Bee Diversity and some Aspects of their Ecological Interactions with Plants in a Successional Tropical Community

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DEDICATION

This work is dedicated to my husband David, and children Samuel, Mark and Ruth.

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1.0 GENERAL INTRODUCTION

1.1 Tropical rain forests

Tropical rain forests are the most endangered ecosystems, yet they offer very important direct and indirect values to man. Examples of indirect values of tropical rain forests include maintenance of soil fertility, prevention of soil erosion and landslides, carbon sequestration and provision of water (Hamilton, 1884). According to studies done by McKane *et al.* (1995), plants and soils of tropical forests hold 460 to 575 billion metric tons of carbon worldwide. The direct values of tropical rain forests include providing shelter for more than half of the world´s species (Struhsaker, 1987), provision of timber, fuel wood, food and medicinal plants among many others. Further studies have shown that at least 80% of the developed world´s diet originates in the tropical rainforests. Examples of such crops and fruits include pineapples, mangoes, lemons, oranges, bananas, yams, pepper, cinnamon, cloves coffee and tomatoes.

According to recent reports, tropical rain forests used to occupy 14% of the earth´s surface (Diamond, 2000) and currently they cover only 6% (Lanly, 1992). Achard *et al.* (2002) estimate that about 0.43% of the rain forests in Africa is cleared for agricultural purposes (Archard *et al*., 2002); and further clearance of 0.7% is accelerated by logging operations (Lanly, 1992; Lawrence, 1999). Tropical rain forests are therefore diminishing at an alarming rate. Unfortunately, most of the forest biodiversity remains poorly studied, and the prevailing anthropogenic factors continue to drive forest biodiversity to extinction. These threats have therefore led to the formation of fragments that cannot harbour viable populations. Stebbins (1979) described them as ``ecological traps´´ because they limit both the movement of animals, as well as the exchange of genetic materials by plants through pollen vectors or seed dispersers. In extreme conditions, disruption of mutualistic relationships between plants and animals can lead to extinction of other species or to ripple effects and consequently, alteration of ecosystems. (Terborgh, 1986; Bawa, 1990).

1.2 Deforestation and biodiversity loss

Deforestation has been identified as the key threat to tropical rain forest biodiversity, and can occur through several ways. Deforestation activities include clearing of forests by small-scale farmers, the so-called ``slash and burn`` cultivation or *shamba* system in East Africa, selective or non-selective logging by commercial loggers using heavy machinery, fire outbreaks and landslides. Other minor causes of deforestation include urbanization and floods from dams. However, the loss of tropical rainforests is generally accompanied by disappearance of both plants and animal species. According to recent estimates by experts, about 137 plant, animal species are lost daily due to rainforest deforestation activities (Stork, 1996). With the continous degradation of primary forests, more species of plants and animals are likely to be destroyed in the near future. Consequently, most tropical forests are currently characterized by secondary forests; this renders support to Gomez-Pompa & Vasquez-Yanes (1974) observation, who referred to this situation as an `era of secondary forests'.

1.3 Secondary forests and biodiversity conservation

Secondary forests cover more than 600 million hectares representing 31% of the total forest land. These forests are, unfortunately, often disregarded by both the policy-makers, and the public (Sandra & Lugo, 1990). Several definitions for fallow or secondary forests have been given. According to Ewel (1979), secondary forests are dominated by only a few species of fast-growing pioneers; as these develop into high-volume successional forests that yield a relatively uniform raw material that make utilization easier. Similarly, Richards (1955) characterizes them as forests dominated by exceedingly fast-growing, short-lived, soft-wood of little or no timber value. A further definition is also given by Lanly (1982) who describes secondary forests as a mosaic of different age forests, including all complexes of woody vegetation derived from the clearing of closed and open forests by shifting cultivation, and patches of uncleared forest and agriculture. Sandra & Lugo (1990) argue that, the vegetation structure of secondary forests is characterized by high total stem density but low density of trees (> 10 cm dbh), low basal area, short trees with small diameters, low wood volume, and high leaf area indices. However, secondary forests can be categorized into two, that is, natural or anthropogenic (depending on origin). The latter is the most common and includes abandonment of cleared forest lands initially for agriculture. Other causes of secondary forests include, continuous logging, grazing activities and firewood collection. In tropical Africa, secondary forests created as a result of logging constitute about 21% as compared to other tropical areas (Sandra & Lugo, 1990). Unfortunately, this rate is bound to continue increasing due to the prevailing land pressure emanating from rapid increase of human population.

Whereas a lot has been documented on the tropical forests succession process (Denslow, 1987; Ewel, 1983), there is very little scientific understanding of tropical secondary forests (Sandra & Lugo, 1990). Observations by Brown and Southwood (1987) indicate that secondary succession is characterized by changes in species richness and structure of vegetation. This in turn influences the availability of nesting and mating sites and food plants for insects. However, disturbance has been identified as the key factor in the maintenance of plant diversity in tropical rain forests (Huston, 1994; Hubbel, 2001). A recent theory on succession and changes in biodiversity predicts that the highest species richness peaks in mid-successional stages of ´´intermediate disturbance ´´ (Connel, 1978; Brown and Southwood, 1987) although only limited studies on animal biodiversity changes regarding successional aspects exists. Thus, the future of tropical forest biodiversity is reliant on proper management of secondary forests and how well they are understood (Sandra & Lugo, 1990; Ewel, 1979). Several values of secondary forests, in relation to human use, as well as their ecological characteristics, have been enlisted by Sandra and Lugo (1990), but their role in conservation of pollination service remains unappreciated and poorly documented.

1.4 Plant succession and pollinators

Pollinators have been identified as a priority group by Decision III/II (1996) of the Conference Of the Parties (COP) to the Convention on Biological Diversity, following some deliberations made during their third meeting (COP3) in Buenos Aires, Argentina (Eardley, 2002). For many years pollination services at ecosystem level have been taken for granted until problems in crop production were observed in some developed countries like Europe and United States following decline in pollinator populations. From the recent studies, it is clearly evident that knowledge on spatial-temporal heterogeneity, dispersal movements of animals (such as pollinators) between habitats, and ecological succession are of great importance in understanding the development of landscapes and ecological processes within them (e.g. Odum, 1969, Dunning *et al.*, 1992, Pulliam and Dunning, 1994).

Interspecific competition and dispersal limitation have been viewed as important determinants for community structure (Etienne & Olff in press). Vogel and Westerkamp (1991) suggest that vegetation structure, vertical layering, species number and composition of the community, the number of zoophilous species increases from simply structured communities to more richly structured communities. Unfortunately, large open areas may negatively affect the abundance of specific pollinators and dispersers of rain forest species (Guevara *et al.* 1986; Chapman & Chapman, 1999). Lack of knowledge on the effects of the heterogeneity of vegetation structure and /or successional stages on pollination modes at the community level has been expressed by Ramírez (2004). Increased knowledge at both local and broad scale level of faunal movements and their interaction with plant species would greatly avert or minimize the escalating extinction of biodiversity in the various ecosystems. Whereas pollinators are the major pollen vectors, only a few studies have been undertaken at community level in many tropical communities. A community-level analysis can provide insight into plant-pollinator communities using additional comparative data in relation to changes in vegetation structure (Ramírez, 2004). In addition, data on pollinator patterns and dispersal movements along forest regeneration gradients and fragmented landscapes is missing in many tropical countries. Such data would provide important basis for planning of the restoration of degraded ecosystems, as well as sustainable exploitation methods. Furthermore, such data would be important in defining the size of an area or stages of natural succession, which can be selected or manipulated for forest biodiversity conservation purposes.

Succession in tropical forest is a dynamic process though only a few studies have attempted to review physiological ecology of tropical successional (e.g. Bazzaz and Pickett, 1980). Data on pollinator populations in regenerating habitats have been equally scarce as it is also a largely unstudied field (Liow *et al.*, 2001; Kang and Bawa, 2003). Observations from a few existing documented studies have shown that insect species composition changes with ecological succession (e.g. Southwood *et al.*, 1979; Ashmole *et al.*, 1992). Early successional plants have been found to depend on toxins such as alkaloids for defence while later-successional plants are defended by digestible reducers such as tannins and lignins and high fiber content and such plants have been speculated to depend on specialist herbivores which are able to sequestrate the toxins (Gaasch *et al., 2005*). Conversely, plant generalization is expected to be high in colonizing weedy species because they require a high degree of reproductive assurance (Baker, 1965), and specialization to be high among the widely dispersed understory shrubs and epiphytes (Feinsinger, 1983).

Based on this argument, early successional plants would therefore benefit from pollinators because they facilitate gene flow among conspecifics such as weeds or pioneer species (Rollins, 1967) which are more vulnerable to pressures from pathogens and herbivores (Levins, 1975). However, Levin (1964) suggests that, as the forest matures, large plants such as trees require less gene flow for they are subjected to less variable lifetime environments as compared to weeds and would not require specialized pollinators. Potts *et al.* (2002) also suggest that the regeneration of floral communities is closely matched by that of their principal pollinators, and the structuring of pollinator communities is mainly influenced by pollen and nectar availability, among other factors, although these resources decrease as regeneration proceeds. In contrast, Feinsinger (1978) suggests that in early successional stages occupying disturbed sites, a linear relationship between plant populations and pollinator populations is rare. Thus, both groups are dominantly generalists. In support of this view, Kang and Bawa (2003) suggest that early successional species would flower any time of the year, but species pollinated by diverse pollinators, as well as dioecious species would flower non-randomly across seasons.

Unfortunately, studies on forest regeneration and pollinator population dynamics have been lacking in East Africa although a few studies on seed dispersal along a regeneration gradient have been documented in Kenya and Uganda in tropical rain forests (Lwanga, 2003), but no information exists on pollinator-interactions in regenerating habitats.

1.5 Plant-pollinator interactions in tropical rainforests

Studies on plant-pollinator interactions have enormously contributed to the understanding of co-evolution and gene-flow between plants (Janzen, 1971; Fensinger, 1983; Bawa 1990). Reproduction of the majority of plant species in tropical rain forests is mediated by animal vectors because individual tree species are spatially distributed and self-incompatible (Chan, 1991; Ha *et al.*, 1988). Bawa (1990) suggests that about 98 to 99% of all flowering plants in tropical lowland rain forests are pollinated by animals. The diversity of pollen vectors include insects, flying mammals such as bats, non-flying mammals and birds (Bawa, 1990). Thus, plant-pollinator communities have been recognized as key contributors to biological diversity and are essential to the maintenance of ecosystem functioning. Other agents of pollination include wind and water, though the former plays a very insignificant role in tropical forests compared to the later (Bawa and Crisp, 1980). A great diversity of pollination mechanisms and breeding systems and co-evolutions between plants and animals have been well documented in the neotropics (Bawa, 1990; Bawa *et al.*, 1985) but very little is known from Africa.

However, the diversity of pollination systems has been found to be highest in the understory community (Bawa *et al.*, 1985). Unfortunately, plant-pollinator interactions are currently under threats from habitat alteration and fragmentation, logging, invasion of alien species, genetically modified species, and intensive use of chemicals (Buchmann and Nabhan, 1996;

Richards, 2001). Further studies have also shown that populations of many native plants and their pollinators are being diminished and lost due to habitat fragmentation, degradation, and loss (Lamont *et al.*, 1993; Kearns and Inouye, 1997). Increased habitat fragmentation and degradation can lead to pollen-limitation due to the reduction in the number of pollinators and, consequently, reduced seed output by 50-60% in rare plants (Jennersten, 1988; Bond, 1995). In addition, habitat disturbance may result to changes in resources diversity (e.g. plants) for pollinators and this effect on pollinators would also influence plants since pollinators are a resource from the plants´ perspective (Diego and Simberloff, 2002). Hence the need to study the contribution of various pollinator groups whose contribution to forest regeneration and to the entire forest biodiversity is poorly understood in many tropical forests, especially in Africa.

1.6 Why insects?

Insects represent more than half of all living species (Strong *et al.*, 1984) and their diversity in species, life forms and their roles in diverse functional groups such as herbivores, pollinators, parasitoids and predators contribute to their importance in terrestrial ecosystems (Lasalle and Gauld, 1993). They are known to facilitate key ecosystem services such as pollination, nutrient recycling, without which terrestrial ecosystems would collapse. Plant-insect interactions such as pollination and seed dispersal benefit the plant populations (Ritchie and Olff, 1999), and may greatly influence the plant community structure especially in herbivory (Steffan-Dewenter, 2002). Furthermore, the vast majority of angiosperms, including agricultural crops are insect pollinated (Kevan, 1999).

Experts have estimated that about 84% of the crops in the European Union are dependent on insect pollination (Williams, 1996; Corbet *et al.*, 1991), and almost 25% of tropical crops depend mostly on stingless bees for pollination (Heard, 1999). Insect groups such as moths, flies, wasps, bees, beetles, butterflies and other invertebrates are critically important for ensuring effective pollination of both cultivated and wild plants (Free, 1993; Roubik, 1995; Buchmann, 1996). Most vegetables, nuts and legumes are insect-pollinated; without them many foods would not be available. Examples of such food plants in the tropics include cucumber, coconut, mango, pawpaw and oil palm. There are, however, other crops that have self-fertile flowers, which are capable of setting seeds without the help of pollen vectors, but floral visits by pollinators improve both the quality and quantity of their seeds or fruits. Examples are cotton, soya, and tomato (Richards, 2001).

Despite the contribution of insects to the well-being of man and biodiversity conservation, their populations are dwindling, mostly due to the prevailing anthropogenic factors. Loss of safe habitats (Richards, 2001) and corridors (Joshua, *et al.*, 2002) for pollinators have been found to be the main threats to pollinators in fragmented landscapes. Corridors facilitate the movement of animals such as pollinators and frugivores. For feeding, roosting and nesting, the same animals require a diversity of habitats which, unfortunately, are disappearing steadily. Due to the increased disruption of habitats in both temperate (Kearns *et al.*, 1998) and tropical landscapes (Vinson *et al.*, 1993) experts have expressed fears on local extinctions of native pollinators, the most vulnerable being bees, especially solitary bees (Westerkamp and Gottsberger, 2000).

1.7 Why bees?

Pollinators have been found declining worldwide (Allen-Wardell *et al.*, 1998). Among the pollinator groups, bees have been considered a priority group (Sao Paulo Declaration on Pollinators, 1999). Bees are the main pollinators of angiosperms (Roubik, 1989; Bawa, 1990; Nabhan and Buchmann, 1997) and solitary bees constitute 85% of the 25,000 known species of bees. They pollinate nearly 60-70% of flowering plants (Axelrod, 1960) while about 15% of the world´s crops are pollinated by domesticated bees (Honey bees, bumble bees), and 80% by solitary bees and other wildlife (Ingram *et al.*,1996). Recent reports have pointed out that most pollinator populations have declined to levels that cannot sustain their pollination services in both agro-ecosystems and natural habitats. In agro-ecosystems, agricultural intensification has been reported as the key threat to bees, especially wild bees (Kremen *et al.*, 2002; Kremen *et al.*, 2004).

Unfortunately, very little is known about bee biology, ecology as well as their economic value in most parts of Africa. Such data are missing in East Africa where very little knowledge on solitary bees exists. There is, therefore, need for knowledge on the spatial-temporal variations in bee diversity and distribution in space and time, especially in their natural habitats.

1.8 Bee diversity and distribution

Bees have been found to be more speciose and abundant in warm-temperate xeric parts of the world (Michener, 2000). Further reports by Michener (2000) suggest that the richest areas in bees include the Mediteranean Basin, Central Asia, Madrean region of North America, desertic regions of the southwestern United States of America, and northern Mexico. Other areas with high diversity of bees include Central Chile, Australia, and western parts of South Africa. Whereas the fore-mentioned bee zones have been identified as the most rich worldwide, there is a lot to be desired because the current data was based on existing collections then and so much data could be missing in poorly collected areas. In support of this view, Michener (2000) argues that African tropics could be richer than oriental tropics but lack appropriate data to prove it.

Data on bee diversity in many countries of Africa remain largely unknown. Only a few countries such as South Africa have data on the diversity of bees in major biomes such as Karoo. A recent report by Eardley (2002) shows that there are about 129 genera in sub-Saharan Africa and an estimate of 3000 species. There is not only lack of comprehensive data but also scarcity of bee specialists from different regions of Africa. Thus, pollination studies have been hampered in several countries of Africa, especially in East Africa, and this makes conservation and utilization of wild bees a big challenge. However, a few studies have been recently documented on bee diversity in natural habitats (Gikungu, 2002; Martins, 2004) and on some cultivated crops and wild crops (Njoroge, 2004; Morimoto *et al.*, 2004). The need to document the diversity and abundance of bee fauna in both agro-ecosystems and natural habitats of Kenya is therefore urgent.

1.9 Research questions

There was no comprehensive inventory, diversity and spatial-temporal variation data in bee species composition and density in different successional stages of Kakamega Forest. This was the first community study on bee fauna in the forest. The following are the research questions that this study endeavoured to unveil:

- Which species of bees are found in Kakamega forest?
- Which are the major food plants for different bee species?
- How does the seasonal variability in bee-plants influence bee food choices?
- How does variation in forest successional stages affect bee diversity?
- Which are the most preferred successional habitats by bees in the forest?
- What are the peak seasons of bees in Western Kenya?

1.10 Research hypothesis

1. Secondary forests are richer in bee species composition than mature forests.
2. The degree of generalization in bee-plant interactions decreases with forest maturity.

3. Sites closely similar in age and vegetation structure have similar bee species composition.
4. Eusocial bees show a higher degree of generalization as compared to solitary bees.

1.11 Specific objectives

1. To determine the bee species composition along a forest maturity gradient within Kakamega forest.
2. To investigate the floral utilization and resource partitioning among eusocial and solitary bees.
3. To investigate the influence of forest maturity on bee diversity and abundance.
4. To investigate the degree of generalization and connectance along a forest maturity gradient.
5. To establish a checklist of bees and their corresponding bee plants.
6. To document the bee flora along a forest maturity gradient within Kakamega forest.

1.12 Selection of study sites

Data on bee-plant interaction was collected using both qualitative and quantitative techniques. The different successional stages or strata were first identified for both qualitative and quantitative sampling of bees and their corresponding food plants. Random transects were then established within the selected strata which included grassland, bushland, secondary forests, mature forest, and riparian zones. Secondly, more detailed quantitative data was recorded in the northern part of the Forest, Buyangu Nature Reserve (BNR). This was the best forest because it had been under the protection of Kenya Wildlife Service (KWS), and had a range of successional habitats that fitted to the objectives of the study. In order to avoid compounding problems, seven sites were randomly selected in BNR and in each four permanent sub-plots established for the monitoring of bees and plants. In addition, replication of data at a spatial and temporal scale was carried out in each sub-plot along belt transects in each month for a period of two years.

1.13 The study area

1.13.1 Why Kakamega Forest?

Kakamega Forest, in Kenya, is the only remnant of the Guino-Congolian rain forest belt of Africa. It is located between latitudes 00^0 08′ 30.5″ N (41 236 in UTM 36 N) and 00^0 22′

12.5″ N (15 984) and longitudes 34^0 46′ 08.0″ E (696 777) and 34^0 57′ 26.5″ E (717 761) and an altitude of about 1500 to 1700 m (Fig 1.1). Kakamega Forest is also known to hold a transitional position between the lowland forests of Congo and Afro-montane forests of the western Rift Valley (Althof, 2005). Due to its high species richness in both flora and fauna, and habitat rarity, the International Union of Conservation of Nature (IUCN) ranked it as the highest priority for conservation among forests in Kenya in 1995. The original area of the forest as gazetted in 1933 was 23,777 ha (Kokwaro, 1988). According to recent reports, the main forest covers an area of 10, 000 ha of closed canopy and 2000 ha of other forests (Wass, 1995, Althof, 2005). Unfortunately, Kakamega forest has been fragmented by anthropogenic disturbances (Mitchell, 2004). It was the main source of fuel during the construction of Mombasa-Kisumu railway (Kokwaro, 1988).

Other human factors that led to fragmentation of the forest include creation of small farms in the forest, the so-called *shamba* system and tea plantations, gold mining in the 1920s as well as both legal and illegal harvesting by the timber industry. To date, human factors continue to exert pressure on the forest because it is located in one of the most densely populated agricultural area in the world, with at least 600 people per square km (Blackett, 1994) with a growth rate of 2.8% (KIFCON, 1994). (Plate1.1). A recent report suggests that more than 50% of the forest has been lost in the last 25 years and the forest is currently fragmented into islands of indigenous growth separated by clear cuts and forest plantations. There are five forest fragments namely Malava, Kisere, Kaimosi, Yala and Ikuywa as indicated in (Fig1.1). Detailed analyses on the history and anthropogenic disturbances in each fragment are given by Mitchell (2004). In addition, a recent vegetation description has been published by Althof (2005).

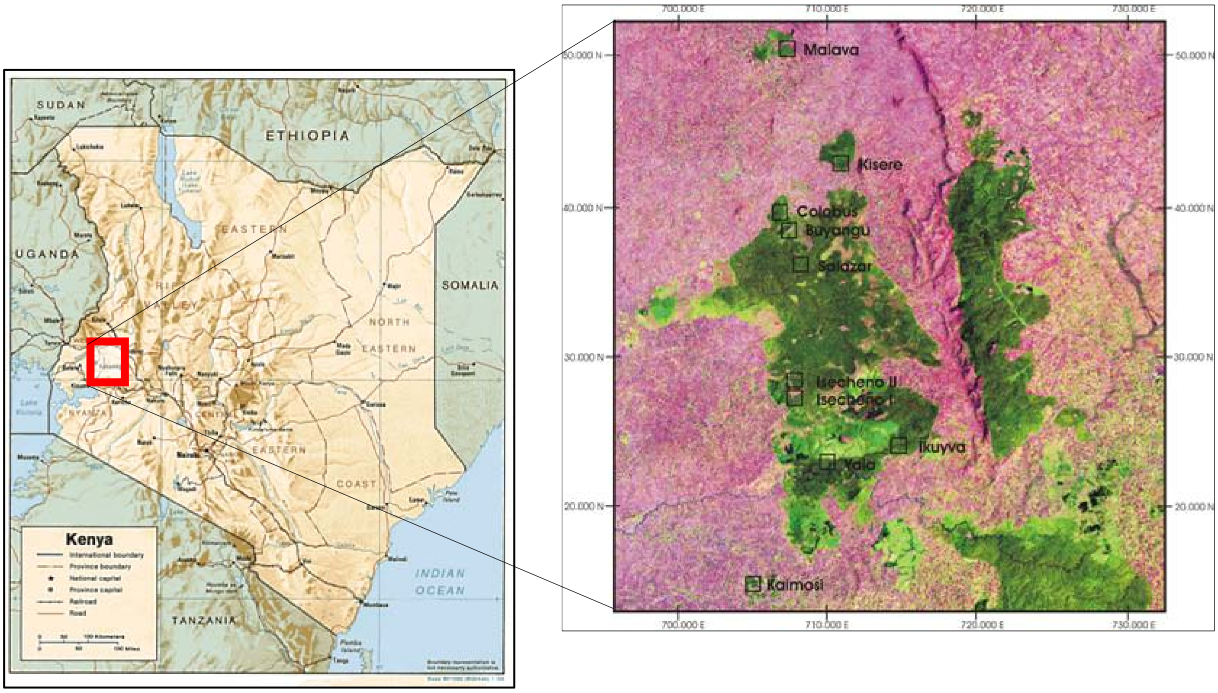


Fig. 1.1 A map of Kenya showing the location of Kakamega forest and its fragments.

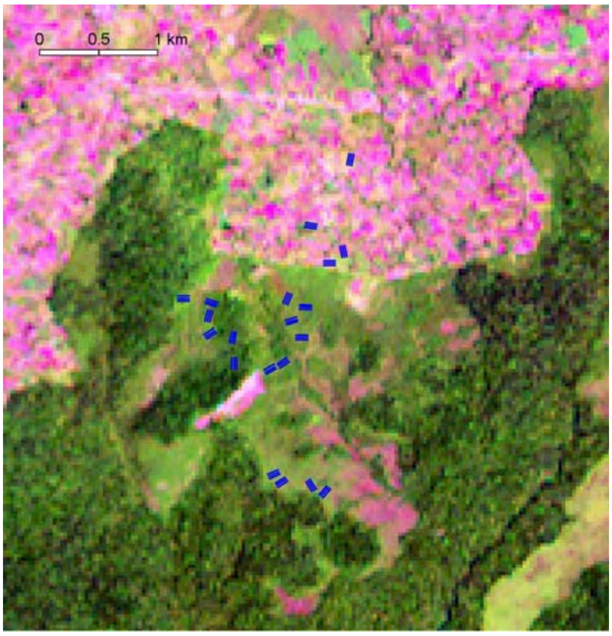


Fig. 1.2 A map of the study area showing the plots and transects established during the study in the northern part of the forest, Buyangu forest.

Plate 1.1 Kakamega Forest and the surrounding agro-ecosystem landscape structures

1.13.2 Buyangu forest

Buyangu forest reserve occupies an area of 4270 ha (Althof, 2005). It has been under the protection by Kenya Wildlife Service (KWS) since 1982 (Mitchell, 2004) and it is generally characterized by a series of abandoned secondary forests at different stages, including pre-mature and mature forests. Thus, these habitats offered the best grounds for both qualitative and quantitative studies on bee-plant interactions along a regeneration or disturbance gradient. Furthermore, due to its consistent protection by KWS, it has the highest stem density and high proportion of relatively young forest growth of all Kakamega forest plots (Mutangah *et al.*, 1992; Mitchell, 2004).

The history of the secondary forest within Buyangu Nature Reserve is also well documented. For instance, some forests such as Salazar, Buyangu Hill and Isiukhu Falls forests were formerly grasslands. Further reports show that one of the supposedly mature site (Colobus forest) is thought to have been afforested 100 years ago (Mitchell, 2004). The most sought-after tree species in the early days by loggers included *Antiaris toxicaria*, *Celtis mildbraedii*, and *Croton megalocarpus.* It has been reported as the best forest patch with full forest to date. However, major logging activities are reported to have occurred in Colobus forest from early 1940s to 1952. The most harvested tree species during this period included *Olea capensis* and *Prunus africanus* (Mitchell, 2004). In Buyangu Hill forest, logging is reported to have taken place in the mid-1970s (Mitchell, 2004).

1.13.3 Geology

The bedrock belong to the Precambrian and are covered by recent alluvium (White, 1983). The geology of the forest area is made up of acid to basic volcanic lavas with minor tuff and agglomerate bands associated with the intermediate rocks (Mutang'a 1996). The soils of Kakamega are of two types, that is, Nitisols and acrisols (Sombroak et al., 1982; Mutang'a, 1996). Unfortunately, the soil fertility has been found declining due to the increased collection of dead wood and logging by the local community and timber industry commercial loggers.

1.13.4 Climate

The rainfall in Kakamega is bimodal. The highest amount of rainfall is received between April-May (Long Rains season), the second rains season occurs in October-November (Short Rains). About 2000 millimeters of rain is received in a year. Other seasons within the area are a Cold-Dry season which occurs in June-August and a short dry season at around December-February. The mean daily minimum temperature is about 11^{o} C while maximum daily temperature is about 26^{o} C (Althof, 2005).

1.13.5 Forest biodiversity

Kakamega forest is one of the most species rich tropical rain forests in Kenya. Over 380 plant species have been documented in the forest, of which 150 species are woody species, 170 herb species, 60 orchid species and 62 fern species. This forest is also characterized by high faunal and plant diversity (Althof, 2005). About 350 species of birds have been recorded in the forest. The most popular and interesting species of birds include Great Blue Turaco, the Dusky Tit, and the Pygmy King fishers. However, the forest is characterized by low large and small mammals densities following the past and current human disturbances and epidemics such as rinderpest which are suspected to have cleared most large and small mammals around 1920s (Mitchell, 2004). Unfortunately, hunting has continued to decimate the forest primates such as the red-tailed monkey and blue-tailed monkeys for their meat (Mitchell, 2004).

Among the invertebrate community, butterflies, dragonflies, beetles and snails have been well documented. About 400 species of butterflies have been documented in the forest. Unfortunately, only a few invertebrate taxa have been well studied. No data had been documented earlier on bees.

1.13.6 Summary description of sites chosen within Buyangu Nature Reserve

1. Farmland

This was the forest riparian zone characterized by small scale farming. There are two main growing seasons, that is Long Rain and Short Rains although most farmers plant during the Long Rain Seasons. The sizes of farms range from one to eight acres on average (Plate 1.1).The main cash crop grown in the region was sugarcane. The subsistence crops included maize, beans, cassava, groundnuts, traditional vegetables and sweet potatoes.

2. Young *Psidium* forest.

This part of the forest was formerly cleared for sugarcane growing in early 80s and later abandoned in the same decade. The vegetation structure was characterized by 60% open areas. The dominant pioneer tree species included young *Psidium guajava, Maesa lanceolata, Combretum collinum* and *Harungana madagascariensis. Psidium guajava* was introduced from tropical America and its seeds are normally dispersed by the bamboons and monkeys as they feed on the fruits. Other tree species that were found to compete with *Psidium guajava* included *Harungana madagascariensis*. The shrub layer was dominated by *Acanthus pubescens*. Among the herbs grass followed by several trailing species of Asteraceae, Acanthaceae and Rubiaceae were the most dominant e.g. *Aspilia mossambicensis*, *Justicia flava*, *Dyshoriste radicans, Asystacia gangetica* and *Spermacoce princeae*.

3. Early secondary forest.

This part of the forest site once cleared for sugar cane growing in 70s. The canopy cover was single-layered with less than 50 % open areas. It bordered the surrounding settlement areas of the forest and river Isiukhu. The dominant tree species were medium-sized *Harungana madagascariensis, Maesa lanceolata and Psidium guajava.* According to the observed forest regeneration process, *Harungana madagascariensis* competes with *Psidium guajava* in the regeneration process (Musila personal communication). The dominant herb layer included *Desmodium repandum, Desmodium adscendens and* some *Justicia* and *Leucas* species.

4. Moderate secondary forest.

This part of the forest was dominated by forest tree species such as *Bridelia micrantha*, *Prunus africana, Funtumia africana* and *Tremma orientalis*. *Prunus africana* and *Funtumia Africana* are among the climax community species (Mutang'a, 1996; Althof, 2005) The herb layer was dominated by shade loving species such *Desmodium repandum*, *Polia condensata*, and *Afromomum* species. A few forest gaps as a result of wind throw were also evident in this apart of the forest which attracted some invader species such *Solanum mauritianum* and some *Croton* species.

5. Advanced secondary forest.

The dominant forest tree species included climax community species *Antiaris toxicaria and Diospyros abyssinica.* Other common tree species such as *Terminaria brownii*, *Funtumia latifolia* and old *Harungana madagascariensis.* The shrub layer was thin and was characterized by sparsely distributed *Coffea eugeniodes* species. In addition, herb layer was equally thin and the dominant herb included *Desmodium repandum*.

6. Pre-mature secondary forest.

This was a near climax community with high abundance of *Antiaris toxicaria*, *Funtumia africana*, *Diospyros abyssinica* and a few *Heinsenia diervilleoides*. The common tree species in this site included huge and tall trees such as *Albizia grandibractea*, *Ficus su*r, *Ficus exersperate*, *Prunus africana*, *Celtis africana* and *Trelipsium madagascariense*.The shrub layer was characterized by *Heinsenia diervilleoides and Draceana fragrans* . The herb layer was very sparse and was dominated by *Polia condensata*.

7. Mature forest.

This was a multi-layered climax community dominated by some forest huge forest gaps and huge trees. Examples of dominant climax tree species included *Antiaris toxicaria, Prunus africana, Diospyrus abyssinica, Funtumia africana.* In the closed canopy, *Teclea nobilis* was quite common. Other common tree species included *Croton megalocarpus*, *Celtis durandii*, *Markhamia lutea*, *Ficus* species etc. The shrub layer was dominated by *Draceana* species and *Heinsenia diervilleoides*. In the forest gaps, several invader species such as *Solanum mauritianum, Mimulopsis, Hypoestes and Justicia* species were the most common.

CHAPTER ONE

2.0 THE BEE FAUNA OF KAKAMEGA

2.1 Abstract

A list of bee species recorded in Kakamega region is presented, including the common genera found in Kenya and new data. The species richness of its bee fauna was found to be high with about 243 species in 36 genera (92 species and 17 *Apidae*, 72 in 8 of *Megachilidae*, 73 and 9 of *Halictidae*, and 6 and 2 of *Colletidae*). The highest number of bee species was recorded in the Long Rains season followed by the Cold Dry seasons. However, there was no significant variation in the number of bee species sampled in different seasons. The generic composition bee fauna documented in Kakamega forest represents 27.9 % of bee genera found in sub-Saharan Africa and 64 % of bee genera found in Kenya.

2.2 Introduction

There are about 25,000 documented bee species worldwide (O' Toole and Raw, 1991) of which 3000 species are found in sub-Saharan Africa (Eardley, 2002). However recent reports suggest that tropical communities are characterized by moderate to low richness of bees (Roubik, 1992) as compared to those of neotropics, and social bees are numerically abundant bees (Bawa, 1990). The reason for low species richness in the tropics is given by Roubik (1992) where he purports that unpredictability in flowering strongly favours certain bees to win in preemptive competition, and prevents many bees and flowers evolving close mutualisms. In support of this view Michener (1979) observed that there are many species genera and higher groups of bees that live in the middle latitudes than at lower latitudes. Conversely, the floral diversity on which the bees depend upon has been found higher in the lower latitudes than in higher latitudes (Michener, 1979; Roubik, 1992). However, the number of bee genera in neotropics is higher (315) than that of African tropics which is about 175 (Michener, 1979).

Unfortunately, bee diversity in many tropical forests remain poorly documented. Similarly, pollination biology at the community level in tropical forests has been less studied as compared to neotropics (Bawa *et al*., 1995). According to Bawa *et al.* (1985) and Kress and Beach (1994), medium-sized to large bees and small diverse insects are the main pollinators in the canopy while humming birds and euglossine bees are the prevalent in the forest understory of La Selva, Costa Rica (Stiles, 1978; Endress, 1994). Such data are missing in most tropical forests.

Data on community survey have been seldom in many tropical forests e.g. Guineo-Congorean forest in Africa, Coastal forests, and Amazonian Forest in South America (Pinheiro, 2002). A similar scenario is found in East African tropical forests where very little is known about the bee fauna in natural forests despite the current unresolved issue of pollinator decline (Ghazoul, 2005). Furthermore, data on bee diversity in major ecological biomes such as savannahs and tropical rain forests are still poorly documented, yet bee-pollination has been regarded as the main pollination mode in many tropical communities (e.g. Bawa *et al.*, 1985; van Dulmen, 2001). The dominance of flowering plants depends largely on the mutual relationships with insects as pollinators and birds as dispersers; but bees are the major pollinators (Regal, 1977). Recent reports from United States of America clearly show that the value of pollination services by both wild and native bees exceed that of honey production by far (Nabhan, 1996). Such data are missing in Kenya. There is an urgent need to document and conserve the abundance and species diversity of the bees in the natural habitats before they are lost as a result of the prevailing habitat degradation.

Bees are among the most poorly studied insect groups in many ecosystems of East Africa. Perhaps the importance of the native solitary bees has been overshadowed by the popularity of the well known honeybees bees *Apis mellifera* due to their economic gain through honey production. The poor knowledge of bee fauna in East Africa can probably be associated with several factors, such as lack of bee specialists in the past and rich bee collections. The few available bee collections in the local institutions, such as Museums, are therefore incidental collections by either naturalists or ecologists who sampled them occasionally as they studied the targeted insect groups. The earliest bee species collected from Kakamega forest included *Xylocopa* (*Mesotrichia*) *flavorufa* (De Geer, L, 1778) followed by *Xylocopa nigrita* (Fabricius, L, 1804). Other bee collections in Kenya were done by bee specialists, such as Charles Michener in the late 1950s and early 1960s. Unfortunately, no detailed publications are available on the species collected from any of the habitats in Kenya. Questions on whether some species documented from Kakamega forest may have disappeared with time remain unanswered. For instance, according to the available list of bees from National Museums of Kenya, *Dactylurina ?cummingsii* (?*schmidti*) has been found missing. According to a recent stingless bee revision in Africa, there are only two species of the genus *Dactylurina*, that is, *Dactylurina schmidti* and *Dactylurina staudingeri*. These are the only stingless bee species in Africa that make vertical exposed combs, and are geographically separated. *Dactylurina staudingeri* (*Gribodoi*) is found among West African species while *Dactylurina schmidti* is found in East Africa (Eardley, 2004).

It was against this background that this study endeavoured to analyze the status of bee fauna in Kakamega forest in different seasons, as well as generic representation in Kenya in order to pave way for future studies on bee fauna in Kenya. In addition, this study also aimed at analyzing both the present and past records of bees from Kakamega forest in order to unveil their diversity in space and time.

2.3 Materials and methods

In order to establish an estimate of bee species in Kakamega forest, bee surveys were conducted in the main forest including the fragments namely Malava, Kisere, Kaimosi, Yala and Ikuywa as indicated in (Fig1.1). In every site, different strata were identified based on the dominant plant species and vegetation structure on which several belt transects in different sub-plots were located. In addition, seven sites were chosen for studies in the northern part of the forest as described in chapter four. Bees were sampled on monthly basis in each site. Details of the method used and justificaton are as described in the chapter four. Additional data on bees of Kakamega forest was gathered from the available literature and the existing bee collection in the National Museums of Kenya.

2.4 Results

2.4.1 Overall bee diversity in Kakamega forest

Altogether 243 bee species represented in four families (*Apidae, Halictidae*, *Megachilidae* and *Colletidae*) were recorded in the understory community of Kakamega forest and its surrounding open areas. The most speciose bee family was *Apidae*, followed by *Megachilidae* and *Halictidae* (Fig. 2.1). Of these, seven species belonged to the highly eusocial bees. They also represented the most abundant groups on flowers e.g. *Apis mellifera*, *Meliponula bocandei* and *Meliponula lendliana*. The family *Colletidae* was the least diverse and was only represented by a few individuals. The number of bee species collected in Kakamega forest during the study period was found to have attained its asymptote and this indicates that the sampling effort was expended (Fig. 2.2).

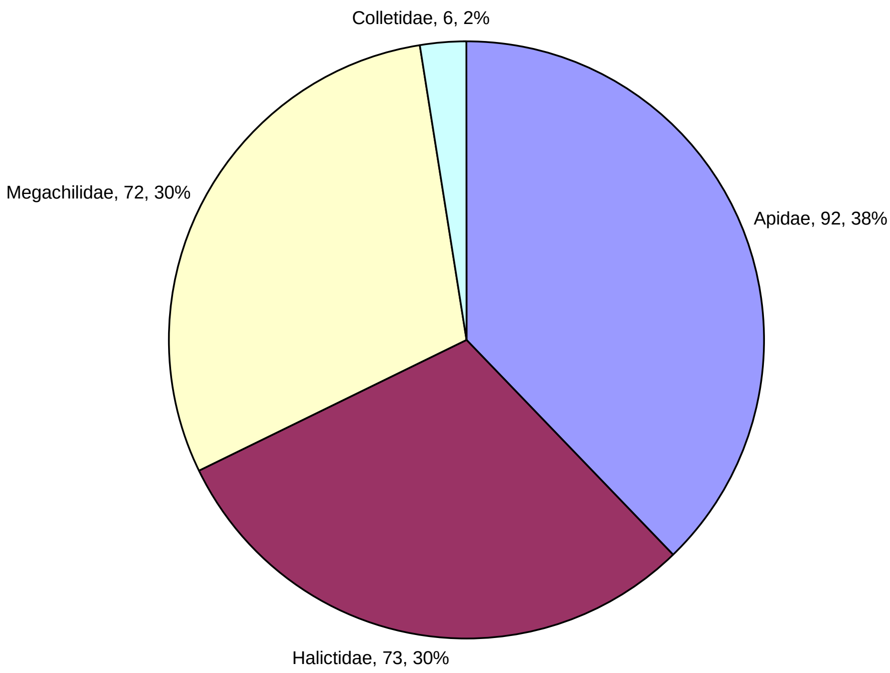


Fig. 2.1 Bee family composition recorded in Kakamega forest and its fragments.

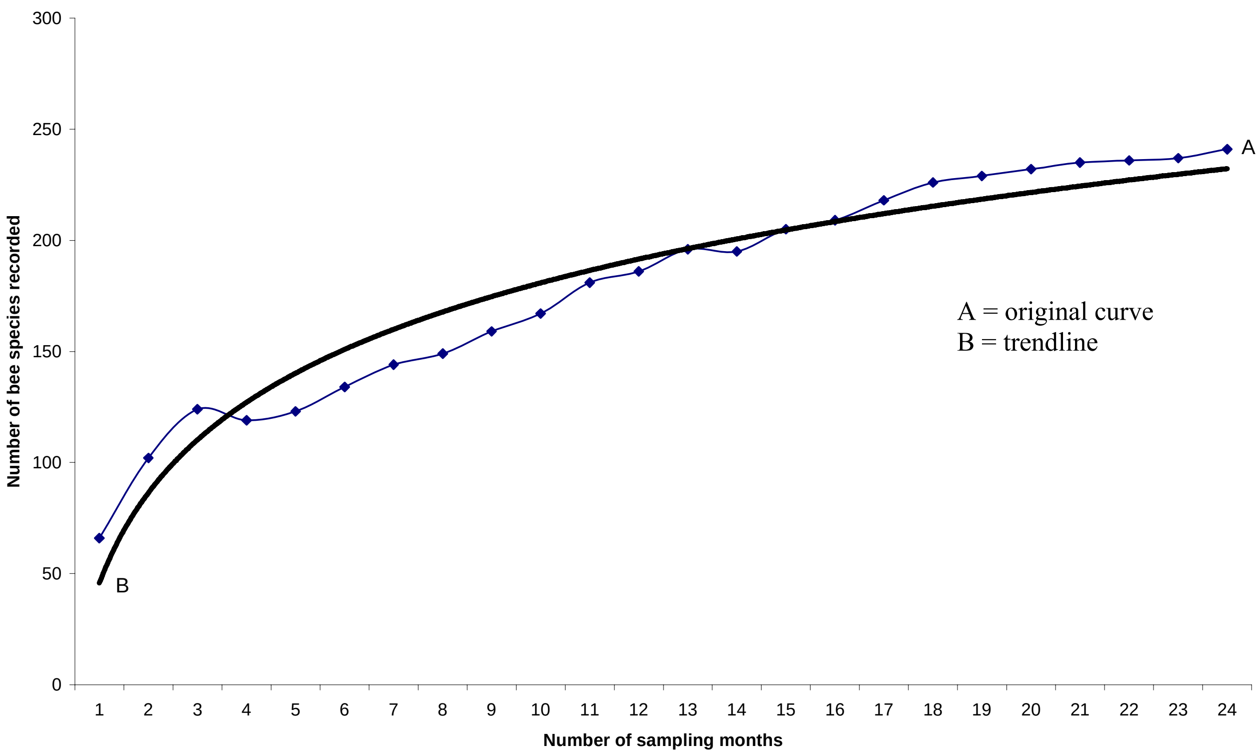


Fig. 2.2 Cumulative number of bee species collected in Kakamega forest for 24 months.

