BEE INTERACTIONS WITH WILD FLORA AROUND ORGANIC AND CONVENTIONAL COFFEE FARMS IN KIAMBU DISTRICT, CENTRAL KENYA

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Abstract—Flower scarcity outside coffee flowering periods leads to a decline of pollinators' abundance and diversity possibly through death or migration. The objective of this study was to assess whether other flowering plants within and around coffee farms act as alternative floral resources that may impact on abundance and diversity of pollinators of coffee flowers. Bee pollinators of coffee were assessed and identified for a period of 27 months. Their abundance and diversity were examined within and around organically and conventionally managed coffee farms in Kiambu District in Kenya. This study provides evidence that 42 plant species from 19 families were alternative floral resources for bees that pollinate coffee. Bee pollinators of coffee were observed to visit coffee flowers as well as other flowering plants close by. Significant relationship existed between plant species and bee species richness in the organic farming ($R^2=0.5918$; $P<0.0001$) and in conventional farming ($R^2=0.6744$; $P<0.0001$). Therefore in coffee monocultures, presence of other flowering plants should be encouraged to support bee pollinators when coffee is not flowering and to enhance abundance and diversity of bees visiting coffee flowers.

Keywords: Bee, conventional farming, interactions, organic farming, pollinators, wild plants

INTRODUCTION

Plant-pollinator interactions have faced increasing threats from man especially through agricultural intensification (Ricketts 2004). Tropical ecosystems are characterized by agroecosystems and there is expanding conversion of natural habitats to agroecosystems. Loss of native habitats within agricultural landscapes may be of particular importance, because crop pollination by wild bee species is provided locally when there are wild plants around cropped areas (Richards 2001). Loss of natural habitats constrains the foraging ranges of bees (Kearns 2001; Richards 2001; Kremen et al., 2002 & Ricketts 2004).

Efforts to conserve biodiversity have been focused primarily on the remaining areas of natural ecosystems. However, only 5% of terrestrial environment is uninhabited and unmanaged. Therefore, most pollinator species that remain in the natural habitats interact with agricultural ecosystems. However, the contribution of management type to these species survival is often ignored, as is the potential value of agroecosystems for conservation (Klein et al. 2002; Power & Flecker 2000).

The repercussions of interrupted plant pollinator relationship are potentially serious (Rathcke & Jules 1993). Plants may experience lower and inferior pollinator visitation and depressed reproductive output in absence of remnant habitat fragments as a result of changes in the pollinator community (Murcia 1996). Pollination studies have revealed that presence of wild habitats enhances pollinator activity in the surrounding agricultural fields. Most pollinators and especially bees need natural plant remnant habitats for foraging purposes, nesting or oviposition, source of water, mating and roosting caves (Roubik 1995; Ricketts 2004).
This study sought to investigate the plants surrounding coffee farms that supply floral resources to pollinators of coffee. Previous pollination studies in Kenya have been carried out on only a few crops e.g. pollination of indigenous crops in Mwingi (Njoroge et al., 2008), pollination of *Citrullus lanatus* (Thunb) Mansf. Nakai (water melon) at Yatta (Njoroge 2005) and bottle guard (*Lagenaria siceraria*) (Morimoto et al. 2004). The economic value of pollinators for crop pollination in Kakamega has also been investigated (Kasina 2007). However, wild floral resources that serve to sustain pollinators outside the flowering period of the crop are not well documented (Njoroge 2005; Morandin et al. 2007; Black et al. 2007).

**METHODOLOGY**

**Study area**

This study was carried out for 27 months from October 2005 to December 2007 in Kiambu District which lies between latitudes 0°75’ and 1° 20’ south of Equator and longitudes 36° 54’ and 36° 85’ east. The district is adjacent to the northern border of Nairobi and it covers an area of 1324 km² with 90% being high agriculture potential land (G.O.K. 1994; Muchena et al. 2004). Two study sites with well managed coffee plantations were selected. The two study sites bordered an indigenous forest. These included an organically (Paradise Lost) and a conventionally (Evergreen) managed farm.

