop production than management less favourable to biodiversity?' If so, then strategies to improve pollination services need to be aligned with strategies to conserve biodiversity in agricultural landscapes (Ghazoul, 2013).

Insect pollination is vitally important to terrestrial ecosystems and to crop production. 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, 2006; Gross, 2008; Goulson *et al*., 2015) 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). 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 *et al*., 2008; van Engelsdorp *et al*., 2009). 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) (Smith *et al*., 2013). 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 ser-vices. 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*. (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*. (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. There is clearly no major pollination crisis yet, but there is evidence for localized limitation of crop yield as a result of inadequate pollination (Goulson *et al*., 2015). The objectives of the study are:

a) Assess honey bee colony population abundance in study area.

b) Assess the main drivers of change in Nigeria, which have led or will trigger significant changes in the abundance of pollinators and food production.

c) Identify targeted activities and methods to manage and mitigate changes in pollinator abundance.

d) Development of best pollinator management strategy.

EXPERIMENTAL

Study Area: Osun State is an inland State in South-Western Nigeria with capital is Osogbo. It's 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. Its boundaries are: Ogun State to the

South; Kwara State to the North; Oyo State to the West; and Ekiti and Ondo State to the East.

Data Collection: Evaluation and characterization of colony bee loses by beekeepers in Osun State, Nigeria, using a detailed questionnaire. A survey on insect pollination management was conducted among researchers and policy makers. Information was collected using interviews and two survey questionnaires for beekeepers and policy makers. The questions used for the beekeeper survey is adapted from the colony loss monitoring questionnaire (Van der Zee *et al*., 2013) for beekeepers in Osun State. The State was selected due to the beekeeper's being well organized under the Federation of Beekeepers Association in Nigeria (FEBKAN), Osun State branch. 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 author 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 analysed to provide salient information, including potential trends in responses. Key informants for the pollination management survey included researchers, agricultural scientists, and government officials.

Data Analysis: After survey results were collected, they were entered into a spread sheet and frequency of response tables calculated.

RESULTS AND DISCUSSION

Beekeeper's Survey

In this study, 31 beekeepers (89% of the total number of beekeepers in Osun State) participated out of a total number of 35 beekeepers. The summary beekeepers response received from respondents is presented in table 2.

Policy Maker's Survey

This study developed a questionnaire and collected information from researchers and government officials to generate policy indicators related to pollination and pollinators for the purpose of description as a guide to action. The summary policy survey response received from respondents is presented in table 3.

Table 2. Summary bee keeper's Response

A/B	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2670	0	0	0	0	-	-	A	75	0	0	0	25%	ABE	ABD
2	20	0	0	0	15	20	-	A	0	0	0	0	-	A	AB
3	12	4	4	-	-	8	-	A	0	0	0	0	-	0	ABD
4	10	3	3	-	-	7	A	A	0	0	0	0	-	0	AD
5	14	4	4	-	-	10	A	A	0	0	0	0	-	0	B
6	44	4	4	-	-	40	A	A	0	0	0	0	-	0	B
7	5	1	0	-	-	-	E	A	0	0	0	0	-	0	AB
8	12	4	4	-	-	8	E	A	0	0	0	0	-	0	D
9	15	3	3	-	-	12	A	A	0	0	0	0	60%	0	AD
10	24	5	2	0	0	20	BCDE	A	0	0	0	0	2%	AC	AD
11	40	10	5	-	-	30	A	A	0	0	0	0	-	A	D
12	4	1	1	-	-	3	A	A	0	0	0	0	-	0	D
13	27	8	4	-	-	27	-	A	0	0	0	0	-	0	D
14	82	6	2	-	46	82	E	A	0	0	0	0	-	0	BD
15	14	6	4	-	-	8	A	A	0	0	0	0	-	0	D
16	9	2	2	-	-	7	A	-	0	0	0	0	55%	0	B
17	15	6	6	-	-	9	A	A	0	0	0	0	55%	0	AB