2.4.2 Monthly and seasonal variations of bees

There was no significant monthly variation in bee abundance ($\chi^2 = 11$, df = 11, P < 0.44) and species richness ($\chi^2 = 11$, df = 11, P < 0.44) based on results from 1-way Test and Chi-square Approximation (Fig. 2.3). Similarly, there was no significant variation with bee species richness across the seasons ($\chi^2 = 4$, df = 4, P < 0.40). However, the highest number of bee species (156) was recorded during the Long Rains season (March, April and May) followed by the Cold Dry season (June, July and August) (Fig. 2.4). The relative abundance of different bee families showed no significant difference was found although *Apidae* was more abundant and dominant than others (Fig.2.5). For instance, representatives of the family *Colletidae* occurred only in three seasons, that is, Cold Dry, Dry (December, January, February) and Long Rains season. In addition, some bee species emerged only in particular seasons and the highest number of such species was recorded in Long Rains season followed by Short Rain (October, November) season (Table 2.1). However, in all the four bee families, there was a sharp decrease during the short dry season as compared to other seasons. (Fig.2.4)

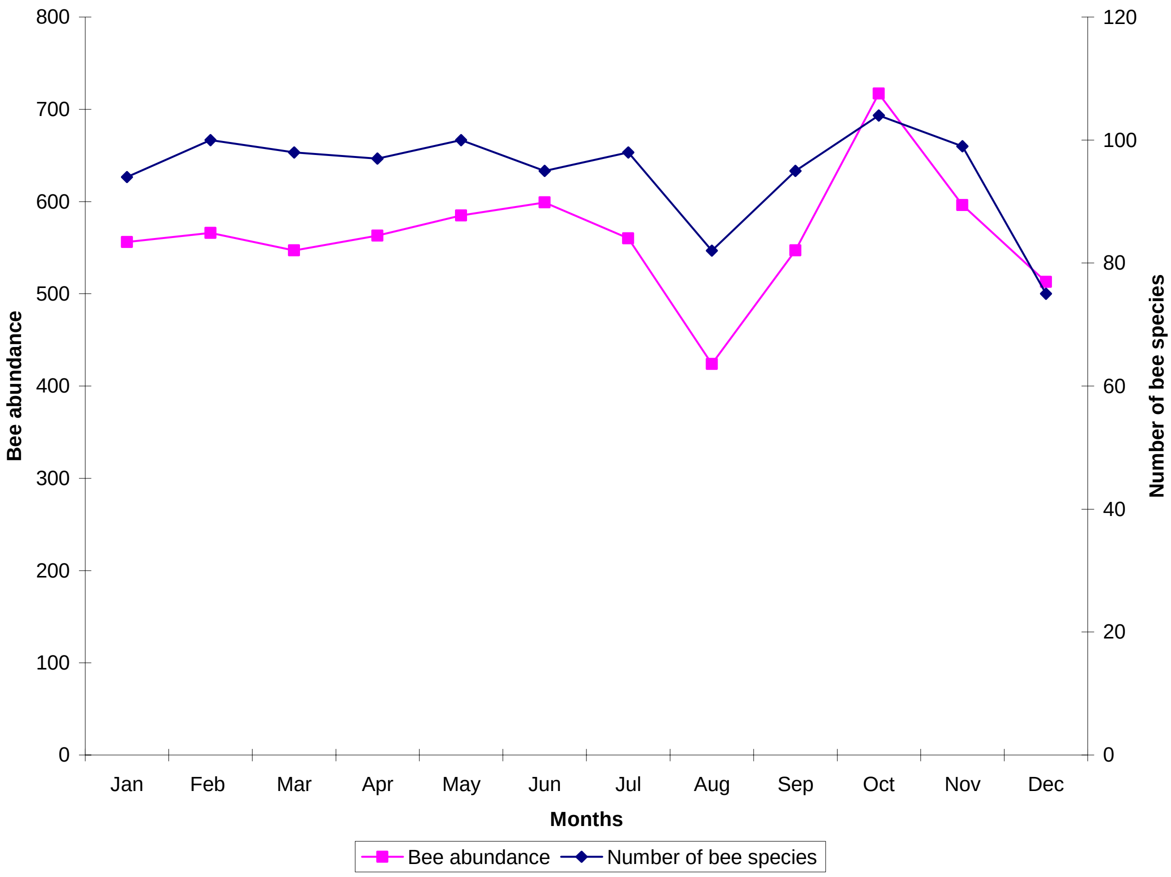


Fig. 2.3. Monthly variation of bee abundance and species richness in Kakamega forest.

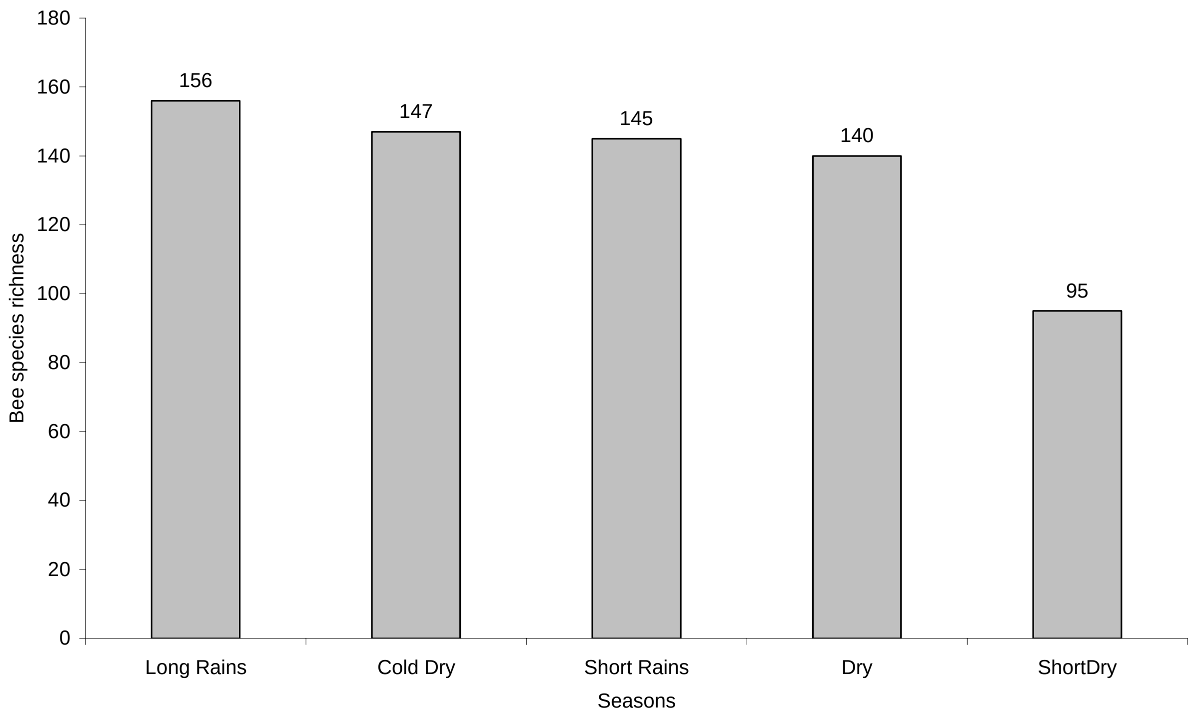


Fig. 2.4. Seasonal variation in bee species richness in Kakamega forest.

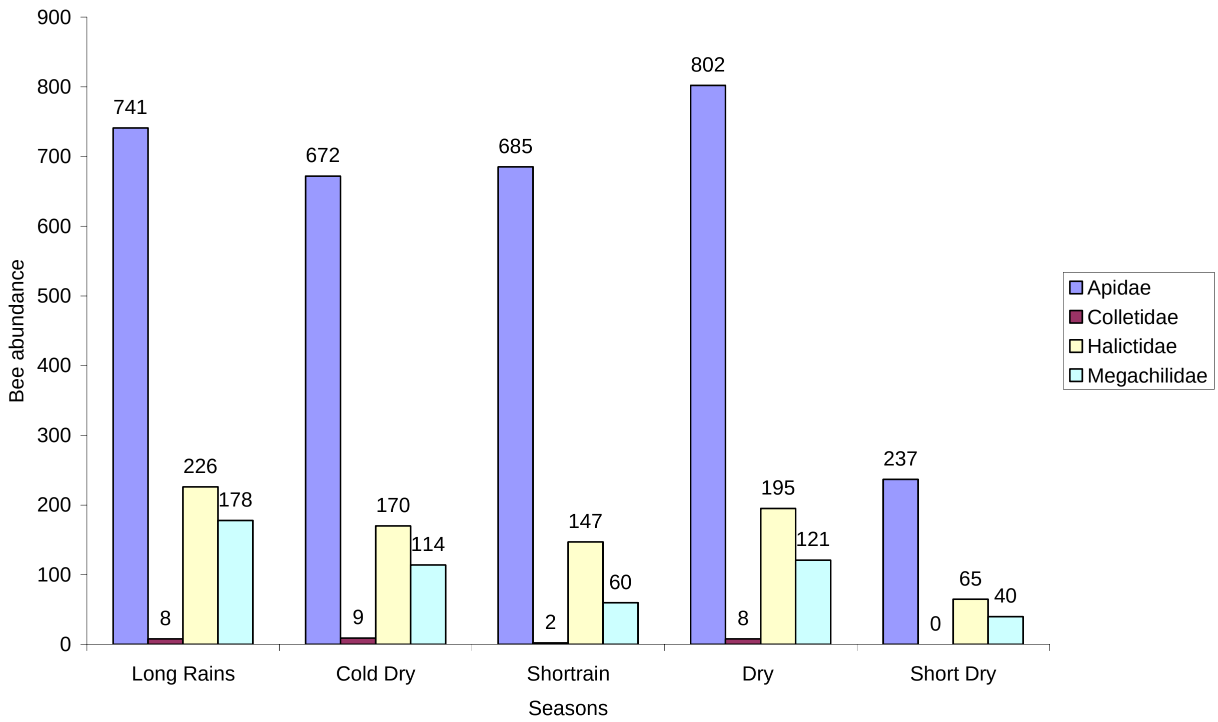


Fig. 2.5. Seasonal variation of bee abundance in different bee families.

Table 2.1. Number of bee species recorded only in particular seasons.

Seasons	No. of bee species	% represented
Dry	7	3%
Cold Dry	7	3%
Short Dry	10	4%
Short Rains	14	6%
Long Rains	20	12%

2.4.3 Comparison of bee genera recorded in Kenya and Kakamega forest

About 56 genera representing 43% of bee genera found in sub-Saharan Africa were documented for Kenya (Fig.2.6). Of these, 64% (36 genera) were documented in Kakamega forest. About 21 genera were categorized as new records for Kenya, and 29 genera as new records for Kakamega forest based on this study. The current number of bees recorded from Kakamega forest was found to be extremely high as compared to the past list of 24 species derived from the past bee collection at the National Museums of Kenya (Table 2.2). The family *Apidae*, followed by *Halictidae* had the highest representation among the new records for Kenya (Table 2.3).

Table 2.2. Past and current bee taxa records in Kakamega forest.

Bee taxa	**Past records**	**Current records**
No. of Bee families	2	4
No. of Bee genera	7	36
No. of Bee species	24	243

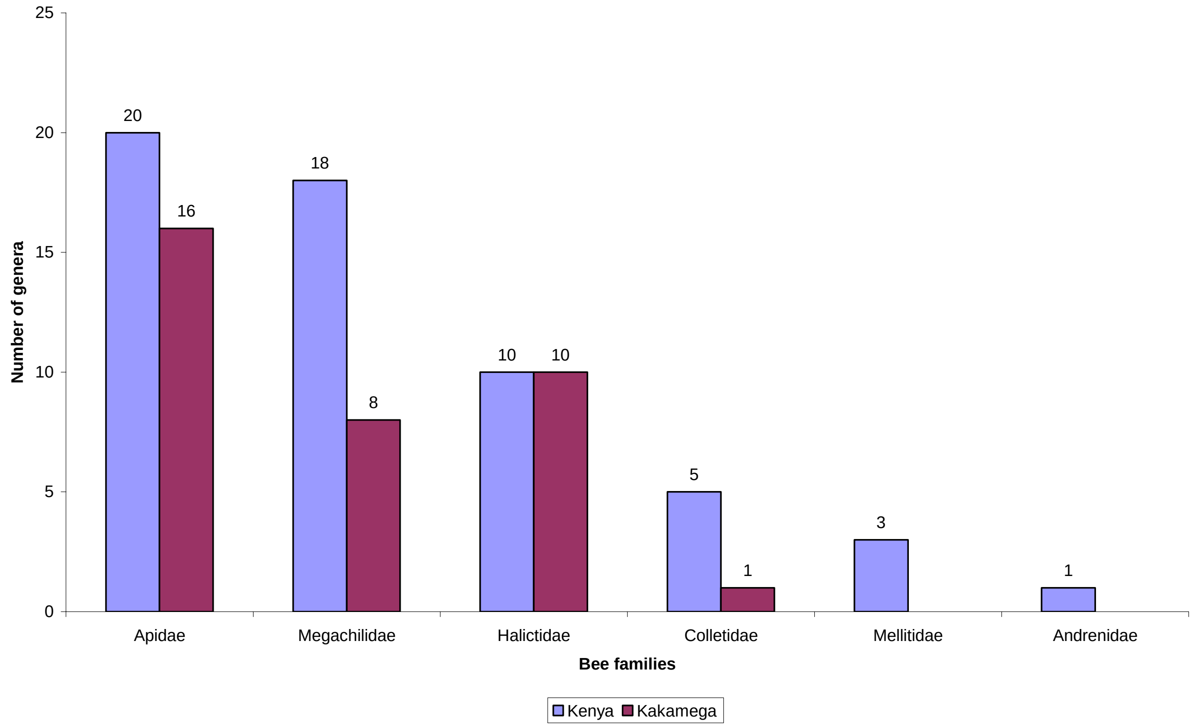


Fig. 2.6. Comparative generic representation of bee genera in different families as documented for Kenya and Kakamega forest.

2.4.4 Rare bee species of Kakamega forest

The bee species composition of Kakamega forest was comprised of 43% of rare species (species with less than 5 individuals). Examples of very rare species include *Amegilla sierra, Xylocopa varipes, Parasites aff humectus, Megachile obtusodentata, Megachile apiformis, Megachile postaigra, Megachile decemsignata, Nomia chandleri, Allodape mirabilis, Megaceratina sculpturata and Colletes* species. Some of the above named species were found only in particular forest fragments or habitats e.g. *Megaceratina sculpturata* was only recorded twice in an advanced secondary forest in while *Amegilla sierra* was recorded once in Ikuywa Forest. In addition, *Megachile obtusodentata* was only recorded in farmland neighbouring Buyangu Nature Reserve.

2.4.5 Records of new species from Kakamega forest

Several new species were documented from Kakamega forest, seven of which have been confirmed. Some description work on one of the new species from genus *Thrinchostoma (Eothrincostoma)* and a key for the genus in Kenya is awaiting publication. Examples of genera with the new species include *Thrinchostoma*, *Tetraloniella*, *Heriades*, *Ctenoplectra*, *Allodape*, *Lipotriches*, *Pseudoanthidium* and *Megachile* (Table 2.2).

Table 2.3. Status of bee genera in Kenya and Kakamega forest.

Bee family	Genus	N. Subgenus	New records(Ke).	New record(KK)	No. of New spp (KK)
Colletidae	Colletes			✔	
	Hylaeus			✔	
	Calloprosopis				
	Alfkenylaeus				
Andrenidae	Meliturgula				
Mellitidae	Samba				
	Meganomia				
	Pseudophilanthus			✔	
Halictidae	Halictus			✔	
	Systropha			✔	
	Lasioglossum	Sellalictus		✔	
	Lipotriches			✔	
	Nomia		✔	✔	
	Patellapis			✔	
	Sphecodes			✔	
	Thrinchostoma	Eothrincostoma	✔	✔	1
	Pseudapis			✔	
	Stegonomus			✔	
Megachilidae	Heriades	Amboheriades	✔	✔	3
		Pachyheriades	✔	✔	
	Hoplitis				
	Othinosmia				
	Pseudoheriades				
	Wainia				
	Afranthidium			✔	
	Anthidiellum				
	Eoanthidium				
	Euapsis			✔	
	Gnathanthidium				
	Icteranthidium				
	Larinostelis				
	Pachyanthidium	Pachyanthidium	✔	✔	
	Pseudoanthidium	Micranthidium	✔	✔	
	Serapista		✔	✔	
	Stelis				
	Coelioxys	Boreocoelioxys	✔		
	Megachile	Creigtoniella	✔		

Table 2.3.. Cont'd.

Bee family	Genus	N. Subgenus	New records(Ke).	New record(KK)	No. of New spp (KK)
Apidae	Xylocopa				
	Ceratina	Pithitis		✓	
	Allodape		✓	✓	1
	Braunsapis		✓	✓	
	Macrogalea				
	Parasites		✓	✓	
	Ctenoplectra		✓	✓	1
	Ctenoplectrina		✓	✓	
	Tetraloniella		✓	✓	1
	Amigella				
	Anthophora			✓	
	Afromelecta				
	Thyreus				
	Cleptotrigona				
	Dactylurina				
	Hypotrigona			✓	
	Liotrigona			✓	
	Meliponula			✓	
	Pleibena				
	Apis				

Key

Ke: Kenya, **KK**: Kakamega forest, **N**: new, ✓ **:** Present

Table 2.4. A checklist of bees from Kakamega forest.

Bee Family	**Bee species**
Apidae	
	Allodape ?chapini
	Allodape ?interrupta
	Allodape ?mirabilis
	Allodape derufata
	Allodape interruptus
	Allodape macula
	Allodape sp 1
	Allodope n. sp
	Amegilla (Aframegilla sp. 1)
	Amegilla (Megamegilla sp 1)
	Amegilla ?caelestina
	Amegilla ?cymatilis
	Amegilla acraensis
	Amegilla aff langi
	Amegilla capensis
	Amegilla fallax
	Amegilla mimadvena
	Amegilla sierra
	Amegilla sp 1

Anthophora (Heliophila aff. vestita)
Apis mellifera
Braunsapis sp
Braunsapis aff luapulana
Braunsapis angolensis
Braunsapis facialis
Braunsapis foveata
Braunsapis gorillanum
Braunsapis leptozonia
Braunsapis sp. 1
Ceratina ?eitriphila
Ceratina ?moerenhonti
Ceratina ?viridis
Ceratina ericia
Ceratina moerenhonti
Ceratina penicillata
Ceratina sp 1
Ceratina sp 2
Ceratina sp 3
Ceratina sp 4
Ceratina sp 5
Ceratina sp 6
Ceratina sp 7
Ceratina sp 8
Ceratina sp 9
Ceratina viridis
Creigtoniella ithanoptera
Ctenoplectra sp 1
Ctenoplectra ?n sp
Ctenoplectra antinorii
Ctenoplectra sp 1
Ctenoplectra sp 2
Ctenoplectra sp 3
Ctenoplectra sp 4
Ctenoplectra sp 5
Ctenoplectra terminalis
Ctenoplectrina ?politula
Halictus (Seladonia sp 2)
Heriades n sp 1
Hypotrigona gribodoi
Liotrigona bottegoi
Meliponula ?denoiti
Meliponula bocandei
Meliponula erthyra
Meliponula lendliana
Pasites ? humectus
Tetraloniella katagensis

	Tetraloniella n. sp. 2
	Tetraloniella sp 1
	Tetraloniella sp 3
	Thyreus ?axillaris
	Thyreus calceatus
	Thyreus interruptus
	Thyreus pictus
	Thyreus sp 1
	Thyreus sp 2
	Xylocopa (koptortotosoma sp 1)
	Xylocopa (Xylomellisa sp 1)
	Xylocopa (Xylomellisa sp 2)
	Xylocopa ?albifrons
	Xylocopa ?calens
	Xylocopa ?hottentota
	Xylocopa ?senior
	Xylocopa aff albifrons
	Xylocopa aff sicheli
	Xylocopa calens
	Xylocopa erythrina
	Xylocopa flavicollis
	Xylocopa flavorufa
	Xylocopa hottentota
	Xylocopa imitator
	Xylocopa incostans
	Xylocopa nigrita
	Xylocopa torrida
	Xylocopa varipes
Colletidae	Colletes sp 1
	Colletes sp 2
	Hylaeus (Deranchylaeus sp)
	Hylaeus sp 1
	Hyleus sp
	Hyleus sp 2
Halictidae	Halictus (Seladonia sp 1)
	Halictus (Seladonia sp 2)
	Halictus sp
	Lasioglossum (Sellalictus sp. 5)
	Lasioglossum (Ctenonomia sp 1)
	Lasioglossum (Ctenonomia sp 2)
	Lasioglossum (Dialictus sp 1)
	Lasioglossum (Ipomalictus sp 1)
	Lasioglossum (Ipomalictus sp 2)
	Lasioglossum (Ipomalictus sp 3)
	Lasioglossum (Rubrihalictus sp 1)

Lasioglossum (Rubrihalictus sp. 2)
Lasioglossum (Sellalictus sp 1)
Lasioglossum (Sellalictus sp 2)
Lasioglossum (Sellalictus sp 3)
Lasioglossum (Sellalictus sp 4)
Lasioglossum (Sellalictus sp 5)
Lasioglossum sp
Lasioglossum sp 1
Lasioglossum sp 2
Lasioglossum sp 5
Lasioglossum sp 6
Lasioglossum sp 7
Lipotiches sp
Lipotriches (Lipotriches sp 1)
Lipotriches (Nebenomia sp)
Lipotriches (Trinomia sp 1)
Lipotriches (Trinomia sp 2)
Lipotriches aff aurifrons
Lipotriches aff panganina
Lipotriches aff welwitschi
Lipotriches orientalis
Lipotriches sp 1
Lipotriches sp 2
Lipotriches sp 3
Lipotriches sp 4
Lipotriches tridentata
Nomia (Leuconomia sp 1)
Nomia (Leuconomia sp 2)
Nomia (Leuconomia sp 3)
Nomia (Leuconomia sp 4)
Nomia aff hylaeoides
Nomia aff panganina
Nomia chandleri
Nomia orientalis
Nomia sp 1
Nomia theryi
Nomia tshindica
Nomia viridiciacta
Patellapis (Homalictus sp. 1)
Patellapis (Zonalictus sp 1)
Patellapis (Zonalictus sp 2)
Patellapis (Zonalictus sp 3)
Patellapis (Zonalictus sp 4)
Patellapis (Zonalictus sp 5)
Patellapis (Zonalictus sp 6)
Patellapis (Zonalictus sp 7)
Patellapis sp 9

	Patellapis sp. 7
	Pseudapis (Pseudapis gr anthidiodes)
	Pseudapis ?sp 1
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudapis sp. 1
	Pseudapis sp. 2
	Steganomus sp
	Steganomus sp 1
	Systropha sp
	Thrinchostoma (Eothrinchostoma n sp.)
	Thrinchostoma telekii
	Thrinchostoma torridum
	Thrinchostoma wissmani
Megachilidae	Afranthidium sjoestdi
	Coelioxys (Boreocoelioxys sp)
	Coelioxys aff. affra
	Coelioxys odin
	Coelioxys sp 1
	Coelioxys sp 2
	Coelioxys sp 3
	Coelioxys verticalis
	Coelioyxs sp 1
	Creigtoniella ithanoptera
	Euaspis abdominalis
	Euaspis erythros
	Heriades (? Amboheriades n. sp. 1)
	Heriades (Amboheriades n. sp 1)
	Heriades (Pachyheriades sp 1)
	Heriades ?retifer (n sp)
	Heriades ?sulcatulus
	Heriades retifer (n.sp)
	Heriades sp 101
	Heriades sp. 1
	Heriades sulcatulus
	Megaceratina sculpturata
	Megachile ?semivenusta
	Megachile (Eutricharacea sp)
	Megachile (Paracella sp 1)
	Megachile ?dariensis
	Megachile ?fulvitarsis
	Megachile ?gratiosa
	Megachile ?mitimia
	Megachile ?montibia
	Megachile ?niveicaula
	Megachile ?polychroma

Megachile ?semierma
Megachile ?semivenusta
Megachile aff rufipes
Megachile apiformis
Megachile basalis
Megachile bituberculata
Megachile ciacta combusta
Megachile crakokensis
Megachile dariensis
Megachile decemsignata
Megachile felina
Megachile fulvitaris
Megachile gratiosa
Megachile maxillosa
Megachile mitimia
Megachile montibia
Megachile obtusodentata
Megachile polychroma
Megachile postaigra
Megachile pyrrhithorax
Megachile rufipennis
Megachile rufipes
Megachile rufiventris
Megachile semierma
Megachile semivenusta
Megachile sinuata bokanica
Megachile sp 1
Megachile sp 2
Megachile sp 3
Megachile sp 4
Megachile sp 5
Megachile sp 6
Megachile torridum
Pachyanthidium (Pachyanthidium sp 1)
Pachyanthidium (Pachyanthidium sp 2)
Pachyanthidium aff bengualense
Pachyanthidium sp. 1
Pseudoanthidium (Micranthidium n. sp. 3)
Pseudoanthidium lanificum
Pseudoanthidium truncatum
Serapista denticulata

2.5 Discussion

2.5.1 Bee species richness in Kakamega forest

Although no comparative data on bee diversity in African tropical rain forests are available, results from this study suggest that Kakamega forest is highly rich in bees. This could be attributed to its geographic location, since it occupies a transitional position between the lowland and Afromontane forests of East Africa. Thus its bee species richness represents species from the two positions as well as those that are found in between. In support of this view, all the species documented in Mt Kenya forest have been recorded (Gikungu, 2002). Bee species richness was, found to be extremely low in Mt. Kenya forest as compared to Kakamega forest; only less than 50 species were documented in Mt. Kenya forest (Gikungu, 2002). In addition, Kakamega forest is characterized by a high diversity of plant species (Althof, 2005) which the bees depend on for floral resources. However, the data presented in this chapter may not be a true indication of the bee records in Kakamega forest. This is because of the well-known taxonomic impediment in bee taxonomy in many continents of the world, including Africa. Furthermore, some bee species recorded in the past, such as *Dactylurina schmidti* (?*cummingsii*) were not documented in the current study; it is suspected that they may have disappeared. The cause of their disappearance remains unknown. However, Roubik (2001) suggests that to detect a decline in pollinators, a minimum of three years is required. The current survey was conducted for two years only. In addition, it could also imply that both foraging and nesting height fidelity (Levin and Kerster, 1973) as well as sampling methods may have limited the capturing of such species. Nevertheless, further monitoring surveys are required in order to ascertain what may have become of such species.

2.5.2 Current challenges in bee studies in Kenya

The shortage of bee taxonomists in East Africa has enormously affected the study of bees in the region. Over the years there has been only one active bee taxonomist in Africa (API Plan of Action, 2003). A recent report from Eardley (2002) indicates that out of 129 genera of bees in sub-Saharan Africa, only 19% are currently being revised. It is also notable that the existing bee collections are few and small and are not true representatives of bee fauna in the region. Lack of adequate bee surveys have also led to poor knowledge of bees in Kenya. In addition, most of the bee collections in East African museums and institutions are characterized by mis-identified or un-updated taxonomic identities, thus making comparative studies very difficult. During the current study, it was difficult to compare the past records of bees from Kakamega forest due to the above-mentioned challenges. For instance, some generic names in the

Megachilidae, such as *Chalicodoma* are no longer in use, and have been replaced by genus *Megachile.* The genus *Chalicodoma* is presently one of the sub-genera in genus *Megachile* (Michener, 2000). In addition, some bee families such as *Anthophoridae* have also been replaced by family *Apidae* (Michener, 2000). Nevertheless, with the help of other bee experts in different regions of the world, the investigator has established a checklist of the bee taxa found in Kenya, as well as Kakamega forest as represented below.

2.5.3 Management implications and bee conservation in Kenya

There is a wide knowledge gap in regard to the importance of tropical forests in conservation of pollination service. A lot has been said and appreciated about the indirect values of tropical forests such as catchment areas and carbon sequestration, but their role as a pollinator reservoir remains poorly documented, especially in the developing countries. Kakamega forest falls under the poorly studied forests of Africa in regard to bee fauna, but this pioneer study suggests that it could be one of the richest forests in East Africa (and maybe in Africa). The current bee data will form baseline data for further research studies on bee populations in Kenya and particularly in Kakamega forest.

It is evident that a lot of gaps exist and that there is need for increased knowledge on bee foraging ranges as well as their preferred nesting sites, among others. It is not yet known whether the majority of the documented species in Kakamega have ``safe´´ sites for nesting and foraging. Disappearance of such sites has been found to be a major threat to bees in both temperate (Kearns *et al.*, 1998) and tropical countries (Vinson *et al.*, 1993), and the solitary bees will be the most threatened (Westerkamp and Gottsberger, 2000). Increased knowledge in nesting biology, as well as their foraging ranges would provide insights on conservation of particular bee habitats, especially for the rare ones in fragmented habitats. In addition, policy makers and conservationists need to be enlightened on the endangered and rare species in order to make wise management and restoration options and strategies.

Knowledge on individual species and their mutualistic relationships with plants increases our understanding on the maintenance and conservation of pollination service. Impoverished habitats have been associated with low biodiversity, as well as increased low seed set (Richards, 2001). This study endeavoured to analyze further detailed bee-plant interactions in order to provide some insights on the conservation of threatened and vulnerable bee species and their food sources in the study area. (See details in the next chapter).

CHAPTER TWO

3.0 FLORAL UTILIZATION AND RESOURCE PARTITIONING BY WILD BEES IN KAKAMEGA FOREST

3.1 Abstract

Data on plant-pollinator interactions are seldom found in East Africa. The current study endeavoured to analyze the diversity of native bees and their interactions with plants in Kakamega forest and its fragments. Data on flower-visiting bees as well as their host plants were collected on monthly basis for a period of two years, May 2002 to April 2004. About 189 plant species were found interacting with 243 bee species documented during the study. Lists of bee-plant interactions (and vice-versa) as well as and their monthly occurrence, are presented in this chapter. The most important plant families to the majority of bee species included *Acanthaceae, Asteraceae, Papilionaceae, Lamiaceae* and *Solanaceae*. A high degree of resource sharing was observed between the highly eusocial and the dominant solitary bee species, although the eusocial species were the most abundant e.g. *Apis mellifera* and *Meliponula bocandei*.

3.2 Introduction

Worldwide, there is a great concern to protect plants and their pollinators in both natural and agricultural landscape structures (Lassale & Gauld, 1993; Buchmann & Nabhan, 1996). Predictions by IUCN suggest that 20,000 flowering plants and their co-dependent pollinators will be lost within the next few decades (Heywood, 1995). There is therefore need to increase the understanding of plant-pollinator interactions and reproductive biology of forest plants; this is a basic requirement for forest management (Bawa, 1990). Restoration of degraded habitats is dependent on maintenance and re-establishment of pollinator communities (Thorp, 1990). Pollinators ensure that there is a continuous exchange of genetic materials between plant populations (Levin, 1978; Schmidt, 1983) and production of viable seeds for forest regeneration and food for frugivores (bats, birds, primates, and rodents).

Among the pollinator groups, insects pollinate the vast majority of angiosperms in tropical rain forests, while bees are the major pollinators of plants (Bawa, 1990). They pollinate nearly 60-70 % of 250,000 flowering plant species. About 40,000 plant species are considered as food sources for honey bees whereas 4000 species are sources of honey production (Crane, 1990; Axelrod, 1960).

A co-evolution of bees and plants emerged as early as the cretaceous period when the flowering plants evolved (Velthuis, 1992). Thus, bees are keystone mutualists as they contribute significantly to maintenance of floral diversity of flowering plants (Lasalle and Gauld, 1993). Unfortunately for several countries in Africa, the only available literature on bee-plant interactions is only on *Apis mellifera* Linnaeus (Hepburn and Radloff, 1998). It is instructive to note that, to many people, the word ``bee`` is always associated with the honeybee *Apis mellifera* Linnaeus. Thus, the diversity and contribution of solitary bees to the functioning of the ecosystem functioning as well as their interactions with plants are still very poorly known. Knowledge on resource partitioning and competition between the highly eusocial and solitary bees remains poorly documented in the tropics. O´ Toole *et al.* (2002) emphasis the need to conserve the solitary bees, for they are endangered by anthropogenic factors more than ever. Similar observations have been made by other studies (Kevan *et al.*, 1990; Buchmann and Nabhan, 1996).

According to the available literature, eusocial bees are much more generalized than solitary bees (Heithaus, 1979; Biesmeijer, 2004). Thus eusocial bees have larger niche breadths than solitary bees and this makes specialists to be more endangered than generalists (Diego and Simberloff, 2003). The presence of resources in a given habitat have been found to determine the animal composition and structure among other factors (Richard, 2001). It is therefore important to evaluate an animal's diet in its habitat in order to be aware of its nutritional needs and its interaction with other animals. Measures of niche breadth, width or niche size are commonly used by ecologists to measure resources quantitatively (Krebs, 1996).

Niche breadth has been found to influence the patterns of diversity among communities. However, in plant-pollinator interaction studies, data of the number of plant species supporting a particular group of pollinators is not sufficient without the consideration of the frequency of visitors and proportions used by a given species. In many occasions, only a few plant species are important to flower visitors in a particular season and some bee species may switch to other plants in the proceeding seasons. Thus, measures of niche breadth are better indications of the proportion of the resource (plant species) used by each species. In addition, it is very important to quantify the degree to which two species overlap in their utilization of resources (space, food, habitats etc). Several measures of niche overlap have been proposed (e.g. Hurlbert, 1978; Manly, 1990; Liebold, 1995). Niche overlap measures proportion of the resource used by each species that it shares with other species. Petraits (1979) suggests that the overlap of niches is one possible determinant of the structure and diversity of communities.

Data on bee-plant interactions in Kenya have also been missing. Conservation of native flora cannot be complete without the knowledge of spatio-temporal variation of local bee assembly and their interactions with flowering plants. The aim of this study was therefore to analyze interactions of bees and flowers and to interpret the trophic relationships of most common eusocial and solitary bee species in the understory community of Kakamega forest.

3.3 Materials and Methods

3.3.1 Bee and Plant sampling

Flower-visiting bees were collected monthly from May 2002 through April 2004. Bees were randomly collected on flowers along belt transects using sweep nets in different fragments of Kakamega forest (Kisere, Malava, Yala, Ikuywa and Kaimosi). To avoid over-representation of particular bee species on plants, a maximum of 50 individual bees was collected from each plant per sampling. Where plant identification was not possible in the field, plants were assigned codes and were later identified by specialists at the Herbarium of the National Museums of Kenya. In addition, samples of foraging bees were collected and put together with flower cuttings in one vial for proper documentation of bee-plant interactions in the laboratory. Bees were then pinned for further identification at the National Museums of Kenya.

3.3.2 Ecological indices

(i)Trophic niche breadth

Trophic niche breadth (NB) of a bee species was calculated as the Shannon index (Pielou, 1969). This method was considered the best because it incorporates both the number of resources utilized by the animals as well as the frequency of use (Wolfgang *et al.*, 1996). Thus NB was calculated as:

$$NBi = \frac{- \sum P_{ik} \text{ x } elP_{ik}}{k}$$

where i = a particular bee species,

$P_{ik} = N_{ik}/Y_i$

N_{ik} = number of individuals of bee species i collected on flowers of species k,

Y_i = total of all individual bees of species i that were collected on flowers

(ii) Trophic niche overlap

Trophic niche overlap (NO) was calculated using Simplified Morisita Index (Krebs, 1996). This index is one of the most commonly used measure of niche overlap and its overlap values compare closely with those of Morisita index (Krebs, 1996). However, each overlap index has been found to have its own strengths and bias. The application of all indices depends on the quality of the emphirical data. According to Smith and Zaret (1982), both percentage overlap index and Simplified Morisita index are the most biased in regard to varying number of resources, sample size, and resource evenness.

$$C_H = \frac{2 \sum^n_i P_{ij} P_{ik}}{\sum^n_i P^2_{ij} + P^2_{ik}}$$

where

C_H = Simplified Morisita index of overlap (Horn, 1966) bee species j and species k

P_{ij} = Proportion resource i is of the total resources used by species j

P_{ik} = Proportion resource i is of the total resources used by species k

n = Total number of resources states (i = 1, 2, 3, ……n)

Calculations on trophic niche breadth were based on the most abundant 5 eusocial bee species and 10 most abundant solitary bee species while niche overlap (NO) values were calculated based on the 10 most important plants and most abundant eusocial bees (5 species) and solitary bees (10 species). In order to establish like bee groups based on niche overlap values, Cluster analysis was carried out (Legendre and Legendre, 1998). In this study, bee species were regarded as the objects and NO values as variables. All data on bee-plant interaction collected for 24 months were pooled to calculate trophic niche breath and trophic niche overlap.

3.4 Results

3.4.1 Floral resource exploitation

There was a distinct variation in the abundance of bees visiting different plant families. The most important plant families were *Acanthaceae, Asteraceae, Lamiaceae Papilionaceae* and Solanaceae. Herbs and shrubs in the understory community of Kakamega forest provided rich floral resources. Some plant species were more heavily visited by bees than others. The 10 most important plant species to bee fauna in the forest are as indicated in Fig.(3.1). *Justicia flava* Vahl, a common herb in forest gaps, as well as in open areas of the forest and the surrounding farming areas emerged as one of the keystone species for bees in Kakamega forest. Other important plant species included *Aspilia mossambicensis* followed by *Asystacia gangetica.* A summary of generic representation and the number of bee species visiting a particular plant family is shown in Table (3.1). Detailed analysis of floral utilization throughout the year is presented in Appendices (8.1 & 8.2.)

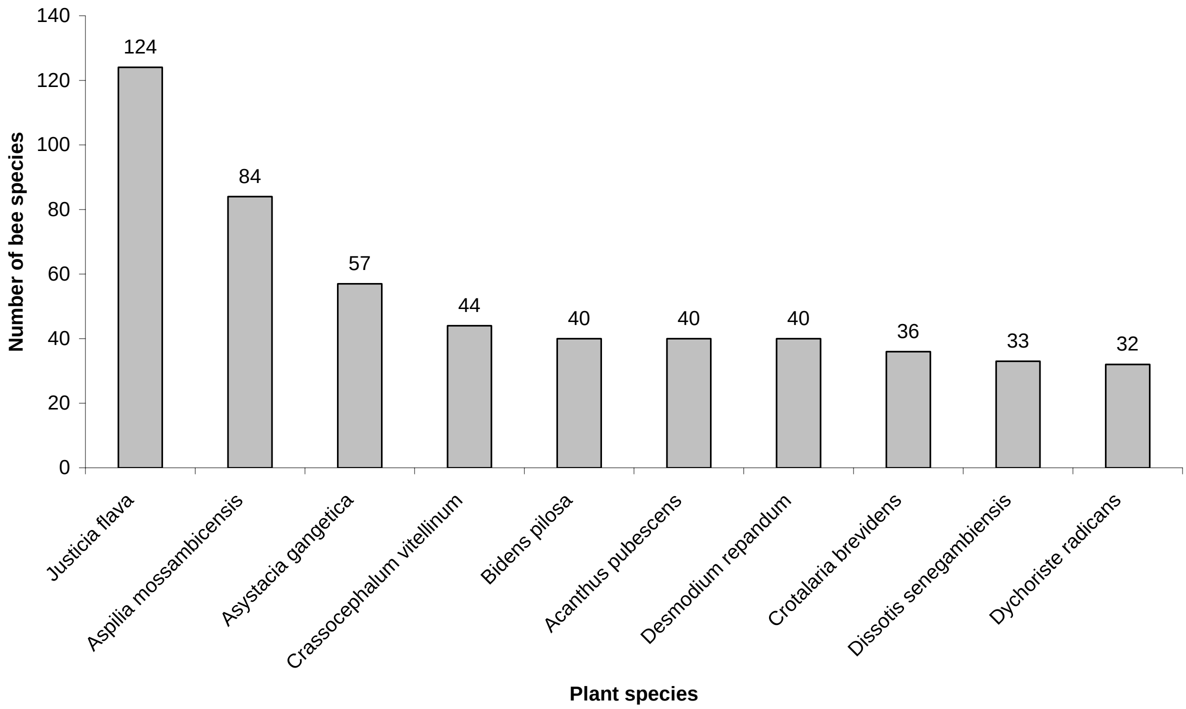


Fig. 3.1. The 10 most important plant species. Ranking based on the number of bees species collected from each plant species.

Shrubs and herbs were the most frequently visited plant species in the forest floor as well as in the open areas of the forest. Apart from *Desmodium repandum* which occurred only under closed forest canopies, the other forest species were predominantly found in the open areas of the forest. Among the weed species, *Bidens pilosa* and *Crotalaria brevidens,* (a local vegetable) were found to be very important plants for the bees in the surrounding farming areas.

Other important plant species to bees included some wood species such as *Maesa lanceolata, Markhamia lutea*, *Bischoffia javanica*, *Croton megalocarpus* and *Psidium guajava.* Among food crops, *Phaseolus vulgaris* (beans), *Ipomoea batatas* (Sweet potato) and *Zea mays* (maize) were the most attractive to bees. *Ipomoea batatas* was found to be a rich alternative food source for bees, especially during the dry season when there was a remarkable floral dearth in the forest. The most abundant group of bees on this particular plant was *Apidae* followed by some *Halictidae* species from the genus *Systropha.*

Table 3.1 A summary of bee visitation on different plant families.

