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The Correlation between Use of Agro-Chemicals and Decline of Insect Pollinators in Agro-Ecosystems

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Abstract*: The world is becoming more crowded place with many more consuming mouths to feed due to ever increasing populations. These are putting increasing pressure on our environment ability to support it. African countries are responding to the challenges through modernization of agriculture. Much of this intensive agriculture is heavily depended on application of agrochemicals. However, the use of chemical fertilizers and pesticides has come with other formerly unforeseen challenges. This study was done to evaluate the use of agrochemicals and their impact on insect pollination in agro-ecosystems. The research was carried out in Mua Hills location in Machakos County in Kenya. Purposive sampling using questionnaires was done to collect data on agrochemicals on farms. Pan traps were used to sample insect diversity and abundance during the field surveys in the farms. The research found out that 80% of the farmers used insecticides and fungicides while 20% of them used foliar fertilizer. Spearman correlation analysis indicated that there was a significant association between type of agrochemicals used and the abundance of insects ($r^2 = 0.402$, $p < 0.028$). This study concluded that the current use of chemical fertilizers and pesticides lead to agro-ecosystem degradation and will should be controlled as it threatens insect pollinator communities. The findings echo the urgent need for environmental management of agro- ecosystems to support ecosystem servicers and functions.*

Keywords: Agro-chemicals, Insect pollinators, Agro-ecosystems, Pollination, Mua Hills, Machakos

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1. Introduction

Pollination is supporting ecosystem function that increases crop production. According to Ollerton et al (2011) insect pollinations are important for about 87.5% of World's wild flowering plants. These pollinations are "ecosystem architects" which play an even greater role comparable to the large mammals in the African savanna land (Kohi 2013). Fruit crops and vegetables that are pollinator dependent contain micronutrient and vitamins (Eilers et al, 2011) which is important for nutritional security in developing countries. Honey bees (*Apis mellifera)* are the key stone species in agricultural pollination but the role of other insects in crop production has shown that a diverse community of pollinators need to be sustained at farm level. Carpenter bees (*Xylocopa spp*) abundance improve the production of French beans, pigeon peas and passion fruits (Masiga et al., 2014: Otieno et al., 2015: Kasina et al., 2021).

Millennium Ecosystem Assessment in (2005) identified pollination as one of the ecosystem services which are on the decline. Research findings have indicated that bees' declines are driven by combined stress from parasites, pesticides and lack of flowers (Goulson D. et al., 2015). According to FAO (2013) there is need for more research to determine the risks of pesticides use to wild bees. Pesticides such as neonicotinoids have shown to be very toxic to honey bees (EASAC 2015) and decrease the foraging success and survival rate in honey bees (Cresswell and Thompson, 2012).

Gomgnimbou et al (2010) study on traditional beekeepers in Burkina Faso noted that bee hives situated near cotton fields treated with pesticides had lower numbers of adult bees and were less productive than those which were kept farther away. Pesticides are inherently toxic and have shown to have the potential to affect non-target insect pollinators (UNEP 2011, EASAC, 2015). During foraging, honey bees are capable of carrying residues of pesticides to their hives (Muli et al., 2014) and this affects the whole colony. Since pesticides can lead to a decline in overall richness of pollinators at a local scale (Archer C. T. et al 2014), therefore, there is need to carry out more research to determine the threats to pollinator declines at geographical regions. Effects of pesticides on pollinators in Africa have received little attention (Donaldson, 2002) and particularly in Kenya relatively little work has been done (Kasina, et al., 2012). This study was done with the aim of determining the correlation of use of agrochemicals on the diversity and abundance of insect pollinators in agro ecosystems in Mua Location, Machakos County, Kenya.