18	18	18	17	-	-	1	-	A	0	0	0	0	-	0	D
19	20	2	2	-	-	18	A	A	0	0	0	0	60%	0	D
20	300	5	10	-	55	210	D	A	5	Jun&Jul	8	150	-	A	ABD
21	40	-	-	-	-	-	A	A	0	0	0	0	-	0	AB
22	10	-	-	-	-	10	-	A	0	0	0	0	60%	0	B
23	22	-	-	-	-	20	-	A	0	0	0	0	-	A	AE
24	100	-	-	-	-	100	A	A&B	0	0	0	0	-	B	BC
25	20	3	-	1	0	-	C	A	0	0	0	0	-	0	BC
26	43	15	15	-	-	28	A	A	0	0	0	0	-	0	B
27	5	1	1	-	-	-	A	A	0	0	0	0	55%	0	B
28	35	10	10	-	-	25	A	A	0	0	0	0	-	0	B
29	30	10	10	-	-	20	-	A	0	0	0	0	-	0	E
30	17	2	2	-	-	15	A	A	0	0	0	0	-	0	B
31	53	9	9	-	-	44	-	A	0	0	0	0	-	0	ABC

A – Respondents; B - Response to Questions

Table 3. 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 programs?	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

Beekeeper's Survey Response

In relation to production colonies during a one year period (October 2014-September 2015), of beekeepers reported a loss of production colonies without dead bees in the hive. However, only 3% of beekeepers reported loss of production colonies due to queen challenges (queen less or drone-laying queen). 9% of beekeepers reported a reduction in total production colony numbers due to uniting/merging. A majority of beekeepers (48%) that responded were ignorant of the cause of the death of their colonies while others attributed the cause to starvation (3%), poor queens (6%) and disease (6%) and other unknown factors (12%). The beekeepers unanimously agreed that origin of queens were through rearing by their colonies. Most beekeepers did not have to provide a new queen (94%) nor was their colonies treated with a product for disease condition (97%). Most beekeepers (97%) reported that their colonies were neither contracted for pollination services nor moved for honey production. Due to a large proportion of small holder farmers in Osun State, bee movement for crop pollination is not practiced presently. This is in contrast with large-scale agricultural production systems such as almonds, apples, melons and other cucurbits where large fields provide limited edges where wild pollinators may nest (Chagnon, 2008). Beekeepers replaced on average, 47% of combs in the majority of production colonies and majority (81%) did not use any supplemental sugar feed while others used honey (19%), Beet sugar (6%) and inverted beet sugar (3%). Colony disturbance reported by beekeepers were mainly by ants, humans (theft), rats and squirrels.

Policy Survey Response

Information from policy makers indicates that population abundance trends in honey bee and other pollinator populations have largely not been documented in Nigeria (table 3). A majority of respondents (90%) were not aware or uncertain of active in-country pollination research on various native and non-native pollinators. This implies that there is an urgent need for special funding for pollination research. A majority of respondents (75%) were not aware or uncertain on the role of managed bees in pollinating major crops. This implies that there is need to create incentives and increase awareness for farmers to increase crop productivity with managed bees. All respondents (100%) were either not aware or uncertain if honey bee population declines have been documented in Nigeria. This is largely because there have not been large scale studies on honey bee abundance and distribution. There is need for a country wide bee abundance assessment. All respondents (100%) were either not aware or uncertain if other non-honey bee pollinator populations have been documented. Abundance in other non-honey bee pollinator populations has been documented (table 1). However, information on non-honey bee pollinator population variations over time is limited. There is need for further studies on non-honey bee pollinators of major crops. When asked if any Ministry has a formal insect pollination policy, a large percentage (50%) of the respondents was not aware of any policy. An outcome from the survey indicates that there is no formal insect pollination policy by the Ministry of Agriculture. When asked if the Federal Ministry of Agriculture has conducted cross-ministerial work, with any other Ministry, incorporating insect pollination into national policies and programs, a percentage (40%) of respondents were not aware while others (55%) expressed uncertainty. However, a general insect pest control policy is available for crop protection in Nigeria. There is need for incorporating insect pollination and pollinators into national policies and programs.

Causes of Pollination Decline

Pollination is the transfer of pollen from the stamen, or the male component of a flower, to the pistil, or the female part. The pollen grain reaches the ovary via the stigma to fertilize the ovules which produce the seeds and fruit. A pollinating species is termed wild when its habitat is located in a natural environment or an environment with no human interference. A native pollinator refers to a species originating in, associated with, and established in a given habitat over a long period. Introduced (managed) pollinators refer to species in which reproduction and survival are controlled by man (Chagnon, 2008). Over the past two decades, there has been considerable concern globally over the apparent reduction in populations of pollinators of all kinds. Several research projects, publications and public awareness campaigns have focused on determining the possible causes of decline in introduced pollinator numbers, particularly among honey bees. Some of the causes include:

Pesticides: Pesticides constitute a major threat to pollinators. It has been known for some time that the use of pesticides to control agricultural pests can have a negative impact on honey bee colonies (Johansen and Mayer, 1990). For decades, there have been massive losses in bee colonies wherever agriculture and beekeeping have co-existed. Losses in bee numbers are often the result of poor handling and application procedures for pesticides or else failure to follow the recommendations printed on the label. Even when the instructions are closely followed, the pesticide will inevitably constitute a serious risk for all the pollinators, regardless of whether they are wild or introduced. Pesticides are potentially able to harm a large number of pollinating species and even to eliminate a certain number of populations of species occurring in an ecosystem (Nabhan and Buchmann, 1997). The presence and abundance of suitable floral resources in an environment are therefore extremely important factors. A relatively new class of widely used systemic insecticides, the neonicotinoids, is highly toxic to insects, including bees, at very low concentrations. The group includes imidacloprid, thiamethoxam, clothianidine and several other compounds which are widely used to coat seeds. These compounds can be taken up via the roots and then carried by the sap to all parts of the plant as it grows. This ensures protection against root pests but also against insects attacking the aerial portions of the plant. Since they are active until the flowering stage, they can be picked up by pollinators in the pollen and nectar. Pesticide use in Nigeria has been on the increase over the decades (Asogwa and Dongo, 2009). It has been estimated that about 125,000-130,000 metric tons of pesticides are applied every year in Nigeria (Ikemefuna, 1998). There is currently a Pesticides Registration Regulations arising from the Drugs and Related Products (Act 19 of 1993). It is well established that the improper use of agricultural pesticides negatively affects development of honey bee colonies. Pesticides should be reduced or completely eliminated. Standard guidelines and label instructions should be correctly applied.

Transgenic Crops (GMOs): Transgenic plants were developed specifically to reduce some of the undesirable and involuntary effects of pesticides. There are concerns, however, about potential impacts the direct effects of insecticide proteins in the pollen may have on non-targeted species, including some pollinators (Losey *et al*., 1999). These concerns focus on the lack of information on the lethal threshold of transgenic insecticide proteins and the sublethal effects of the proteins on the physiological and reproductive behavior of the insects feeding on them. Published results suggest that the impacts of transgenic plants on bees should be examined case by case and depend on the portion of the plant that is ingested (Malone and Pham-Delegue, 2001. In Nigeria, no method has been developed to assess the impact of genetically modified organisms on pollinators under natural conditions.

Fragmentation and Habitat Loss: Fragmentation and habitat loss are two types of disruption that have been recognized as important factors in loss of biodiversity on a local as well as global scale. Habitat loss refers to the loss of a natural environment arising from a primary succession *i.e.* a natural landscape. Fragmentation of a habitat refers to the breakup of a habitat into fragments that are often too small to ensure the viability of populations of all species. Pollinators and pollination-dependent plants are not protected from this type of disruption (Kevan, 2001). In Nigeria, the traditional land tenure system in Nigeria coupled with increasing population encourages land fragmentation with attendant consequences for agricultural productivity and pollinator loss. Beekeepers in Osun State, observed that major challenges include pressures due to reduction in native vegetation area and indiscriminate pesticide use. Land fragmentation has severe consequences for agricultural development; it leads to scattering of plots, little incentive for improvements, lack of security of tenure, restricted scale of operations (Idowu and Oladebo, 1999). In spite of these associated costs, land fragmentation is still persistent and wide spread in Nigerian agricultural practice. Land fragmentation practices not only reduce natural and semi-natural habitats, they also cause loss of diversity among cultivated plants, further impoverishing the range of floral resources available to the natural pollinators in the area. Habitat fragmentation and loss affect pollinators in two ways. First, they reduce the availability of the range of plants capable of meeting all food needs throughout a season (Kearns and Inuoye, 1997). Loss of access to resources could increase competition among local species for the limited resources. Secondly, habitat loss could also disrupt nesting among a number of bee species that dig their nests in burrows.