Plant family	Bee genera	Bee species	Bee abundance
Acanthaceae	32	164	1301
Asteraceae	34	154	1442
Lamiaceae	28	108	484
Papilionaceae	26	87	288
Solanaceae	22	50	144
Verbenaceae	21	48	181
Malvaceae	21	45	151
Melastomataceae	16	38	67
Convolvulaceae	17	34	145
Rubiaceae	16	32	65
Papaveraceae	14	30	65
Caesalpiniaceae	12	29	123
Myrtaceae	14	27	80
Balsaminaceae	13	22	45
Gramineae	12	22	64
Sterculiaceae	15	22	39
Cyperaceae	12	21	54
Myrsinaceae	14	21	98
Cucurbitaceae	11	19	44
Commelinaceae	10	17	51
Fabaceae	6	17	33
Guttiferae	8	13	43
Sapindaceae	7	12	21
Vitaceae	7	10	12
Euphorbiaceae	3	7	7
Meliaceae	7	7	15
Poaceae	5	7	15
Apocynaceae	5	6	7
Amaranthaceae	5	5	6
Cruciferae	4	5	7
Flacourtiaceae	5	5	13
Oxalidaceae	5	5	5
Rosaceae	5	5	5
Combretaceae	3	4	4
Passifloraceae	3	3	3
Thymeleaceae	3	3	8
Caryophyllaceae	3	2	2
Dracaenaceae	2	2	3
Rutaceae	2	2	2
Tiliaceae	2	2	2
Bischoffiaceae	1	1	1
Boraginaceae	2	1	3

Caricaceae	1	1	1
Vahliaceae	1	1	1
Zingiberaceae	1	1	1

3.4.2 Trophic niche breadth

The mean number of *Apis mellifera* individuals captured on flowers was also high (Fig.3.2) and over 55 % of all the recorded bee plants were visited by honey bees. The niche breadth of the five most common eusocial bee species and 10 most abundant solitary bee species was found to vary within and between the two groups of bees (Fig. 3.3). There was evident generalization and a high degree of resource sharing among different bee species. The widest niche breadth was observed from the workers of *Apis mellifera* which foraged on a wide resource spectrum.

Among stingless bees, *Meliponula lendliana,* followed by *Meliponula bocandei* showed the widest niche breadth. However, some solitary bee species such as *Ceratina ericia* and *Ceratina* sp 2 seemed to go for similar resources with highly eusocial bees and had second broadest niche breadth. The number of plant species visited by these two species was also high as compared to other solitary bees. *Ceratina ericia* visited about 56 plant species with a mean number 4.09 per plant while *Ceratina* sp 2 visited about 46 with a mean number of 3.13 per plant species. Other species of solitary bees with remarkable niche breadths included *Halictus* (*Seladonia* sp 1) and *Halictus* (*Seladonia* sp 2). However, the mean number of bee individuals collected per plant was lowest in *Halictus* (*Seladonia* sp 2) as compared to other solitary bees. These two species seemed to prefer similar resources with *Ceratina* species.

The narrowest niche breadths among the 15 most abundant species were observed between *Xylocopa nigrita* and ***Meliponula erthyra.*** Similarly, these two species had the lowest number of individuals and visited less than 10 % of the recorded bee plants in the study area thus contributing to the low niche breadth.

Plate 3.1 *Xylocopa calens* on a local vegetable *Vigna unguiculata.*

Plate 3.2 *Meliponula erthyra* gleaning on pollen grains on petals of *V. unguiculata* dropped by bigger bees such as *X. calens*

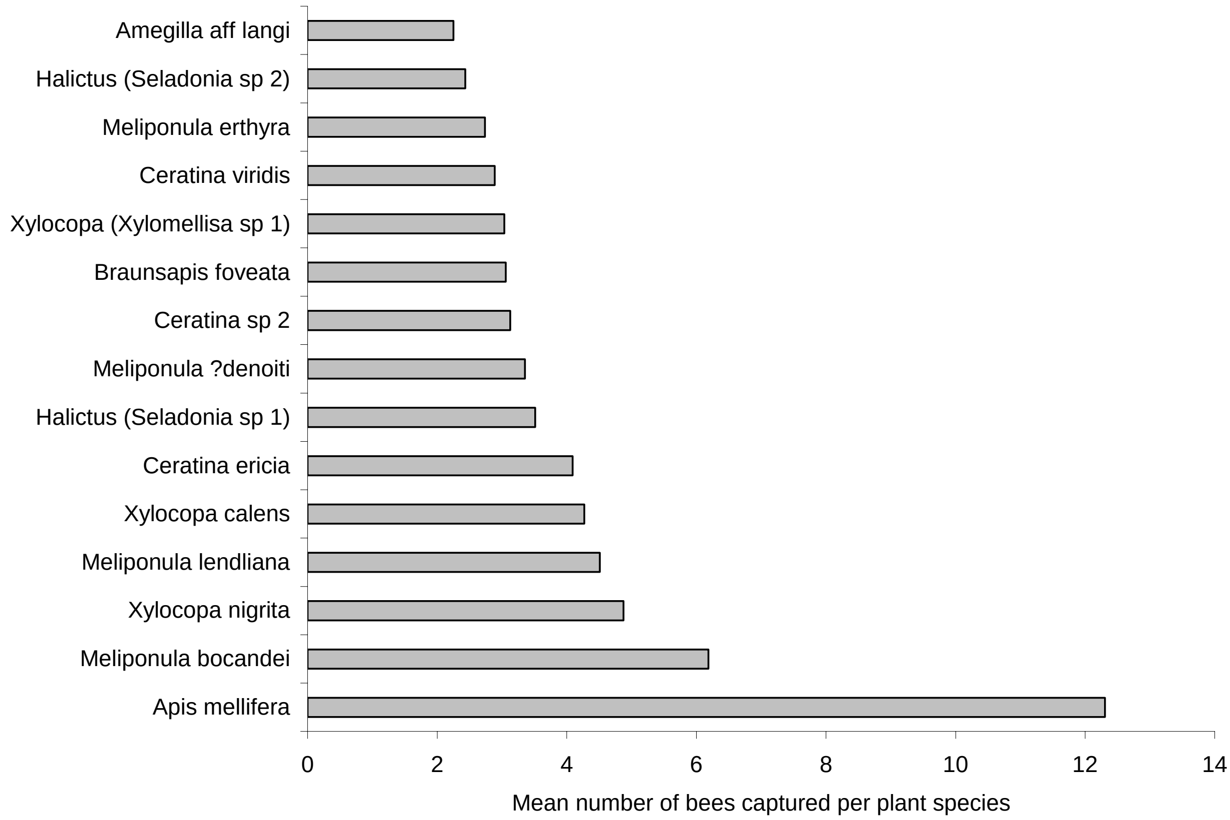


Fig.3.2 Mean number of plant species visited by the most common bee species.

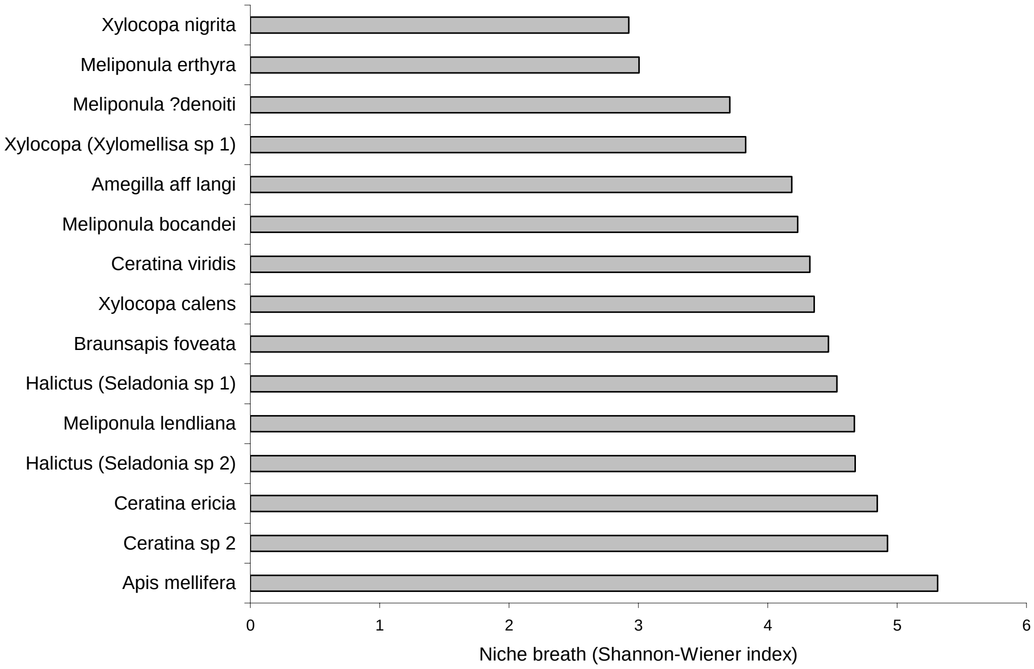


Fig. 3.3 Niche breadth of the most common bee species.

3.4.3 Trophic niche overlap

Ecologically, similar species should tend to have spatial ranges at local scale that do not overlap. Trophic niche overlap (NO) calculations were based on the 10 most important plant species visited by the five most abundant eusocial species and 10 most abundant solitary species in the study area. Overlap values were considered high when surpassing C_H = 0.60. Whereas niche overlap indices alone are not very good measures of inter-specific competition, stingless bees and honeybees seemed to have a high degree of resource sharing as indicated by NO range of 0.6 – 0.76 (Table 3.2). For instance, *Meliponula denoiti* had the highest NO of 0.76 with *Apis mellifera.* However, the average NO among stingless bees was relatively low (0.41) and ranged from (0.19-0.82). *Meliponula ?denoiti* and *Meliponula bocandei* had NO of 0.50 and 0.32 consecutively with *Meliponula erthyra*.

Resource sharing was also more evident between some species of solitary bees and eusocial species. With *Apis mellifera,* the NO indices were above 0.56 with all the other common bees except with *Xylocopa nigrita* which was as low as 0.08. Similarly, stingless bees were found to have relatively high N0s with particular solitary bee species such as *Braunsapis foveata*, *Amegilla langi***,** *Ceratina ericia*, *Ceratina viridis*, *Ceratina* sp 2 and *Halictus (Seladonia sp 2*).

However, apart from *Meliponula erthyra* all the other species of stingless bees had high NOs with *Halictus (Seladonia sp 2)* of over 0.64 except with *Meliponula erthyra*.

Table 3.2. Matrix of absolute Simplified Morisita's niche overlap values between highly eusocial and solitary bee species based on the 10 most important plant species.

	Al (1)	Am (2)	Bf (3)	Ce (4)	C2 (5)	Cv (6)	H1(7)	H2 (8)	Md (9)	Mb (10)	Me (11)	Ml (12)	Xx1 (13)	Xc (14)	Xn (15)
Al (1)	1	0.69	0.34	0.36	0.62	0.5	0.18	0.28	0.44	0.46	0.86	0.28	0.89	0.95	0.08
Am (2)		1	0.95	0.77	1	0.64	0.91	0.78	0.76	0.73	0.56	0.6	0.68	0.69	0.08
Bf (3)			1	0.7	1.4	0.81	0.55	0.45	0.66	0.81	0.27	1	0.34	0.35	0.04
Ce (4)				1	1	0.66	0.96	0.92	0.82	0.62	0.39	0.69	0.41	0.38	0.13
C2 (5)					1	0.97	1	0.94	1	0.53	0.47	0.76	0.66	0.08	0.08
Cv (6)						1	0.62	0.55	0.64	0.26	0.55	0.49	0.46	0.64	0.35
H1(7)							1	0.97	0.8	0.52	0.13	0.8	0.17	0.16	0.03
H2 (8)								1	0.75	0.64	0.21	0.73	0.31	0.26	0.06
Md (9)									1	0.51	0.32	0.82	0.39	0.39	0.01
Mb (10)										1	0.38	0.28	0.55	0.56	0.47
Me (11)											1	0.19	0.7	0.88	0.29
Ml (12)												1	0.27	0.26	0.1
Xx1 (13)													1	0.86	0.14
Xc (14)														1	0.36
Xn (15)															1

Key

Al (1).-*Amegilla aff langi*, **Am (2)**- *Apis mellifera*, **Bf (3)**- *Braunsapis foveata*, **Ce (4)**- *Ceratina ericia*, **C sp 2 (5)**- *Ceratina* sp 2, **Cv (6)**- *Ceratina viridis*, **H1 (7)**- *Halictus (Seladonia sp 1)*, **H2 (8)** – *Halictus* (*Seladonia* sp 2), **Md (9)** – *Meliponula ?denoiti*, **Mb (10)** – Meliponula bocandei, **Me (11)** – *Meliponula erthyra,* **Ml (12)** – *Meliponula lendliana,* **Xx sp 1 (13)** – *Xylocopa (Xylomellisa sp 1)*, **Xc** (**14**)– *Xylocopa calens*, **Xn (15)** – *Xylocopa nigrita*.

Resource sharing relationships among the eusocial and solitary bees did not, however, provide a clear pattern with the calculated values of NOs. In order to reveal different eusocial and solitary bee assemblages, a cluster based on the above pair-wise niche overlap values was used (Fig. 3.4). Clustering of species produced three main assemblages and three independent species from each. The upper assemblage was comprised of *Amegilla langi*, *Xylocopa (Xylomellisa* sp 1), *Xylocopa calens* and *Meliponula erthyra*. Although *Xylocopa nigrita* was grouped among this cluster, it was found to be somehow independent from the other species.
The middle assemblage had the fewest number of species and these included *Apis mellifera*, *Braunsapis foveata*, *Ceratina* sp 2 but *Ceratina viridis* seemed to be independent from the others. The lower assemblage comprised of *Ceratina ericia*, *Meliponula denoiti*, *Halictus (Seladonia* sp 1), *Halictus (Seladonia* sp 2) although *Meliponula lendliana* seemed to slightly different from the members of this group. One of the most similar cluster was identified in this assemblage, that is, *Halictus (Seladonia sp* 1*), Halictus (Seladonia sp* 2*).* Other species of bees that were closely grouped together as a cluster include *Amegilla lang*i and *Xylocopa (Xylomellisa sp 1*). Similar results were revealed by Pearson correlation coefficient values based on niche overlap values as indicated in appendix (8.5).

Hierarchical Clustering, Method = Ward

Clustering History

Number of Clusters	Distance	Leader	Joiner
14	0.758547564	1	13
13	0.9144831878	7	8
12	1.0643411128	4	9
11	1.3471898627	11	14
10	1.6040769949	4	7
9	1.7326177305	1	11
8	2.4075725873	4	12
7	2.4172313121	2	3
6	2.7239416921	2	5
5	3.2175453201	2	6
4	3.7973434418	2	4
3	4.3120530757	2	10
2	6.0226006569	1	15
1	10.068185017	1	2

Dendrogram

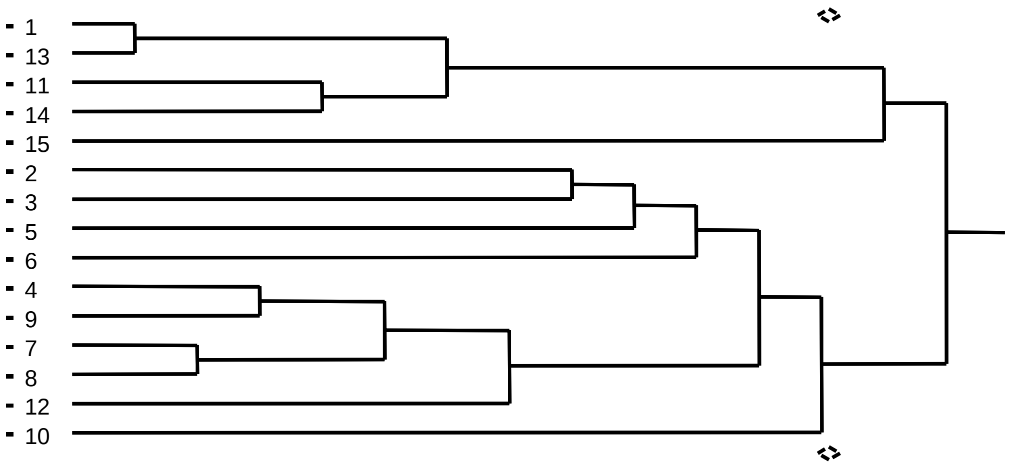


Fig. 3.4. Dendrograms yielded by hierachical cluster-analysis of niche overlap values of different species of bees.

3.5 DISCUSSION

3.5.1 Bee-plant interactions in Kakamega forest

Over 40% of the flowering plant species were found to provide floral resources to bee fauna in Kakamega forest although the specific flower resource offered to particular bee species, that is, either pollen or nectar were not recorded. The main plant families included *Acanthaceae, Asteraceae, Labiatae, Papilionaceae* and *Solanaceae*. These five families of plants had a visitation index of more than 60% by both highly eusocial and solitary bees. The plant species of families *Acanthaceae* and *Asteraceae* were the most important to bees due to their availability throughout the year and wide distribution in forest gaps, secondary forests and bush land. In comparison, the ranking of main food sources was closely similar to that of other forests of East Africa (Gikungu, 2002, Byarugaba, 2004) and those of other neotropic forests (Wolfgang *et al.*, 1996). Unfortunately, no fair comparison on plant-bee interactions could be made between Mt. Kenya forest and Kakamega forest because of the inherent differences in climatic and ecological regimes given that Mt. Kenya forest is an Afromontane forest.

However, a majority of bee species was found to visit a multiple of plant species and this observation agrees with observations made by other ecologists in that plant-pollinator interactions are highly generalized especially in the tropics (e.g. Waser *et al.*, 1996). However, some plant species were visited by a particular group of bees than the others. For instance, species of family Solanaceae such as *Solanum mauritianum* were commonly visited by *Xylocopa* species the so-called buzz pollinators. Solanaceae have poricide stamens and the vibrations shake the pollen off the flower anthers and onto the bee body.

Some plant species were found to support more bees than the others (Fig.3.2). Such plants included invader (*Justicia flava*) and weed species (*Bidens pilosa*) which flowered throughout the year, thus providing floral resources to the emerging bee species in different seasons. The importance of *Justicia flava* to several species of bees could be attributed to its ability to provide floral resources to bees in terms of both nectar and pollen, and its continuous flowering throughout the year. In addition, following continuous disturbance in the farming areas, this facilitated succession of various weed species and fence plants such as *Galinsonga parviflora* and *Tithonia diversifolia* which were found to be very important pollen plants for various species of bees.

3.5.2 Resource sharing and partitioning

The eusocial bees were the most dominant and seemed to have no specialization on the plant species they visited. Faced with the pressure to sustain large perennial colonies, these bees cannot afford to specialize on particular plant species and this accounted for their wide niche breath. Similar observations were made by Wolfgang *et al* (1996). They are therefore opportunistic generalists, which compete for resources with solitary bees. They are more advantaged than the other bees because they have special galleries to store the rapidly harvested foods unlike the solitary bees that collect just enough to provision their larvae. This view was also corroborated by other bee ecologists in other parts of the continent (Roubik, 1998; Olesen and Jordano, 2002).

However, both the eusocial and solitary bees seemed to utilize more or less similar resources throughout the year which may have been distributed in different habitats of the forest. Thus, high niche overlaps were documented between some species but this did mean competition for plant resources existed among the studied species. This view was echoed by Abrams (1980) where he states that overlap measure does not imply competition if resources are abundant. However, the first bee assemblage based on cluster analysis comprised of large buzz pollinators long-tongue bees (*Xylocopa nigrita*, *Xylocopa calens*, *Xylocopa (Xylomellisa* sp. 1 and *Amegilla aff langi*) seemed to visit similar type of flowers. In this case, the size of the body, as well as flowers visited, and foraging behaviour on flowers seemed to play a very important role in resource sharing. However, *Meliponula erthyra* a small-bodied stingless belonged to this assemblage but it seemed to have a special niche. This species was suspected to be a "gleaner" meaning it collects dropped pollen on petal or leaves following a flower visit by big bees (Plate 3.2 & 3.3).

Nevertheless it was suspected that foraging behaviour, relative abundance of some species and body size had a great influence on resource sharing. Some species of stingless bees including *Meliponula erthyra* and *Meliponula lendliana* were found collecting the loose pollen dropped by carpenter bees flowers after buzz pollination (Author's personnal observation). Among the seven documented eusocial bee species *Meliponula bocandei* and *Meliponula ?denoiti* seemed to highly overlap for with *Apis mellifera*. This could be attributed to the relative similarity in body size between *Apis mellifera* and *Meliponula bocandei;* but other factors that were not considered during the studies, such as closeness to the nests, could also have contributed. Nevertheless, low niche overlap (0.41 mean) was found among the stingless bees and this results agreed with the findings of Wolfgang *et al.*, (1996) where they suggest that niche overlap between stingless bees species should not exceed 0.5.

In conclusion, the principle of competition exclusion seems to apply in plant-pollinator interactions; but the pollinators especially bees are able to overcome it by foraging at different times and also in different habitats. The differential production and distribution of floral and non-floral resources in space and time increase the degree of resource sharing among different groups of bees. Given that bees are both coarse-grained and fine-grained animals, further data were collected in different successional habitats. The details are given in the next chapter.

CHAPTER THREE

4.0 BEE DIVERSITY AND ABUNDANCE ALONG A REGENERATION GRADIENT

4.1 Abstract

This study was carried out in Kakamega Forest with the objectives of establishing species composition and diversity of bees in different habitats of Buyangu forest. Seven sites were carefully selected along a forest maturity gradient. Bees were sampled using sweep nets along belt transects for a period of two years, that is, May 2002 to April 2004. About 234 species of bees representing four families (*Apidae, Halictidae, Megachilidae* and *Colletidae)*, were recorded during the study. The abundance and diversity of bees were found to be influenced by floral diversity . The highest species richness and bee diversity were recorded in the open areas, followed by secondary forests. This observation agreed with the expected trend., that is, decrease of bee species richness with forest age. However, the surrounding farming areas seemed to support bee communities especially when most of the flowering plants in the forest were not in bloom. Availability of food sources, bare ground and pithy plants were suspected to be the key determinants of bee community structure. Thus, the future of forest biodiversity conservation, as well as the pollination service, are dependent on strategic and holistic management of both natural forests and secondary forests as well as the surrounding agro-ecosystems.

4.2 Introduction

Interest in studying pollinators' assemblages at broad and local spatial scales in natural and agro-ecosystems is currently high, following the observed decline in pollinator populations. Such studies are highly needed in resource management at ecosystem level, especially in the tropics, where biodiversity is under the threat of anthropogenic factors; and yet still very poorly documented. Increased alteration of primary forests has further resulted in the development of piece-meal secondary forests and the creation of new matrix habitats whose role in tropical biodiversity is poorly understood (Harris, 1984; Fahrig and Merriam, 1994). The type of vegetation cover in the matrix habitats helps to determine faunal movements between habitats. For instance, high second growth forest has been found to be analogous to a filter with large pores, allowing faunal movement because of its structural similarity to primary forests (Gascon and Love-Joy, 1998). Unfortunately, most conservation efforts of tropical biodiversity have been biased towards protection of undisturbed primary forests; very little is, therefore, known about habitat or pollinator connectivity through floral resource sharing, succession and dispersal movements in forest matrices.

4.2.1 Why bee diversity and abundance?

Recent studies have shown that animal natural resources are not only defined by species composition, but also by their abundance in natural habitats (e.g. Banaszak, 1993). Data on relative abundance and diversity of a population gives an indication of the population size or pollinator force (Kevan, 1999) within an ecosystem. Secondly, from an individual species´ perspective, population density may be an indicator of habitat quality (Gram and Sork, 1999). However, data on bee abundance is virtually lacking in many ecosystems in Africa. Such data would help in the estimation of pollination failure of certain plant and crops species. According to Wilcock and Neiland (2002), pollination failure is highly associated with sparse and too small pollinator populations, among other factors. Similarly, data on bee diversity is also currently lacking in East Africa. Such data would assist in the assessment of habitat quality, as well as in bio-monitoring programmes since bees are good bio-indicators of habitat quality (Kevan, 1999).

4.2.2 Why understory bee community?

Studies on plant-pollinator interactions in high canopy layers of tropical forests are rare (Inoue, 1995, 1998; Kuniyasu, *et al.*, 1998). This is because of the technical difficulties and high expenses associated with such studies. Thus, this study chose to concentrate on the understory community of the forest, which depends mainly on animal pollen vectors to reproduce especially in the tropics (Meffe, 1998). Furthermore, data on reproductive biology of the understory community is also scarce, although a few records have been documented in neotropics (Manuel *et al.*, 1999). The aim of this study was therefore to establish temporal and spatial trends of bee species composition, and their diversity within Buyangu forest. Other questions to be answered in the study included: Are there some similarities between sites in regard to bee species composition? Are there differences in bee species composition across the forest maturity gradient? Are there fauna movements between different successional stages? How does forest age influence bee diversity?

4.3 Materials and Methods

The study was conducted in seven habitats selected according to the dominant tree species and plant physiognomy. Detailed descriptions for the selected seven sites are as given in the general introduction. The abundance of bees were sampled monthly using the belt transect method. Belt transects have been found to be the most effective active sampling methods for bees, as compared with timed observations of quadrats or sweeping vegetation (Benedek, 1970; Dylewska *et al.*, 1970; Banaszak, 1980, 1996; Fussel & Corbet, 1992; Dicks *et al.*, 2002). In each site, four randomly selected plots, each comprising three permanent belt transects of 100 m length and 2 m width were established (Banazak, 1980; Fussell & Corbet, 1992). Bees were sampled with a sweep nets at each site three times per month from May 2002 and April 2004 between 8.30 a.m - 10.30 a.m and 11.30 a.m -1.30 p.m per day in alternating manner. Data on flower visiting bees were collected at relatively uniform weather conditions to allow for comparisons. These sampling times coincided with the peak period of bee activity in the study area. The belt method depends on counting or catching of observed bees visiting flowers along a belt (Banaszak, 1980). The number of bee individuals visiting any plant species at any time during the flowering season was considered as an estimate of bee abundance in each site (Diego and Simberloff, 2002).

Bees and the associated bee plants were recorded to species as far as possible. However, the bees that were difficult to identify in the field were collected, killed and later pinned for further identification in the laboratory. To minimize reduction of the least common and largest species, the bees that were easier to identify on flight or on flowers were not collected (Heithaus, 1979). Identifications were carried out using standard keys and reference collections at the National Museums of Kenya. Samples that could not be identified locally were identified by specialists at USDA-RS-Bee lab in Logan, Kansas University bee lab (USA), and at the IPRR-bee lab in Pretoria (South Africa). Due to lack of local identification keys for bees, some species were only identified as morphotypes.

4.3.1 Data analysis

In order to make a comparative analysis on bee diversity in the selected habitats, Rényi diversity index family was used owing to the inconsistencies (Patil & Taillie, 1979) that arise when using a single number generated by the commonly used indices, such as Shannon-Wiener or Simpsons (Krebs, 1996). Rényi´s diversity index family has been found to be the best index family for ordering communities of all sizes, for it shows sensitivities to both the rare and the common species as the scale parameter. In addition, the diversity profiles allow comparison of different communities that are consistent with their relative diversity.

Renyi´s diversity index family and the Logarithmic dominance ordering have been found to be the most useful methods for ordering communities of all sizes (Tothmérész, 1995, 1998). The calculations for Rényi indices and diversity profiles were done using DIVORD programme (Tothmérész, 1997). Similarities between sites in regard to bees were calculated using Horn's index (Horn, 1966). This index calculates the probability that specimens drawn from two sites will be of the same species, relative to the probability that specimens randomly drawn from the same site will be of the same species. Horn's index is relatively little affected by sample size but it is not as robust as Morisita's index (Krebs, 1996).

Horn's index formular:

$$R_o = \frac{\sum[(X_{ij} + X_{ik}) \log (X_{ij} X_{ik})] - \sum (X_{ij} \log X_{ij}) - (X_{ik} \log X_{ik})}{[(N_J + N_K) \log (N_J + N_K)] - (N_J \log N_J) - (N_K \log N_K)}$$

where

R_o = Horn's index of similarity for samples j and k

X_{ij} , X_{ik} = Number of individuals of species i in sample j and sample k

$N_J = \sum X_{ij}$ = Total number of individuals in sample j

$N_K = \sum X_{ik}$ = Total number of individuals in sample k

Further analysis on variations of bees species abundance between and within sites were analyzed using multivariate tests with the help of JMP 1997, and SIGMA PLOT 2000 for Windows version 6.00.

4.4 Results

4.4.1 Overall bee species richness and abundance across the gradient

Altogether 234 species and 4485 individuals from four bee families (*Apidae, Halictidae, Megachilidae* and *Colletidae*) were sampled for 514 days in the selected study sites of Buyangu Nature Reserve (BNR) and its surrounding settlement areas. The largest family was Apidae followed by *Halictidae* and *Megachilidae* as shown in Fig. 4.1. The cumulative collection curve over a 24 month sampling period seemed to attain their asmptotes during the study (Fig. 4.2). However, those of Farmland, Guava bushland, and young secondary forest were found to continue gradually rising.

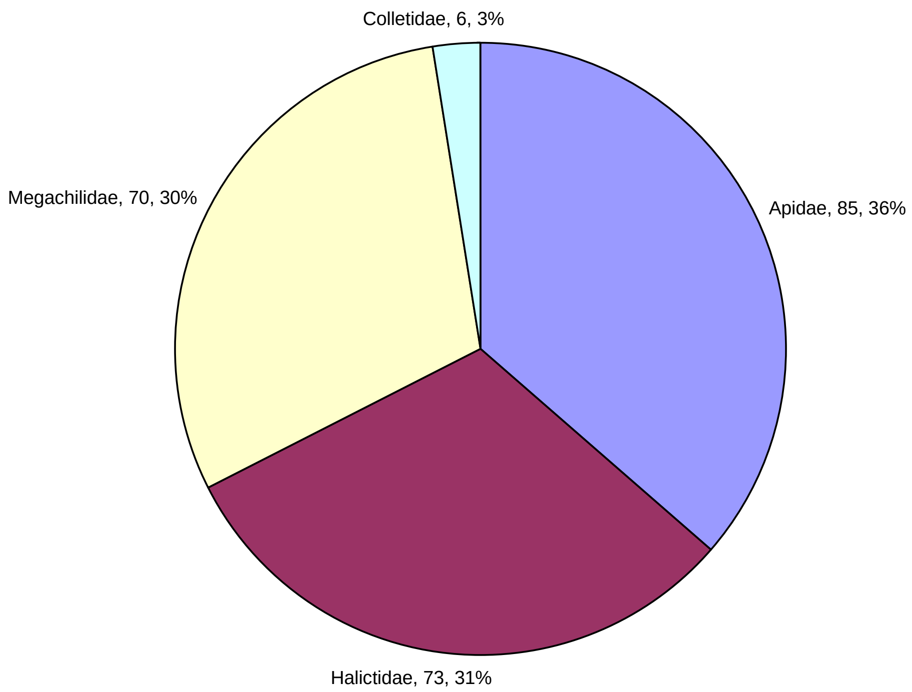


Fig.4.1. Composition of bee fauna of Buyangu forest: families, number of species and proportion in percentages.

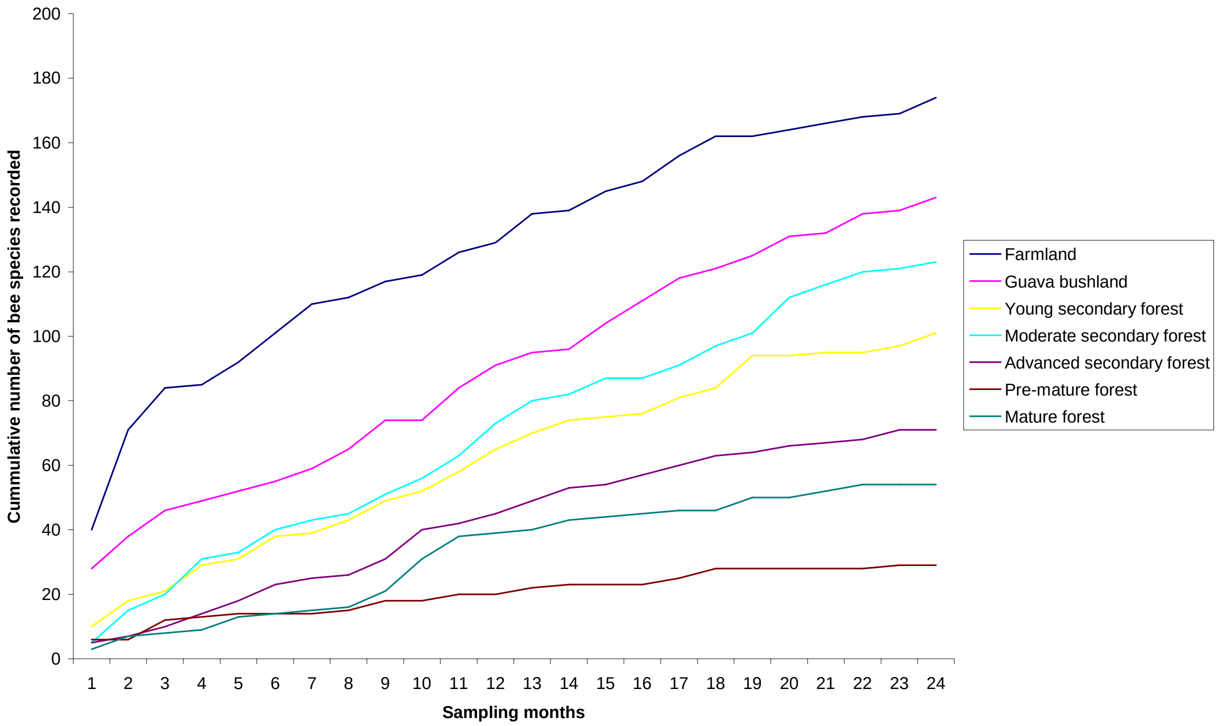


Fig. 4.2. The cumulative number of bee species collected at the seven study sites over 24 months period.

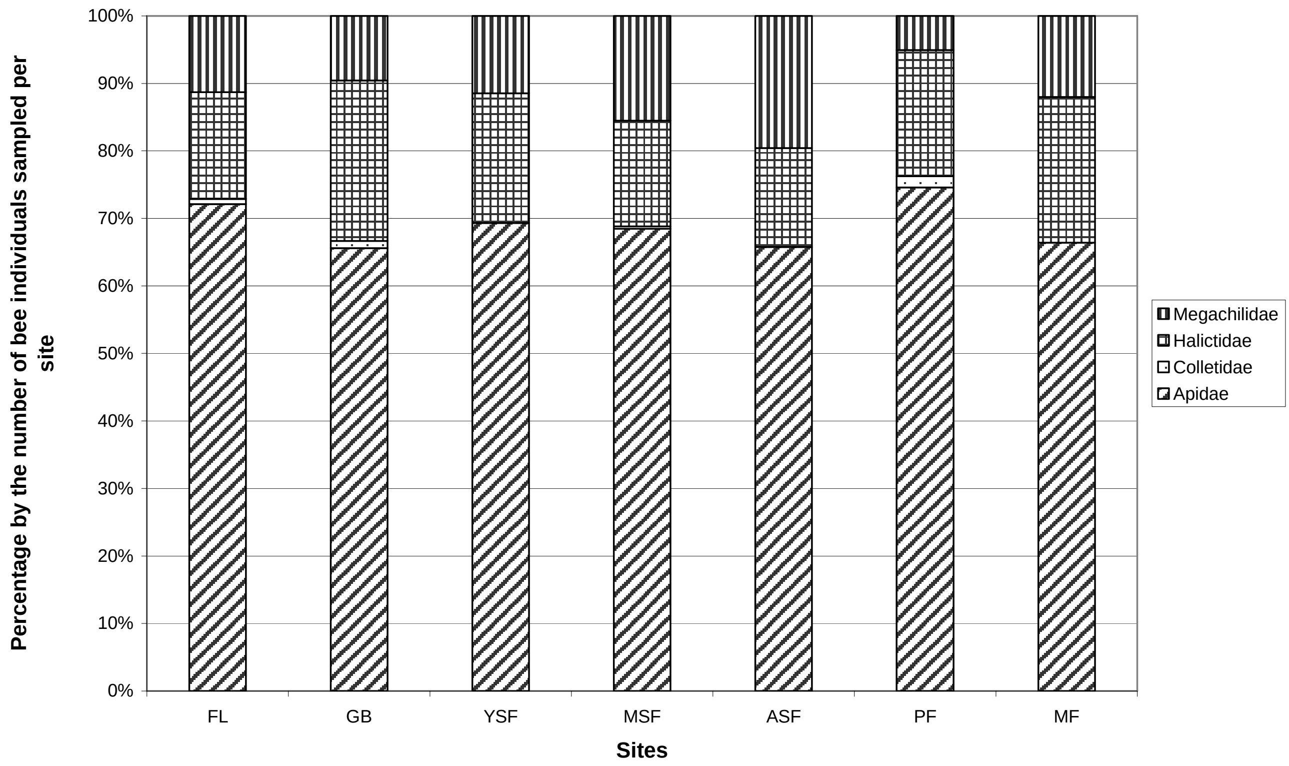


Fig. 4.3 (a) Proportion of bee families collected at each site (based on the number of individuals collected).

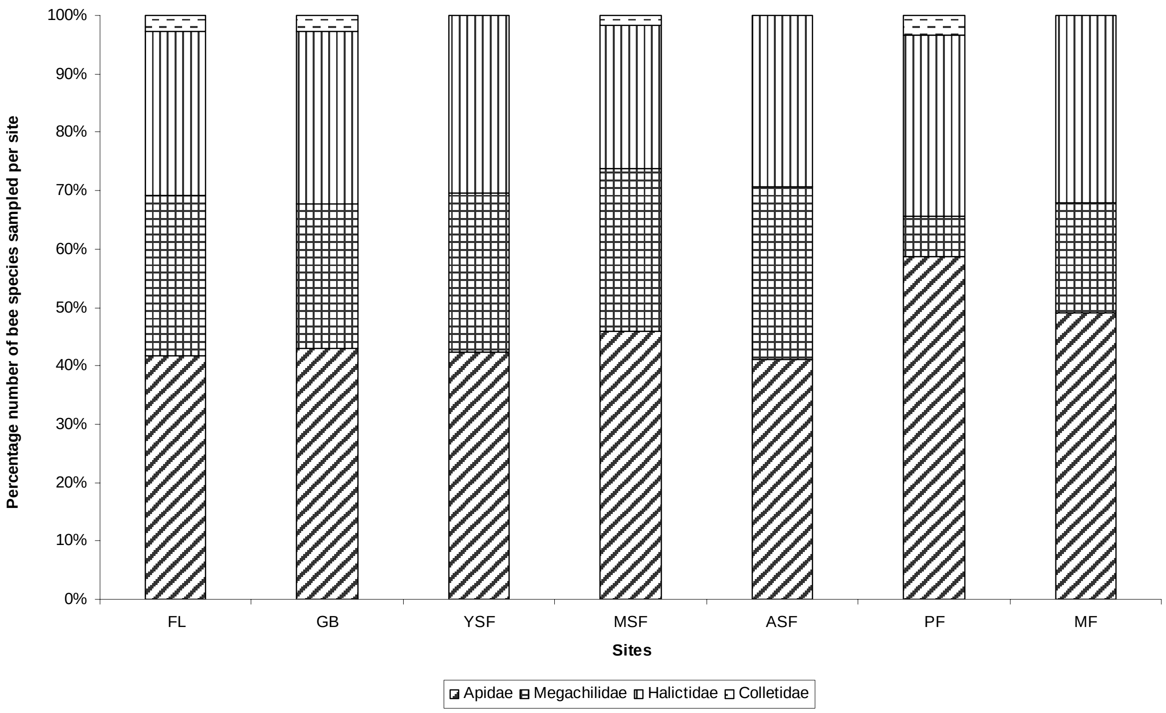


Fig. 4.3 (b) Proportion of bee families collected at each site (based on the number of species collected).

Key for sites

FL (Farmland), **GB** (Guava Bush land), **YSF** (Young Secondary Forest), **MSF** (Moderate Secondary Forest), **ASF** (Advanced Secondary Forest), **PF** (Premature Forest), **MF** (Mature Forest).

The most dominant families in all the study sites were *Apidae*, *Halictidae* and *Megachilidae*. (Fig.4.3 (a) & b)). The representatives of the family *Colletidae* was found to be very sparsely distributed and was only recorded in four sites. Among the Apidae species, *Apis mellifera* followed by some stingless bee species *Meliponula bocandei* and *Meliponula lendliana* were the most abundant. There was a clear pattern in the variation of bee species richness along the gradient. The highest number of species was recorded in the farmland followed by the Guava bushland (Fig. 4.4). However, bee species richness, was found to decrease with forest age in almost every family (Fig. 4.5. Similar results were revealed by linear regression analysis and both bee species richness ($F_{1,6}$ = 31.32, R^2 = 0.86, P = 0.0025) and abundance (($F_{1,6}$ = 9.78, R^2 = 0.66, P = 0.02) were found to differ significantly along the gradient. (Fig. 4.6 (a) & (b)) .