2. Literature Review

Horticulture is a major source of livelihood to many farmers in Kenya, it generates in excess of I.0 Billion dollars in foreign earnings annually (HCDA, 2010). However, this has in turn caused an increase in demand for agrochemical in the Kenyan horticultural sector and pesticides have now become the main method of crop and plant protection (NES, 2006). While they may seem to be best option, the main challenge is in the use, storage and disposal of these pesticides and fertilizers used in agricultural production. Gemmil et al (2014) recommend research in Africa on assessment of effects of pesticide use on crop pollinations because most African farmers rely on natural pollination services (Styger et al., 2006) and wild insect pollinations are of paramount importance for fruit set. The role of native bees and natural habitats to the pollination of eggplants has been documented (Gemmil-Herren and Ochieng, 2008). The contributions of a diversity of pollinators to small holder agriculture in Western Kenya and their economic benefits have been recorded by Kasina et al (2009). The role of hawk moths in papaya pollination has been shown to be of great significance (Martins et al., 2009) and by Martin et al (2013) Study, Hawk moths were found to also visit numerous indigenous plant species.

Efforts to control plant pests and improve soil fertility can have severe unintended consequences for pollination. Research has shown that one of the probable causes for the population declines of pollinators, including honeybees, is the indiscriminate use of pesticides (Klein et al., 2007; Potts et al., 2010; Nakasu et al; 2014). Chemical insecticides targeting crop management strategies but these chemicals can also be harmful to beneficial insects (Cresswel, 2011). There is evidence that wild bee and butterfly species richness tend to be lower where pesticide loads and cumulative exposure risk are higher (Brittan et al., 2010). Recent experiments have shown that sub-lethal neonicotinoid (Systematic pesticide) exposure impaired the ability of foraging honey bees to relocate the hive (Henry et al., 2012). The status of research on African pollination biology was reviewed in 2004 (Rodgers and Balkwill, 2004) at which point it was noted that relatively little work had been done on pollination biology in Africa. Progress has been made on making taxonomic information on African bees accessible to end-users, with a key to the African genera of bees (Eardley et al., 2010). However, reports on a decline of the abundance and diversity of the pollinator species in Kenya have been published in the recent past (Kasina et al., 2009 a, b, c: Mwangi et al., 2010). This decline has been noted on some crops that require wild pollinators such as passion fruits which are already showing a deficiency of pollination (Kasina et al., 2010). The reduction in the pollinator species could be as a result of the shift in common farm practices such as mono cropping, increased use of crop pesticides, continuous tilling of land and the absence of shrubs in the farms (Kasina et al., 2012). This has placed pollinator conservation at considerable current interest worldwide and significant concerns have been raised in many countries about the long-term viability of insect pollinators in both agricultural settings and conservation areas (Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services, 2016). Understanding the causes of pollinator decline is an absolute priority in ecological research, (Viana et al., 2012) and this study was undertaken to determine the use of agrochemicals and their impact on insect pollinators in the agro-chemicals.

3. Methodology

The location of the study was Mua hills situated in Machakos County This study area is important for horticultural farming and in Kenya, horticulture comes third in ranking just after tourism and tea in exports and it is a rapidly developing sector in agricultural production (Gioe, 2006).

Sampling and Data Collection

The area which was sampled had been selected using a line transect that was laid across three agro-ecological zones along the gradient of Mua hill. Respondents were identified with the assistance of Ministry of Agriculture Extension Officers who were in-charge of Mua Ward. The Participatory Rural Appraisal (PRA) methods were used to gather data about the safety of the agrochemicals that were being used, the effects and challenges observed during their utilization. These techniques included group discussions and interviewing people who were knowledgeable (Bernard, 1994). To ensure the research remains objective during data collection, the interviews involved the use of structured questions as a guideline. The agrochemicals considered in this study were pesticides (insecticides and fungicide) and foliar fertilizer.

Insect sampling was done using the strip transect method. Two strip transects were established systematically in each of the sampling plot measuring 100m x 200m. Each strip transect was 200m long and 5m wide and they were 40m apart. Transect walks for insect observation, counts and identification were done in this strip transects. Observation and sweep netting of insects were made in 30 minutes and, use of pan traps for three hours per strip transect in the selected quadrats within specified period from 09:00 to 12:00 hours each day. Every agro-ecological zone in Mua hills was sampled twice a week during the month of March and August 2016. Insect specimens were identified at National Museums of Kenya.

