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Review

Towards achieving food security: Adaptive management of pollinators for crop plant and wildlife

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Floral ecology and conservation of pollinators are new concerns within the environmental community which has not been explored adequately. The role of Pollinators towards achieving food security is critical function to all humanity and that full attention to it is long overdue. There is a keen interest in identifying practices that will encourage the presence of diverse wild pollinators on farms growing pollinator-dependent crops. Losses of pollination services are difficult to quantify; unlike pests which damage crops, the benefit of pollinators are not immediately known. The benefits of their work are reflected in crop yields at the time of harvest. It is quite understandable that farmers may not readily link the presence of pollinators to much later improved yields. The aim of this paper therefore, is to provide the role of pollinators towards achieving food security and evaluate the impact of pollinator-friendly practices on the survival of pollinators. Monitoring, conservation, management and case examples of pollinator losses are also discussed. The paper also provides research interventions needed and the wayforward for conservation of pollinators. This paper is targeted at organizations working with farmers and farmers' groups to help them improve their production systems and practices so that they can meet their livelihood needs. This includes extension services, farmer field schools, cooperatives and marketing agents.

Key words: Pollinators, ecosystem services, food security, adaptive, ecology and conservation.

INTRODUCTION

Pollinators provide an essential ecosystem service that result in the out-crossing and sexual reproduction of many plants (Ashman et al., 2004). They benefit society by increasing food security and improving livelihood and by the role they play in conserving biological diversity in the agriculture and natural ecosystem. Reduced agricultural yields and deformed fruits often results from insufficient pollination rather than from a deficiency of other agricultural inputs, such as agrochemicals and plant nutrients. In natural ecosystem, the visual clues of insufficient pollination are more subtle than in agriculture, but the consequences can be as severe as the local extinction of plantspecies, a noticeable decline in fruit and seed eating animals, the loss of vegetation cover and the demise of health ecosystem and their services (Ashman et al., 2004). Ecosystem services, defined as the benefits to human welfare provided by organisms interacting in ecosystems, are considered to be at risk (Steffan et al., 2005). Ecosystem services provide the basis for human well-being and survival. Pollination by wild animals is a key ecosystem service.

Animal pollination is important to the sexual reproduction of many crops (Westerkamp and Gottsberger, 2000) and the majority of wild plants (Larson and Barrett, 2000; Ashman et al., 2004), which can also be important for providing calories and micronutrients for humans (Sundriyal and Sundriyal, 2004). Yields of some fruit, seed and nut crops decrease by more than 90% without these pollinators (Southwick and Southwick, 1992). Pollinator diversity is very vital as it influence pollinator availability. There are more than 20,000 pollinating species in the world, as well as numerous other insects and vertebrates pollinators (Burd Bateman, 1996). The decline of pollinating species can lead to a corresponding decline of plant species thereby leading to decline in plant reproductive success (Biesmeijer et al., 2006).

Food Security Ghana (FSG) highlighted the fact that

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food security is not only a global issue of concern. A fundamental issue of food security is poverty and unemployment (FAO, 2008). One very vital area that needs attention is the issue of pollinators without which investment in agriculture to ensuring food security would not be achieved. These declines are taken place during a period when agriculture has become even more dependent on insect pollinated crops (Allen et al., 1998). However, it is possible that improved plant varieties and husbandry has helped to avoid us reaching the worse levels in insect pollination. The issue of food security being threatened by insufficient pollination resulting from declining levels of insect pollination has not received the much needed attention it deserves. Much attention has gone into development of crop varieties; fertilizer types and pests and diseases control measures as a means of increasing crop productivity. This paper highlights the importance and decline of insect pollinators in both managed and unmanaged agro-ecosystems. It is hope that these will raise awareness about plant pollinators and the importance of monitoring and conserving them.

CONSERVATION OF POLLINATORS

Agro-ecosystem and wild lands may be losing the pollinator communities that are critical to their productivity. There are well documented losses of pollinators (Buchmann and Nabhan, 1996). Long-term global trends in crop yield and production reveal no current pollination shortage but increasing pollinator dependency. There is evidence that pollinators are declining as a result of local and global environmental degradation. It is said that any loss in biodiversity is a matter of public concern, but losses of pollinating insects may be particularly troublesome because of the potential effects on plant reproduction and hence on food supply security (Chapin, 2000). The following describe some of the factors that affect pollination/pollinators.