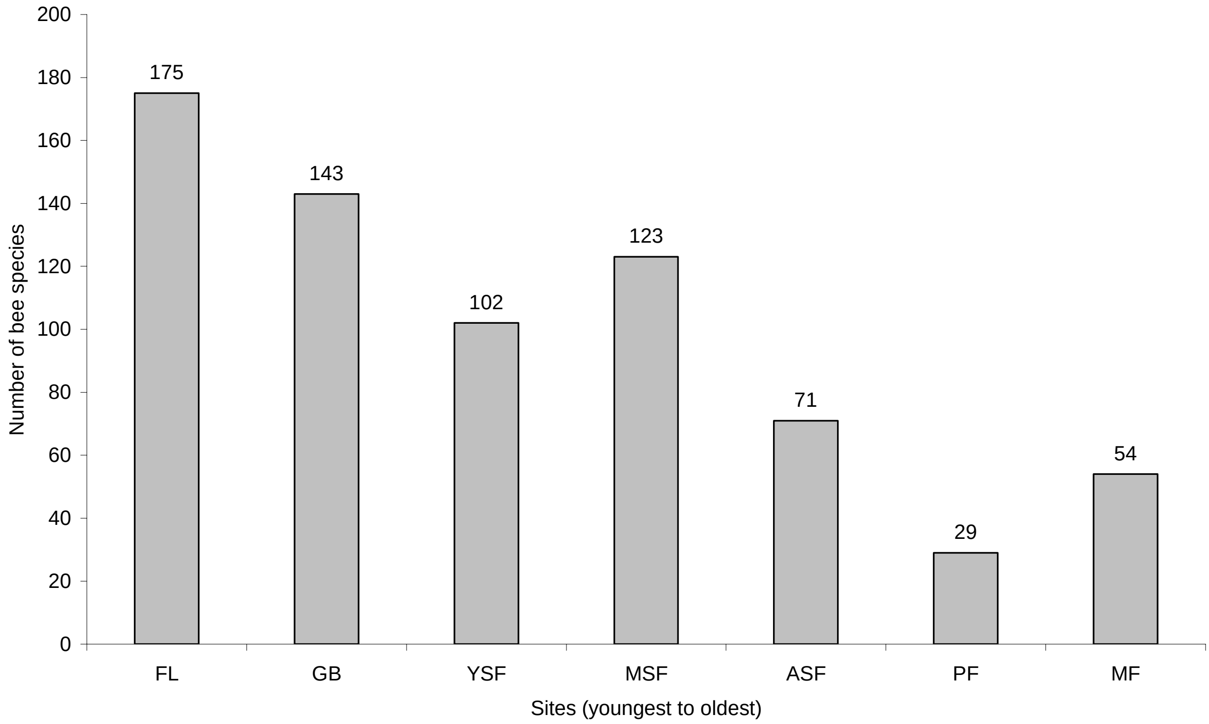


Fig. 4.4. Species richness as recorded in each study site. The sequence of the sites represents the actual cline from farmland into the mature forest.

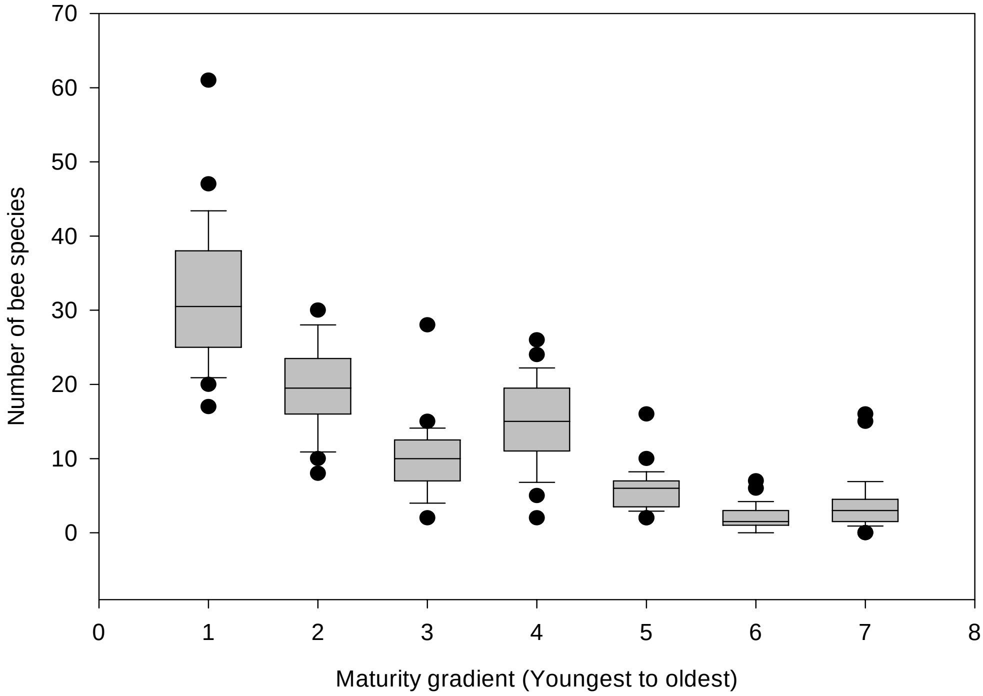


Fig. 4.5 Monthly variation in bee species richness across the forest

Maturity gradient (**1**-Farmland,**2**-Guava Bushland, **3**-Young secondary forest, **4**-Moderate secondary forest, **5**-Advanced secondary forest, **6**-Pre-mature forest and **7**-Mature forest). Samples of bees are represented by the boxes whose top and bottom represent the upper and lower quartiles. The median is marked by the center horizontal line splitting the data in halves. The whisker is drawn from the top of the box to the largest value within 1.5 interquartile ranges of top and the same from the bottom. The bullet-like symbols are outliers.

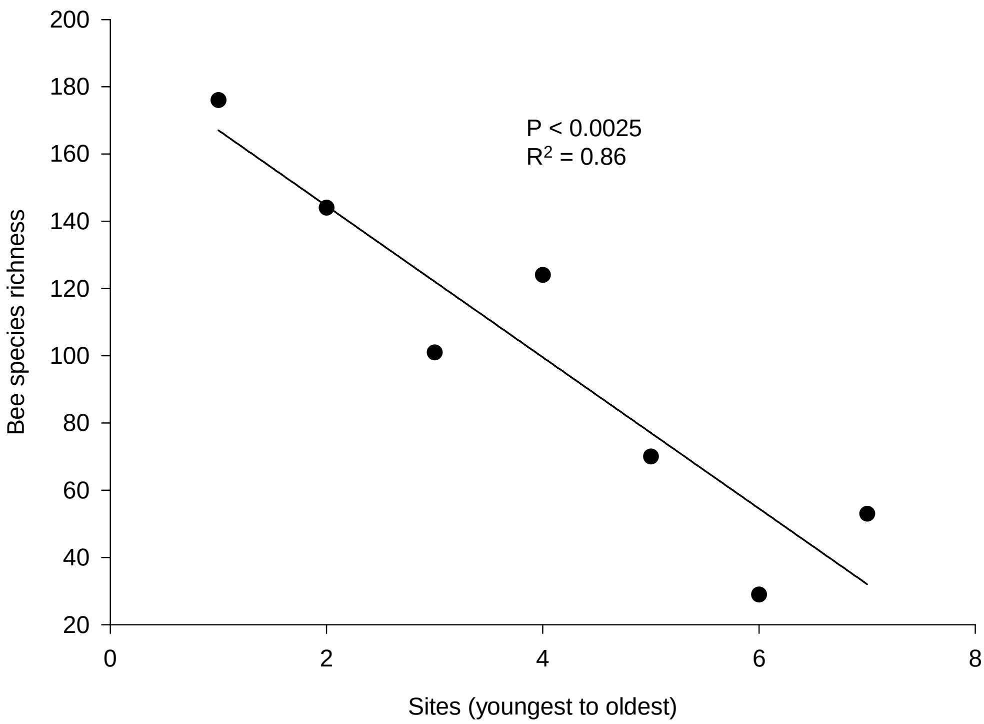


Fig. 4.6 (a) Variation of bee species richness across the sites for 24 months period.

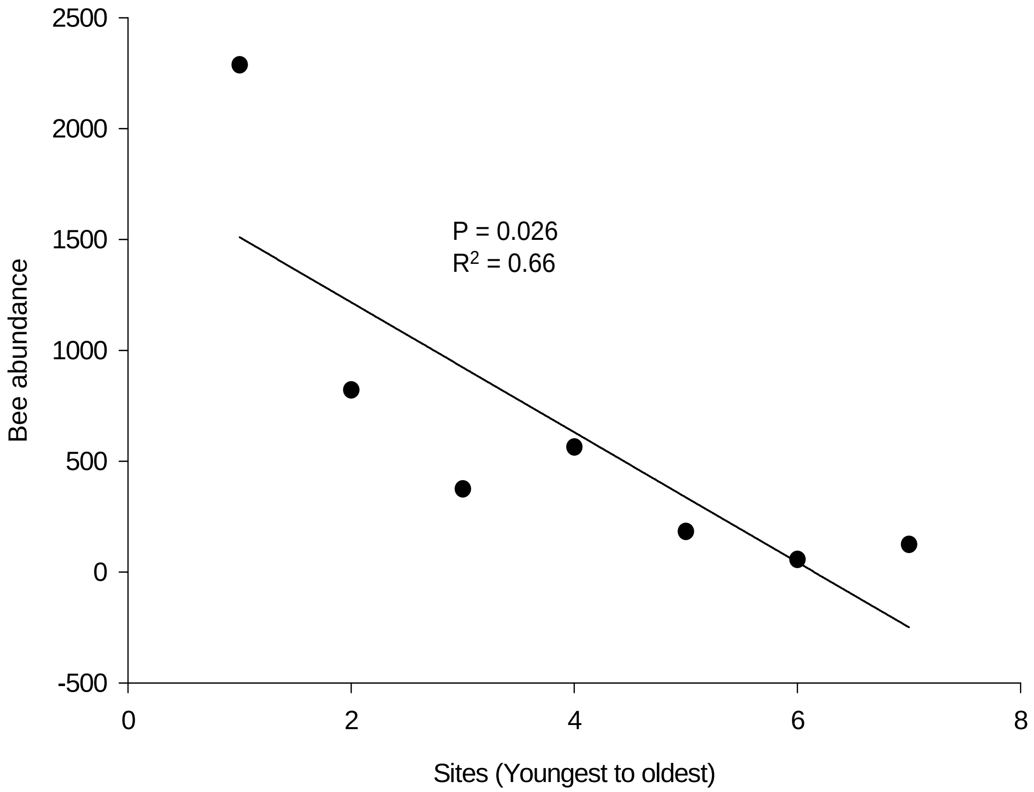


Fig. 4.6 (b) Variation of bee abundance across the sites for 24 months period.

Based on One-way non-parametric test (Wilcoxon/Kruskal-Wallis test) results, both bee species richness and abundance were also found to differ significantly in the different stages of forest regeneration ($\chi^2 = 134.29$, df = 6, P < .001). In order to differentiate which sites were more different from others, pairs of means were then compared with the help of Tukey Kramer test at alpha = 0.05. This comparative test of pairs of means, revealed that farmland followed by the youngest forest, that is, the *Psidium* bushland were the most different as compared to other forest sites.

4.4.2 Bee diversity

Diversity of bees along the forest succession gradient was analysed using the Rényi's diversity measure. As mentioned earlier, this index is more robust than the commonly used indices such as Shannon-Wiener and Simpsons (Magurran, 1988). It combines the two indices with the help of a scale parameter and, more importantly, it is extremely sensitive to rare species when the scale parameter is 0.

The diversity profiles based on combined data for two years across the study sites indicated that most of the forest sites were incomparable and could only be compared easily in terms of rare species or common species (Fig.4.7). A very insignificant difference was indicated by the overlying profile curves on the right side of the graph in terms of diversity of common species. According to these results, farmland could be easily compared with the pre-mature forest and was obviously more diverse than the latter. Ranking of species rareness was analyzed as follows: Farmland > Guava bushland >Moderate secondary forest > Young secondary forest > Advanced secondary forest > Mature forest > Premature forest.

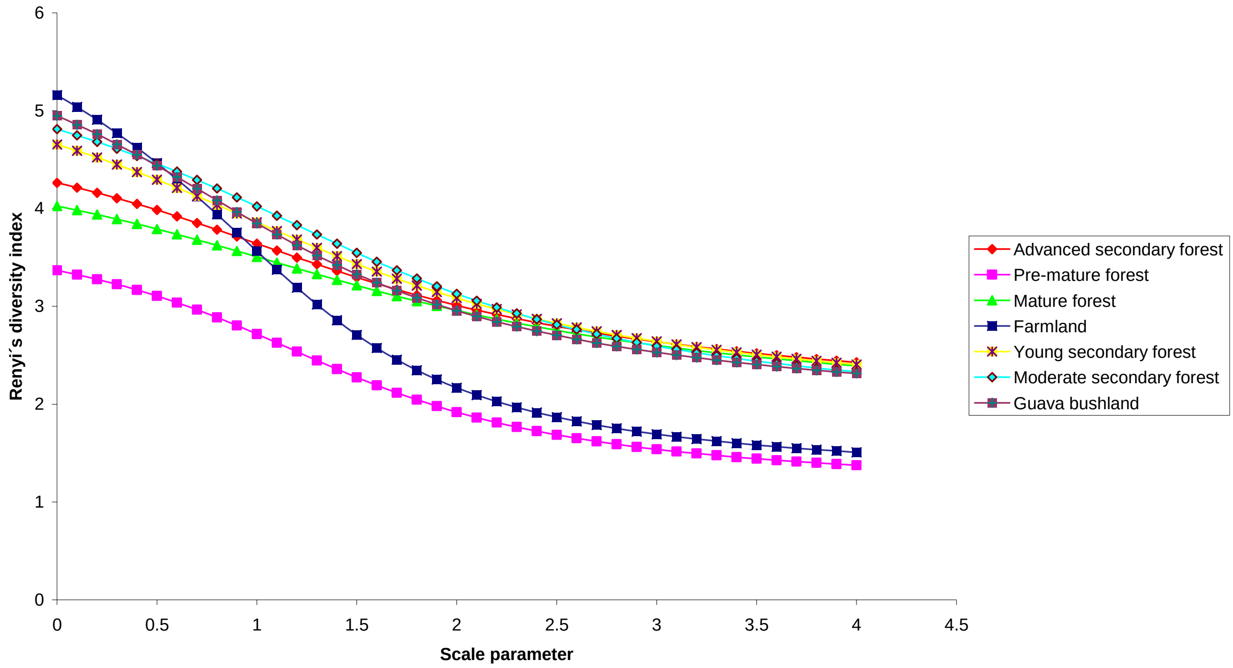


Fig. 4.7 Overall Rényi's bee diversity profiles for 24 months period across the sites. Farmland is comparable to pre-mature forest and has highest bee diversity.

Further analyses were carried out on bee diversity variation in different seasons. The results indicated that the bee diversity was incomparable in most seasons and could only be compared easily in terms of common species (Fig.4.7). However, Long Rains, Dry and Cold Dry seasons were found to be equally diverse in rare species. The scenario was different in the case of common species. The Short Dry season was thus the least diverse in terms of rare species, while Short Rains was the least diverse in terms of common species.

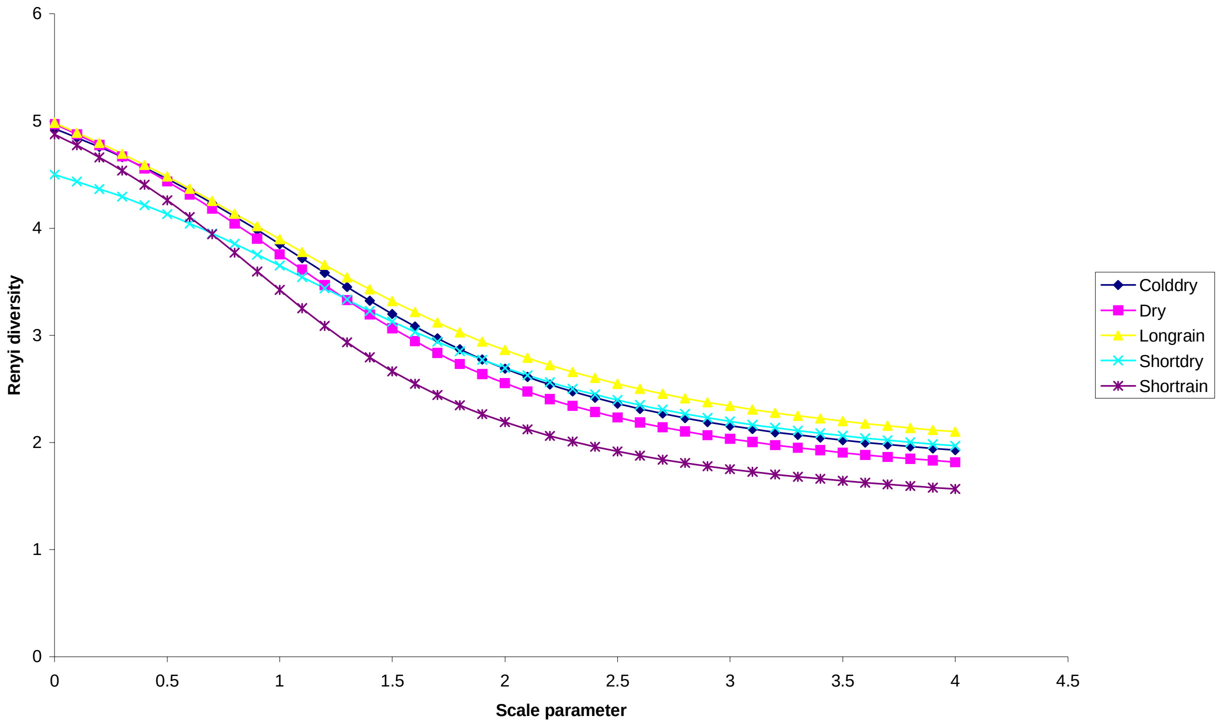


Fig. 4.8. Rényi's bee diversity profiles in different seasons. Bee diversity is uncomparable in most seasons but Long Rains seasons is more diverse than the Dry season. The two seasons are comparable.

Bee diversity was also found to vary across the sites in different seasons (Fig. 4.8). Farmland always appeared as the most diverse site in terms of rare species. This site was found incomparable with several forest habitats, except with the pre-mature forests, which appeared always as the least diverse in all the seasons (e.g. Fig.4.9 & 4.10). Among the forest sites, moderate secondary forest and the Guava forest were found to be the most important sites for bees, especially during the Short Dry and Dry seasons (Fig. 4.10 & 4.11). However, a distinct variation in bee diversity across the sites was recorded in the cold dry season (Fig. 4.12), and only two sites were incomparable, that is, farmland and Guava forest. In addition, farmland was the most diverse in terms of rare species and was second to Guava bushland in terms of common species. Ranking of bee diversity in other forest sites during the cold dry season was as follows: Moderate secondary forest > Young secondary forest > Advanced secondary forest >Mature forest > Pre-mature forest.

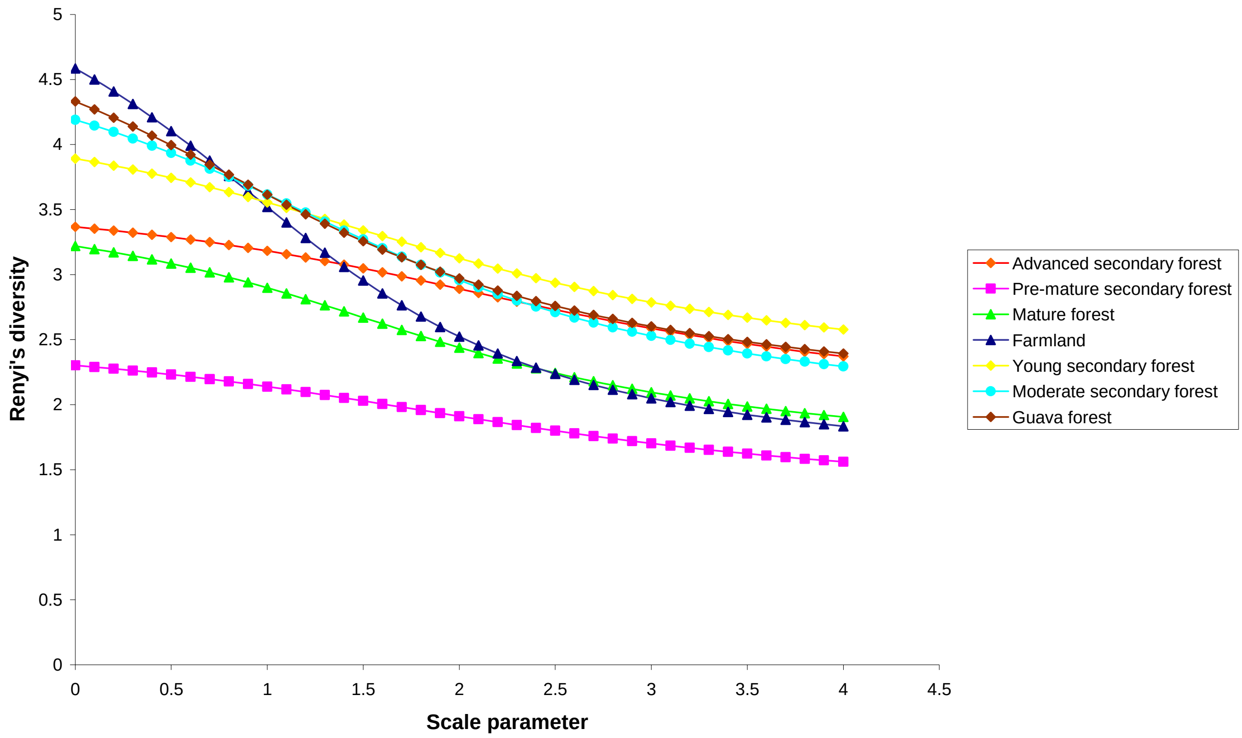


Fig. 4.9 Rényi's bee diversity profiles during the Long Rains season across the sites. Farmland is comparable to only pre-mature forest.

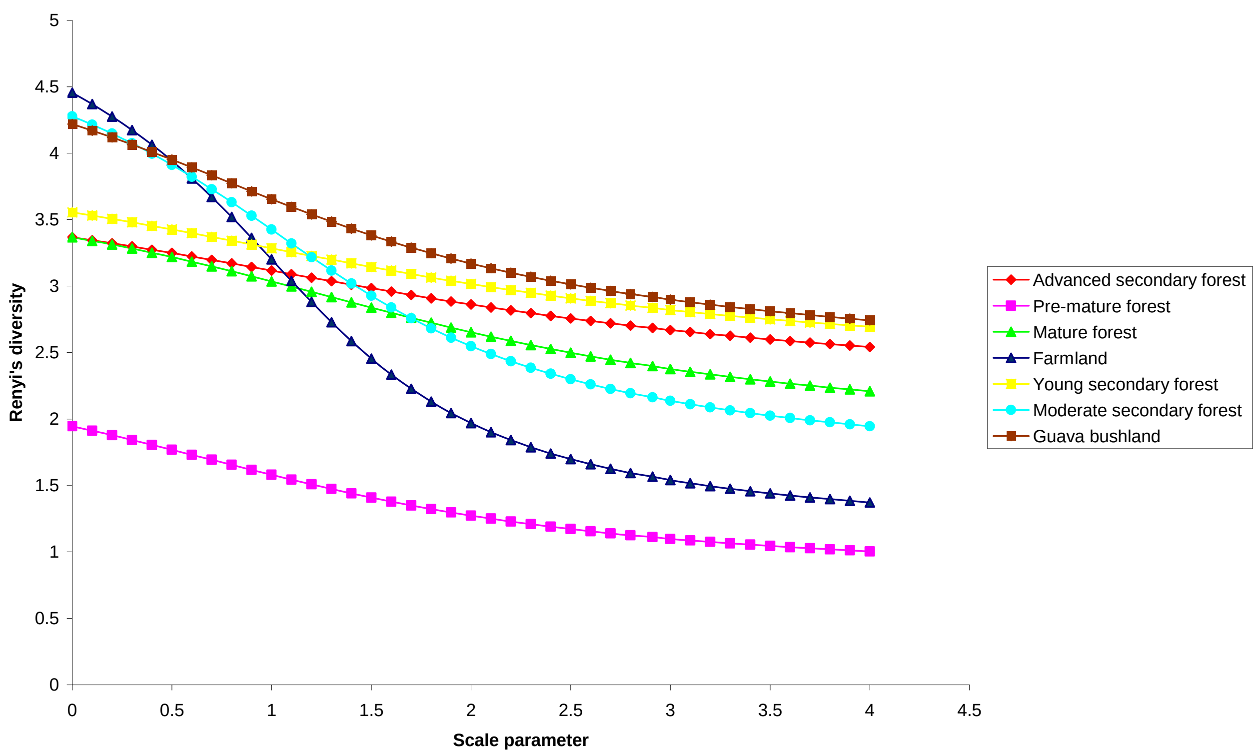


Fig. 4.10 Rényi's bee profiles during the Dry season across the sites.

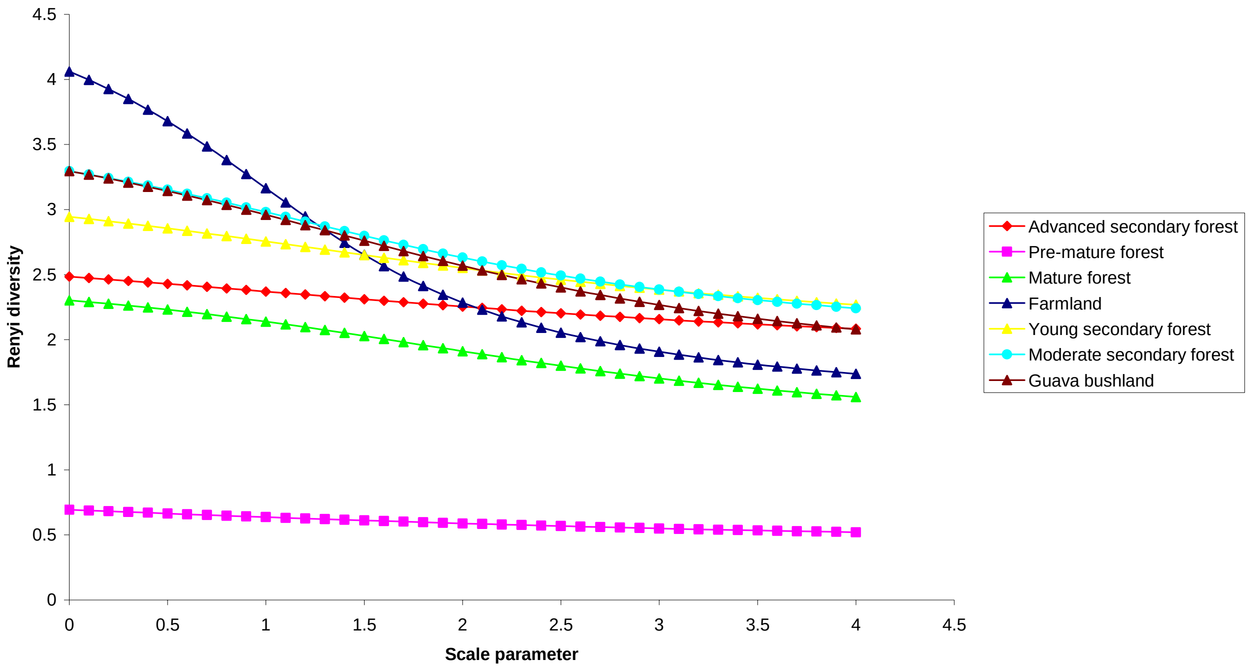


Fig. 4.11 Rényi's bee diversity profiles during Short Dry season across the sites.

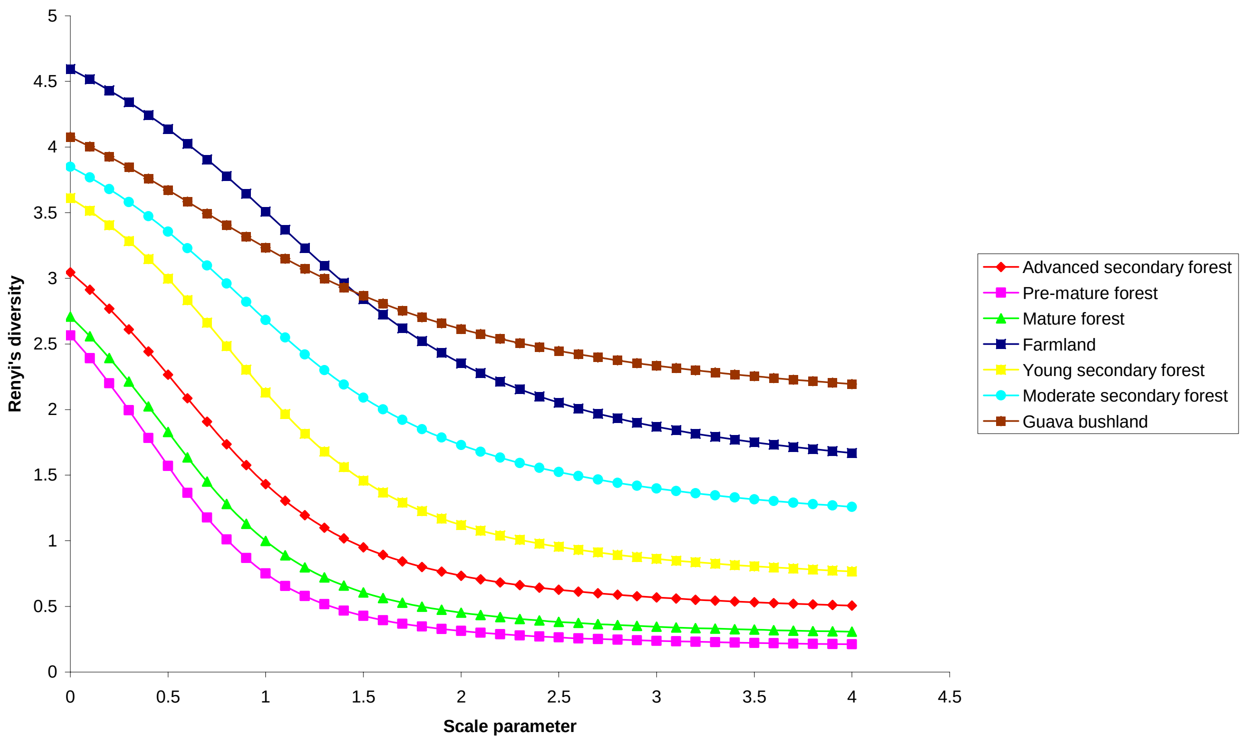


Fig.4.12 Rényi's diversity profiles during the Cold Dry season across the sites

Seasonal uniqueness of different successional habitats to bee community was also noted during the study. Some habitats were found to be more important to bees in different seasons while some were more or less stable in all the seasons. The diversity of bee communities in farmland (Fig.4.13) did not seem to differ significantly as compared to mature forest (Fig.4.14). The highest diversity of bees in the mature forest was recorded during the Dry season, followed by the Long Rains season; the diversity profiles were incomparable. Comparing farmland with mature forest bee diversity, it was evident that the former was more diverse in rare species during all seasons than the latter. The highest diversity in terms of rare species was in the Long Rains season (Fig. 4.9) and Cold Dry season(Fig.4.12) followed by Dry season (Fig. 4.10). However, farmland bee diversity in terms of common species was clearly different as ranking in the figure below shows: Long Rains > Short Dry > Cold Dry > Dry > Short Rains (Fig. 4.13).

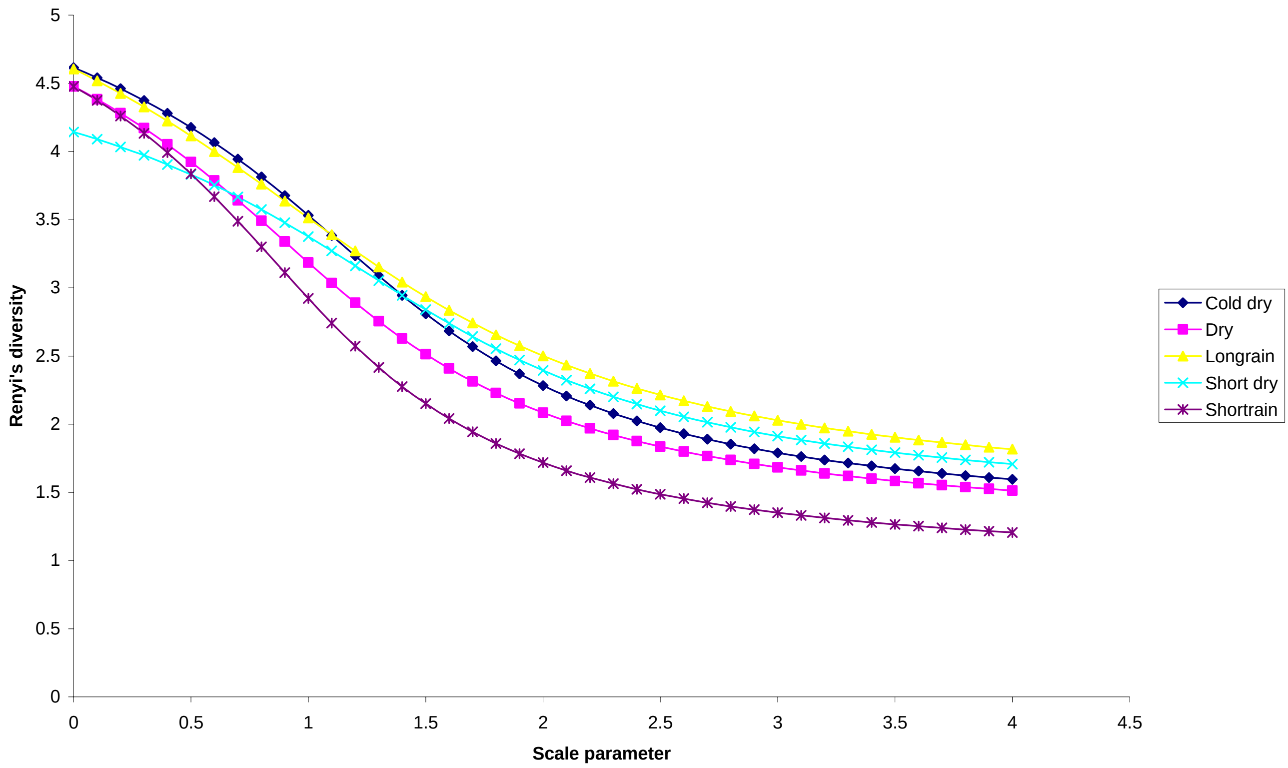


Fig.4.13 Rényi's diversity profiles in farmland across different seasons.

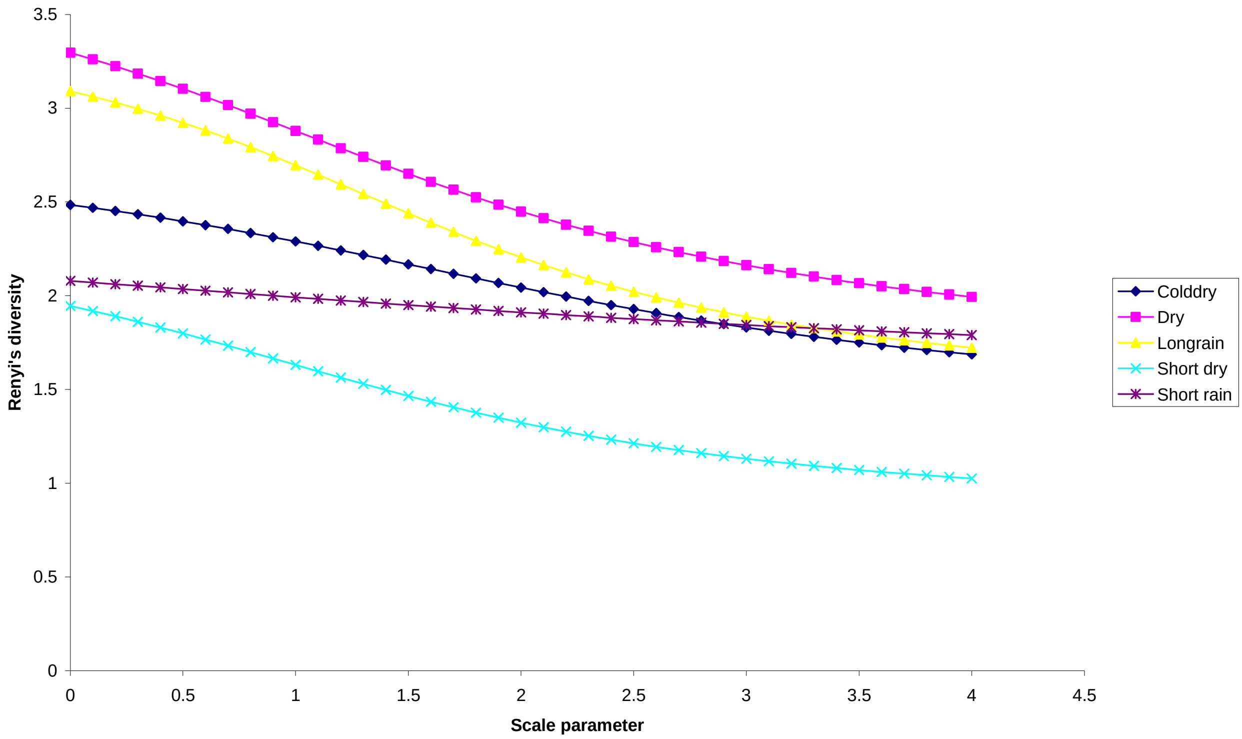


Fig. 4.14 Rényi's diversity profiles in a mature forest in different seasons. Dry season shows the highest diversity followed by the Long Rain Season.

4.4.3 Effects of floral resources on bee diversity along the gradient

Between sites a significant difference was recorded in bee plant species richness 1-way Test, $\chi^2 = 60.81$, df = 6, P < 0.0001). The surrounding farming area was different from the other sites followed by Guava bushland based on Tukey Kramer results. The highest variation in bee food sources was recorded on both extreme sides of the gradient, that is, in farmland and mature forest (Fig.4.15). The bee species (B) richness was found to be strongly influenced by the availability of bee plants (P) (B = 3.009 + 1.153 P, $R^2 = 0.62$, $F_{(1, 153)} = 259.63$, P < 0.001) (Fig. 4.16). Similarly, the number of plant species was also found to influence bee abundance (Bee abundance = - 19.46 + 7.28P, $R^2 = 0.445$, $F_{(1,153,)} = 122.78$, P < 0.001) (Fig. 4.17). The most important plant families included Acanthaceae, Labiatae, Rubiaceae and Papilionaceae. Among the plant species in the understory community, *Desmodium repandum* followed by *Pollia condensata* were found to be the most important to bees.

Examples of tree species that were attractive to bees in the forest included *Bischoffia javanica*, *Psidium guajava*, *Maesa lanceolata*, *Markhamia lutea*, *Albizia grandibractea*. Outside the forest, *Eucalptus saligna* and *Markhamia lutea and Erythrina abessinica* were also found to be highly attractive to bees. In the open areas of the forest as well as agroecosystem, *Justicia flava* (Plate 4.1) and *Aspilia mossambicensis* (Plate 4.2) *were* visited by the highest number of bee species along the gradient. Among the edge community, *Caesalpinia decapetala* was frequently visited by different types of bees such as carpenter bees, stingless bees and honeybees. *Bidens pilosa*, *Ocimum kilimandscharicum* were found to be very important resources to bee fauna in the farming area.

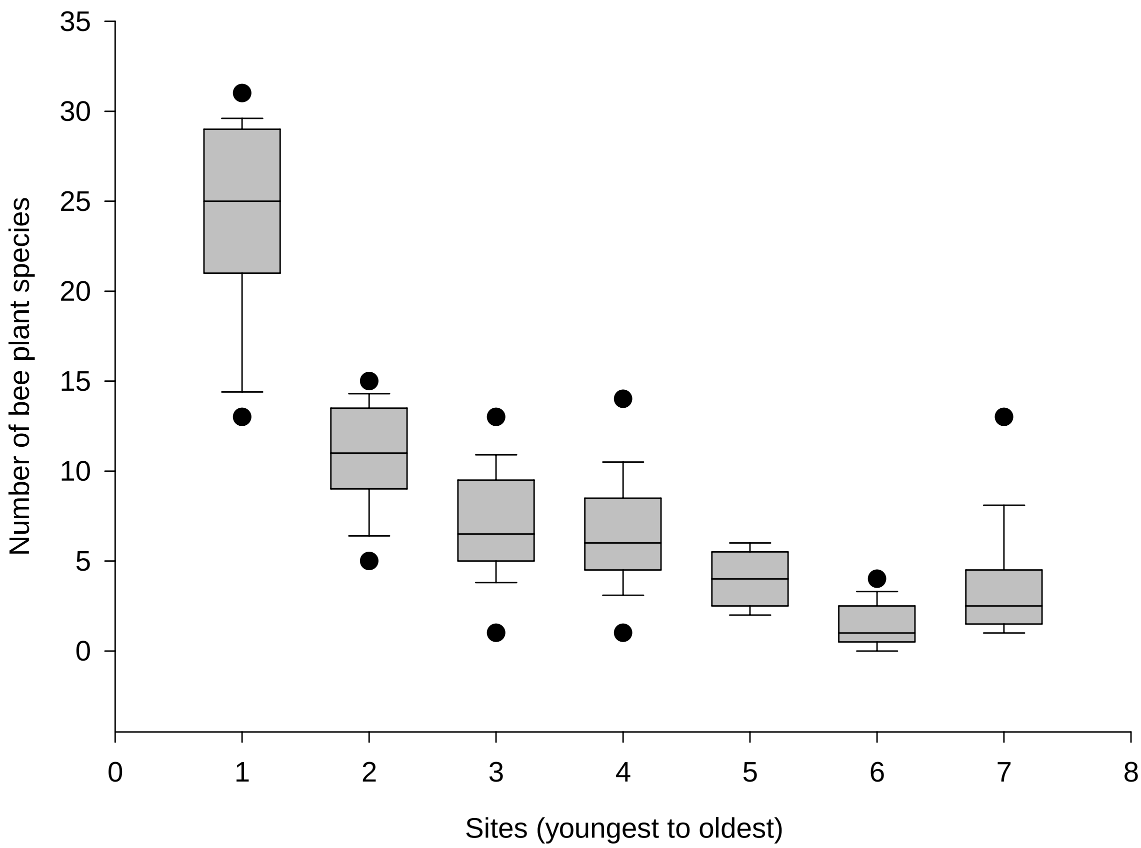


Fig. 4.15 Variation of bee plant diversity along a forest maturity gradient.