The main idea behind organic farming is 'zero impact' on the environment. Organically grown means grown without use of synthetic agrochemicals and inorganic fertilizers for at least three years. Conventional farming systems involve use of whatever means to kill pests and maximize output: It involves use of chemical plant protectants, chemical fertilizers, synthetics and even genetically-modified organisms (Ponte 2002).

**Quantification of wild plants visited by bees in coffee farms**

Diversity of flowering wild plant species used as floral resources by bees in the study area. The organic farm had all the 19 families of plants and 40 species while the conventional farm had 14 families and 25 wild plant species (Appendix 1). The organically managed farm had a higher abundance and richness of both the rare and common plants collected in this study (Tab. 1; Fig. 1).

For the first time in Kenya, this study has documented the important plant families in proximity to coffee farms that provide floral resources to bees when coffee is not flowering or enhance the number of bees visiting coffee flowers (Appendix 1). An important finding in this study is that wild plants act as alternative floral resources for bees visiting coffee flowers. *Bidens pilosa* L., *Galinsoga parviflora* Cav. and *Justicia uncinulata* Oliv. were found to be very common and attracted the highest number of bees. The families Acanthaceae and Asteraceae act as reliable source of floral resources due to their availability throughout the year, and their wide distribution in forest gaps, secondary forests and bushlands (Gikungu 2006).

**RESULTS AND DISCUSSION**

**Diversity of wild plants visited by bee pollinators of coffee**

A total of 42 plant species represented in 19 plant families were recorded as plants visited by bees in the study area. The organic farm had all the 19 families of plants and 40 species while the conventional farm had 14 families and 25 wild plant species (Appendix 1). The organically managed farm had a higher abundance and richness of both the rare and common plants collected in this study (Tab. 1; Fig. 1).

**Table 1: Diversity of flowering plant families sampled in the coffee farms**

| Diversity index | Organic Farm | Conventional |
|-----------------|--------------|--------------|
| Richness        | 19 (100%)    | 14 (73.6)    |
| Shannon index   | 3.123        | 2.505        |
organic farms, whereas conventional farms, due to their lower diversity, were more affected by the absence of bees during coffee flowering seasons.

**Correlation between bee species and wild plants floral resources diversity**

Wild plant floral resources richness has a positive impact on bee richness in conventional farming. Higher bee abundance and diversity were recorded where there was high plant species diversity (Fig. 3). The relationship between plant species richness and bee diversity in the conventional farming was highly significant ($R^2=0.6744$; $P<0.0001$). In this study, bees found visiting coffee flowers were also noted visiting other flowering plant species surrounding the coffee farm.

In organic farming, bee diversity was found to increase with an increase in wild plants floral resources diversity (Fig. 3). The relationship between other plants near coffee farms and bee diversity was highly significant with bees visiting coffee flowers also visiting flowers of other plant species ($R^2=0.5918$; $P<0.0001$).

The above findings are important because they give an indication that absence of other flowering plants when coffee is not flowering may lead to a loss of bees and compromise pollinator visitors in subsequent seasons when coffee is flowering. Pollinators have been found to be noticeably less diverse and less numerous when natural habitats are either highly fragmented or completely absent (Richards 2001). A study in England showed that species richness of the fauna in field boundaries and crop centres was significantly greater in boundaries of margins sown with diverse plant species. Analysis of total bees caught showed highly significant positive effects of sown margins. Overall diversity of bees was lower in the field centres where the 6m margin strips were absent (Marshal et al. 2006).
Relationship between number of bees sampled in plant species per month

Average number of plant and bee species arranged from the highest to the lowest

- Bee richness-organic farm
- Wild plant richness-organic farm
- Bee richness-Conventional farm
- Wild plants-Conventional farm
- Linear (Bee richness-organic farm)
- Linear (Wild plants-Conventional farm)