Climate Change: According to some specialists, behavioral changes linked to the species' physiology have already been observed in some pollinators. Over the past two decades, British butterflies have made their first appearance of the season earlier and earlier and the peak period has also been brought forward. Similar changes have also been observed in California's butterflies (Forister and Shapiro, 2003). The average period for the first flight of 16 species studied tended to occur earlier. An average difference of 24 days for four of them represented a statistically significant trend. On the other hand, seven species tended to appear later in the season. Different species of pollinators are consequently going to react differently to climate change, which will affect the diversity and abundance of their populations in varying degrees. In terms of physiology, some factors like the photoperiod and temperature exert a control on endocrine activity and can modify fertility, the mode and rate of reproduction as well as the rate of development. These physiological reactions may differ from one species to the next. The underlying causes for changes within a pollinator community are therefore highly variable. Climate change and variability from 1961-2010 and projections up to 2050 and its impacts on the oil palm leaf miner- *Coelaenomenodera elaeidis* in Edo State, Nigeria has been evaluated (Aneni, *et al*., 2015). Currently, honey bee farmers in Nigeria, have observed low yield and the crystallized honey combs in their hives (CEBRAD, 2016) which has been attributed to increased rainfall intensity (scarcity period for honey bee activity) (Oyerinde *et al*., 2014). Information gathered from this study indicates that there are limited published studies on pollinators and climate change interaction in Nigeria. However, it can largely be deduced from other insect studies that climate change would have an impact on insect pollinators in Nigeria.

RECOMMENDATIONS AND PROPOSED ACTIONS

The clear message of this study is that pollination is a key factor in agricultural productivity and pollinators are essential in providing this service. Fears over pollinators and pollination services continue to build up in the scientific and public space. Therefore, 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.

Pollinator Gap Analysis: There is mismatch between government and local understanding of the problem of pollination service loss and governance priorities. This points out that while larger institutions can form the pillar for wider activities, practical measures need to be adapted to facilitate rather than hinder local farmers. The insect pollination gap analysis highlighting strengths and challenges in Nigeria is presented table 4.

Pollinator Management

Pollinator management practices have been identified, to conserve and manage pollinator populations. These practices not only benefit pollination ecosystem services, but contribute to crop diversity (biodiversity), soil health and reduced pesticide use. They include:

***Reduced Pesticide Usage*:** Pest control practices such as Integrated Pest Management that enhances natural pest controls reduce or eliminate the use of pesticides. At the same time, this greatly benefits pollinators which may be heavily impacted by pesticides.

***Maintaining Hedgerows and Floral diversity*:** Hedgerows provide habitat and forage resources for bees, and by diversifying the floral resources, insect pollinators are encouraged to remain on-site even in the following year. This also contributes to biodiversity conservation.

Pollinators of Major crops in Nigeria: Develop regulations, guidelines and tools for the safe management of insect pollinators.

Legislation and Policy: Develop comprehensive policies for an integrated approach to insect pollinators' management using a life-cycle approach.

Coordination, Collaboration and Partnership: Implement inter-sectorial coordination mechanisms for the safe management of insect pollinators. National multi-sectorial task forces that deal with issues related to crops and the environment to include insect pollinators on their agenda.

Human Resource Capacity: Develop training packages on pollinators that can be used to upgrade the capacity and capability of farmers.

Surveillance Capacity: Enhance surveillance capacity for monitoring insect pollinators that could have impact on agricultural production. Foster inter-sectorial collaboration in the sharing of information and surveillance data

Laboratory Capacity: Develop at the minimum capability for laboratory analysis of lethal and sub-lethal pesticide levels in insect pollinators.

Table 4. Strengths and challenges in the management of insect pollination in Nigeria

Factors	Strengths	Challenges
Insect pollinators of major crops	Insect pollinators of major crops identified	Inadequate capacity for appropriate management of the pollinators
Potential drivers of pollinator decline	Potential drivers of pollinator decline defined	Limited knowledge on drivers of pollinator decline
Policy on pollinator management	Progress in the development of national policies on agriculture	Pollinators not taken into account in existing national policies
Coordination, collaboration and partnership	Formal and informal structures for collaboration of relevant sectors exist	Lack of mechanisms for coordination and collaboration among relevant sectors
Human resource capacity on pollinator management	National training institutions available	Inadequate human resource for pollinator management
Surveillance capacity for pollinators	Relevant government institutions available	Surveillance systems for pollinator monitoring generally absent
Laboratory capacity for testing pollinator pesticide lethal and sub-lethal levels	Reference laboratories that deal with most chemicals identified as being of major public concern to pollinators available	Inadequate laboratory equipment and essential reagents

Priority Actions

The Sustainable Development Goals 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.
- Provision of technical support to research institutions for the implementation, monitoring and evaluation of the 2017–2020 country strategy after it is developed.

CONCLUSION

Overall, the Nigerian honeybee populations in the study area have not exhibited significant losses (number of dead bees in production colonies), 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.

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