Key for sites

1 (Farmland), **2** (Guava bushland), **3** (Young secondary forest), **4** (Moderate secondary forest), **5** (Advanced secondary forest), **6** (Pre-mature forest) and **7** (Mature forest)

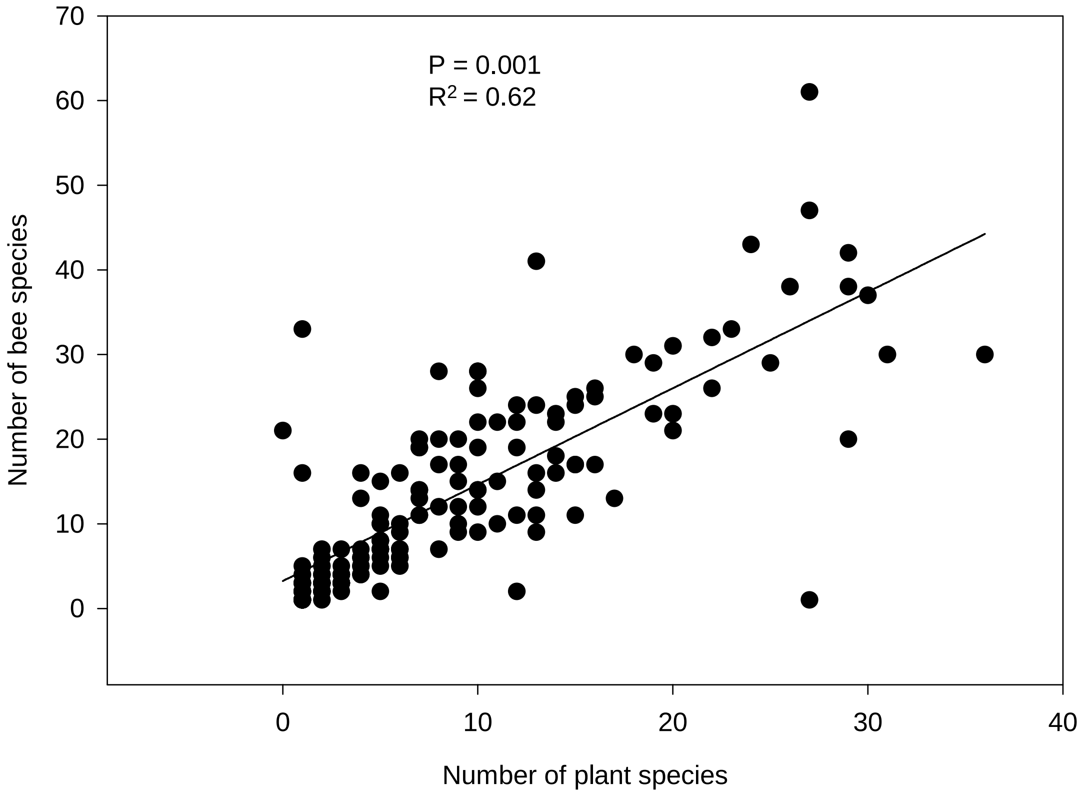


Fig. 4.16. Relationship between plant species richness and bee species richness. The number of plant and bee species were based on monthly records across the sites.

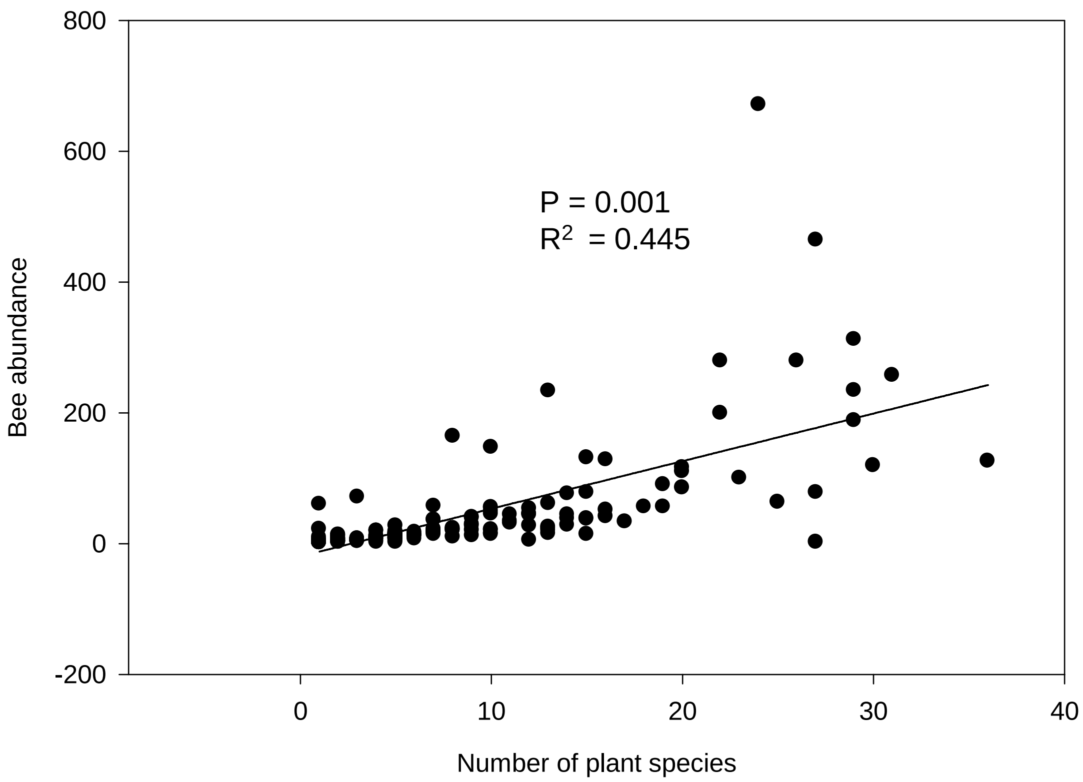


Fig. 4.17. Relationship between plant species richness and bee abundance. The number of plant and bee species were based on monthly records across the sites.

The most important bee plant in the edge community in the agroecosystem included *Tithonia diversifolia* (Plate 4.3) and *Acanthus pubescens.* Over 70 % of bee plants in the farmland were weedy species. They included *Bidens pilosa*, *Ocimum kilimandscharicum, Reichardia brasiliensis*, *Galinsoga parviflora* (Plate 4.4).

Plate 4.1 *Justicia flava*, the most attractive bee plant in open areas of Kakamega forest.

Plate 4.2 *Aspilia mossambicensis*, a common bee plant in open areas of Kakamega forest.

Plate 4.3. *Tithonia diversifolia*, a common bee plants along hedges and roadsides.

Plate 4.4. *Galinsoga parviflora*, a common bee plant in farmland.

4.4.4 Distribution of rare bee species

Rare bee species seemed to be randomly distributed across the sites. Species represented by less than 5 individuals in a particular site were regarded as rare. There was no significant difference across the sites ($\chi^2 = 6$, df = 6, $p < 0.42$), although according to Rényi diversity profiles there was a noticeable rarity in the early succession sites. The highest number of bee rare species according to sites was observed in the Guava bushland followed by farmland.

4.4.5 Habitat specificity

Although the highest number of species was recorded in the surrounding farming areas, the forest habitats were generally found to be richer in bees when all the species recorded in each site were combined (Fig. 4.18). In addition, some species were found to be habitat-specific, while the majority seemed to be randomly distributed across the regeneration gradient. About 26% of the species were forest-dependent, while 13% were farmland-dependent. Further details on site-dependent species in different families are as shown in Fig. 4.19 & 4.20. List of the individual species are shown in Appendices 8.3 & 8.4.

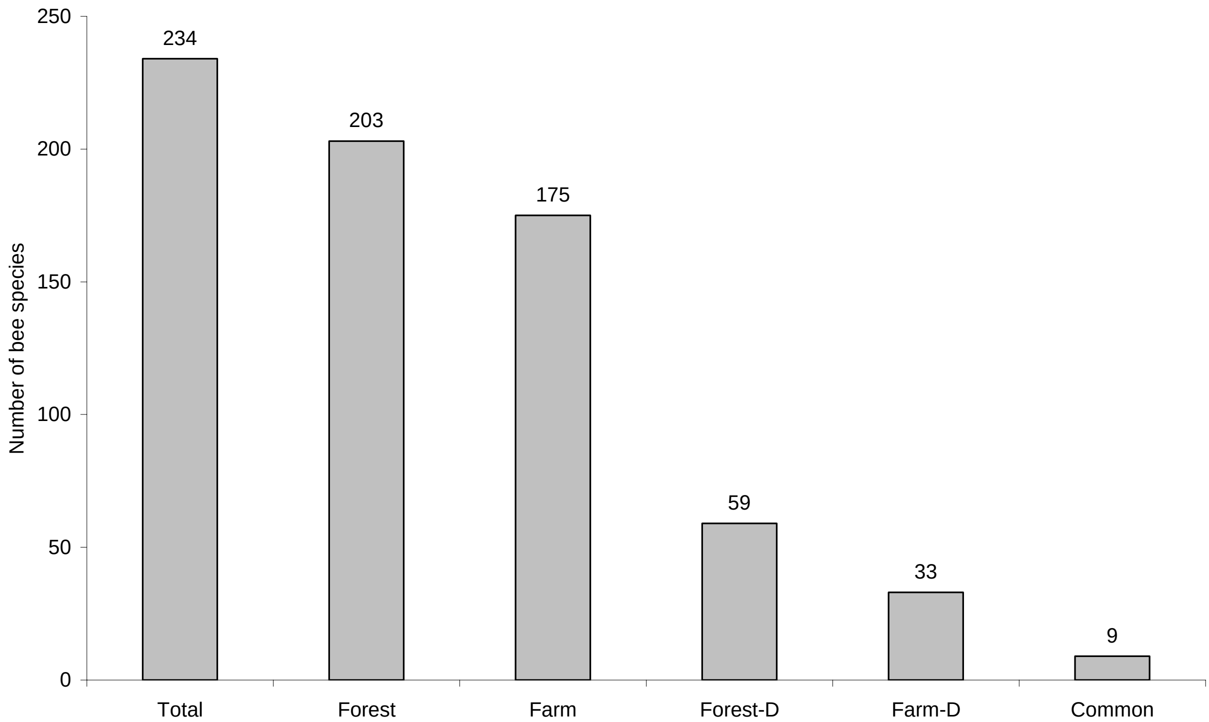


Fig. 4.18 Bee species distribution between forest and the surrounding agro-ecosystems (**Key**: **Forest-D** =.Forest dependent species, **Farm-D** = Farm dependent species).

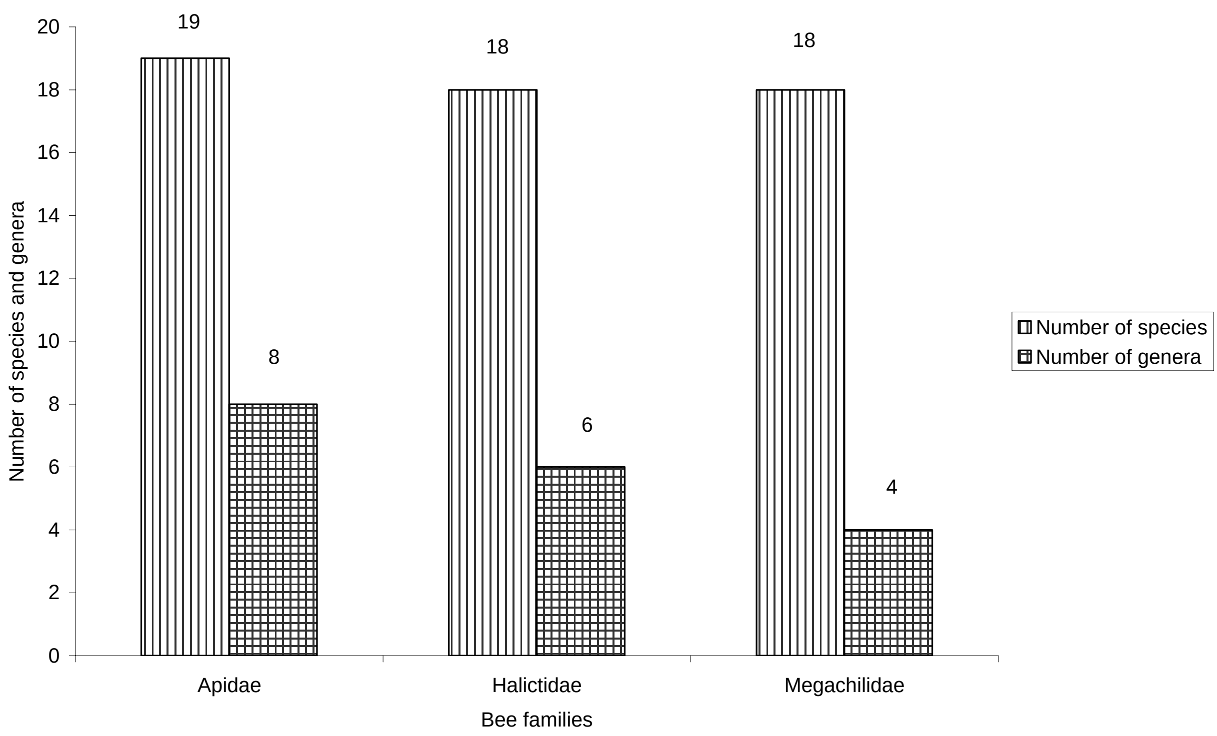


Fig. 4.19 Number of forest-dependent species and genera across the study sites.

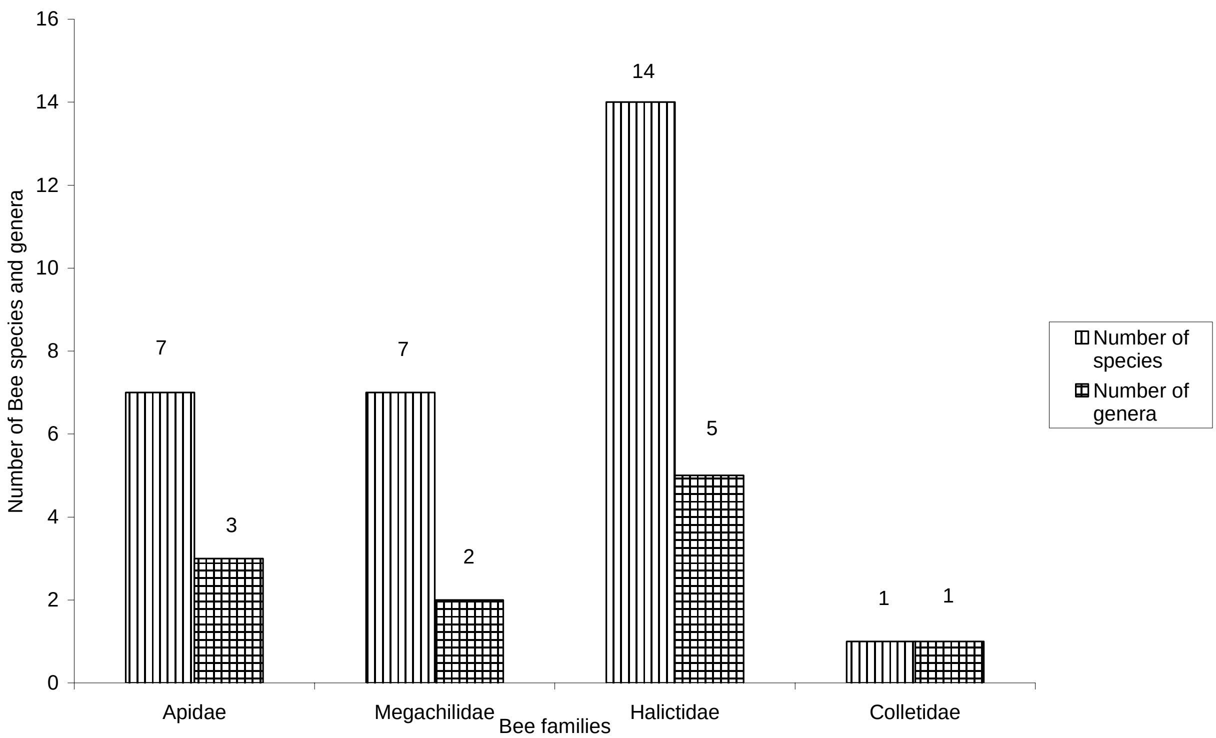


Fig. 4.20 Number of farmland-dependent species and genera.

According to One-way ANOVA test, there was a significant difference in the mean number of dependent species in the two sites (forest and farmland) based on the recorded bee families ($\chi^2 = 4.67$, df = 1, $p < 0.03308$). This analysis was based on both rare and common species, that is, both rare and common species were pooled together during the analysis. Means were later compared, using Tukey-Kramer HSD test and the *forest* was found to be quite different compared to farmland. However, no significant difference was found in relation to generic variation.

4.4.6 Habitat similarity

There was a general similarity between sites in relation to commonality in bee species composition, especially between those of almost similar age or vegetation structure (Table 4.1). According to Horn's index, R_o values were defined as follows: No similarity (0), Low similarity (0.55 – 0.60), Moderately similar (0.6 – 0.75), Highly similar (0 .75 - 0.99), and equal (1.0). The highest similarity was found between moderate secondary forest and young secondary forest while the lowest was between mature forest and pre-mature forest. Other sites with a high degree of similarity were young secondary forest and Guava bush land as well as farmland and Guava forest.

Table 4.1. Similarity of bee fauna of different habitats based on Horn's index**.**

	ASF	PF	MF	FL	YSF	MSF	GB
ASF	1	0.65	0.6	0.74	0.73	0.75	0.73
PF		1	0.55	0.78	0.71	0.7	0.7
MF			1	0.63	0.64	0.7	0.62
FL				1	0.81	0.83	0.83
YSF					1	0.85	0.83
MSF						1	0.82
GB							1

Key

ASF: Advanced Secondary Forest**; PF:** Pre-mature Forest**; MF:** Mature Forest; **FL:**Farmland; **YSF:** Young Secondary Forest; **MSF:** Moderate Secondary Forest; **GB:** Guava Bushland.

44.5 Discussion

4.5.1 Bee diversity

Although the findings of this study were based on understory communities, it was evident that the bee diversity was higher in the open areas and early successional and mid-successional stages as compared to mature forests. Increased light intensity in the open areas and secondary forests was suspected to favour the growth of perennials mainly the shrubs and herbs that were very attractive to the bees. Variation in the richness and abundance of bee visitors recorded was clearly linked to that of flower species. These results agree with the findings of (Rincón *et al.*, 1999; Liow *et al.*, 2002; Potts *et al.,* 2003). Similar observations were made elsewhere although in temperate habitat in calcareous grasslands where below-ground nesting solitary bees were more abundant on regularly or grazed sites with sparse vegetation and open soil, whereas the abundance of above-ground nesting bees increased with increasing cover of shrubs (Steffan-Dewenter and Tscharntke, 2000). In addition, Banaszak (1996) found a similar trend in Europe where environments arranged from cultivated areas to natural forests were characterized by a decrease in bee density and diversity.

Certain species of bees were, however, more dominant in young succession stages of the forest e.g. *Apis mellifera*, *Megachile* species and *Ceratina* species. Their dominance could be attributed to some factors that were not taken into consideration such as nesting preferences, as well as foraging behaviour. *Apis mellifera* was generally dominant in both open and young forests and riparian forest sites. This could be attributed to their mode of foraging behaviour, as well as their perennial large colonies. Honeybees are also known to be super generalists (e.g. Olesen and Jordano 2002) and floral density dependent. Given that they are long distance foragers, this increases their ability to visit distant and sparsely distributed floral-rich patches from their hives. According to some studies done in the Congo forest, honey bees can forage up to a distance of 25 km away from the hives (Roubik, 2000)

The number of site-specific species did not deviate much from the expected. Forest habitats were expected to be rich in micro-habitats, as well as in habitat-dependent species. However, narrowness of foraging ranges could be attributed to the localization of various species in a particular site. While the *Apidae*, *Megachilidae* and *Halictidae* seemed to be uniformly distributed in the forest, there was a clear difference in the farmland where *Halictidae* was the most dominant. Localization of solitary bees such as several species of *Halictidae, Apidae* and *Megachilidae* in open habitats was more pronounced in certain genera such as *Lasioglossum*, *Heriades*, *Megachile*, *Ceratina*. Most of the species from these genera nest in soil and in pithy stems of herbs and shrubs. The abundance of pithy stems in young forests, such as herbs and shrubs could have influenced their abundance. This finding agrees with that of Potts *et al.*, (2005) where they observed that availability of bare ground and potential cavities were the two primary factors influencing the structure of the entire bee community, the composition of the guilds, and also the abundance of the dominant species in different stages of post-fire regeneration in a Mediterranean landscape. Several species of genera *Pseudoanthidium, Heriades*, *Ceratina*, *Allodape*, *Braunsapis* were found to nest in pithy stems of particular plants such as *Ocimum kilimandascharicum* which was found only in the open areas as well as in the forest bushlands. O´Toole and Raw (1998) made similar observations where they observed that cavity nesting bees were more common in disturbed sites dominated by pithy plants; and such plants decrease as the forest grows.

Whereas other abiotic and biotic interactions could influence the distribution of bee species across the gradient, differences in vegetation structure, availability of nesting sites as well as their short foraging ranges could have limited their movement within the gradient. Similar observations on short foraging ranges of mainly 50cm by some *Ceratina* and *Halictus* species were made by Ginsberg (1983). However, the increased microhabitats for bees in the open areas such as vertical soil banks, muddy house walls, thatched roofs, open sandy areas, house rafts and compact soils along the road sides may have played a greater role in the diversity of bees more than other biotic factors (such as diversity and abundance of food plants).

4.5.2 Distribution of rare species

High species rarity in almost all the selected habitats did not deviate from what was expected. Basset (1997) argues that insect rarity in tropical rain forests may be an artifact resulting from a combination of high habitat diversity, contamination from these habitats and insufficient sampling effort. Conversely, bees are also known to be both coarse- grained and fine-grained insects (Roubik, 1999). Coarse-grained animals are those animals that share common resources but live in different habitats, while fine-grained animals are those animals that live in the same habitats but rely on different resources. Thus bees are good examples of vagrant insects that are often found in habitats where they do not belong and this increases their rarity in some habitats. On the other hand, emergence of rare bee species could be attributed to the blooming time of their host plants. Other studies have further shown that the emergence of certain solitary bees is governed by the blooming time of their host plants and that the distribution of their host plants directly influence their distribution (Minckley, 2000). For instance, during this study some oil collecting bees *Ctenoplectra* and *Ctenoplectrina* species were only sampled in the farmland where their host plant *Mormodica foetida* was found. In addition, some species of leafcutter bees were only recorded in farmland during the flowering seasons (May and November) of some legumes, such as beans, and the flowering of the indigenous leguminous vegetables during the dry season such as *Crotalaria brevidens.*

However, rare bee species were common in the open areas. This was attributed to foraging behaviour of the bees which is mostly dependent on their foraging ranges. Some trap-liner such as several species of *Amegilla* and *Xylocopa* were found to be more common in such areas. Similar observations were made by Liow *et al.* (2002) and Manuel *et al.* (1999). According to Manuel *et al.* (1999), rarity of native bees was higher in sunny and exposed sites. This observation agrees with the findings of the current study. On other hand, open bare sites seemed to attract particular species of bees especially the ground nesters. Most species of *Lasioglossum* were found mostly in farmlands where bare nesting sites were more readily available. Similarly, *Amegilla aff langi* was found to be not only a trap-liner but also a ground and house walls nester. It was mostly sampled in farmland on the raised soil banks of terraces made by farmers for reducing soil erosion or along the draining ditches in farmland and long forest paths. Occasionally, the muddy house walls offered better alternative sites for nesting to several bees in the farmland such *Megachile ithanoptera*, *Megachile ciacta combusta*, *Hypotrigona* species. Thus species rarity was found to be influenced by availability of floral resource, sunny open habitats, and diversity of micro-habitats for nesting.

In conclusion, bee diversity along the forest regeneration gradient was found to be highly influenced by the availability of flowering plants as well as nesting sites and materials for nesting which were more available in the younger forest sites. Thus, secondary forests are good bee reservoirs for the bees in tropical rain forests. Nevertheless, there is need to understand whether there is any degree of specialization or generalization in regard pollinator-plant interactions within successional habitats in order to manage the forest effectively. Further studies on generalization were conducted and reported in the next chapter.

CHAPTER FOUR

5.0 GENERALIZATION AND CONNECTANCE IN PLANT-POLLINATOR INTERACTIONS ALONG A SUCCESSIONAL GRADIENT

5.1 Abstract

The study was carried out with the objectives of establishing the degree of generalization and connectance in plant-bee interactions along a successional gradient in Kakamega forest. A high level of generalization was observed in eusocial bee species, as compared to solitary bees. The degree of generalization, measured as a percentage connectance, was however found to deviate from the expected, along the regeneration gradient or disturbance gradient. The expected trend was a decrease in generalization as the forest matures but a reverse of this trend was observed. Similarly, generalization was expected to increase with increase in plant species richness but the opposite of this trend was observed in both eusocial and solitary bees.

5.2 Introduction

Mutualistic interactions in real communities are highly nested (Bascompte *et al*., 2003), that is, there is a subset of generalist animals and plants interacting among themselves and also subsets of specialists interacting with generalists. According to Jordano *et al.* (2003) mutualistic interactions are also highly heterogenous. In this case, majority of species have fewer interactions while a few species are much more connected than expected by chance. Unfortunately, generalists have been viewed as the most vulnerable community in case of habitat destruction. This is because they depend on so many species they interact with. On the other hand, species that are less connected or connected by chance mostly the specialists are the first to disappear (Fortuna and Bascompte *in press*).

Mutualistic interactions are more pronounced between plants and pollinators or plants and seed dispersers. A co-evolution theory between plants and pollinators was envisaged by Darwin (1862), and since then there have been increased debates and reviews on specialization and generalization in the recent past (Waser *et al*. 1996; Ollerton, 1996; Johnson and Steiner, 2000). However, Waser *et al*. (1996) suggest that plant-pollinator systems are widely generalized. Generalization has been found to favour short-lived plants that depend on seeds for reproduction (Bond, 1994) while as specialization increases the reproductive success of long-lived or vegetative species (Waser *et al*. 1996; Bond, 1994).

Plant-Pollinator (P-P) networks have been used in the analysis of generalization at various ecological levels (Biesmeijer, 2005). Recent studies on P-P networks indicate correlates with latitudes (Ollerton and Cranmer, 2002), and altitudes (Malo and Baonza, 2002; Medan *et al.* 2002), rainfall (Devoto *et al.* 2005) as well as habitats (Biesmeijer, 2005). Further studies have revealed that habitat loss is affected by the network structure and this affects the mutual interaction between plants and animals. This is because animals such as pollinators cannot survive in a given patch without plants and on the other hand plants cannot reproduce without pollen vectors. Network structure has been useful in explaining emphirical plant species decline with habitat loss in plant-pollinator community (Asworth *et al.* 2004).

However, a lot has been documented on P-P relationships in many tropical countries (e.g. Roubik, 1989) but very little is known about the effect of food web on two–mode network of social and solitary bees, and their plants (e.g. Biesmeijer, 2005). Data on P-P networks in relation to bee communities along a succession gradient are still rare (e.g. Potts *et al.* 2001) especially at community level. Yet issues on generalization or specialization in early stages of succession remain unresolved (Baker, 1965; Gaasch *et al*., 2005). Unfortunately, data on tropical pollination networks are seldom in Africa. Such data would increase the understanding of the influence of particular environmental factors on structure and functioning of terrestrial ecosystems (Hawkins *et al.* 2003). It was against this background that this study endeavoured to investigate the level of generalization and connectance in plant-bee interactions along a succession gradient and the underlying factors behind it such as plant species richness and floral density.

5.3 Materials and Methods

The study was conducted in seven habitats selected according to the dominant tree species and plant physiognomy. Detailed descriptions for the selected seven sites are as given in the general introduction. The diversity and abundance of bees as well as bee plants were sampled monthly for two years using the belt transect method. Belt transects have been found to be the most effective active sampling methods for bees (details of sampling bees on flowers are as given in chapter 4). In addition, the number of open flowers along the belt transects was counted after the first sampling exercise every month for a period of 22 months (July, 2002 – April, 2004).

5.4 Data analysis

In order to analyse the level of generalization in the selected habitats, a Two-way bee-food plant network was defined as a matrix following the method used by Olesen and Jordano (2002), and Biesmeijer (2005). Network size (M) was given by M = BP, where B and P were the number of interacting bees and plants in the habitat, respectively. M was used as a measure of maximum possible number of interactions in a habitat. The level of generalization was then calculated using the number of observed interactions (I) and the connectance (C), where C = 100 I / M. Connectance was then calculated as the percentage of all possible interactions observed within a network. Linear regression models and correlation tests were then carried out to establish the relationships between BP, M, I and C on each other, for both eusocial and solitary bees. Variation in connectance across the study sites was analysed using Wilcoxon-Kruskal / Wallis test. To identify the sites that were very different from others, pairs of means were compared using Tukey Kramer test at alpha = 0.05.

5.5 Results

5.5.1 Generalization and connectance across the habitats

Six species of eusocial bees foraging on 123 plant species and 228 species of solitary bees (including some semi-social *Lasioglossum* species) and 167 bee plants were considered for analysis respectively. With the eusocial bees community, the number of interactions in the different habitats ranged from 1- 198 (mean 17.45) and increased with the network size (I = 2.64 + 0.34M), $p < 0.0001$, $R^2 = 0.83$, $F_{(1, 33)} = 167.11$). Connectance (C) ranged from 24.48 – 100 % (mean 53.54) and decreased linearly with network size (M or BP) (C = 62.51 – 0.21M), $R^2 = 0.21$, $p < 0.005$, $F_{(1, 33)} = 8.98$) (Fig.5.1(a)), and also with the bee species richness across the sites (C = 89.52 – 11.66M), $R^2 = 0.51$, $P < 0.0001$, $F_{(1, 33)} = 35.24$) (Fig. 4.18(c)). Similar variation in connectance (C = 33.17 + 5. 09 S), $R^2 = 0.18$, $p < 0.01$, $F_{(1, 33)} = 7.47$) across the seven habitats to those of solitary bees were obtained on carrying out a 1-way Test based on Wilcoxon/Kruskal-Wallis test ($\chi^2 = 13.90$, df = 6, $P < 0.03$) (Fig.5.1(b)). With the help of Tukey Kramer Test, the mature forest site, followed by young secondary forest were found to be slightly different from the other successional sites. Plant species′ richness along the regeneration gradient seemed to influence the degree of connectance to some extent (C = 66.42 + 1.16P, $R^2 = 0.21$, $F_{(1, 33)} = 8.88$, $p < 0.0054$) (Fig. 5.1d)). In addition, the low connectance in younger or more disturbed sites could also be attributed to the observed high floral density (Fig. 4.19), ($R^2 = 0.83$, $P < 0.0042$, $F_{(1, 5)} = 24.78$).

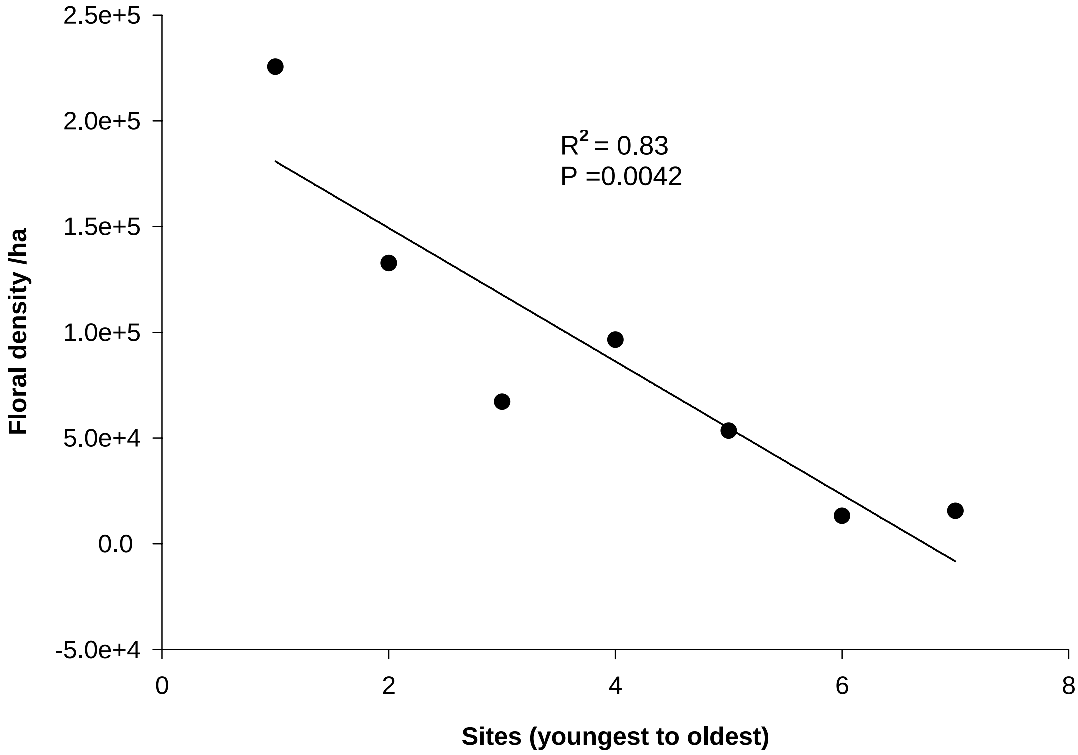
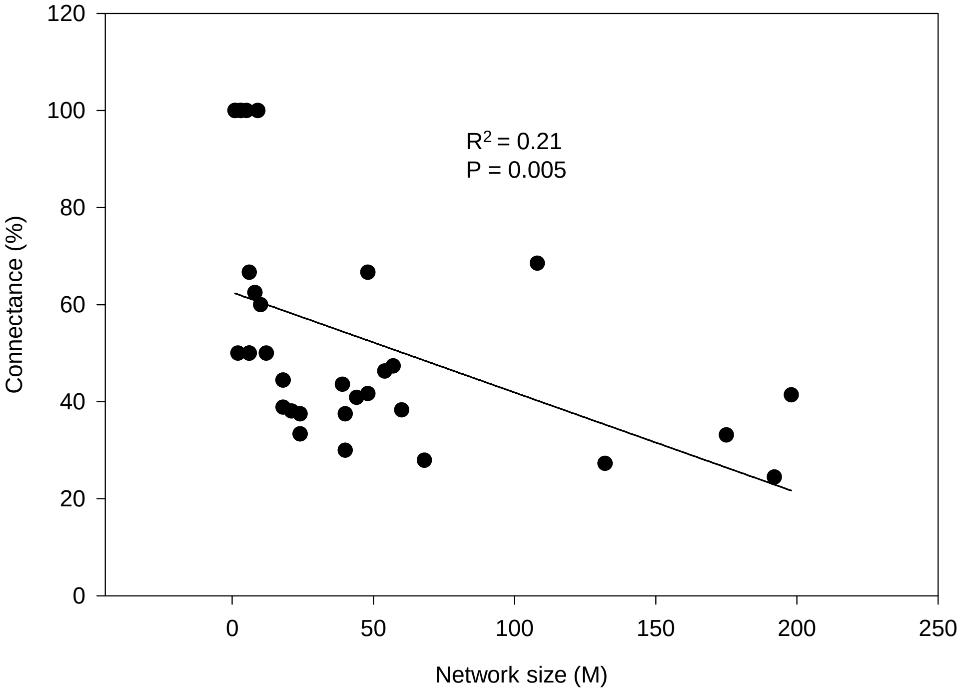


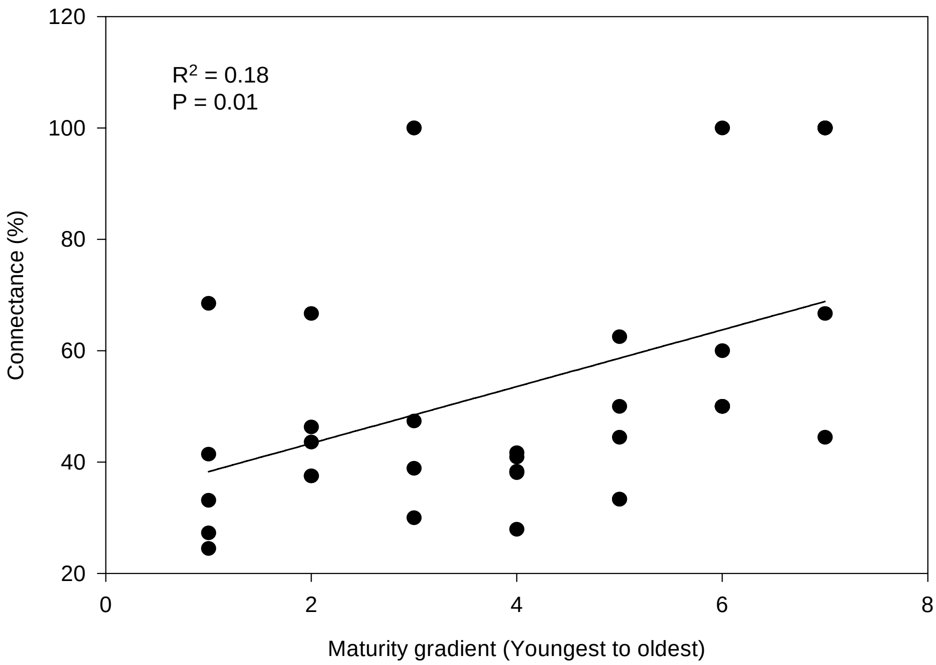
Fig. 5.1. The relationship between forest maturity gradient and floral density.

The number of interactions in solitary bees ranged from 3-203 (mean 59.4) and increased significantly with network size (I = 10.98 + 0.051M), $p < 0.001$, $R^2 = 0.94$, $F_{(1, 32)} = 462.46$). Connectance (C) ranged from 4.84 % to 22.85 % (mean 8.69) and decreased linearly with the network size (Fig.5.3(a)) as well as with the total number of bee species per site per season (C = 12.63 – 0.108B), $P < 0.001$, $R^2 = 0.29$, $F_{(1, 32)} = 13.46$) (Fig.5.3(c)). Further analysis based on Wilcoxon/Kruskal-Wallis test indicated that connectance differed among the seven habitats (1-way Test, $\chi^2 = 13.40$, df = 6, P < .03) (Fig.5.3(b)). Pairs of means were then compared using Tukey Kramer test and the *mature forest* site followed by the *Advanced secondary forest* were found to be slightly different from the others.

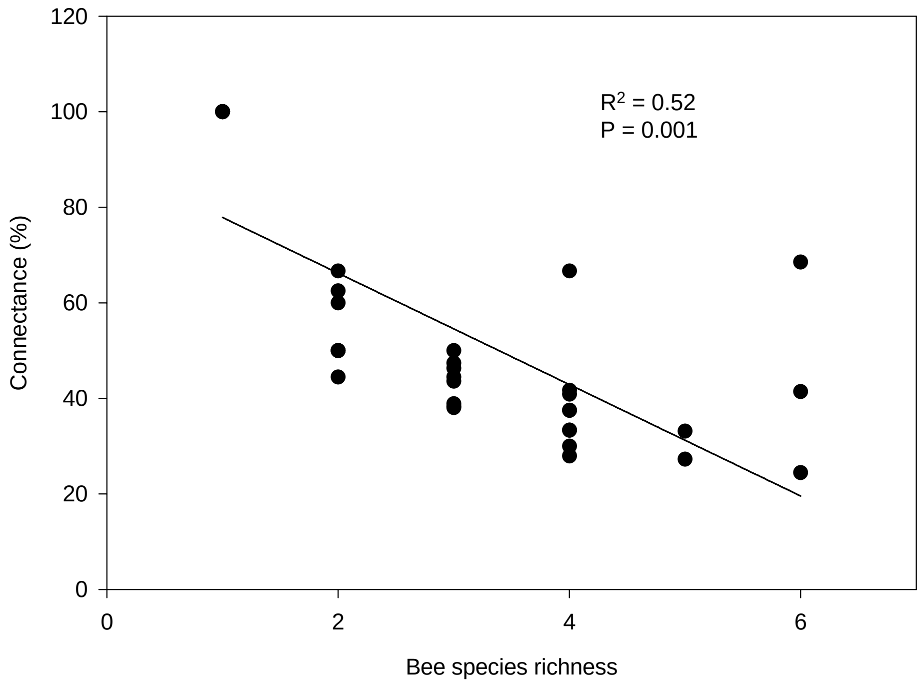
To have a clearer understanding of connectance among the solitary bees, connectance was also analysed against the plant species richness and a correlation was recorded, although the power of stastistical test (0.19) was below the desired value 0.8 (C = 12.93-0.20P, $R^2 = 0.29$, $F_{(1, 32)} = 13.69$, $p < 0.008$) (Fig. 5.3(d)). Based on the above results, generalization measured as percentage connectance in plant-bee networks was found higher in eusocial bees as compared to solitary bees. Surprisingly, the generalization was found to increase with forest maturity gradient in contrast to the expected trend.