**Fig. 3:** Relationship between wild plants floral resources and bee richness in an organic and a conventional farm

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### APPENDIX

#### APPENDIX 1: Wild plant species visited by bees in coffee farms

| Plant family       | Plant species                                      | Present in Organic Farm | Present in conventional farm |
|--------------------|---------------------------------------------------|-------------------------|------------------------------|
| Acanthaceae        | Asystasia schimperi T. Anderson                   | √                       | √                            |
|                    | Justicia uncinata Oliv.ex C.B. Clarke             | √                       | √                            |
| Amaranthaceae      | Amaranthus hybridus L.                            | √                       | √                            |
|                    | Amaranthus graecizans L.                          | √                       | -                            |
| Commelinaceae      | Commelina benghalensis L.                         | √                       | √                            |
| Compositae         | Ageratum conyzoides L.                            | -                       | -                            |
|                    | Bidens pilosa L.                                  | √                       | √                            |
|                    | Conyza schimperi L.                               | √                       | √                            |
|                    | Conyza bonariensis L.                             | -                       | √                            |
|                    | Erlandea cordifolia (Benth.) S. Moore              | √                       | -                            |
|                    | Gálánsoga parviflora Cav.                         | √                       | √                            |
|                    | Sencis doumifolius L.                             | √                       | -                            |
|                    | Sonchus exuiculatus (Oliv. & Hiern) O. Hoffm.     | √                       | √                            |
|                    | Sonchus oleraceus L.                              | √                       | √                            |
|                    | Sonchus schweinfurthi L.                          | √                       | -                            |
|                    | Tagetes minuta L.                                 | √                       | √                            |
| Cruciferae         | Raphanus raphanistrum L.                          | √                       | -                            |
| Euphorbiaceae      | Euophorbia hirta L.                               | √                       | -                            |
| Graminaceae        | Dactyloctenium aegyptianum                       | √                       | -                            |
|                    | Digitaria velutina (Forssk.) P. Beauv.            | √                       | √                            |
|                    | Digitaria sitchensis (Hochst. ex A. Rich.) Stapf  | √                       | √                            |
|                    | Pennisetum clandestinum (Hochst. ex Chiov.) Chiov.| √                       | √                            |
|                    | Setaria Verticillata (L.) P. Beauv.               | √                       | -                            |
| Labiatae           | Plectranthus barbatus L.                          | √                       | -                            |
|                    | Plectranthus loniginosus L.                       | -                       | √                            |
| Leguminosae        | Physeolus vulgaris L.                             | √                       | √                            |
| Malvaceae          | Sida cuneifolia A.Gray.                           | √                       | √                            |
|                    | Sida rhombifolia L.                               | √                       | -                            |
| Oxalidaceae        | Oxalis latifolia Kunth.                           | √                       | √                            |
|                    | Oxalis comniculata L.                             | √                       | √                            |
| Papilionaceae      | Indigofera spicata Forssk.                        | √                       | -                            |
| Papilionoideae     | Rhynchosia elegans A.Rich                         | √                       | -                            |
| Polygonaceae       | Polygonum convolvulus L.                          | -                       | √                            |
|                    | Oxygonum sinuatum (Mrisn.) Dammer.                | √                       | √                            |
| Portulacaceae      | Portulaea oleracea L.                             | √                       | -                            |
| Rubiaceae          | Richardia brasiliensis Gomez                      | √                       | -                            |
|                    | Rubia cordifolia L.                               | √                       | √                            |
| Solanaceae         | Central aurantiacum Lindl.                       | √                       | -                            |
|                    | Solanum nigrum L.                                 | √                       | √                            |
|                    | Solanum tuberosum L.                              | √                       | √                            |
| Verbenaceae        | Lantana cansa L.                                  | √                       | -                            |
| Zygophyllaceae     | Tribulus terrestris L.                            | √                       | -                            |