Statistical Package for Social Sciences (SPSS version 16.0) software was used for analysis of the use of fertilizers and pesticides; time of application; frequency of pesticide usage on a particular crop; the amount applied; information regarding leftover pesticides; disposal of pesticide containers and packages; knowledge about insect pollinators and their importance in agriculture; and the effect of pesticides in the environment and insect pollinators.

To assess the diversity index of insect pollinators, Shannon Weiner Index was used. The value of Shannon Weiner function was chosen because of the assumption that it was more sensitive to the presence of rare insect species in the sample. Spearman Correlation Coefficient (Spearman, 1904; Wayne, 1990) was used to describe strength and statistical significance between the two variables.

4. Results and Discussion

In total, we collected 3783 insects belonging to 30 species, 18 genera and11 families. Halitidae and Pieridae were the richest family (3 genera each), followed by Apidae (2 genera), Nymphalidae (2 genera) and Lyaeridae (1 genus). The rare species were Xylocopa nigrita (Fabricius, 1775) and Xylocopa flavorufa. The distribution was tabulated and analyzed according to three agro ecological zones and Shannon Weiner diversity was performed (table 1 below).

Table 1: Mean abundance and diversity of Insect pollinators

Agro-ecological Zones	Mean abundance of insect pollinators during Dry Season	Shannon Weiner Diversity Index
IV	20.5 +– 8.5a	1.1+-0.02a
II	7.9+- 4.5b	1.2 +_0.07b
II	7.6+- 4.4c	1.0+-0.33c
	$F_{2,108}$= P=0.005	$F_{2,108}$= P=0.005

F- Test is used to compare two variances (null hypothesis- the variances are equal) and the assumptions are: The population is approximately normally distributed

Samples are independent events

The research found out that 80% of the farmers use insecticides and fungicides while 20% of them use foliar fertilizers.

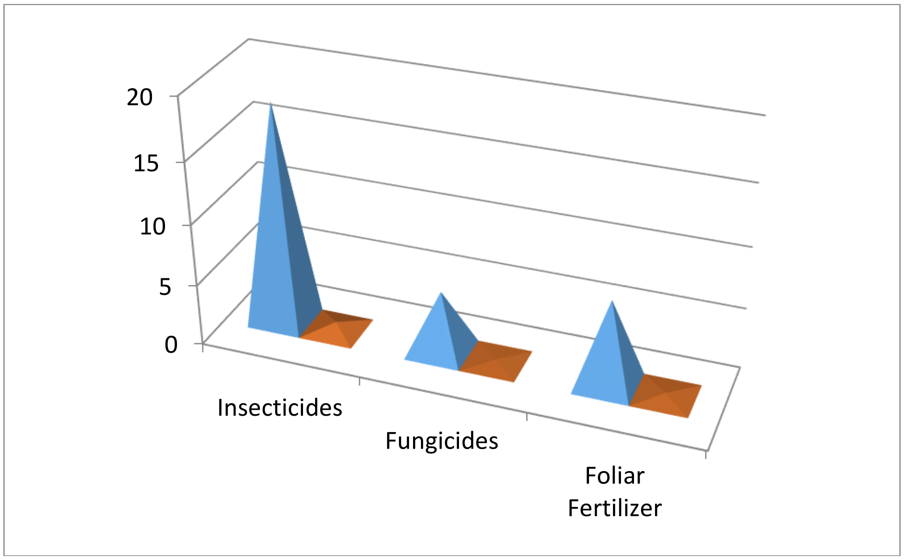

Figure 2: Showing Pesticides used by farmers in Mua hills location, (Emily, 2018).