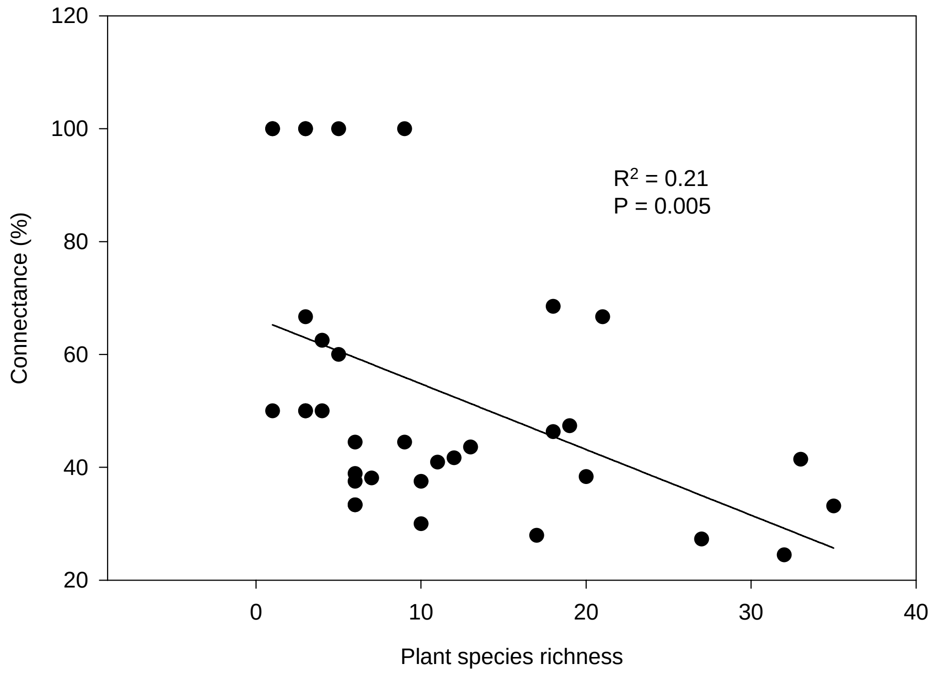
a)



b)

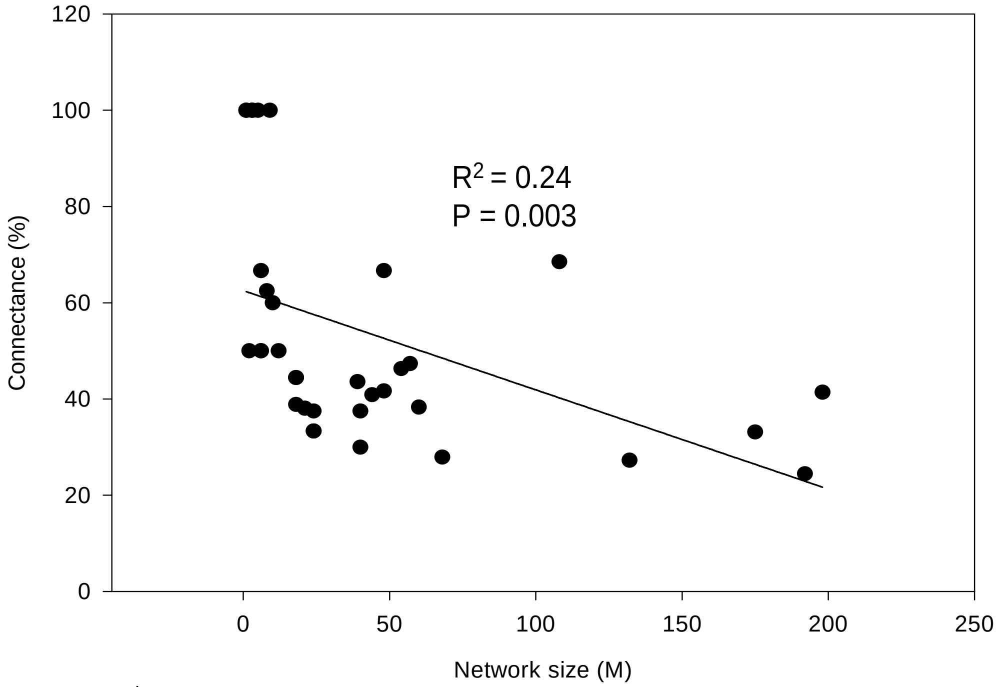


c)

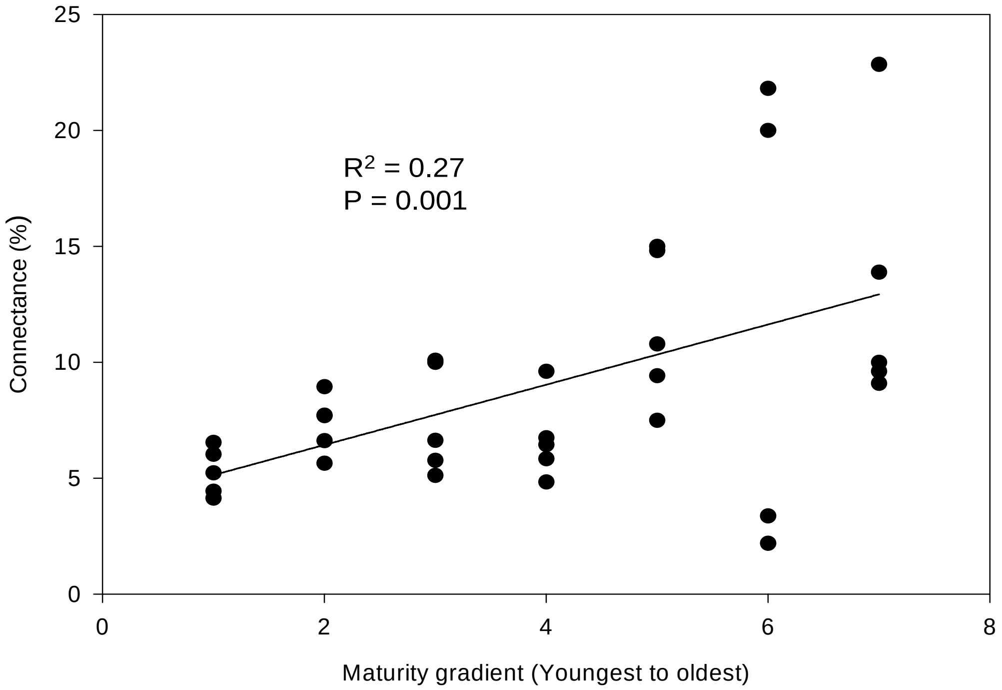


d)

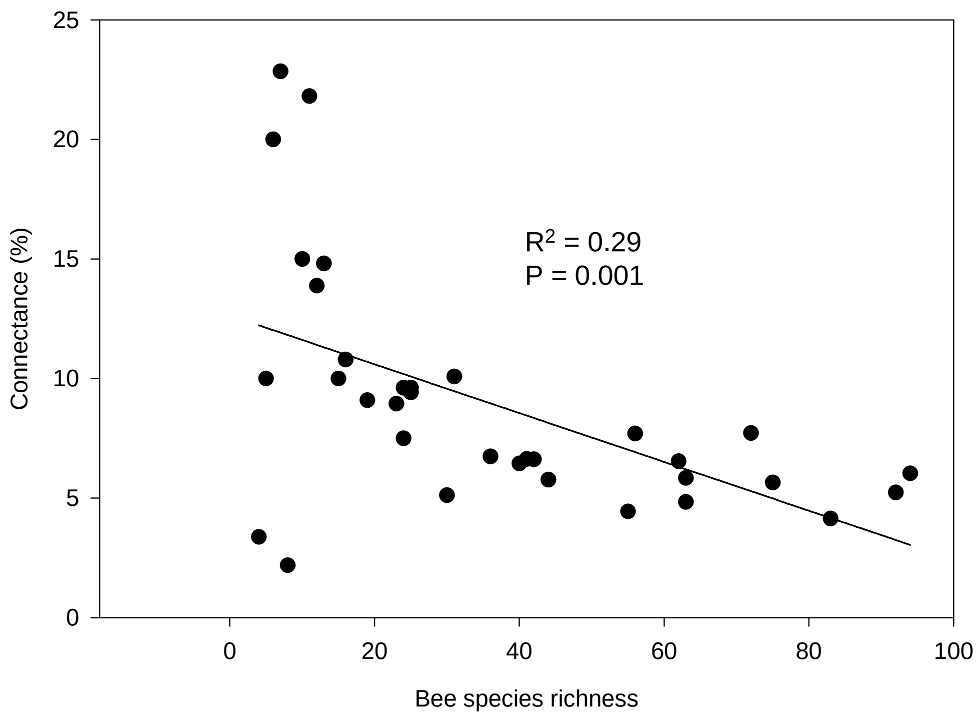
Fig. 5.2 (a) Relationship between connectance and network size in eusocial bees, (b) Variation of eusocial bees connectance along a forest maturity gradient, (c) Relationship between connectance and eusocial bees species richness and (d) Relationship between connectance and bee plants diversity.


120
100
80
60
40
20
0
Connectance (%)
R^2 = 0.24
P = 0.003
0
50
100
150
200
250
Network size (M)

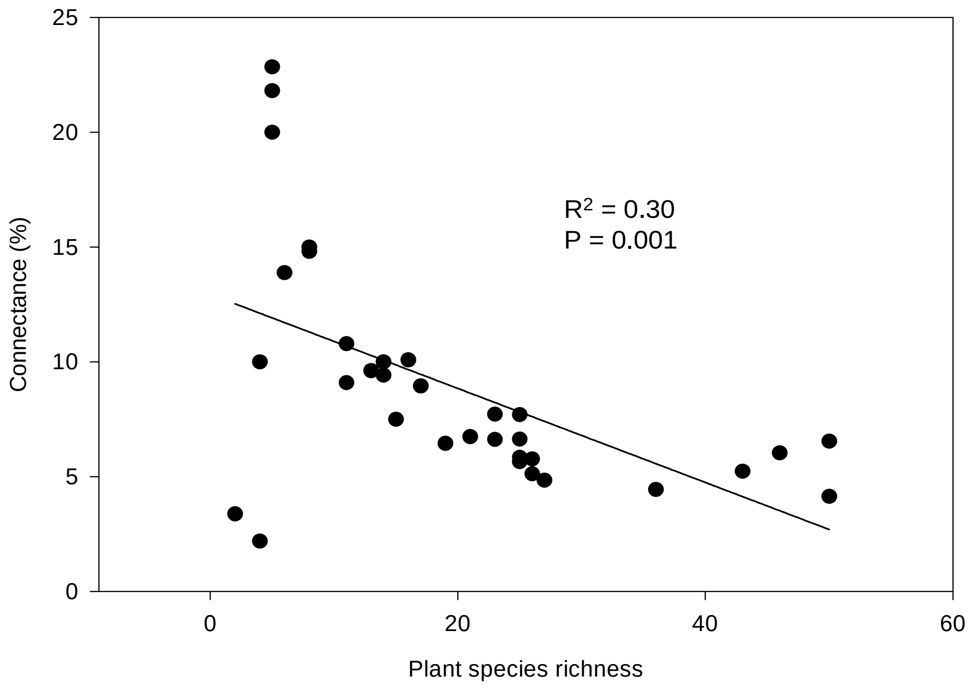
a)


25
20
15
10
5
0
Connectance (%)
R^2 = 0.27
P = 0.001
0
2
4
6
8
Maturity gradient (Youngest to oldest)

b)



c)



d)

Fig. 5.3. (a) Relationship between connectance and network size in solitary bees, (b) Variation of solitary bees connectance along a forest maturity gradient, (c) Relationship between connectance and solitary bees species richness, and (d) Relationship between connectance and plant diversity in solitary bees.

5.6 Discussion

5.6.1 Patterns of interactions between bee and plants

Lack of plant-pollinator studies, especially on bee fauna, limits fair comparisons of the findings of this study with other studies in tropical Africa. The findings could only be compared cautiously with those of neotropics, due to some major differences that exist between the two areas. Firstly, the diversity of bees in neotropics is generally higher and different from that of African tropics. Secondly, more studies on pollinator-plant interactions have been conducted in the neotropics. However, the results of this study show that there was a high level of generalization as opposed to specialization in both eusocial and solitary bee species along the regeneration or disturbance gradient. This view was also corroborated by other viewers who observed that plant-pollinator interactions are mostly generalized in tropical forests (Waser *et al.*, 1996) where a plant species is visited by more than one insect species and each insect visits several plant species (Neff and Simpson, 1993; Waser *et al.*, 1996). Further studies by Diego and Simberloff (2002) point out that plant-pollinator interactions tend to be asymmetric with no relationship between the degree of specialization of a given species and the degree of specialization of its interaction partners. According to Rincón *et al.* (1999), association of a closed-forest bee fauna with pioneer plants was an evidence of foraging generalization in the bee species, both with regard to plant taxa and microclimate or other small-scale environmental conditions within the forest.

Nevertheless, a relationship between network size (M) and connectance (C) was found in both eusocial and solitary bees. This observation agrees with the findings of Jordano (1987) and Devoto *et al.* (2005). Connectance decreased very significantly with network size. On the other hand, the degree of generalization among eusocial bees was higher than that of solitary species. These results agree with the findings of Biesmeijer *et al.* (2005). However, the average generalization in eusocial bees deviated from that of Biesmeijer *et al.* (2005) and Olesen and Jordano (2002) which was 19 % and 11 % respectively. During this study, the average generalization in eusocial bees was 53.34 %. This deviation could be attributed to bee species´ richness. Recent studies have shown that the degree of connectance is highly influenced by species richness and that it is higher where the species richness is low (Waser *et al.*, 1996; Biesmeijer *et al.*, 2005). In this study, there were only six eusocial bee species in Kakamega Forest, as compared to 72 species sampled from different habitats of Brazil by Biesmeijer *et al.*, (2005). Conversely, the degree of connectance among 228 solitary species was low and had an average connectance of 8.69 % owing to their high species richness.

The degree of generalization, measured as a percentage connection, was however found to deviate from the expected, along the regeneration gradient or disturbance gradient. The expected trend was a decrease in generalization as the forest matures but a reverse of this trend was observed. Similarly, generalization was expected to increase with increase in plant species richness but the opposite of this trend was observed. These findings contrasted the observations made by Baker (1965), where he pointed out that generalization would be expected in colonizing weedy species, because these require a high degree of reproductive assurance. In support of this view, Feinsinger (1983) argues that dispersed understory shrubs and epiphytes tend to have specialized pollination systems, while mass-blooming trees often are pollinated by a variety of generalist insects. However, the increased generalization along a maturity gradient could be attributed to low floral density (Fig. 5.2) of bee plants in the understory. especially in the mature forest where the floral density was low. According to optimal foraging theory, generalization would be expected to be high where the floral resources are low.

Habitat has also been found to influence connectance or generalization (Biesmeijer *et al.*, 2005) although on the other hand species richness is dependent on habitat and the diversity of microhabitats within a given site. In this study, connectance was also suspected to be influenced by the habitat. Other factors that were suspected to influence connectance or generalization included collectors, taxonomy, sampling methods, timings of sampling and duration of sampling. For instance, long-term studies tend to show more generalization as compared to short studies. This is because some plants flower longer and outlive their flower visitors flight period and this increases visitation from even the rare species. Alternatively, pollinators too outlive the flowering period of any one plant species. Examples of such species from this study include *Xylcopa calens*, *Ceratina ericia*, eusocial bees (*Apis mellifera*, *Meliponula bocandei*), *Megachile rufipes.* The current study was undertaken on monthly basis for a period of two years and this could be one of the reasons why the degree of generalization was higher than in the other studies conducted in neotropics and other tropical countries. Secondly, the method of collecting data on bee-plant interactions may have underestimated the degree of connectance given that the canopy bees were not sampled. In addition, neither the stored pollen in the nests nor the external pollen found on bee bodies were analyzed and this may have led to underestimation of connectance level. Nevertheless, the results of this study provide a clear indication of high resilience within bee-plant communities of Kakamega

Forest. However, high generalization may affect the rare plant species fitness because they are likely to benefit more from the specialists (Waser *et al*., 1996).

6.0 GENERAL DISCUSSION

6.1 Bees and habitat conservation

The reproductive ecology of bee species of the Eastern Africa tropical rain forests is one of the most poorly documented disciplines in natural history. Among the insect fauna, bees are the least studied group of invertebrates (Hoffman, 1992). Bee conservation is currently faced with challenges of limited knowledge in taxonomy, population dynamics, diversity, feeding habits, as well as their nesting biology. According to Gaston *et al* (2000), population persistence is more dependent on the number of individuals. Banaszak (1992) argues that bee populations provide a basis for biomonitoring, prognosis for yields of crops and insights on rules of occurrence in a landscape.

The current data on bee-plant interactions provides sufficient justification as to why Kakamega forest and the farming areas surrounding should be preserved. This is because bees play a pivotal role in the maintenance of pollination service in the ecosystem.. Most of the datasets on bee-plant interactions that are available in Kenya are mainly on honeybees. Besides the efforts to conserve bee plants, it is important to understand that bees require a lot of resources, including non-floral resources, for their survival. Examples of such resources are resins, mud, water, “safe” nesting sites such as slope-exposed soils, dead wood, pithy herbs and shrubs. Kakamega forest has been undergoing tree logging – a major threat to the bees – as it denies them suitable nesting sites. Bees prefer huge trees with 10-40 % dead wood (Byrugaba, 2004). Cavity nesting bees such as honey bees, stingless bees, leafcutter bees, and carpenter bees are the most affected. The huge trees that normally provide nesting sites for bees have, unfortunately, been the target of loggers over the years. During this study, the few colonies of bees such as *Meliponula bocandei* and honey bees recorded were only found in *mature* forests with huge old trees. However, some cluster builder stingless bees such as *Hypotrigona gribodoi* were found mainly nesting in muddy house walls.

Unfortunately, conservation of refugia sites for bees continues to pose a serious challenge. Such sites include forest pathways and roadsides, which are often cleared without much consideration as to their role in pollinator conservation. In the secondary forests, several bees were found to nest along such paths with bare and compact soils. Examples of bee species found nesting in such sites include *Megachile ithanoptera* and some species of the genus *Thyreus*. Most of the species in the genus *Megachile* were found to be ground nesters. These species were found to be more endangered in the farming areas where the farmers, who are oblivious of their existence destroy their nests. Other solitary species, such as *Xylocopa*, were found to be equally endangered – largely because of their preference to nest in roofing rafts. Most farmers burn and destroy their nests because they regard them as wasps or pests of timber. Majority of carpenter bees have, therefore, no suitable trees to nest in, both in the forest and in the farming areas – yet they are known to be the most effective bees in gene flow between plant populations.

The hedgerow plant community was found to play a key role in bee conservation. Some plant species such as *Tithonia diversifolia*, *Caesalpinea decapetala*, *Acanthus pubescens*, *Lantana camara* and other hedgerow community species runners and herbs e.g. *Thunburgia alata*, *Crassocephalum vitellinum* were found to support both the forest and farmland bees. Stingless bees were more abundant on *Tithonia diversifolia* and *Caesalpinia decapetala* especially in the sites that were close to the forest. Several species of carpenter bees were also highly attracted to *Caesalpinia decapetala*. This plant was also common along the forest edges. Increased clearing of the edges and demand for fuel were, however, found to be a major threat to bee plants because the local people do not have alternative trees for firewood.

Nevertheless, the bee fauna in the farms neighbouring Kakamega forest was found to be less threatened by human factors. This is because of the existing mode of cultivation and the degree of land intensification. The local community cultivates their land during the Long Rains season, which starts in March facilitating the growth of crops that are harvested in July and August. After the harvest the land is left fallow until the next Long Rains season. This enhances the growth of herbs and shrubs, which provide rich food sources for bees. In addition, farmers around the forest were found not to use chemicals such as fungicides or herbicides, unlike many farmers in other parts of Kenya, especially around Mt. Kenya forest where the surrounding farms pose as ´’poisoning grounds´´. Hence the low pollinator diversity and abundance around Mt. Kenya forest.

6.2 Bees and Forest disturbance

Protecting old native trees and unharvested reserves within the forest landscape offers some insurance to declining forest biodiversity, but maintaining key animal populations is also necessary for long-term viability; this may require additional attention (Howe & Westley 188). Availability of large, old and hollow trees has been found to benefit pollinators such as bees and seed dispersers as they offer nesting or resting sites (Gordon *et al.*, 1990).

Unfortunately, with the current degradation of forests, such trees have been lost in many tropical forests and such losses can lead to long-term consequences (Gordon *et al.*, (1990) with the resultant inexplicable declines or failures in forest regeneration around the world.

A certain degree of habitat disturbance, however, favours bee diversity (Liow 2001). During this study, the majority of bee species were found to benefit from disturbed or secondary forests. Similarly, natural forest gaps were found to attract a lot of bees because of the presence of invader-bee plant species such as *Justicia flava*, *Solanum spp.* Species that forage in habitats of high humidity in the understory community are, however, affected by canopy opening (Rincón *et al*., 2000). Certain species of the genus *Xylocopa* such *Xylomellisa* sp1 were found to predominate the understory foragers. Some species of bees were found to be more common in the understory community of closed canopies. Examples of such species were *Xylocopa* (*Xylomellisa* sp 1), *Xylocopa varipes* and *Amegilla* (*Aframegilla* sp. 1). Extreme opening of the canopy would affect such species – especially *Amegilla* (*Aframegilla sp 1*) which was only collected in the mature and advanced secondary forests. Territorial bees would, at the same time, be more affected by forest degradation than other bees because they require their female numbers and food resources in a given habitat to be guarded. Some species of the genus *Xylocopa imitator* were found to prefer the *pre-mature forest* and *mature forest* where abundant and safe nesting sites were available. The male herds were found to congregate and fight each other around the female nests.

6.3 Bee conservation in protected areas

Studies conducted by Gordon *et al.* (1990) showed that Central-American forest pollinators depend on non-forest areas outside gazetted reserves. Similar observations were documented in this study where various plant species, including crops, were found to support the forest bees, especially when most of the flowering plants in the forest were not in bloom. This implies that the surrounding agroecosystems to the protected areas need to be included in long-term management of forest biodiversity. Based on the knowledge derived from this and other studies in tropical forests from other continents, it is very clear that strictly protected areas will never be an absolute solution to conservation of a wide diversity of bee species as well as other animal species. The fate of majority species of pollinators, such as bees, depends upon what happens within the protected areas, as well as outside the protected areas. Maintenance of a healthy successional gradient within a protected reserve would ensure enough resources for bees throughout the flight season. Habitat heterogeneity and structural diversity are among the most important determining species-rich communities in natural forest settings. But the main question remains, what kind of data are available to guide the forest managers on how to manage and preserve particular habitats? To do this, there is need for a concerted effort and multi-disciplinary studies. This would also involve overlying of fauna data, including other pollinators and seed dispersers in order to have a common understanding on the most crucial corridors, vertical and horizontal stratification of vegetation structure for pollinator and general biodiversity conservation.

6.4 Conclusions and recommendations

6.4.1 Conclusions

In conclusion, bees need a diversity of habitats within a given community. It is not enough to conserve undisturbed patches of forest for bees and ignore the ``ugly´´ ones such as secondary forests. A high degree of generalization was found to characterize the bee fauna of Kakamega Forest and this view agrees with other observations made in other tropical countries (Waser *et al*., 1996)

6.4.2 Recommendations

- The management strategies to conserve the forest pollinators must incorporate riparian zones, as well as involvement of the local community who are the custodian of biodiversity. Further studies are therefore needed for the establishment of the right zonation of bee reserves, both inside and outside the forested areas.

- Seasons and habitat heterogeneity dictate what kind of bee species utilize the available resources, either in terms of food, mating or nesting in space and time and efforts to conserve particular species of plants or bees should be made.

- Bees are vagrants; there is urgent need to increase public awareness through community workshops, on their importance as pollinators and indicators of habitat quality.

- More studies should be conducted on their nesting behaviour and site preferences. In addition, more pollination studies on rare and endangered plant species should be carried out in order to conserve the pollination service.

- Increased beekeeping, especially stingless bees (Meliponiculture) should be encouraged in the region; there is also urgent need to educate the community on how to rear them.
- There is urgent need to increase capacity building in bee taxonomy and pollination biology in order to conserve pollination service and bee fauna in Kenya.

- Regular biomonitoring of bee fauna should be conducted after every three years given that Kakamega Forest is faced with anthropogenic factors like any other natural habitat in the world. This will provide insights of pollinator population status and habitat quality in the forest and the surrounding agro-ecosystem.

- With the increased forest fragmentation in Kakamega Forest over the years, there is need to study dispersal corridors for bees and seed dispersers. This calls for more studies on impact of forest fragmentation on gene flow in plant populations in regard to pollinator movements.

SUMMARY

This study aimed at establishing bee species composition and diversity, bee-plant interactions and some aspects of generalization and connectance along a forest regeneration gradient in Kakamega Forest. This project was prompted by the fact that there was no comprehensive data on bee diversity as well as bee-plant interactions and this was the pioneer study. Secondly, based on the current global outcry on pollinator decline, it was of necessity to urgently document the bee fauna in the only remnants of Guineo-Congolian forest in Kenya in order to conserve and manage bees for the pollination service. To determine the bee species composition in Kakamega Forest, data was collected from past records and qualitative surveys in all the forest fragments. Further data on bee variation and sites similarity along a forest regeneration was collected within Buyangu National Reserve. Bees were sampled using sweep nets along belt transects for a period of two years, that is, May 2002 to April 2004. In order to analyze and compare bee diversity in different sites, the most robust diversity index, that is, Rényi's diversity family was used. About 243 species of bees represented in four families, of which 234 were sampled in Buyangu Nature Reserve were recorded during the study. These families included Apidae, Halictidae, Megachilidae and Colletidae.

The abundance and diversity of bees were found to be influenced by floral diversity as well as changes in vegetation structure. The highest species richness and bee diversity were recorded in the open areas, followed by secondary forests. In addition, 40 families of plants representing 190 species of plants were found to support the bee community. The most important plant families included Acanthaceae, Asteraceae and Papilionaceae. A high degree of resource sharing based on niche overlap values was observed between the highly eusocial and the dominant solitary bee species, although the eusocial bees showed the largest niche breadth. Similarly, generalization was more pronounced among the eusocial bees as compared to solitary bees. The results from this study agreed with the expected trend of increased diversity in secondary forests as compared to mature forests. In contrast, generalization was found to increase with forest maturity.

In conclusion, the study clearly indicates that bees require a diversity of microhabitats. Secondary forests and the open areas surrounding offer the best refugia sites for bees especially when there is floral dearth in the forest. On the other hand, the bees cannot survive without the forest for it offers nesting sites and abundant floral resources especially during the

dry season when there are no flowers in the open areas. Based on the current results, Kakamega forest stands out as one of the best bee hot-spots in East Africa.

The study recommends that the policy makers, forest managers and the local community to be trained on the importance of bees and their mutual relationships with plants. Farmers need to be trained on how to protect the bees given that majority of forest bees move into the farming areas to forage and vice-versa. Regular community workshops for different categories of people should be conducted in order to increase awareness on important pollinators such as bees. In addition, the study advocates further research in pollination biology of wild plants especially on rare plants given that a high level of generalization was documented among the eusocial and solitary bees but little is known on plants' perspective.

Finally, I wish to recommend establishment of bee reserves within the forest with a diversity of habitats. This is because the future of forest biodiversity conservation as well as the pollination service seems to be dependent on holistic management of secondary forests and the surrounding agro-ecosystems. A further research on whether to alter the natural forest regeneration process should be conducted in order to save the bees for the forest and the forest for the bees.

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Appendix 8.1. Bee-plant interactions in different months

BEE FAMILY, SPECIES AND PLANT FAMILY	MONTH (S) RECORDED	BEE PLANTS
APIDAE		
Allodape ?mirabilis	VII	
Lamiaceae		*Leucas sp. A*
Allodape ?chapini	VIII	
Lamiaceae		*Ocimum gratissimum L.*
Allodape derufata	X-XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Crassocephalum montuosum* (S.Moore) Milne-Redh
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Ocimum gratissimum* L.
Allodape interruptus	I-VI, IX-XII	
Acanthaceae		Acanthaceae sp. 1
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Blepharis rotundifolia*
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum montuosum* (S.Moore) Milne-Redh
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Convolvulaceae		*Ipomoea batatas* (L.) Lam.
Convolvulaceae		*Ipomoea* sp.
Brassicaceae		*Gynandropsis gynandra* (L.) Briq.
Lamiaceae		*Hoslundia opposita* Vahl
Lamiaceae		*Leucas* sp.
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia* sp.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Sapindaceae		*Allophylus ferrugineus* Taub.
Verbenaceae		*Lantana camara* L.
Zingiberaceae		*Aframomum angustifolia*
Allodape macula	I,III,VII-IX,XI	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum* sp.
Piperaceae		*Piper umbellatum* L.

***Allodape* sp. 1**	II, VII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Allodape* n. sp.**	II	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Amegilla (Aframegilla* sp. 1)**	III-V, VII, XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Solanaceae		*Solanum seafathianum*
Verbenaceae		*Stachytarpheta jamaicaensis*
***Amegilla (Megamegilla* sp. 1)**	I-XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Convolvulaceae		*Ipomoea batatas* (L.) Lam.
Lamiaceae		*Lamiaceae sp. B*
Malvaceae		*Pavonia* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Caesalpinia decapetala* (Roth) Alston
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum tuberosum*
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
Amegilla ?caelestina	I, IV-VI, X-XI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Caesalpiniaceae		*Senna didymobotrya* (Fresen.) Irwin & Barneby
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Mussaenda arcuata* Poir
Verbenaceae		*Stachytarpheta jamaicaensis*
Amegilla ?cymatilis	II-III, IX, XI	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Brassicaceae		*Gynandropsis gynandra* (L.) Briq.
Asteraceae		*Vernonia lasiopus* O. Hoffm
Acanthaceae		*Justicia flava* Vahl
Amegilla acraensis	I-III, VI-VII, XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild

Amegilla aff langi	I-V, VII-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Amaranthaceae		*Amaranthus* sp.
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia lasiopus* O. Hoffm
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Commelinaceae		*Commelina* sp.
Brassicaceae		*Gynandropsis gynandra* (L.) Briq.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Leonotis nepetifolia* (L.) R.Br
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Rotheca myricoides* Oliv.
Malvaceae		*Hibiscus* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Oxalidaceae		*Oxalis* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Dyschoriste radicans* Nees
Papilionaceae		*Phaseolus aureus*
Papilionaceae		*Indigofera* sp.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Solanaceae		*Lycopersicum esculentum*
Solanaceae		*Solanum incanum* L.
Solanaceae		*Solanum melongena*
Sterculiaceae		*Dombeya burgessiae* Gerrard
Verbenaceae		*Stachytarpheta urtifolia*
Verbenaceae		*Stachytarpheta jamaicaensis*
Amegilla capensis	IX-X, XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Vernonia* sp.
Amegilla fallax	III, V, VII	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Vernonia ?hymenolepis*
Papilionaceae		*Crotalaria brevidens* Benth.
Amegilla mimadvena	IV-VII, IX-XI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Rotheca myricoides* Oliv.
Malvaceae		*Sida* sp.
Malvaceae		*Pavonia urens* Cav.

Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Solanaceae		*Solanum tuberosum*
Amegilla sierra		
Asteraceae	V	*Tithonia diversifolia* (Hemsl.) Gray
***Amegilla* sp. 1**	I, XI-XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Ageratum conyzoides* L.
Anthophora aff vestita	VI-X	
Acanthaceae		*Aspilia mossambicensis* (Oliv.) Wild
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Bothriocline fusca* (S.Moore) M. Gilbert
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Helichrysum* sp.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Sida* sp.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Solanaceae		*Lycopersicum esculentum*
Solanaceae		*Solanum mauritianum* Scop
Tiliaceae		*Triumfetta rhomboidea* Jacq
Verbanaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
Apis mellifera	I-XII	
Acanthaceae		Acanthaceae sp. 1
Acanthaceae		Acanthaceae sp. 2
Acanthaceae		*Acanthus eminens* C. B.Cl.
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Amaranthaceae		*Amaranthus* sp.
Apocynaceae		Apocynaceae sp 1
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		Asteraceae sp. 1
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum crepidiodes* (Benth)
Asteraceae		*Crassocephalum* sp.

Asteraceae	*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae	*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae	*Galinsoga parviflora* Cav.
Asteraceae	*Guizotia reptans* Hutch
Asteraceae	*Helichrysum schimperi* (Sch. Bip)
Asteraceae	*Richardia brasiliensis* Gomes
Asteraceae	*Tagetes minuta* L.
Asteraceae	*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae	*Vernonia lasiopus* O. Hoffm
Asteraceae	*Vernonia* sp.
Balsaminaceae	*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Caesalpinaceae	*Caesalpinia decapetala* (Roth) Alston
Caesalpinaceae	*Chamaecrista hildebrandtii* E. Meyer
Combretaceae	*Combretum* sp.
Commelinaceae	*Commelina africana* L.
Commelinaceae	*Commelina* sp.
Commelinaceae	*Pollia condensata* C. B. Cl.
Convolvulaceae	*Astripomoea* sp.
Convolvulaceae	*Ipomoea ?wightii*
Convolvulaceae	I*pomoea batatas* (L.) Lam.
Convolvulaceae	*Ipomoea* sp.
Convolvulaceae	*Ipomoea wightii* (Wall.) Choisy
Brassicaceae	*Gynandropsis gynandra* (L.) Briq.
Cucurbitaceae	*Citrullus lanatus*
Cucurbitaceae	*Cucurbita maxima* Duch.
Cucurbitaceae	*Zehneria scabra* (L.f.)
Cyperaceae	Cyperaceae sp. 1
Cyperaceae	*Cyperus* sp.
Dracaenaceae	*Dracaena fragrans* (L.) Ker-Gawl.
Poaceae	*Zea mays* L.
Guttiferae	*Harungana madagascariensis* Poir
Lamiaceae	*Clerodendrum johnstonii* Oliv.
Lamiaceae	*Clerodendrum* sp.
Lamiaceae	*Geniosporum rotundifolium* Briq.
Lamiaceae	*Leonotis nepetifolia* (L.) R.Br
Lamiaceae	*Leucas* sp.
Lamiaceae	*Leucas* sp. A
Lamiaceae	*Ocimum gratissimum* L.
Lamiaceae	*Ocimum kilimandscharicum* Guerke
Malvaceae	*Hibiscus* sp.
Malvaceae	*Pavonia* sp.
Malvaceae	*Pavonia urens* Cav.
Malvaceae	*Urena lobata* L.
Melastomataceae	*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Meliaceae	*Lepidotrichilia volkensii* (Gürke)
Mimosaceae	*Acacia mellifera* (Vahl.) Benth.
Myrsinaceae	*Maesa lanceolata* Forssk
Myrtaceae	*Psidium guajava* L.
Piperaceae	*Piper umbellatum* L.
Papilionaceae	*Crotalaria brevidens* Benth.
Papilionaceae	*Crotalaria* sp.
Papilionaceae	*Desmodium repandum* (Vahl.) DC.
Papilionaceae	*Desmodium* sp. 1
Papilionaceae	*Phaseols aureus*
Papilionaceae	*Kotschya recurvifolia* (Taub.) F. White
Papilionaceae	Sp. L1

Papilionaceae		Leguminosae sp. B
Papilionaceae		*Phaseolus vulgaris*
Papilionaceae		*Tephrosia* sp.
Passifloraceae		*Passiflora endulis*
Poaceae		*Cynodon dactylon* (L.) Pers.
Poaceae		*Digitaria ?scabra*
Poaceae		*Eragrostis tenuifolia* (A.Rich.) Hochst ex.Steud
Poaceae		Poaceae sp. 1
Rubiaceae		*Coffea eugeniodes* S.Moore
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Rubiaceae		*Tarenna pavettoides* (Harv.) Sim
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Capsicum frutescens* L.
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum* sp.
Solanaceae		*Solanum tuberosum*
Sterculiaceae		*Dombeya ? torrida*
Sterculiaceae		*Dombeya burgessiae* Gerrard
Sterculiaceae		*Dombeya* sp.
Thymeleaceae		*Peddia fischeli* Engl.
Verbanaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
Vitaceaea		*Leea guineensis* G. Don
***Braunsapis* sp.**	V	
Cyperaceae		*Cyperus* sp.
***Braunsapis* sp. 1**	XII	
Tiliaceae		*Triumfetta tomentosa*
Braunsapis ?angolensis	II-III, V, VII, X	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Myrtaceae		*Psidium guajava* L.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Solanaceae		*Solanum mauritianum* Scop
Vitaceae		*Leea guineensis* G. Don
Braunsapis aff luapulana	II-VII, IX-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Cucurbitaceae		*Momordica foetida* Schumach
Cyperaceae		*Cyperus* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Ocimum* sp.

Papilionaceae		*Desmodium adscendens* (Sw.) DC
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Vitaceae		*Leea guineensis* G. Don
Braunsapis facialis	VII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Lamiaceae		*Leucas* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Braunsapis foveata	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum montuosum* (S.Moore) Milne-Redh
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Vernonia* sp.
Commelinaceae		*Pollia condensata* C. B. Cl.
Convolvulaceae		*Astripomoea* sp.
Convolvulaceae		*Ipomoea* sp.
Cucurbitaceae		*Momordica foetida* Schumach
Cyperaceae		*Cyperus* sp.
Lamiaceae		*Leucas* sp.
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Plectranthus comosus* Sims
Malvaceae		*Sida* sp.
Melastomataceae		*Dissotis* sp.
Meliaceae		*Lepidotrichilia volkensii* (Gürke)
Myrsinaceae		*Maesa lanceolata* Forssk
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Rubiaceae		*Pavetta abyssinica* Fres
Rubiaceae		*Pavetta* sp.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Solanaceae		*Solanum mauritianum* Scop
Sterculiaceae		*Dombeya burgessia*e Gerrard
Verbenaceae		*Stachytarpheta jamaicaensis*
Braunsapis gorillanum	I, V-VI	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Boraginaceae		*Ehretia cymosa* Thonn.
Braunsapis leptozonia	I-VII, X	

Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Commelinaceae		*Commelina africana* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Vitaceae		*Leea guineensis* G. Don
Braunsapis sp.	VI	
Myrsinaceae		*Maesa lanceolata* Forssk
Ceratina ?eitriphila	IV, VII-IX, XII	
Acanthaceae		*Justicia* sp.
Acanthaceae		*Thunbergia alata* Sims
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Bidens pilosa* L.
Commelinaceae		*Commelina africana* L.
Cucurbitaceae		*Momordica foetida* Schumach
Ceratina eitriphila	III, VI	
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Ceratina ericia	I-XII	
Acanthaceae		
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Amaranthaceae		*Achyranthes aspera* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Combretaceae		*Combretum* sp.
Comelinaceae		*Commelina africana* L.
Convolvulaceae		*Ipomoea* sp.
Brassicaceae		*Gynandropsis gynandra* (L.) Briq.
Cucurbitaceae		*Momordica foetida* Schumach
Cucurbitaceae		*Zehneria scabra* (L.f.)

Cyperaceae		*Cyperus* sp.
Guttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Hoslundia opposita* Vahl
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Plectranthus comosus* Sims
Malvaceae		*Hibiscus* sp.
Malvaceae		*Sida* sp.
Malvaceae		*Urena lobata* L.
Malvaceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Melastomataceae		*Maesa lanceolata* Forssk
Myrsinaceae		*Piper capense* L.f.
Piperaceae		*Piper umbellatum* L.
Piperaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Crotalaria* sp. A
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Desmodium* sp. 1
Papilionaceae		*Phaseolus aureus*
Papilionaceae		*Digitaria ?scabra*
Poaceae		*Eragrostis tenuifolia* (A.Rich.) Hochst ex.Steud
Poaceae		Poaceae sp.
Poaceae		*Pavetta subcana* Brem.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Rubiaceae		*Tarenna pavettoides* (Harv.) Sim
Sapindaceae		*Allophylus rubifolius* (A. Rich.) Engel
Verbanaceae		*Lantana camara* L.
Vitaceae		*Leea guineensis* G. Don
Ceratina moerenhonti	I-VII, IX, XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Convolvulaceae		*Ipomoea batatas* (L.) Lam.
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Piperaceae		*Piper umbellatum* L.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Ceratina peniciliata	II, VI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Ceratina* sp. 1**	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Amaranthaceae		*Achyranthes aspera* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Convolvulaceae		*Ipomoea* sp.

Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
***Ceratina* sp. 2**	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Hoslundia opposita* Vahl
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum montuosum* (S.Moore) Milne-Redh
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Balsaminaceae		*Impatiens burton*i Hook.f. (I.eminnii Warb.)
Commelinaceae		*Commelina africana* L.
Convolvulaceae		*Ipomoea ?wightii*
Convolvulaceae		*Ipomoea batatas* (L.) Lam.
Cucurbitaceae		*Momordica foetida* Schumach
Cyperaceae		*Cyperus* sp.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Plectranthus* sp.
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Meliaceae		*Lepidotrichilia volkensii* (Gürke)
Meliaceae		*Turraea holstii* Gürke
Myrsinaceae		*Maesa lanceolata* Forssk
Oxalidaceae		*Oxalis* sp.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Poaceae		*Digitaria ?scabra*
Rosaceae		*Rubus* sp.
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Solanum mauritianum* Scop
Thymeleaceae		*Peddia fischeli* Engl.
Tiliaceae		*Triumfetta rhomboidea* Jacq
Verbenaceae		*Lantana camara* L.
***Ceratina* sp. 3**	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.

Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Galinsoga parviflora* Cav.
Convolvulaceae		*Ipomoea* sp.
Guttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia urens* Cav.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Myrsinaceae		*Maesa lanceolata* Forssk
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Poaceae		*Eragrostis tenuifolia* (A.Rich.) Hochst ex.Steud
Poaceae		Poaceae sp.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Solanum mauritianum* Scop
***Ceratina* sp. 4**	I-II, V, X-XII	
Acanthaceae		*Asystasia gangetic*a (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Crassulaceae		*Kalenchoe crenata* (Andrews) Haworth
Lamiaceae		*Leucas* sp.
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
***Ceratina* sp. 5**	II, X	
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Tiliaceae		*Triumfetta rhomboidea* Jacq
***Ceratina* sp. 6**	II	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Ocimum kilimandscharicum* Guerke
***Ceratina* sp. 7**	IX	Plant sp. a
***Ceratina* sp. 8**	III	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
***Ceratina* sp. 9**	I	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Ceratina viridis	I-IX, XI	
Sapindaceae		*Allophylus ferrugineus* Taub.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore

Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Crotalaria* sp.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium* sp. 1
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Acanthaceae		*Dyschoriste radicans* Nees
Asteraceae		*Galinsoga parviflora* Cav.
Papilionaceae		Green grams
Asteraceae		*Helichrysum* sp.
Convolvulaceae		*Ipomoea* sp.
Acanthaceae		*Justicia flava* Vahl
Verbenaceae		*Lantana camara* L.
Cucurbitaceae		*Momordica foetida* Schumach
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Phaseolus vulgaris*
Papilionaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia ?ouristella*
Poaceae		*Zea mays* L.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Verbenaceae		*Stachytarpheta jamaicaensis*
***Ctenoplectra* ?n sp.**	II, VI-IX, XI	
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Richardia brasiliensis* Gomes
Convolvulaceae		*Ipomoea* sp.
Cucurbitaceae		*Momordica foetida* Schumach
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Solanum mauritianum* Scop
Sterculiaceae		*Dombeya burgessiae* Gerrard
Ctenoplectra antinorii	I-II, IV-XI	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Convolvulaceae		*Ipomoea* sp.
Cucurbitaceae		*Momordica foetida* Schumach
Gruttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Pavonia urens* Cav.
Myrtaceae		*Psidium guajava* L.
Sapindaceae		*Allophylus ferrugineus* Taub.
Sterculiaceae		*Dombeya* sp.
Ctenoplectrina politula	VII, X-XI	
Asteraceae		*Galinsoga parviflora* Cav.
Convolvulaceae		*Ipomoea* sp.