Loss of native pollinators can result from habitat loss, a storage bare ground for nesting caused by alien plant, and the insidious effects of invasive alien pollinators (Chen et al., 2004). Loss of pollinators can results from the spread of diseases or invasive alien species. This situation also highlights the potential risk of sole reliance on honeybees for agricultural pollination (Hines and Hendrix, 2005). Agricultural intensification jeopardizes wild bee communities and their stabilizing effect on pollination services at the landscape scale. Experiences have shown that micro-climate disruptions created by land use changes can have a damaging effect on pollinators.

CASE EXAMPLES OF POLLINATOR LOSSES

The International Centre of Integrated Mountain Development (ICIMOD) carried out research on pollination and associated productivity of mountain crops in Asia over the past decade. The project identified loss of habitat and the associated decrease in food and nesting sites for pollinators, resulting from the expansion of farming into forests and grassland areas, as a major effort cause of decreased mountain crop productivity. As a result of their findings, the project is making efforts towards conservation of pollinators through raising awareness among farmers and policy makers (Morandin, 2006). The government of Ghana has initiated programmes encouraging the conversion of croplands by farmers to forest and grasslands. Such programmes may help restore pollinator populations and natural ecosystems.

A decline in pollinating insects in India is resulting in reduced vegetable yields and could limit people's access to a nutritional diet, a study warns (Adams, 2007). Indian researchers found out that there was a "clear indication" that pollinator abundance was linked to productivity. They added that the loss of the natural service could have a long-term impact on the farming sector, which accounts for almost a fifth of the nation's Gross domestic product (GDP).

Inadequate pollinators in cocoa and oil palm plantations have been identified as one of the major causes of low yields per hectare of these cash crops in Ghana (Global Pollination Project-Ghana, 2012). This is an outcome of a research conducted by a team of entomologists and plant scientists at the Kubease/Bobiri study site of the Global Pollination Project-Ghana. They reported inadequate pollinators in cocoa and oil palm plantations might be accountable for the low yields in cocoa and oil palm produced in Ghana despite government’s intervention of mass spraying exercise and the hi-tech cocoa seedlings in the cocoa sector (Global Pollination Project-Ghana, 2012). There is, therefore, the need for the Ghana government to take deliberate steps to increase pollinator population in cocoa plantations across the country. This will enable the country to produce the desired crop yield per hectare as compared to other cocoa producing countries in the world since Ghana’s economy is heavily dependent on cocoa which heavily demands animal pollination for high yields. It is therefore, important for the country to pay attention to the issue of conservation and sustainable utilization of pollinators within the environment.

PROMOTING POLLINATOR HUSBANDRY

Floral ecology and pollinator conservation are relatively new concerns within the environmental community. Pollination by insects, however, is such a fundamentally critical function to all terrestrial ecosystems that full attention to it is long overdue. The increase in yield associated with improved pollination may seem of little

consequence. But some of the practices and the effect of improved pollination may lengthen the production period and allow production outside of the peak season. Pollinator husbandry is the use of technology for keeping pollinators mostly through the provisions of nest and nesting materials and promoting pollinator friendly practices. The practices include adequate nectar, pollen, larval host plants and ensuring that nesting site and nest-making materials are available (Shuler et al., 2005). Flowering plants in the vicinity should be diverse and have long and overlapping blooming periods. Rehabilitation of Landscapes promotes pollinator numbers (Ghazoul, 2006). Loss of habitat through land use changes, such as conversion of area to agriculture; mining or urban development has been identified as the principal causes of pollinator decline. Farmers can be encouraged to restore some of their farmland to forest or grasslands, road planners can ensure roadside and infrastructure servitude are reseeded with pollinator-friendly plant species and urban planners should encouraged native floral diversity in parks (Goulson, 2003). Increased productivity and sustainable land use should be sufficient incentive for sustainable pollinator species and numbers, and government incentives should encourage this process. Although not necessarily targeting pollination per se, such incentives are increasingly becoming part of national policies. The use of pesticides or other agrochemicals may cause pollinator declines so care should be taken to avoid the use of toxic agrochemicals (Delaplane and Mayer, 2000). Farmers must be trained and encouraged to apply recommended pesticide rates on their crops. Pollinator-friendly practices are likely to reduce the cost of purchased inputs as pesticide use is reduced or made more effective. Here rehabilitation strategies should focus on using other methods of pest control, such as biological and integrated pest management.