Table 2: Spearman Correlational Analysis

Statement		Insect Abundance	type pesticides	time of pesticides use	amount applied	Frequency of use	application method	Disposal of leftover pesticides	disposal of empty containers	insects mostly found on plant flowers	importance of insect
Insect Abundance	**Correlation Coefficient**	1									
	Sig. (2-tailed)	.									
type pesticides	**Correlation Coefficient**	-.402*	1								
	Sig. (2-tailed)	0.028	.								
time of pesticides use	**Correlation Coefficient**	-.562**	0.176	1							
	Sig. (2-tailed)	0.001	0.352	.							
amount applied	**Correlation Coefficient**	-.398*	.388*	0.068	1						
	Sig. (2-tailed)	0.029	0.034	0.72	.						
Frequency of use	**Correlation Coefficient**	-0.402*	0.351	0.247	0.015	1					
	Sig. (2-tailed)	0.028	0.057	0.188	0.935	.					
application method	**Correlation Coefficient**	-.398*	-0.035	0.255	-0.304	0.247	1				
	Sig. (2-tailed)	0.029	0.853	0.174	0.102	0.188	.				
Disposal of leftover pesticides	**Correlation Coefficient**	-.451	0.331	-0.005	.472**	0.251	-0.005	1			
	Sig. (2-tailed)	0.214	0.074	0.978	0.008	0.182	0.978	.			
disposal of empty containers	**Correlation Coefficient**	-.367	0	.515**	-0.129	-0.12	0.193	-0.027	1		
	Sig. (2-tailed)	0.146	1	0.004	0.498	0.527	0.307	0.885	.		
insects mostly found on plant flowers	**Correlation Coefficient**	-0.257	0.293	0.327	0.155	0.171	0.155	0.015	0.059	1	
	Sig. (2-tailed)	0.171	0.116	0.078	0.414	0.366	0.414	0.939	0.755	.	
importance of insects	**Correlation Coefficient**	-.408*	0.098	.499**	0.327	.385*	-0.017	0.015	0.208	0.048	1
	Sig. (2-tailed)	0.025	0.608	0.005	0.078	0.036	0.928	0.939	0.27	0.803	.

*** Correlation is significant at the 0.05 level (2-tailed).**

**** Correlation is significant at the 0.01 level (2-tailed).**

The table revealed that application of pesticides had a negative and significant relationship with the abundance of insects (r=-0.562, p=0.001). The table further indicated that the amount of applied pesticides had a negative and significant relation with the abundance of insects in the zones (r=-0.504, p=0.000). Similarly, the results showed that the frequency of application of the agrochemicals related negatively and significant with the abundance of insects (r=-0.402, p=0.028).
In addition, the application method proved a negative and significant relationship with the abundance of insects (r=-0.398, p=0.029). However the disposal of left overs and pesticides cans proved a negative but an insignificant association with the increase in the number of insects in the respective zones. That is (r=-0.451, p=0.214) and (r=-0.367, p=0.146) respectively. The location where the insects were mostly found on the flower parts also had a negative but an insignificant relationship with the number of insects in the respective zones (r=-0.257, p=0.1716).

Discussion

The utilization of artificial fertilizers and pesticides was indicated by 29 (96.7%) of the study participants, 1(3.3%) of the participant indicated that the use manure only for crop production. Many farmers have knowledge about organic farming as alternative method, but this type of production is still very uncommon in this region. In agro-ecosystems where organic farming is practiced more insects are found in farms compared to areas where pesticides were being used. These results indicate that majority of the farmers at this study area has been relying more on increased use of agrochemicals such as pesticides and chemical fertilizers and, these are placing pressure on the agro-ecosystem functions and biodiversity. Over reliance on using agro-chemicals is likely to cause soil degradation and affect plant growth according to Altieri and Anderson (1992). There is significant evidence that these agro-chemicals are affecting the environmental health since few insect diversity and abundance were found in horticultural farms. Pesticides often kill directly, but sub-lethal amounts can also be detrimental to bees and other pollinators by impeding their ability to navigate or forage (FAO, 2012).