Cucurbitaceae		*Momordica foetida* Schumach
***Ctenoplectra* sp. 1**	I-II, IV-V, VII, IX, XI	
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Dyschoriste radicans* Nees
Asteraceae		*Galinsoga parviflora* Cav.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Piperaceae		*Piper umbellatum* L.
Tiliaceae		*Triumfetta rhomboidea* Jacq
***Ctenoplectra* sp. 2**	VII	
Asteraceae		*Galinsoga parviflora* Cav.
***Ctenoplectra* sp. 3**	IX	
Cucurbitaceae		*Momordica foetida* Schumach
***Ctenoplectra* sp. 4**	V	
Papilionaceae		*Desmodium adscendens* (Sw.) DC
***Ctenoplectra* sp. 5**	IV	
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Ctenoplectra terminalis	II, IX-X	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Cucurbitaceae		*Momordica foetida* Schumach
Hypotrigona gribodoi	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Poaceae		Poaceae sp.
Liotrigona bottegoi	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Bidens pilosa* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
Megaceratina sculpturata	IV, XI	
Verbenaceae		*Lantana camara* L.
Meliponula ?denoiti	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia lasiopus* O. Hoffm
Commelinaceae		*Commelina* sp.

Convolvulaceae		*Ipomoea* sp.
Cucurbitaceae		*Momordica foetida* Schumach
Poaceae		*Zea mays* L.
Gruttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Pavonia* sp.
Piperaceae		*Piper umbellatum* L.
Meliponula bocandei	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Apocynaceae		Apocynaceae sp 1
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Blepharis rotundifolia*
Asteraceae		*Bidens pilosa* L.
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Clerodendrum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Crotalaria* sp.
Cyperaceae		*Cyperus* sp.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Melastomataceae		*Dissotis* sp.
Asteraceae		*Galinsoga parviflora* Cav.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Papilionaceae		Green grams
Asteraceae		*Guizotia reptans* Hutch
Gruttiferae		*Harungana madagascariensis* Poir
Convolvulaceae		*Ipomoea* sp.
Acanthaceae		*Justicia flava* Vahl
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Lantana trifolia* L.
Lamiaceae		*Leucas calostachys* Oliv.
Myrsinaceae		*Maesa lanceolata* Forssk
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Malvaceae		*Pavonia urens* Cav.
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Piperaceae		*Piper umbellatum* L.
Myrtaceae		*Psidium guajava* L.
Lamiaceae		*Rotheca myricoides* Oliv.
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum melongena*
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Tiliaceae		*Triumfetta tomentosa*
Asteraceae		*Vernonia* sp.
Rubiaceae		*Mussaenda arcuata* Poir
Meliponula erthyra	I-XII	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl

Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Bischofficiaceae		*Bischoffia javanica* Blume
Caesalpinianaceae		*Caesalpinia decapetala* (Roth) Alston
Commelinaceae		*Commelina* sp.
Cucurbitaceae		*Momordica foetida* Schumach
Euphorbiaceae		*Manihot esulenta* Crantz
Poaceae		*Zea mays* L.
Gruttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Sida* sp.
Myrsinaceae		*Maesa lanceolata* Forssk
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Poaceae		*Digitaria ?scabra*
Rutaceae		*Teclea nobilis* Del.
Verbenaceae		*Stachytarpheta jamaicensis*
Meliponula lendliana	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Dracaenaceae		*Dracaena fragrans* (L.) Ker-Gawl.
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Tagetes minuta* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Boraginaceae		*Ehretia cymosa* Thonn.
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Commelinaceae		*Commelina africana* L.
Commelinaceae		*Commelina* sp.
Cyperaceae		*Cyperus* sp.
Flacourtiaceae		*Dovyalis macrocalyx* (Oliv.) Warb.
Verbenaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Hoslundia opposita* Vahl
Lamiaceae		*Leucas* sp.
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia* sp.
Malvaceae		*Pavonia urens* Cav.
Malvaceae		*Sida* sp.
Malvaceae		*Urena lobata* L.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.

Meliaceae		*Turraea holstii* Gürke
Myrsinaceae		*Maesa lanceolata* Forssk
Oxalidaceae		*Oxalis* sp.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		Green grams
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Lantana camara* L.
Vitaceae		*Leea guineensis* G. Don
Tetraloniella katagensis	V-VII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Myrsinaceae		*Maesa lanceolata* Forssk
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Phaseolus vulgaris*
***Tetraloniella* n sp. 2**	VII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Tetraloniella* sp. 1**	V	
Acanthaceae		*Justicia flava* Vahl
***Tetraloniella* sp. 3**	I	
Acanthaceae		*Justicia flava* Vahl
Thyreus ?axillaris	I, IV-VII, IX, X, XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Poaceae		*Cynodon dactylon* (L.) Pers.
Solanaceae		*Solanum mauritianum* Scop
Thyreus calceatus	I-VII, X, XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Vernonia* sp.
Lamiaceae		*Plectranthus* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC

Thyreus interruptus	III-V, VIII, X	
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Solanaceae		*Solanum* sp.
Thyreus pictus	I-X, XII	
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Clerodendrum* sp.
Lamiaceae		*Leucas calostachys* Oliv.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Myrsinaceae		*Maesa lanceolata* Forssk
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicensis*
T*hyreus* sp. 2	VIII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Xylocopa aff albifrons	X	
Lamiaceae		*Leucas* sp. A
***Xylocopa (Koptortotosoma* sp. 1)**	I-III, VII, X, XII	
Acanthaceae		*Acanthus eminens* C. B.Cl.
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		Lamiaceae sp. B (Purple)
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Tephrosia* sp.
Solanaceae		*Solanum mauritianum* Scop
***Xylocopa (Xylomelissa* sp. 1)**	I-VI, VII-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Acanthaceae		*Asystasia* sp.
Asteraceae		*Bidens pilosa* L.
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Malvaceae		*Hibiscus* sp.
Acanthaceae		*Hypoestes trifolia* (Forsk.) Roem. & Schultes

Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Convolvulaceae		*Ipomoea* sp.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Lamiaceae		*Lamiaceae* sp. B
Lamiaceae		*Leucas* sp. A
Acanthaceae		*Mimulopsis* sp.
Lamiaceae		*Ocimum gratissimum* L.
Malvaceae		*Pavonia* sp.
Malvaceae		*Pavonia urens* Cav.
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum* sp.
Xylocopa (Xylomelissa sp. 2)	I-VI, IX-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Malvaceae		*Pavonia urens* Cav.
Myrsinaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria* sp.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Solanaceae		*Solanum incanum* L.
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Starchytarpheta urtifolia*
Xylocopa ?albifrons	I, III, VII-VIII, X-XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Malvaceae		*Pavonia* sp.
Malvaceae		*Pavonia urens* Cav.
Papilionaceae		*Crotalaria brevidens* Benth.
Xylocopa ?calens	XI	
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Xylocopa ?hottentota	III, X-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Cucurbitaceae		*Momordica foetida* Schumach
Xylocopa ?senior	I-III, VII, X, XI	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Xylocopa aff sicheli	IX	
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Xylocopa calens	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Bidens pilosa* L.
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston

Lamiaceae		*Clerodendrum johnstonii* Oliv.
Commelinaceae		*Commelina africana* L.
Commelinaceae		*Commelina* sp.
Asteraceae		*Crassocephalum picridifolium* (DC.) S.Moore
Asteraceae		*Crassocephalum* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Melastomataceae		*Dissotis* sp.
Myrsinaceae		*Embelia schimperi* Vatke
Balsaminaceae		*Impatiens burton*i Hook.f. (I.eminnii Warb.)
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Verbenaceae		*Lantana camara* L.
Papilionaceae		Leguminosae sp. 3
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Oxyanthus* sp.
Papilionaceae		*Phaseolus vulgaris*
Papilionaceae		*Pseudarthia ?hookeri*
Myrtaceae		*Psidium guajava* L.
Rubiaceae		*Psychotria peduncularis* (Salisb.) Steyerm.
Lamiaceae		*Rotheca myricoides* Oliv.
Caesalpiniaceae		*Senna didymobotrya* (Fresen.) Irwin & Barneby
Solanaceae		*Solanum incanum* L.
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum melongena*
Solanaceae		*Solanum* sp.
Solanaceae		*Solanum tuberosum*
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Papilionaceae		*Vigna unguiculat*a L.
Verbenaceae		*Stachytarpheta jamaicensis*
Lamiaceae		*Salvia* sp.
Xylocopa erythrina	II, VII	
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Malvaceae		*Hibiscus* sp.
Xylocopa flavicollis	I-II, X-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Xylocopa flavorufa	I, IV-VII, IX-XII	
Acanthaceae		*Acanthus eminens* C. B.Cl.
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Mimulopsis* sp.
Asteraceae		*Bidens pilosa* L.
Bignoniaceae		*Markhamia lutea* (Benth.) K. Schum
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Caesalpinaceae		*Senna didymobotrya* (Fresen.) Irwin & Barneby
Euphorbiaceae		*Croton macrostachyus* Del.
Lamiaceae		*Rotheca myricoides* Oliv.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.

Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Vigna unguiculata* L.
Papilionaceae		*Phaseolus vulgaris* L:
Solanaceae		*Solanum mauritianum* Scop
Xylocopa hottentota	II, VIII-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Mimulopsis* sp.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Gruttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Clerodendrum* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Solanaceae		*Solanum mauritianum* Scop
Xylocopa imitator	I, V-VII, IX-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Mimulopsis* sp.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Caesalpinaceae		*Cassia* sp.
Lamiaceae		*Rotheca myricoides* Oliv.
Malvaceae		*Pavonia urens* Cav.
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Papilionaceae		*Phaseolus vulgaris* L.
Papilionaceae		*Psidium guajava* L.
Solanaceae		*Solanum mauritianum* Scop
Xylocopa incostans	I-IX, XI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria* sp.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Vigna unguiculata* L.
Papilionaceae		*Phaseolus vulgaris* L.
Passifloraceae		*Passiflora endulis*
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum melongena*
Solanaceae		*Solanum* sp.
Sterculiaceae		*Dombeya burgessiae* Gerrard
Verbenaceae		*Lantana camara* L.
Xylocopa nigrita	I-III, V-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Mimulopsis* sp.

Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Bignoniaceae		*Markhamia lutea* (Benth.) K. Schum
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Euphorbiaceae		*Croton macrostachyus* Del.
Lamiaceae		*Clerodendrum* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Melastomataceae		*Dissotis* sp.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Bidens pilosa* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Phaseolus vulgaris* L.
Papilionaceae		*Vigna unguiculata* L.
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Lantana camara* L.
Xylocopa torrida	I-VII, IX-XI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Mimulopsis* sp.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Bignoniaceae		*Markhamia lutea* (Benth.) K. Schum
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Melastomataceae		*Dissotis* sp.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Phaseolus vulgaris* L.
Papilionaceae		*Vigna unguiculata* L.
Xylocopa varipes	X	
Acanthaceae		*Justicia flava* Vahl
MEGACHILIDAE		
Afranthidium sjoestd**i**	IV-IX	
Acanthaceae		*Hibiscus* sp.
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Richardia brasiliensis* Gomes
Solanaceae		*Solanum mauritianum* Scop
***Coelioxys (Boreocoelioxys* sp.)**	I,III-IV, VIII	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Leucas* sp. A
Coelioxys aff affra	XI	
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Leucas* sp. B
Coelioxys odin	II	
Acanthaceae		*Justicia flava* Vahl

Acanthaceae		*Asystasia* sp.
Asteraceae		*Vernonia* sp.
***Coelioxys* sp.**	I, VI	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Coelioxys sp. 1	V, X-XI	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Coelioxys sp. 2	X	
Lamiaceae		*Ocimum gratissimum* L.
Coelioxys sp. 3	XI	
Acanthaceae		*Justicia flava* Vahl
Coelioxys verticalis	I, III-IV, IX-XI	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Justicia flava* Vahl
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Rubiaceae		*Triumfetta rhomboidea* Jacq
Creigtoniella ithanoptera	III-IX	
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Euphorbiaceae		*Crotalaria brevidens* Benth.
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Phaseolus vulgaris* L.
Asteraceae		*Vernonia* sp.
Poaceae		*Zea mays* L.
Euapis abdominalis	II-III, V-VI, X-XI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum* sp.
Myrsinaceae		*Maesa lanceolata* Forssk
Myrtaceae		*Psidium guajava* L.
Solanaceae		*Solanum melongena*
Solanaceae		*Solanum tuberosum*
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicensis*
Euapis erythros	I-II, IV-VI	
Acanthaceae		*Justicia flava* Vahl
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Solanaceae		*Solanum tuberosum*
***Heriades* (? *Amboheriades* n. sp. 1)**	II	
Lamiaceae		*Ocimum gratissimum* L.
***Heriades* (*Amboheriades* n. sp. 1)**	II, IV, VI, IX	
		Dyschoriste radicans Nees

Cucurbitaceae		*Zehneria scabra* (L.f.)
Lamiaceae		*Ocimum gratissimum* L.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
***Heriades (Pachyheriades sp. 1*)**	II-V, VII, IX-X	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Crassocephalum* sp.
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Heriades ? retifer	III	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Heriades retifer* (n sp.)**	VII-IX	
Apocynaceae		Apocynaceae
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Piperaceae		*Piper umbellatum* L.
Heriades ?sulcatulus	II, IV	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Heriades sulcatulus	I-III, V-VI, X, XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Vernonia sp.*
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Poaceae		*Eragrostis tenuifolia* (A.Rich.) Hochst ex.Steud
Sapindaceae		*Allophylus ferrugineus* Taub.
***Heriades* sp. 101**	I, III-V, VII-VIII, XI	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Richardia brasiliensis* Gomes
Euphorbiaceae		*Manihot esulenta* Crantz
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Ocimum sp.*
Malvaceae		*Hibiscus sp.*

Malvaceae		*Urena lobata* L.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Myrtaceae		*Psidium guajava* L.
Rubiaceae		*Coffea eugeniodes* S.Moore
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
***Heriades* sp. 1**	III, V	
Acanthaceae		*Dyschoriste radicans* Nees
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Megachile* (*Eutricharaca* sp.)**	I-II, IV-V	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia sp.*
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Verbenaceae		*Lantana camara* L.
***Megachile* (*Paracella* sp. 1)**	VI	
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Vernonia lasiopus* O. Hoffm
Megachile ? ciacta combusta	IV-V, X-XI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Megachile ciacta combusta	I-II, IV-VII, IX-X	
Acanthaceae		*Asystasia sp.*
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum sp.*
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Ocimum gratissimum* L.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Crotalaria sp.*
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Tephrosia sp.*
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Stachytarpheta jamaicaensis*
Megachile ?dariensis	I, IV, IX-XI	
Acanthaceae		*Justicia flava* Vahl
Caricaceae		*Carica papaya* Linnaeus
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Desmodium* sp. 1
Papilionaceae		*Phaseolus aureus*
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White

Poaceae		*Poaceae* sp.
Megachile dariensis	III-IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Poaceae		*Zea mays* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Megachile ?fulvitarsis	I-VI, X-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Commelinaceae		*Pollia condensata* C. B. Cl.
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Pavonia* sp.
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Phaseolus vulgaris*
Sterculiaceae		*Dombeya burgessiae* Gerrard
Verbenaceae		*Lantana camara* L.
Megachile ?gratiosa	III-VII, IX, XI	
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Guttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papillionaceae		*Crotalaria brevidens* Benth.
Papillionaceae		*Desmodium adscendens* (Sw.) DC
Rosaceae		*Rubus* sp.
Verbenaceae		*Stachytarpheta jamaicensis*
Megachile mitimia	III-IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Papilionaceae		*Phaseolus vulgaris* L.
Megachile montibia	III, V-VII, IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Galinsoga parviflora* Cav.
Papilionaceae		*Phaseolus vulgaris*
Papilionaceae		*Desmodium repandum* (Vahl.) DC.

Megachile ?niveicaula	I-VI, VIII, X-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Asteraceae		*Bidens pilosa* L.
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Apocynaceae		*Funtumia latifolia* (Benth.) Stapf
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Myrsinaceae		*Maesa lanceolata* Forssk
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Crotalaria brevidens* Benth.
Solanaceae		*Solanum mauritianum* Scop
Verbenaceae		*Lantana camara* L.
Megachile ?polychroma	II-VII, IX-XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia (Oliv.)* C. Jeffrey
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Vernonia lasiopus* O. Hoffm
Asteraceae		*Vernonia* sp.
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Lamiaceae* sp. B (Purple)
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Megachile ?rufipes	III, IX	
Acanthaceae		*Justicia flava* Vahl
Papilionaceae		*Crotalaria brevidens* Benth.
Megachile rufipes	I-XI	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Mimulopsis* sp.
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Poaceae		*Zea mays* L.
Lamiaceae		*Ocimum gratissimum* L.
Malvaceae		*Hibiscus* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Phaseolus vulgaris* L.
Rubiaceae		*Coffea eugeniodes* S.Moore
Solanaceae		*Solanum incanum* L.
Solanaceae		*Solanum mauritianum* Scop
Megachile rufiventris	X	
Acanthaceae		*Justicia flava* Vahl

Megachile ?semierma	III-VI, XI-XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Oxalidaceae		*Oxalis* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Megachile ?semivenusta	I-III, X	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Megachile apiformis	III, V, IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Megachile basalis	IX-XII	
Acanthaceae		*Justicia flava* Vahl
Myrtaceae		*Psidium guajava* L.
Papilionaceae		Papilionaceae sp. A
Megachile bituberculata	I-XII	
Acanthaceae		*Aspilia mossambicensis* (Oliv.) Wild
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
Papilionaceae		*Phaseolus* vulgaris L.
Solanaceae		*Solanum mauritianum* Scop
Solanaceae		*Solanum tuberosum*
Megachile crakokensis	I-II	
Papilionaceae		*Crotalaria brevidens* Benth.
Megachile felina	I-IV, VII, IX-X	
Acanthaceae		*Asystasia sp.*
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Megachile decemsignata	I-II	
Acanthaceae		*Justicia flava* Vahl
Solanaceae		*Solanum mauritianum* Scop
Megachile maxillosa	X	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray

Megachile mitimia	III-IV, VI-IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Kotschya recurvifolia (*Taub.) F. White
Papilionaceae		*Phaseolus vulgaris* L.
Megachile obtusodentata	V	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Bidens pilosa* L.
Megachile polychroma	VI, VIII	
Acanthaceae		*Justicia flava* Vahl
Lamiaceae		*Rotheca myricoides* Oliv.
Poaceae		*Zea mays* L.
Megachile postaigra	IX-X	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Vernonia* sp.
Megachile pyrrhithorax	IV-V, VIII-X	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Asteraceae		*Crassocephalum* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Phaseolus vulgaris*
Megachile rufipennis	IX-X	
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Megachile sinuata bokanica	V-VII	
Asteraceae		*Bidens pilosa* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
		Crotalaria brevidens Benth.
Megachile sp. 1	XI-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava Vahl*
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
***Megachile* sp. 2**	I, XII	
Acanthaceae		*Justicia flava* Vahl
Lamiaceae		*Leucas* sp. A
***Megachile* sp. 3**	I, XI	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Megachile* sp. 4**	I, XI	
Papilionaceae		*Kotschya recurvifolia* (Taub.) F. White
***Megachile* sp. 5**	VII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Megachile* sp. 6**	IV	

Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Megachile torrida	II, IV-VI, VIII-IX	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Vernonia* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Papilionaceae		*Crotalaria brevidens* Benth.
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Rhizophoraceae		*Cassipourea ruwensorensis* (Engl.) Alston
Sterculiaceae		*Dombeya rotundifolia* (Hochst.) Planch
Tiliaceae		*Triumfetta rhomboidea* Jacq
Pachyanthidium aff bengualense	VIII	
Lamiaceae		*Ocimum gratissimum* L.
Pachyanthidium **sp. 1**	III	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Pseudoanthidium (Micranthidium **n sp. 3*)***	II-VII, IX, XI	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Commelinaceae		*Commelina* sp.
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Rubiaceae		*Pavetta* sp.
Rubiaceae		*Pavetta ternifolia* (Oliv.) Hiern
Verbenaceae		*Lantana camara* L.
Verbenaceae		*Stachytarpheta jamaicaensis*
Pseudoanthidium lanificum	I-VIII, X-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia declipteriodes* Lindau
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Vernonia sp.*
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alsto*n*
Lamiaceae		*Leucas* sp. A
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Myrtaceae		*Psidium guajava* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Solanaceae		*Solanum mauritianum* Scop
Pseudoanthidium truncatum	I-II, VI-XII	
Acanthaceae		*Justicia declipteriodes* Lindau
Acanthaceae		*Justicia flava* Vahl

Asteraceae		*Bidens pilosa* L.
Asteraceae		*Galinsoga parviflora* Cav.
Balsaminaceae		*Impatiens burtoni* Hook.f. *(I.eminnii* Warb.*)*
Lamiaceae		*Ocimum gratissimum* L.
Melastomataceae		*Dissotis* sp.
Papilionaceae		*Desmodium* sp. 1
Poaceae		*Cyperus* sp.
Solanaceae		*Solanum mauritianum* Scop
Serapista denticulata	I, V-VI	
Asteraceae		*Bidens pilosa* L.
Papilionaceae		*Crotalaria brevidens* Benth.
HALICTIDAE		
***Halictid* sp. 34**	VII	
Lamiaceae		*Ocimum kilimandscharicum* Guerke
***Halictus* (*Seladonia* sp. 1)**	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Acanthaceae		*Thunbergia alata* Sims
Acanthaceae		*Thunbergia* sp.
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum montuosum* (S.Moore) Milne-Redh
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia (Oliv.)* C. Jeffrey
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Caesalpinaceae		*Caesalpinia decapetala* (Roth) Alston
Commelinaceae		*Commelina africana* L.
Guttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Galinsoga parviflora Cav.*
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Pavonia urens* Cav.
Meliaceae		*Turraea holstii* Gürke
Myrsinaceae		*Maesa lanceolata* Forssk
Myrtaceae		*Psidium guajava* L.
Piperaceae		*Piper umbellatum L.*
Papilionaceae		*Crotalaria brevidens Benth.*
Papilionaceae		*Desmodium adscendens (Sw.) DC*
Poaceae		*Cynodon dactylon (L.) Pers.*
Poaceae		*Digitaria ?scabra*
Rubiaceae		*Pavetta sp.*
Rubiaceae		*Spermacoce princeae (K. Schum.) Verdc.*

Sapindaceae		*Allophylus ferrugineus Taub.*
Solanaceae		*Solanum sp.*
Sterculiaceae		*Dombeya burgessiae Gerrard*
Verbenaceae		*Lantana camara L.*
Verbenaceae		*Lantana trifolia L.*
Vitaceae		*Leea guineensis G. Don*
***Halictus (Seladonia* sp. 2)**	I-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Hoslundia opposita* Vahl
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Caesalpiaceae		*Caesalpinia decapetala* (Roth) Alston
Commelinaceae		*Pollia condensata* C. B. Cl.
Lamiaceae		*Leonitis nepetifolia* (L.) Ait. F.
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia urens* Cav.
Malvaceae		*Sida* sp.
Malvaceae		*Urena lobata* L.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Myrsinaceae		*Maesa lanceolata* Forssk
Myrsinaceae		*Psidium guajava* L.
Piperaceae		*Piper umbellatum* L.
Poaceae		*Cynodon dactylon* (L.) Pers.
Poaceae		*Cyperus* sp.
Poaceae		*Poaceae* sp.
Rosaceae		*Rubus* sp.
Sapindaceae		*Allophylus ferrugineus* Taub.
Solanaceae		*Solanum tuberosum*
Thymeleaceae		*Peddia fischeli* Engl.
Verbenaceae		*Lantana camara* L.
Vitaceae		*Leea guineensis* G. Don
Halictus sp. 1		
Asteraceae		*Bidens pilosa* L.
***Lasioglossum (?Rubrihalictus* sp.)**	XI	
Papilionaceae		*Crotalaria brevidens* Benth.
***Lasioglossum (Ctenonomia* sp. 1)**	I-V, VII, XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Guizotia reptans* Hutch

Lamiaceae		*Ocimum kilimandscharicum* Guerke
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Vitaceae		*Piper umbellatum* L.
***Lasioglossum* (*Ctenonomia* sp. 2)**	I-II, IV-VII, IX-XI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Commelinaceae		*Pollia condensata* C. B. Cl.
Lamiaceae		*Geniosporum rotundifolium* Briq.
Lamiaceae		*Leonotis nepetifolia* (L.) R.Br
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Papilionaceae		*Desmodium* sp. 1
Poaceae		Poaceae sp.
Sterculiaceae		*Dombeya burgessiae* Gerrard
***Lasioglossum (Dialictus* sp. 1)**	I, VI-XI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Acmella calirhiza* Del.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Meliaceae		*Turraea holstii* Gürke
Poaceae		*Digitaria ?scabra*
Lasioglossum (Ipomalictus sp. 1)	I-II, V-VII, IX, XI-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia (*Oliv.) C. Jeffre*y*
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Pavonia urens* Cav.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Dyschoriste radicans* Nees
Vitaceae		*Leea guineensis* G. Don
Lasioglossum (Ipomalictus* sp. 2*)	III-IV, IX-X, XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Thunbergia alata* Sims
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Convolvulaceae		*Ipomoea* sp.
Lasioglossum (Ipomalictus* sp. *3)	III-VI, IX-XII	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild

Convolvulaceae		*Ipomoea* sp.
Malvaceae		*Pavonia* sp.
Myrsinaceae		*Psidium guajava* L.
Piperaceae		*Piper umbellatum* L.
Poaceae		*Digitaria ?scabra*
Rubiaceae		*Pavetta abyssinica* Fres
Sterculiaceae		*Dombeya* sp.
Verbenaceae		*Lantana camara* L.
***Lasioglossum (Ipomohalictus* sp. 2)**	VI	
Asteraceae		*Galinsoga parviflora* Cav.
***Lasioglossum (Rubrihalictus* sp.)**	V, XI	
Malvaceae		*Pavonia* sp.
Poaceae		*Cyperus* sp.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
***Lasioglossum* (*Rubrihalictus* sp. 2)**	II	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Lasioglossum* (*Sellalictus* sp. 1)**	I, V-VII, IX-X	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum* sp.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Poaceae		*Cyperus* sp.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Poaceae		*Digitaria ?scabra*
Papilionaceae		*Phaseolus aureus*
Lamiaceae		*Leonitis nepetifolia* (L.) Ait. F.
Poaceae		Poaceae sp. 1
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
***Lasioglossum* (*Sellalictus* sp. 2)**	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum sp. A*
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Galinsoga parviflora* Cav.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Convolvulaceae		*Ipomoea hildebrandtii* Vatke
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Malvaceae		*Pavonia* sp.
Malvaceae		*Sida* sp.
Malvaceae		*Urena lobata* L.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Poaceae		*Poaceae* sp.
Solanaceae		*Solanum incanum* L.

Solanaceae		*Solanum mauritianum* Scop
***Lasioglossum* (*Sellalictus* sp. 3)**	II-III, V, IX	
Acanthaceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Lamiaceae		*Ocimum gratissimum* L.
Malvaceae		*Sida* sp.
***Lasioglossum* (*Sellalictus* sp. 4)**	II, X-XI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Richardia brasiliensis* Gomes
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Lasioglossum (Sellalictus sp. 5)	III, XI	
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Convolvulaceae		*Ipomoea* sp.
***Lasioglossum* sp.**	I-V, IX-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia* sp.
Acanthaceae		*Thunbergia alata* Sims
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Convolvulaceae		*Commelina africana* L.
Guttiferae		*Harungana madagascariensis* Poir
Lamiaceae		*Clerodendrum johnstonii* Oliv.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Rutaceae		*Clausena anisata* (Wild.) Benth.
***Lasioglossum* sp. 1**	I, XI	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Lasioglossum* sp. 2**	IX, XI	
Convolvulaceae		*Ipomoea* sp.
Solanaceae		*Solanum mauritianum* Scop
***Lasioglossum* sp. 5**	II, VI	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Asteraceae		*Galinsoga parviflora* Cav.
***Lasioglossum* sp. 6**	X, XI	
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)
Lamiaceae		*Ocimum kilimandscharicum* Guerke
***Lasioglossum* sp. 7**	VII, X	
Acanthaceae		*Dyschoriste radicans* Nees
Lamiaceae		*Ocimum kilimandscharicum* Guerke
***Lipotriches* sp.**	XI	
Sterculiaceae		*Dombeya burgessiae* Gerrard
***Lipotriches (Lipotriches* sp. 1)**	IV-V, VII, IX, XI	

Acanthaceae		*Justicia flava* Vahl
Balsaminaceae		*Impatiens burtoni* Hook.f. *(I.eminnii Warb.)*
Meliaceae		*Turraea holstii* Gürke
Solanaceae		*Solanum* sp.
Verbenaceae		*Stachytarpheta jamaicensis*
Lipotriches (Nebenomia* sp.*)	IV	
Acanthaceae		*Justicia flava* Vahl
Lipotriches (Trinomia* sp. *1)	IX	
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lipotriches (Trinomia* sp. *2)	X	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lipotriches aff aurifrons	VIII	
Piperaceae		*Piper umbellatum* L.
Lipotriches aff panganina	IV-XII	
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Cucurbitaceae		*Momordica foetida* Schumach
Cyperaceae		*Cyperaceae* sp. 1
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Sida* sp.
Piperaceae		*Piper umbellatum* L.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium repandum* (Vahl.) DC*.*
Poaceae		*Digitaria ?scabra*
Poaceae		Poaceae sp.
Rosaceae		*Rubus* sp.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Solanaceae		*Solanum mauritianum* Scop
Lipotriches aff welwitschi	I, IV-X, XII	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Richardia brasiliensis* Gomes
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Melastomataceae		*Dissotis* sp.
Myrsinaceae		*Maesa lanceolata* Forssk
Piperaceae		*Piper capense* L.f.
Poaceae		Poaceae sp. 1
Solanaceae		*Solanum mauritianum* Scop
Sterculiaceae		*Dombeya burgessiae* Gerrard
Lipotriches orientalis	IV-VI, VIII- IX, XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl

Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Vernonia* sp.
Cyperaceae		*Cyperus* sp.
Lamiaceae		*Leucas* sp.
Malvaceae		*Hibiscus* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Rubiaceae		*Pavetta subcana* Brem.
***Lipotriches* sp. 1**	VII-X	
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Lamiaceae		*Clerodendrum* sp.
Papilionaceae		*Phaseolus aureus*
Solanaceae		*Solanum incanum* L.
***Lipotriches* sp. 2**	X	*Sida* sp.
***Lipotriches* sp. 3**	IX	*Crassocephalum vitellinum* (Benth.) S. Moore
***Lipotriches* sp. 4**	IV	*Vernonia* sp.
Lipotriches tridentata	I-II, V-VIII, XI, XII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Galinsoga parviflora* Cav.
Malvaceae		*Hibiscus sp.*
Acanthaceae		*Justicia flava* Vahl
Vitaceae		*Leea guineensis* G. Don
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Myrtaceae		*Psidium guajava* L.
***Nomia (Leuconomia* sp. 1)**	I-II, IV-VII, IX-XI	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia sp.*
Asteraceae		*Ageratum conyzoides* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Guizotia reptans* Hutch
Caryphyllaceae		*Cassia* sp.
Convolvulaceae		*Ipomoea* sp.
Poaceae		*Poaceae* sp. 1
Solanaceae		*Solanum mauritianum* Scop
Sterculiaceae		*Dombeya burgessiae* Gerrard
***Nomia (Leuconomia* sp. 2)**	I-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Justicia sp.*
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Asteraceae		*Galinsoga parviflora* Cav.

Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Asteraceae		*Vernonia* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Lamiaceae		*Plectranthus comosus* Sims
Lamiaceae		*Plectranthus* sp.
Malvaceae		*Sida* sp.
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		*Desmodium sp.* 1
Papilionaceae		*Phaseolus aureus*
Poaceae		*Poaceae sp. 1*
Sterculiaceae		*Dombeya burgessiae* Gerrard
***Nomia (Leuconomia* sp. 3)**	II-V	
Acanthaceae		*Dyschoriste radicans* Nees
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Vernonia sp.*
Malvaceae		*Urena lobata* L.
Myrtaceae		*Psidium guajava* L.
***Nomia (Leuconomi*a sp. 4)**	X	
Papillionaceae		*Phaseolus aureus*
Nomia aff hylaeonides	IV-VI, IX	
Acanthaceae		*Justicia flava* Vahl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Piperaceae		*Piper umbellatum* L.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Verbenaceae		*Lantana trifolia* L.
Nomia aff panganina	V, VII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Poaceae		*Digitaria ?scabra*
Nomia chandleri	IV	
Acanthaceae		*Justicia flava* Vahl
Nomia orientalis	III, IV, XI-XII	
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Vernonia* sp.
Lamiaceae		*Clerodendrum* sp.
Piperaceae		*Piper umbellatum* L.
Rosaceae		*Rubus* sp.
***Nomia* sp. 1**	IV	*Vernonia* sp.
Nomia theryi	II, V-VII, X-XI	
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Papilionaceae		*Crotalaria brevidens* Benth.
Papilionaceae		*Crotalaria* sp.
Papilionaceae		*Leguminosae* sp.

Nomia tshindica	VI	
Acanthaceae		*Justicia flava* Vahl
Nomia viridiciacta	II, V-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Asystasia* sp.
Acanthaceae		*Justica calyculata* (Deflers) T. Anders.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Richardia brasiliensis* Gomes
Caesalpiniaceae		*Caesalpinia decapetala* (Roth) Alston
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum gratissimum* L.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Myrsinaceae		*Maesa lanceolata* Forssk
Papilionaceae		*Crotalaria agatiflora* Schweinf.
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Solanaceae		*Lycopersicum esculentum*
Verbenaceae		*Lantana camara* L.
***Patellapis (Homalictus* sp. 1)**	XII	
Acanthaceae		*Phaulopsis imbricata* (Forsk.) Sweet
***Patellapis* (*Zonalictus* sp. 1)**	I-II, IV-VI, VIII-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Apocynaceae		*Funtumia latifolia* (Benth.) Stapf
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Balsaminaceae		*Impatiens burtoni* Hook.f. *(I.eminnii* Warb*.)*
Cucurbitaceae		*Momordica foetida* Schumach
Lamiaceae		*Leucas sp. B*
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Oxalidaceae		*Oxalis* sp.
Papilionaceae		*Crotalaria sp. (*Pl.Sp.H*)*
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Papilionaceae		Green grams
Patellapis (Zonalictus sp. 2)	I-IV, VII-XII	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Dyschoriste radicans* Nees
Acanthaceae		*Justicia flava* Vahl
Asteraceae		*Bidens pilosa* L.
Asteraceae		*Guizotia reptans* Hutch
Asteraceae		*Richardia brasiliensis* Gomes
Asteraceae		*Tithonia diversifolia* (Hemsl.) Gray
Convolvulaceae		*Ipomoea* sp.
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Piperaceae		*Piper umbellatum* L.
Rubiaceae		*Spermacoce princeae* (K. Schum.) Verdc.
Solanaceae		*Lycopersicum esculentum*
Solanaceae		*Solanum mauritianum* Scop
***Patellapis* (*Zonalictus* sp. 3)**	I, IX, XI-XII	

Acanthaceae		*Hoslundia opposita* Vahl
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Justicia flava* Vahl
Piperaceae		*Piper umbellatum* L.
Patellapis (*Zonalictus* sp. 4)	IV	
Lamiaceae		*Ocimum gratissimum* L.
Patellapis (Zonalictus **sp. 5)**	II-III	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Leucas* sp. A
Patellapis **(*Zonalictus* sp. 6)**	I-II, IV-V, VII, VIII-IX, XII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
Lamiaceae		*Leucas* sp.
Malvaceae		*Hibiscus* sp.
Malvaceae		*Urena lobata* L.
Piperaceae		*Piper umbellatum* L.
Passifloraceae		*Passiflora endulis*
Solanaceae		*Solanum mauritianum* Scop
Patellapis **(*Zonalictus* sp. 7)**	IX	
Acanthaceae		*Dyschoriste radicans* Nees
Patellapis **sp. 9**	IV	
Piperaceae		*Piper umbellatum* L.
Patellapis **sp. 7**	II	
Lamiaceae		*Leucas* sp. B
Pseudapis (Pseudapis **gr *anthidiodes)***	IX, XI	
Melastomataceae		*Dissotis senegambiensis* (Guill. & Perra.) Triana.
Solanaceae		*Solanum mauritianum* Scop
Pseudapis ?amoenula	IV	
Amaranthaceae		*Achyranthes aspera* L.
Pseudapis **sp. 1**	III	
Acanthaceae		*Asystasia* sp.
Pseudapis sp. 2	III	
Acanthaceae		*Justicia flava* Vahl
Steganomus **sp.**	IX	
Asteraceae		*Acmella calirhiza* Del.
Steganomus **sp. 1**	II, VII	
Acanthaceae		*Justicia flava* Vahl
Papilionaceae		*Desmodium adscendens* (Sw.) DC
Systropha **sp.**	III, VI-XII	
Acanthaceae		*Asystasia gangetica* (L.) T. Anders
Acanthaceae		*Thunbergia alata* Sims
Balsaminaceae		*Impatiens burtoni* Hook.f. (I.eminnii Warb.)