The following measures could also help enhance pollination; encouraging field borders with flowering plants or crops, such as cassava, protecting sacred groves for pollination as well as religious values, mixed crop types over a growing season to reduce or eliminate dearth period with no crops in flower, shade tree cultivation, conservation of natural and semi-natural habitat providing pollen sources for pollinators, selective weeding to conserve weeds good for pollinators, no till agriculture and avoidance of flood irrigation (Shuler et al., 2005). Incorporating more trees in the farming system would also be beneficial to pollination but farmers do not want to do this because it would take up too much land in their already small land holdings. Crop rotation using these flowering plants would also help to enhance other ecosystem services.

Pollinator restoration and the management of native pollinators are in the infancy and it may be necessary to reintroduce native pollinators. This is not easy, and the procedure for doing this is yet to be fully explored especially in Ghana. There is therefore the need to undertake these practices in order to increase the levels of pollination service observed in farmer's fields.

RESEARCH NEEDS AND INTERVENTIONS

The targeting of the areas of research should address specific concerns. The expanding awareness, understanding and value of multiple goods and services provided by pollinators can help make forest and agriculture more sustainable and improve productivity in agro-ecosystem. The technologies that promote positive and mitigate the negative impact of human on pollinator diversity need to be identified and conveyed to the agricultural and forestry communities. Where pollination service are inadequate, pollination management is required. There are a number of potential approaches, and targeted research may be needed to identify the bestone.

To enhance pollinator-friendly agriculture and natural ecosystem there is the need to conduct a research on the following;

1. Identifying interactions between pollinator functioning.
2. Conservation practices of natural areas needed to optimize pollinator services.
3. Develop pollination management technologies, such as bombiculture and meliponiculture.
4. Develop a plant list for nectar and pollen
5. Compare the effect of conventional agriculture with "ecological farming" to enhanced pollinator service.

WAY FORWARD

To enhance pollinator service, the impact of agrochemical on pollinators, the timing and methods of application of the pesticides should be considered. When applying any pesticide, or other agrochemical, strict adherence to safety (operator and pollinator) guidelines should be followed. Often less toxic alternative insecticides could be used. Honey bee colonies can be covered to keep forages in their nest during spraying and spraying can be done at night.

To help in breeding of midges and insects which are efficient pollinators of the cocoa tree, it has been suggested that farmers increased the dumping of cocoa husks and stems of plantain and banana in cocoa plantations to help in the pollination service. It is also recommended that the cocoa trees should also be interspersed with plantain and bananas to aid pollination in cocoa farms.

Crops generally have limited flowering periods, maximizing the floral diversity in the ecosystem will help maintain the abundance and diversity of pollinators for adequate pollination of crops and wild plants.

The assemblage of flowering plants that will maintain pollinator should include those with a variety of floral structure and long, overlapping blooming periods. Hybrids should be introduced with caution because they often have inadequate pollen and nectar since plant breeders do not breed for these characters.

In highly depleted areas of pollinators their losses are usually reversible in carefully planned rehabilitation programs. Nesting materials, which include inter alia plant resins, leaves, mud, sand and dead trees have to be provided.

It is also important that pollinator diversity and abundance is maximized to improve pollination, including floral diversity in the ecosystem. The flowering plant that will maintain pollinators should include those with different floral structure and overlapping blooming period.

It is recommended that the importation of exotic species should be a last resort. It is always important to first try and manage indigenous species and never import species that may become invasive later. Before any exotic species is imported, we should ensure that appropriate risk analysis and cost/benefits studies are undertaken. Farmers' knowledge can be increased through participatory on-farm studies, farmer field school and improved activities of agricultural extension agents. It is concluded that on a global scale conservationist, farmers, foresters, horticulturist, landscape architects, town planners, researchers and other stake holders need to work with policy makers on the economic and ecological importance of pollinators to biodiversity and food security.

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