Most Pesticides are used during the short rain season (October to December) when farmers grow vegetables in bulk. Majority of the farmers are literate, but most of them have never used safety information and instruction on pesticide container. Pesticides are used more frequently in vegetables production than in maize. In maize and vegetable production, no herbicides are used since the households practice weeding instead of using herbicides. The farmers use between four and six different compounds. Systemic pesticides are used in the Mua hills location. According to the farmers the most significant environmental effects of pesticides usage was, piles of dead bees under fruit trees. None of the farmers was aware of any significant environmental effects of pesticides usage on the decline in abundance of pollinating insects.

We observed that use of pesticides in intensively farmed land harm insect pollinators, the most affected insect were the bees and butterflies.

5. Conclusion and Recommendations

There is need to limit use of agro-chemicals to stop pollinator declines for ecological function, agricultural production and human health. Pollinators are indicators of environmental health and their declines may destabilize the ecosystem. This study concluded that the current use of chemical fertilizers and pesticides lead to agro-ecosystem degradation and will should be controlled as it threatens insect pollinator communities. The findings echo the urgent need for environmental management of agro-ecosystems to support ecosystem servicers and functions.

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References

Archer, C. R., Pirk, C. W. W., Carvalheiro L G and Nicolson, S. W. (2014) Economic and ecological implications of geographic bias in pollinator ecology in the light of pollinator declines. *Oikos. 123* (4): 401-407.

EASAC. (2015). Ecosystem services, agriculture and neonicotinoids. Halle: European Academies Science Advisory Council.

Goulson, D. Nicholls, E, Botias, C., & Rotheray E. L. (2015). Bee declines driven by combined stress from parasites and lack of flowers. Science 347 (6229), 1255957.

FAO (2016). FAO's global action on pollination services for sustainable agriculture. http://www.fao.org/pollination..

Kasina, M. J. (2012). *Bees require protection for* *sustainable horticultural crops production in Kenya*. Julius-kuhn-Archiv, Nr.437: 167-172.

Kiatoko, N., Raina, S. ., Muli, E and Mueke, J. (2014). Enhancement of fruit quality in Capsicum annum through pollination by Hypotrigonagribodoi in Kakamega,WesternKenya. *Entomological Science*, *17*: 106-110.

Luvanga E.B (2015) Diversity and pollination activity of flower visiting insects associated with avocado along the slopes of Taita Hills in Kenya. Master's Thesis. Masinde Muliro University of Science and Technology, Kenya.

Muli, E., Patch, H., Frazier, M., Frazier, J., Torto, B., et al, (2014). Evaluation of the distribution and impacts of parasites, pathogens, and pesticides on honey bee (*Apis mellifera*) population in East Africa. PLos One 9(4) e 94459.

Nderitu, J., Kasina, M., Nyamasyo, G. and Oronje, M. (2007). Effects of Insecticide Application on Sunflower (Helianthus annuus L). Pollination in Eastern Kenya.

Ntow, J. (2008). The use and fate of pesticides in tomato-based Agro systems in Ghana. Nutrition Data www.nutritiondata.com.

Ollerton J., Price V., Armbruster, W.S., Memmott J., Watts, S, et al., (2012) overplaying the role of honey bees as pollinators; a comment on Aebi and Neumann (2011). *Treads Ecol. Evol 27* (3), 141-142.

Otieno, M., Sheena, C. S., Woodcock, B. A., Wilby, A., Voglatzakis, I. N., Mauchline, A. l., Gikungu, M. W., Potts, S. G. 2015. Local and landscape effects on bee functional guilds in pigeon pea crops in Kenya. *Journal of insect conservation 84* (4): 260-270.

UNEP (2011). Bees under bombardment: report shows multiple factors behind pollinator losses, Press Release 10 March 2011, United Nations Environmental Program, Nairobi.

Spearman, C. (1904). The proof and measurement of association between two things. *American Journal of Psychology*, *15*: 72-101.

Stout, J. C and Morales, C. L. (2009). *Ecological impacts of invasive alien species on bees*. Apidologie, 40: 388-409.

Taki, H. and Kevan, P. G. (2007). *Does habitat loss affect the communities of plants and insects equally in plant pollinator interactions? Preliminary findings.* Biodiversity and Conservation, 16: 3147-3161.