Convolvulaceae		*Ipomoea ?wightii*
Convolvulaceae		*Ipomoea* sp.
Convolvulaceae		*Ipomoea wightii* (Wall.) Choisy
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Malvaceae		*Hibiscus* sp.
Solanaceae		*Solanum tuberosum*
COLLETIDAE		
***Colletes* sp.**	II-III, V, IX	
Asteraceae		*Emilia discifolia* (Oliv.) C. Jeffrey
Asteraceae		*Bidens pilosa* L.
Cyperaceae		*Cyperus* sp.
Papaveraraceae		*Piper umbellatum* L.
Asteraceae		*Crassocephalum vitellinum* (Benth.) S. Moore
***Colletes* sp. 1**	III	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Colletes* sp. 2**	III-IV, XII	
Convolvulaceae		*Ipomoea batatas* (L.) Lam.
Solanaceae		*Solanum mauritianum* Scop
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
***Hyleaus (Deranchylaeus* sp.)**	V-VIII	
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Myrsinaceae		*Maesa lanceolata* Forssk
Papilionaceae		*Crotalaria* sp.
***Hyleaus* sp. 1**	I, III-IV, VI	
Acanthaceae		*Acanthus pubescens* (Oliv.) Engl
Asteraceae		*Bidens pilosa* L.
Combretaceae		*Combretum* sp.
Myrsinaceae		*Embelia schimperi* Vatke
Balsaminaceae		*Impatiens burtoni* Hook.f. (*I.eminnii* Warb.)
Rubiaceae		Rubiaceae sp. 1
***Hyleus* sp. 2**	X	
Papilionaceae		*Desmodium adscendens* (Sw.) DC
MEGACHILIDAE		
***Pachyanthidium (Pachyanthidium* sp. *1*)**	IV-V, IX	
Papilionaceae		*Desmodium repandum* (Vahl.) DC.
Acanthaceae		*Justicia flava* Vahl
Lamiaceae		*Ocimum kilimandscharicum* Guerke
Pachyanthidium (Pachyanthidium* sp. *2)	IX	
Asteraceae		*Vernonia* sp.
Pachyanthidium* aff *bengualense	IV-VIII	
Lamiaceae		*Ocimum gratissimum* L.
Asteraceae		*Aspilia mossambicensis* (Oliv.) Wild

Appendix 8.2. A list of plant-bee interactions in Kakamega Forest

Plant species	Bee species
Ipomoea sp.	*Lipotriches aff welwitschi*
Rubus sp.	*Lipotriches aff panganina*
Acanthaceae sp. 1	*Apis mellifera*
Acanthaceae sp. 2	*Apis mellifera*
Acanthus eminens C. B.Cl.	*Apis mellifera* *Xylocopa (koptortotosoma* sp. 1*)* *Xylocopa flavorufa*
Acanthus pubescens (Oliv.) Engl	*Amegilla ?caelestina* *Apis mellifera* *Braunsapis aff luapulana* *Braunsapis foveata* *Braunsapis gorillanum* *Ceratina ericia* *Ceratina moerenhonti* *Ceratina sp.* 2 *Ceratina sp.* 9 *Halictus (Seladonia sp.* 1*)* *Halictus (Seladonia sp.* 2*)* *Hyleus* sp. *Hypotrigona gribodoi* *Lasioglossum (Ctenonomia sp.* 1*)* *Lasioglossum (Ctenonomia* sp. 2*)* *Lasioglossum (Dialictus sp.* 1*)* *Lasioglossum sp.* *Megachile ?fulvitarsis* *Megachile* sp. 1 *Meliponula bocandei* *Meliponula lendliana* *Patellapis (Zonalictus sp.* 1*)* *Patellapis (Zonalictus sp.* 2*)* *Pseudapis ?tshindica* *Pseudapis aff amoenula* *Pseudoanthidium lanificum* *Xylocopa (koptortotosoma sp.* 1*)* *Xylocopa (Xylomellisa sp.* 1*)* *Xylocopa (Xylomellisa sp.* 2*)* *Xylocopa ?albifrons* *Xylocopa ?hottentota* *Xylocopa ?senior* *Xylocopa aff albifrons* *Xylocopa calens* *Xylocopa flavicollis* *Xylocopa flavorufa* *Xylocopa hottentota* *Xylocopa imitator* *Xylocopa incostans* *Xylocopa nigrita* *Xylocopa torrida*
A*chyranthes aspera* L.	*Ceratina ericia* *Ceratina* sp. 1 *Pseudapis aff amoenula*

Acmella calirhiza Del.	*Amegilla aff langi*
	Apis mellifera
	Braunsapis foveata
	Halictus (Seladonia sp. 1*)*
	Lasioglossum (Dialictus sp. 1*)*
	Steganomus sp.
	Thyreus calceatus
Aframomum sp.	*Allodape ?interrupta*
Ageratum conyzoides L.	*Amegilla fallax*
	Amegilla sp. 1
	Apis mellifera
	Ceratina sp. 2
	Halictus (Seladonia sp. 1*)*
	Halictus (Seladonia sp. 2*)*
	Meliponula lendliana
	Nomia (Leuconomia sp. 1*)*
	Pasites ? humectus
Allophylus ferrugineus Taub*.*	*Allodape interruptus*
	Apis mellifera
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	*Ctenoplectra ?*n sp.
	Ctenoplectra antinorii
	Halictus (Seladonia sp. 1*)*
	Halictus (Seladonia sp. 2*)*
	Heriades sulcatulus
	Meliponula lendliana
Allophylus rubifolius (A. Rich.) Engel	*Ceratina ericia*
	Amegilla aff langi
	Apis mellifera
Apocynaceae sp. 1	*Apis mellifera*
	Heriades retifer (n.sp.)
	Meliponula bocandei
	Systropha sp.
Aspilia mossambicensis (Oliv.) Wild	*Allodape ?interrupta*
	Allodape interruptus
	Allodape macula
	Amegilla (Aframegilla sp. 1)
	Amegilla ?cymatilis
	Amegilla acraensis
	Amegilla mimadvena
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis angolensis
	Braunsapis foveata
	Braunsapis gorillanum
	Braunsapis leptozonia
	Ceratina ericia
	Ceratina moerenhonti
	Ceratina penicillata
	Ceratina sp. 1
	Ceratina sp. 2
	Ceratina sp. 3

Ceratina sp. 4
Ceratina sp. 6
Ceratina viridis
Coelioxys (Boreocoelioxys sp.)
Coelioxys sp. 1
Coelioxys verticalis
Colletes sp. 1
Colletes sp. 2
Ctenoplectra ?n sp.
Halictus (Seladonia sp. 1)
Halictus (Seladonia sp. 2)
Heraides sulcatulus
Heriades ?retifer (n sp.)
Heriades ?sulcatulus
Heriades sp. 101
Heriades sp. 1
Heriades sulcatulus
Hylaeus (Deranchylaeus sp.)
Lasioglossum (Ctenonomia sp. 2)
Lasioglossum (Dialictus sp. 1)
Lasioglossum (Ipomalictus sp. 3)
Lasioglossum (Sellalictus sp. 1)
Lasioglossum (Sellalictus sp. 2)
Lasioglossum (Sellalictus sp. 3)
Lasioglossum sp.
Lasioglossum sp. 1
Lipotriches (Trinomia sp. 2)
Lipotriches aff panganina
Lipotriches aff welwitschi
Lipotriches orientalis
Lipotriches tridentata
Megachile (Eutricharacea sp.)
Megachile ?fulvitarsis
Megachile ?gratiosa
Megachile ?niveicaula
Megachile ?polychroma
Megachile ?semierma
Megachile apiformis
Megachile bituberculata
Megachile gratiosa
Megachile sp. 5
Megachile sp. 6
Meliponula ?denoiti
Meliponula bocandei
Meliponula lendliana
Nomia (Leuconomia sp. 1)
Nomia (Leuconomia sp. 2)
Nomia (Leuconomia sp. 3)
Nomia theryi
Pachyanthidium aff bengualense
Patellapis (Zonalictus sp. 1)
Patellapis (Zonalictus sp. 5)
Patellapis (Zonalictus sp. 6)
Pseudapis ?tshindica
Pseudapis aff amoenula
Pseudoanthidium (Micranthidium n. sp. 3)
Pseudoanthidium lanificum
Tetraloniella katagensis
Tetraloniella n. sp. 2
Thrinchostoma (Eothrinchostoma sp. 1)
Thrinchostoma sp.
Thrinchostoma torridum

	Thyreus calceatus
	Thyreus sp. 2
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
Asteraceae sp.1	*Apis mellifera*
Astripomoea sp.	*Apis mellifera*
	Braunsapis foveata
	Systropha sp.
Asystasia gangetica (L.) T. Anders	*Braunsapis leptozonia*
	Allodape interruptus
	Allodape macula
	Amegilla ?caelestina
	Amegilla aff langi
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis angolensis
	Braunsapis facialis
	Braunsapis foveata
	Braunsapis leptozonia
	Ceratina ?eitriphila
	Ceratina ericia
	Ceratina sp. 1
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina sp. 4
	Ceratina viridis
	Ctenoplectra antinorii
	Halictus (Seladonia sp. 1)
	Heriades (Pachyheriades sp. 1)
	Heriades ?sulcatulus
	Heriades sulcatulus
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Ipomalictus sp. 2)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp.
	Lasioglossum sp. 5
	Liotrigona bottegoi
	Lipotriches orientalis
	Megachile ?fulvitarsis
	Megachile ?niveicaula
	Megachile bituberculata
	Meliponula ?denoiti
	Meliponula lendliana
	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
	Nomia aff hylaeoides
	Nomia aff panganina
	Nomia viridiciacta
	Pachyanthidium sp. 1
	Patellapis (Zonalictus sp. 1)
	Patellapis (Zonalictus sp. 2)
	Patellapis (Zonalictus sp. 3)
	Pseudapis ?tshindica
	Systropha sp.
	Tetraloniella katagensis
	Thyreus calceatus
Asystasia sp.	*Allodape ?interrupta*

	Allodape interruptus
	Amegilla (Aframegilla sp. 1)
	Amegilla acraensis
	Amegilla aff langi
	Apis mellifera
	Ceratina ericia
	Coelioxys odin
	Ctenoplectra ?n sp.
	Ctenoplectra sp. 1
	Ctenoplectra terminalis
	Megachile ?fulvitarsis
	Megachile ?niveicaula
	Megachile ciacta combusta
	Megachile felina
	Meliponula bocandei
	Nomia viridiciacta
	Pseudapis sp. 1
	Thrinchostoma (Eothrinchostoma sp. 1)
	Thrinchostoma (Thrinchostoma sp. 1)
	Thyreus interruptus
	Thyreus pictus
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
Asystasia sp.	*Apis mellifera*
Blepharis rotundifolia	*Allodape interruptus*
	Meliponula bocandei
Bidens pilosa L.	*Afranthidium sjoestdi*
	Amegilla aff langi
	Apis mellifera
	Ceratina ?eitriphila
	Ceratina ericia
	Ceratina sp. 2
	Colletes sp. 1
	Euapis abdominalis
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Halictus sp.
	Heriades ?retifer (n sp.)
	Heriades sp. 101
	Heriades sp. 1
	Heriades sulcatulus
	Hylaeus sp. 1
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Sellalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum (Sellalictus sp. 3)
	Liotrigona bottegoi
	Lipotriches aff welwitschi
	Lipotriches orientalis
	Lipotriches tridentata
	Megachile (Paracella sp. 1)
	Megachile ?niveicaula
	Megachile bituberculata
	Megachile mitimia
	Megachile obtusodentata
	Megachile sinuata bokanica
	Meliponula ?denoiti
	Meliponula bocandei

	Meliponula lendliana *Nomia (Leuconomia sp. 2)* *Nomia orientalis* *Patellapis (Zonalictus sp. 1)* *Patellapis (Zonalictus sp. 2)* *Pseudapis ?tshindica* *Pseudoanthidium truncatum* *Thyreus calceatus* *Thyreus pictus* *Xylocopa (Xylomellisa sp. 1)*
Bischoffia javanica Blume	*Meliponula erthyra*
Bothricline fusca (S.Moore) M. Gilbert	*Anthophora (Heliophila aff. vestita)*
Caesalpinia decapetala (Roth) Alston	*Amegilla (Megamegilla sp. 1)* *Amegilla ?caelestina* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis angolensis* *Ceratina viridis* *Creigtoniella ithanoptera* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Hypotrigona gribodoi* *Megachile felina* *Megachile rufipes* *Meliponula bocandei* *Meliponula erthyra* *Meliponula lendliana* *Nomia viridiciacta* *Pseudoanthidium lanificum* *Xylocopa (Xylomellisa sp. 1)* *Xylocopa (Xylomellisa sp. 2)* *Xylocopa aff albifrons* *Xylocopa calens* *Xylocopa erythrina* *Xylocopa flavicollis* *Xylocopa flavorufa* *Xylocopa hottentota* *Xylocopa imitator* *Xylocopa incostans* *Xylocopa nigrita* *Xylocopa torrida*
Capsicum frutescens L.	*Apis mellifera*
Carica papaya Linnaeus	*Megachile ?dariensis*
Cassia sp.	*Nomia (Leuconomia sp. 1)* *Xylocopa imitator*
Chamaecrista hildebrandtii E. Meyer	*Apis mellifera*
Clausena anisata (Wild.) Benth.	*Lasioglossum sp.*
Clerodendrum johnstonii Oliv.	*Apis mellifera* *Ceratina sp. 3* *Coelioxys sp. 1* *Lasioglossum sp.* *Megachile ?polychroma* *Megachile ciacta combusta*

	Meliponula ?denoiti *Meliponula bocandei* *Meliponula lendliana* *Xylocopa (Xylomellisa sp. 1)* *Xylocopa aff albifrons* *Xylocopa calens* *Xylocopa incostans*
Clerodendrum sp.	*Apis mellifera* *Lipotriches sp. 1* *Meliponula bocandei* *Nomia orientalis* *Thyreus pictus* *Xylocopa hottentota* *Xylocopa nigrita*
Coffea eugeniodes S.Moore	*Apis mellifera* *Heriades sp. 101* *Megachile rufipes*
Combretum sp.	*Apis mellifera* *Ceratina ericia* *Hyleus sp.*
Commelina africana L.	*Apis mellifera* *Braunsapis leptozonia* *Ceratina ?eitriphila* *Ceratina ericia* *Ceratina sp. 2* *Halictus (Seladonia sp. 1)* *Lasioglossum sp.* *Meliponula lendliana* *Xylocopa calens*
Commelina sp.	*Amegilla aff langi* *Apis mellifera* *Meliponula ?denoiti* *Meliponula erthyra* *Meliponula lendliana* *Pseudoanthidium (Micranthidium n. sp. 3)* *Xylocopa calens*
Crassocephalum crepidioides (Benth) S. Moore	*Apis mellifera*
Crassocephalum montuosum (S.Moore) Milne-Redh	*Allodape derufata* *Allodape interruptus* *Braunsapis foveata* *Ceratina sp. 2* *Halictus (Seladonia sp. 1)*
Crassocephalum picridifolium (DC.) S.Moore	*Xylocopa calens*
Crassocephalum sp.	*Allodape macula* *Apis mellifera* *Ceratina ericia* *Ceratina sp. 2* *Ceratina sp. 3* *Creigtoniella ithanoptera* *Euapis abdominalis* *Halictus (Seladonia sp. 2)*

	Heriades (Pachyheriades sp. 1)
	Lasioglossum (Sellalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Megachile ciacta combusta
	Megachile pyrrhithorax
	Megachile semivenusta
	Thyreus calceatus
	Xylocopa calens
Crassocephalum vitellinum (Benth.) S.Moore	*Afranthidium sjoestdi*
	Allodape interruptus
	Amegilla aff langi
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis foveata
	Braunsapis leptozonia
	Ceratina ?eitriphila
	Ceratina ?moerenhonti
	Ceratina ericia
	Ceratina sp. 1
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	Colletes sp. 1
	Ctenoplectra ?n sp.
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Heriades sp. 101
	Heriades sp. 1
	Heriades sulcatulus
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Sellalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum (Sellalictus sp. 5)
	Lipotriches aff welwitschi
	Lipotriches orientalis
	Lipotriches sp. 1
	Lipotriches sp. 3
	Megachile ?polychroma
	Megachile felina
	Megachile torridum
	Meliponula ?denoiti
	Meliponula bocandei
	Meliponula lendliana
	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
	Pasites ? humectus
	Patellapis (Zonalictus sp. 6)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Thrinchostoma sp.
	Thyreus pictus
Crotalaria ?agatiflora	*Nomia viridiciacta*
Crotalaria brevidens Benth.	*Amegilla aff langi*
	Amegilla fallax
	Apis mellifera
	Ceratina ericia

	Ceratina viridis *Creigtoniella ithanoptera* *Halictus (Seladonia sp. 1)* *Lasioglossum (?Rubrihalictus sp.)* *Megachile ?fulvitarsis* *Megachile ?gratiosa* *Megachile ?montibia* *Megachile ?niveicaula* *Megachile ?semierma* *Megachile aff rufipes* *Megachile apiformis* *Megachile bituberculata* *Megachile ciacta combusta* *Megachile crakokensis* *Megachile dariensis* *Megachile felina* *Megachile mitimia* *Megachile rufipes* *Megachile sinuata bokanica* *Megachile torridum* *Meliponula bocandei* *Meliponula erthyra* *Nomia theryi* *Serapista denticulata* *Tetraloniella katagensis* *Thyreus ?axillaris* *Thyreus calceatus* *Thyreus interruptus* *Xylocopa ?albifrons* *Xylocopa calens* *Xylocopa flavorufa* *Xylocopa nigrita* *Xylocopa torrida*
Crotalaria sp.	*Apis mellifera* *Ceratina viridis* *Hylaeus (Deranchylaeus sp.)* *Megachile ciacta combusta* *Meliponula bocandei* *Nomia theryi* *Xylocopa (Xylomellisa sp. 2)* *Xylocopa incostans* *Ceratina ericia* *Patellapis (Zonalictus sp. 1)*
Croton macrostachyus Del	*Xylocopa flavorufa* *Xylocopa nigrita*
Cucumis sativus L.	*Apis mellifera*
Cucurbita maxima Duch.	*Apis mellifera*
Cynodon dactylon (L.) Pers.	*Apis mellifera* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Thyreus ?axillaris*
Cyperaceae sp.	*Apis mellifera*
Cyperus sp.	*Apis mellifera* *Braunsapis sp.* *Braunsapis aff luapulana*

	Braunsapis foveata
	Ceratina ericia
	Ceratina sp. 2
	Colletes sp. 1
	Halictus (Seladonia sp. 2)
	Lasioglossum (Rubrihalictus sp.)
	Lasioglossum (Sellalictus sp. 1)
	Lipotriches aff panganina
	Lipotriches orientalis
	Meliponula bocandei
	Meliponula lendliana
	Pseudoanthidium truncatum
	Thrinchostoma sp.
Desmodium adscendens (Sw.) DC	*Allodape interruptus*
	Amegilla aff langi
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis foveata
	Braunsapis leptozonia
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	Coelioxys verticalis
	Ctenoplectra sp. 4
	Halictus (Seladonia sp. 1)
	Hyleus sp. 2
	Lasioglossum (Ctenonomia sp. 1)
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Rubrihalictus sp.)
	Lasioglossum (Sellalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp.
	Lipotriches aff panganina
	Megachile ?dariensis
	Megachile ?gratiosa
	Megachile felina
	Megachile rufipes
	Meliponula erthyra
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Patellapis (Zonalictus sp. 1)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudoanthidium lanificum
	Pseudoanthidium truncatum
	Steganomus sp. 1
	Thyreus calceatus
	Thyreus interruptus
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa (Xylomellisa sp. 2)
	Xylocopa ?senior
Desmodium repandum (Vahl.) DC.	*Allodape interruptus*
	Amegilla aff langi
	Amegilla mimadvena
	Apis mellifera
	Ceratina ericia
	Ceratina sp. 2

	Heriades (Amboheriades n. sp. 1)
	Heriades sulcatulus
	Lasioglossum (Ctenonomia sp. 2)
	Lipotriches aff panganina
	Megachile ?dariensis
	Megachile ?polychroma
	Megachile bituberculata
	Megachile ciacta combusta
	Megachile fulvitaris
	Megachile montibia
	Meliponula bocandei
	Nomia viridiciacta
	Pachyanthidium (Pachyanthidium sp. 1)
	Pseudapis aff amoenula
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa calens
	Xylocopa incostans
	Xylocopa nigrita
Digitaria ?scabra	*Apis mellifera*
	Ceratina ericia
	Ceratina sp. 2
	Halictus (Seladonia sp. 1)
	Lasioglossum (Dialictus sp. 1)
	Lasioglossum (Ipomalictus sp. 3)
	Lasioglossum (Sellalictus sp. 1)
	Lipotriches aff panganina
	Meliponula erthyra
	Nomia aff panganina
	Pseudapis ?tshindica
Dissotis senegambiensis (Guill. & Perra.) Triana*.*	*Amegilla (Megamegilla sp. 1)*
	Amegilla aff langi
	Amegilla mimadvena
	Apis mellifera
	Braunsapis leptozonia
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	Euapis erythros
	Halictus (Seladonia sp. 2)
	Heriades sp. 101
	Heriades sulcatulus
	Lasioglossum (Ctenonomia sp. 1)
	Lipotriches orientalis
	Megachile ?gratiosa
	Megachile ?niveicaula
	Megachile pyrrhithorax
	Megachile sp. 1
	Meliponula bocandei
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Pseudapis (Pseudapis gr anthidiodes)
	Thyreus calceatus
	Thyreus pictus
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa ?senior
	Xylocopa aff sicheli
	Xylocopa calens

	Xylocopa flavorufa
	Xylocopa hottentota
	Xylocopa nigrita
	Xylocopa torrida
Dissotis sp.	*Braunsapis foveata*
	Heriades n sp. 1
	Lipotriches aff welwitschi
	Meliponula bocandei
	Pseudoanthidium truncatum
	Xylocopa calens
	Xylocopa nigrita
	Xylocopa torrida
Dombeya ? torrida	*Apis mellifera*
Dombeya burgessiae Gerrard	*Amegilla aff langi*
	Apis mellifera
	Braunsapis foveata
	Ctenoplectra ?n sp.
	Ctenoplectra antinorii
	Halictus (Seladonia sp. 1)
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Ipomalictus sp. 3)
	Lipotiches sp.
	Lipotriches aff welwitschi
	Megachile ?fulvitarsis
	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
	Pseudapis ?tshindica
	Xylocopa incostans
Dombeya rotundifolia (Hochst.) Planch	*Megachile torridum*
Dovyalis macrocalyx (Oliv.) Warb.	*Apis mellifera*
	Braunsapis aff luapulana
	Ceratina sp. 3
	Lasioglossum (Sellalictus sp. 2)
	Meliponula lendliana
Dracaena fragrans (L.) Ker-Gawl	*Apis mellifera*
	Meliponula lendliana
Dyschoriste radicans Nees	*Amegilla aff langi*
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis foveata
	Braunsapis gorillanum
	Braunsapis leptozonia
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	Ctenoplectra sp. 1
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Heriades (Amboheriades n. sp. 1)
	Heriades sp. 101
	Heriades sp. 1
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp.

	Lasioglossum sp. 7 *Lipotriches aff panganina* *Megachile (Eutricharacea sp.)* *Megachile ?niveicaula* *Megachile ?semivenusta* *Meliponula erthyra* *Meliponula lendliana* *Nomia (Leuconomia sp. 2)* *Nomia (Leuconomia sp. 3)* *Nomia aff panganina* *Patellapis (Zonalictus sp. 2)* *Patellapis (Zonalictus sp. 7)* *Thrinchostoma sp.* *Thyreus calceatus*
Ehretia cymosa Thonn.	*Braunsapis gorillanum* *Meliponula lendliana*
Embelia schimperi Vatke	*Hyleus sp.* *Xylocopa calens*
Emilia discifolia (Oliv.) C. Jeffrey	*Allodape ?interrupta* *Amegilla aff langi* *Apis mellifera* *Braunsapis foveata* *Braunsapis leptozonia* *Ceratina ericia* *Ceratina moerenhonti* *Ceratina sp. 2* *Colletes sp. 1* *Ctenoplectra antinorii* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Lasioglossum (Ipomalictus sp. 1)* *Lasioglossum (Sellalictus sp. 2)* *Lipotriches aff welwitschi* *Megachile ?gratiosa* *Megachile ?polychroma* *Megachile gratiosa* *Meliponula erthyra* *Meliponula lendliana* *Patellapis (Zonalictus sp. 1)* *Pseudapis ?tshindica* *Pseudapis aff amoenula* *Thrinchostoma (Thrinchostoma sp. 1)*
Eragrostis tenuifolia (A.Rich.) Hochst ex.Steud	*Apis mellifera* *Ceratina ericia* *Ceratina sp. 3* *Heriades sulcatulus*
Funtumia latifolia (Benth.) Stapf	*Megachile ?niveicaula* *Patellapis (Zonalictus sp. 1)*
Galinsoga parviflora Cav.	*Allodape ?interrupta* *Allodape interruptus* *Amegilla aff langi* *Apis mellifera* *Braunsapis foveata* *Braunsapis leptozonia* *Ceratina ?moerenhonti*

	Ceratina ericia
	Ceratina moerenhonti
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina viridis
	Ctenoplectra sp. 1
	Ctenoplectra sp. 2
	Ctenoplectrina ?politula
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Hypotrigona gribodoi
	Lasioglossum (Ipomalictus sp. 2)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp. 5
	Lipotriches tridentata
	Megachile montibia
	Meliponula ?denoiti
	Meliponula bocandei
	Meliponula erthyra
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Pseudapis aff amoenula
	Pseudoanthidium lanificum
	Pseudoanthidium truncatum
Geniosporum rotundifolium Briq.	*Allodape derufata*
	Amegilla aff langi
	Apis mellifera
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 3
	Coelioxys sp. 1
	Halictus (Seladonia sp. 1)
	Lasioglossum (Ctenonomia sp. 2)
	Megachile ?polychroma
	Megachile ciacta combusta
	Meliponula bocandei
Poaceae sp. 1	*Apis mellifera*
	Ceratina ericia
	Ceratina sp. 3
	Halictus (Seladonia sp. 2)
	Hypotrigona gribodoi
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Sellalictus sp. 1)
	Lasioglossum (Sellalictus sp. 2)
	Lipotriches aff panganina
	Lipotriches aff welwitschi
	Megachile ?dariensis
	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
Phaseolus aureus	*Amegilla aff langi*
	Apis mellifera
	Ceratina ericia
	Ceratina viridis
	Lasioglossum (Sellalictus sp. 1)
	Lipotriches sp. 1
	Megachile ?dariensis
	Meliponula bocandei
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)

	Nomia (Leuconomia sp. 4) *Patellapis (Zonalictus sp. 1)* *Pseudapis aff amoenula* *Thrinchostoma (Thrinchostoma sp. 1)*
Guizotia reptans Hutch	*Allodape interruptus* *Apis mellifera* *Ceratina sp. 2* *Halictus (Seladonia sp. 2)* *Heriades sp. 101* *Lasioglossum (Ctenonomia sp. 1)* *Lasioglossum (Sellalictus sp. 2)* *Megachile ciacta combusta* *Megachile gratiosa* *Meliponula bocandei* *Nomia (Leuconomia sp. 1)* *Nomia viridiciacta* *Patellapis (Zonalictus sp. 2)*
Gynandropsis gynandra (L.) Briq.	*Allodape ?interrupta* *Amegilla ?cymatilis* *Amegilla aff langi* *Apis mellifera* *Ceratina ericia*
Harungana madagascariensis Poir	*Apis mellifera* *Ceratina ericia* *Ceratina sp. 3* *Ctenoplectra antinorii* *Lasioglossum (Sellalictus sp. 1)* *Lasioglossum sp.* *Megachile ?gratiosa* *Meliponula ?denoiti* *Meliponula bocandei* *Meliponula erthyra* *Thrinchostoma (Thrinchostoma sp. 1)* *Thrinchostoma torridum* *Xylocopa hottentota*
Helichrysum schimperi (Sch. Bip)	*Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Ceratina viridis*
Hibiscus sp.	*Afranthidium sjoestdi* *Allodape ?interrupta* *Allodape interruptus* *Amegilla aff langi* *Apis mellifera* *Ceratina ericia* *Ceratina sp. 2* *Ceratina sp. 3* *Halictus (Seladonia sp. 2)* *Heriades sp. 101* *Lasioglossum (Sellalictus sp. 2)* *Lipotriches aff welwitschi* *Lipotriches orientalis* *Lipotriches tridentata* *Megachile ?polychroma* *Megachile rufipes* *Megachile torridum* *Meliponula lendliana* *Patellapis (Zonalictus sp. 6)*

	Systropha sp.
	Thrinchostoma sp.
	Thyreus ?axillaris
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa erythrina
Hoslundia opposita Vahl	*Allodape ?interrupta*
	Allodape interruptus
	Ceratina ericia
	Ceratina sp. 2
	Halictus (Seladonia sp. 2)
	Meliponula lendliana
	Patellapis (Zonalictus sp. 3)
Impatiens burtoni Hook.f. *(I.eminnii Warb.)*	*Allodape interruptus*
	Amegilla aff langi
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 5
	Ctenoplectra antinorii
	Hyleus sp.
	Lasioglossum (Ipomalictus sp. 2)
	Lasioglossum (Sellalictus sp. 4)
	Lasioglossum sp. 6
	Lipotriches (Lipotriches sp. 1)
	Meliponula lendliana
	Patellapis (Zonalictus sp. 1)
	Pseudoanthidium truncatum
	Systropha sp.
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa ?calens
	Xylocopa calens
	Xylocopa hottentota
	Xylocopa imitator
Indigofera sp.	*Amegilla aff langi*
Ipomoea ?wightii	*Apis mellifera*
	Ceratina sp. 2
	Systropha sp.
Ipomoea batata (L.) Lam	*Allodape interruptus*
	Amegilla (Megamegilla sp. 1)
	Apis mellifera
	Ceratina moerenhonti
	Ceratina sp. 2
	Colletes sp. 2
Ipomoea hildebrandtii Vatke	*Lasioglossum (Sellalictus sp. 2)*
Ipomoea sp.	*Allodape ?interrupta*
	Apis mellifera
	Braunsapis foveata
	Ceratina ? viridis
	Ceratina ericia
	Ceratina moerenhonti
	Ceratina sp. 1
	Ceratina sp. 3
	Ctenoplectra ?n sp.
	Ctenoplectra antinorii

	Ctenoplectrina ?politula
	Heriades (Pachyheriades sp. 1)
	Lasioglossum (Sellalictus sp. 5)
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Ipomalictus sp. 2)
	Lasioglossum (Ipomalictus sp. 3)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp. 2
	Lipotriches aff welwitschi
	Megachile ciacta combusta
	Meliponula ?denoiti
	Meliponula bocandei
	Nomia (Leuconomia sp. 1)
	Nomia viridiciacta
	Patellapis (Zonalictus sp. 2)
	Pseudapis sp. 1
	Systropha sp.
	Thrinchostoma (Thrinchostoma sp. 1)
	Thrinchostoma sp.
	Thrinchostoma torridum
	Xylocopa (Xylomellisa sp. 1)
Justicia calyculata (Deflers) T. Anders.	*Afranthidium sjoestdi*
	Allodape ?interrupta
	Apis mellifera
	Braunsapis aff luapulana
	Braunsapis foveata
	Ceratina ericia
	Creigtoniella ithanoptera
	Halictus (Seladonia sp. 1)
	Lasioglossum (Ctenonomia sp. 2)
	Megachile gratiosa
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Nomia viridiciacta
	Thrinchostoma sp.
Justicia declipteriodes Lindau	*Pseudoanthidium lanificum*
	Pseudoanthidium truncatum
Justicia flava Vahl	*Afranthidium sjoestdi*
	Allodape derufata
	Allodape interruptus
	Allodape sp. 1
	Amegilla (Aframegilla sp. 1)
	Amegilla (Megamegilla sp. 1)
	Amegilla ?caelestina
	Amegilla ?cymatilis
	Amegilla acraensis
	Amegilla aff langi
	Amegilla capensis
	Amegilla fallax
	Amegilla mimadvena
	Amegilla sp. 1
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Braunsapis angolensis
	Braunsapis foveata
	Ceratina ericia
	Ceratina moerenhonti
	Ceratina penicillata
	Ceratina sp. 1

Ceratina sp. 2
Ceratina sp. 3
Ceratina sp. 4
Ceratina viridis
Coelioxys (Boreocoelioxys sp.)
Coelioxys odin
Coelioxys sp. 3
Coelioxys verticalis
Creigtoniella ithanoptera
Ctenoplectra antinorii
Ctenoplectra terminalis
Euapis abdominalis
Euapis erythros
Halictus (Seladonia sp. 1)
Halictus (Seladonia sp. 2)
Heriades sp. 101
Heriades sulcatulus
Lasioglossum (Ctenonomia sp. 1)
Lasioglossum (Ctenonomia sp. 2)
Lasioglossum (Ipomalictus sp. 1)
Lasioglossum (Ipomalictus sp. 2)
Lasioglossum (Ipomalictus sp. 3)
Lasioglossum (Sellalictus sp. 1)
Lasioglossum (Sellalictus sp. 2)
Lasioglossum (Sellalictus sp. 4)
Lasioglossum sp.
Lipotriches (Lipotriches sp. 1)
Lipotriches (Nebenomia sp.)
Lipotriches aff welwitschi
Lipotriches orientalis
Lipotriches tridentata
Megachile (Eutricharacea sp.)
Megachile ?dariensis
Megachile ?fulvitarsis
Megachile ?gratiosa
Megachile ?montibia
Megachile ?niveicaula
Megachile ?polychroma
Megachile ?semierma
Megachile ?semivenusta
Megachile aff rufipes
Megachile apiformis
Megachile basalis
Megachile bituberculata
Megachile ciacta combusta
Megachile decemsignata
Megachile felina
Megachile mitimia
Megachile montibia
Megachile polychroma
Megachile postaigra
Megachile pyrrhithorax
Megachile rufipes
Megachile rufiventris
Megachile semierma
Megachile sp. 1
Megachile sp. 2
Megachile torridum
Meliponula ?denoiti
Meliponula bocandei
Meliponula erthyra
Meliponula lendliana

	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
	Nomia aff hylaeoides
	Nomia chandleri
	Nomia theryi
	Nomia tshindica
	Nomia viridiciacta
	Pachyanthidium (Pachyanthidium sp. 1)
	Patellapis (Zonalictus sp. 1)
	Patellapis (Zonalictus sp. 2)
	Patellapis (Zonalictus sp. 3)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudapis sp. 2
	Pseudoanthidium (Micranthidium n. sp. 3)
	Pseudoanthidium lanificum
	Pseudoanthidium truncatum
	Serapista denticulata
	Steganomus sp. 1
	Tetraloniella sp. 1
	Tetraloniella sp. 3
	Thrinchostoma sp.
	Thyreus ?axillaris
	Thyreus calceatus
	Thyreus interruptus
	Thyreus pictus
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa (Xylomellisa sp. 2)
	Xylocopa ?albifrons
	Xylocopa ?hottentota
	Xylocopa ?senior
	Xylocopa aff albifrons
	Xylocopa calens
	Xylocopa flavicollis
	Xylocopa flavorufa
	Xylocopa hottentota
	Xylocopa imitator
	Xylocopa incostans
	Xylocopa nigrita
	Xylocopa varipes
Kalanchoe crenata (Andrews) Haworth	*Ceratina sp. 4*
Kotschya recurvifolia (Taub.) F. White	*Apis mellifera*
	Megachile ?dariensis
	Megachile ?mitimia
	Megachile ?montibia
	Megachile bituberculata
	Megachile dariensis
	Megachile sp. 4
	Xylocopa (Xylomellisa sp. 2)
	Xylocopa flavicollis
	Xylocopa hottentota
	Xylocopa imitator
Papilionaceae sp. L1	*Apis mellifera*
	Megachile bituberculata
	Megachile dariensis
	Xylocopa (Xylomellisa sp. 1)
Labiatae sp. A	*Coelioxys aff. affra*

Lantana camara L.	*Allodape interruptus*
	Amegilla (Megamegilla sp. 1)
	Amegilla aff langi
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Ceratina ericia
	Ceratina sp. 2
	Ceratina viridis
	Euapis abdominalis
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Heriades sp. 101
	Lasioglossum (Ipomalictus sp. 3)
	Megaceratina sculpturata
	Megachile (Eutricharacea sp.)
	Megachile ?fulvitarsis
	Megachile ?niveicaula
	Meliponula bocandei
	Meliponula lendliana
	Nomia viridiciacta
	Pseudoanthidium (Micranthidium n. sp. 3)
	Thrinchostoma (Thrinchostoma sp. 1)
	Thrinchostoma wissmani
	Thyreus pictus
	Xylocopa calens
	Xylocopa incostans
	Xylocopa nigrita
Lantana trifolia L.	*Halictus (Seladonia sp. 1)*
	Meliponula bocandei
	Nomia aff hylaeoides
Cassipourea ruwensorensis (Engl.) Alston	*Megachile torridum*
Leea guineensis G. Don	*Apis mellifera*
	Braunsapis aff luapulana
	Braunsapis angolensis
	Braunsapis leptozonia
	Ceratina ericia
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Lasioglossum (Ipomalictus sp. 1)
	Lipotriches tridentata
	Meliponula lendliana
Leonotis nepetifolia (L.) R.Br	*Amegilla aff langi*
	Apis mellifera
	Halictus (Seladonia sp. 2)
	Lasioglossum (Ctenonomia sp. 2)
	Lasioglossum (Sellalictus sp. 1)
Lepidotrichilia volkensii (Gürke)	*Apis mellifera*
	Braunsapis foveata
	Ceratina sp. 2
Leucas calostachys Oliv.	*Meliponula bocandei*
	Thyreus pictus
Leucas sp.	*Allodape ?interrupta*
	Allodape ?mirabilis
	Allodape interruptus

	Amegilla (Megamegilla sp. 1)
	Apis mellifera
	Braunsapis facialis
	Braunsapis foveata
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 4
	Coelioxys (Boreocoelioxys sp.)
	Heriades (Pachyheriades sp. 1)
	Lipotriches orientalis
	Megachile ?polychroma
	Megachile ?semivenusta
	Megachile sp. 2
	Meliponula lendliana
	Patellapis (Zonalictus sp. 1)
	Patellapis (Zonalictus sp. 5)
	Patellapis (Zonalictus sp. 6)
	Patellapis sp. 7
	Pseudapis aff amoenula
	Pseudoanthidium lanificum
	Thrinchostoma (Thrinchostoma sp. 1)
	Thrinchostoma sp.
	Thyreus interruptus
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa aff albifrons
Lycopersicum esculentum Mill	*Amegilla aff langi*
	Anthophora (Heliophila aff. vestita)
	Nomia viridiciacta
	Patellapis (Zonalictus sp. 2)
Maesa lanceolata Forssk	*Apis mellifera*
	Braunsapis foveata
	Braunsapis sp. 1
	Ceratina ericia
	Ceratina sp. 2
	Ceratina sp. 3
	Euapis abdominalis
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Hylaeus (Deranchylaeus sp.)
	Lipotriches aff welwitschi
	Megachile ?niveicaula
	Meliponula bocandei
	Meliponula erthyra
	Meliponula lendliana
	Nomia viridiciacta
	Tetraloniella katagensis
	Thrinchostoma (Thrinchostoma sp. 1)
	Thyreus pictus
Manihot esulenta Crantz	*Heriades sp. 101*
	Meliponula erthyra
Mimulopsis sp.	*Ceratina viridis*
	Megachile rufipes
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa flavorufa
	Xylocopa hottentota
	Xylocopa imitator
	Xylocopa nigrita

	Xylocopa torrida
Momordica foetida Schumach	*Braunsapis aff luapulana* *Braunsapis foveata* *Ceratina ?eitriphila* *Ceratina ericia* *Ceratina sp. 2* *Ceratina viridis* *Ctenoplectra ?n sp.* *Ctenoplectra antinorii* *Ctenoplectra sp. 3* *Ctenoplectra terminalis* *Ctenoplectrina ?politula* *Lipotriches aff panganina* *Meliponula ?denoiti* *Meliponula erthyra* *Patellapis (Zonalictus sp. 1)* *Pseudapis aff amoenula* *Xylocopa ?hottentota*
Mussaenda arcuata Poir	*Amegilla ?caelestina* *Meliponula bocandei*
	Xylocopa incostans
	Xylocopa calens *Xylocopa imitator*
Ocimum gratissimum L.	*Allodape ?chapini* *Allodape derufata* *Allodape interruptus* *Amegilla ?caelestina* *Apis mellifera* *Braunsapis angolensis* *Braunsapis foveata* *Ceratina ?moerenhonti* *Ceratina ericia* *Ceratina sp. 2* *Ceratina viridis* *Coelioxys aff. affra* *Coelioxys sp. 2* *Halictus (Seladonia sp. 2)* *Heriades (? Amboheriades n. sp. 1)* *Heriades (Amboheriades n. sp. 1)* *Heriades sp. 101* *Heriades sulcatulus* *Lasioglossum (Ipomalictus sp. 1)* *Lasioglossum (Sellalictus sp. 3)* *Megachile ?fulvitarsis* *Megachile ?gratiosa* *Megachile ?semivenusta* *Megachile ciacta combusta* *Megachile rufipes* *Meliponula bocandei* *Meliponula lendliana* *Nomia viridiciacta* *Pachyanthidium aff bengualense* *Patellapis (Zonalictus sp. 4)* *Pseudoanthidium (Micranthidium n. sp. 3)* *Pseudoanthidium lanificum*

	Pseudoanthidium truncatum *Thyreus interruptus* *Xylocopa (Xylomellisa sp. 1)*
Ocimum kilimandscharicum Guerke	*Allodape ?mirabilis* *Allodape interruptus* *Amegilla ?caelestina* *Amegilla aff langi* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis aff luapulana* *Braunsapis angolensis* *Braunsapis facialis* *Braunsapis foveata* *Braunsapis leptozonia* *Ceratina ?moerenhonti* *Ceratina ericia* *Ceratina moerenhonti* *Ceratina sp. 1* *Ceratina sp. 2* *Ceratina sp. 3* *Ceratina sp. 6* *Ceratina viridis* *Coelioxys aff. affra* *Creigtoniella ithanoptera* *Ctenoplectra sp. 1* *Ctenoplectra ?n sp.* *Ctenoplectra antinorii* *Ctenoplectra sp. 5* *Halictid 34* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Heriades (Pachyheriades sp. 1)* *Heriades sp. 101* *Heriades sulcatulus* *Hylaeus (Deranchylaeus sp.)* *Hypotrigona gribodoi* *Lasioglossum (Ctenonomia sp. 1)* *Lasioglossum (Ctenonomia sp. 2)* *Lasioglossum (Dialictus sp. 1)* *Lasioglossum (Ipomalictus sp. 1)* *Lasioglossum (Sellalictus sp. 2)* *Lasioglossum sp.* *Lasioglossum sp. 6* *Lasioglossum sp. 7* *Lipotriches (Trinomia sp. 1)* *Lipotriches aff panganina* *Lipotriches aff welwitschi* *Lipotriches tridentata* *Megachile ?fulvitarsis* *Megachile ?gratiosa* *Megachile ?niveicaula* *Megachile ?polychroma* *Megachile ?semivenusta* *Megachile apiformis* *Megachile bituberculata* *Megachile gratiosa* *Megachile mitimia* *Megachile sinuata bokanica* *Megachile torridum* *Meliponula ?denoiti* *Meliponula bocandei*

	Meliponula erthyra
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Nomia theryi
	Nomia viridiciacta
	Pachyanthidium (Pachyanthidium sp. 1)
	Patellapis (Zonalictus sp. 1)
	Patellapis (Zonalictus sp. 2)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudoanthidium (Micranthidium n. sp. 3)
	Pseudoanthidium lanificum
	Systropha sp.
	Thrinchostoma sp.
	Thyreus ?axillaris
	Thyreus pictus
	Xylocopa calens
Ocimum sp.	*Braunsapis aff luapulana*
	Heriades sp. 101
Oxalis sp.	*Amegilla aff langi*
	Ceratina sp. 2
	Megachile semierma
	Meliponula lendliana
	Patellapis (Zonalictus sp. 1)
Oxyanthus ? *speciosus* D. C	*Xylocopa calens*
Oxyanthus sp.	*Xylocopa calens*
Papilionaceae sp. A	*Megachile basalis*
Papilionaceae sp. B	*Apis mellifera*
	Nomia theryi
Papilionaceae sp. C	*Xylocopa calens*
Passiflora endulis F.	*Apis mellifera*
	Patellapis (Zonalictus sp. 6)
	Xylocopa incostans
Pavetta abyssinica Fres	*Braunsapis foveata*
	Lasioglossum (Ipomalictus sp. 3)
Pavetta sp.	*Braunsapis foveata*
	Halictus (Seladonia sp. 1)
	Pseudoanthidium (Micranthidium n. sp. 3)
Pavetta subcana Brem.	*Ceratina ericia*
	Lipotriches orientalis
Pavetta ternifolia (Oliv.) Hiern	*Apis mellifera*
	Ceratina sp. 2
	Ceratina sp. 4
	Heriades (Pachyheriades sp. 1)
	Megachile torridum
	Meliponula bocandei
	Meliponula lendliana
	Pseudoanthidium (Micranthidium n. sp. 3)
Pavonia sp.	*Allodape interruptus*

	Amegilla (Megamegilla sp. 1)
	Apis mellifera
	Ceratina sp. 2
	Halictus (Seladonia sp. 1)
	Lasioglossum (Ipomalictus sp. 3)
	Lasioglossum (Rubrihalictus sp.)
	Lasioglossum (Sellalictus sp. 2)
	Megachile ?fulvitarsis
	Meliponula ?denoiti
	Meliponula lendliana
	Pseudapis aff amoenula
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa aff albifrons
Pavonia urens Cav.	*Amegilla mimadvena*
	Apis mellifera
	Ceratina sp. 3
	Ctenoplectra antinorii
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Lasioglossum (Ipomalictus sp. 1)
	Meliponula bocandei
	Meliponula lendliana
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa (Xylomellisa sp. 2)
	Xylocopa aff albifrons
	Xylocopa imitator
	Xylocopa incostans
Peddia fischeli Engl.	*Apis mellifera*
	Ceratina sp. 2
	Halictus (Seladonia sp. 2)
Phaseolus vulgaris L.	*Apis mellifera*
	Ceratina viridis
	Creigtoniella ithanoptera
	Megachile ?dariensis
	Megachile ?fulvitarsis
	Megachile aff rufipes
	Megachile bituberculata
	Megachile ciacta combusta
	Megachile mitimia
	Megachile montibia
	Megachile pyrrhithorax
	Tetraloniella katagensis
	Xylocopa calens
	Xylocopa imitator
	Xylocopa nigrita
	Xylocopa torrida
Phaulopsis imbricata (Forsk.) Sweet	*Allodape ?interrupta*
	Allodape sp. 1
	Allodope n. sp.
	Amegilla aff langi
	Amegilla fallax
	Apis mellifera
	Braunsapis foveata
	Ceratina ?eitriphila
	Ceratina ericia

	Ceratina sp. 1
	Ceratina sp. 2
	Ceratina sp. 3
	Ceratina sp. 4
	Ceratina viridis
	Coelioxys (Boreocoelioxys sp.)
	Halictus (Seladonia sp. 1)
	Heriades ?retifer (n sp.)
	Heriades sulcatulus
	Lasioglossum (Rubrihalictus sp. 2)
	Lasioglossum sp.
	Lipotriches aff panganina
	Megachile (Eutricharacea sp.)
	Megachile ?niveicaula
	Megachile pyrrhithorax
	Megachile sp. 3
	Meliponula bocandei
	Nomia (Leuconomia sp. 1)
	Nomia (Leuconomia sp. 2)
	Patellapis (Homalictus sp. 1)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudoanthidium (Micranthidium n. sp. 3)
	Pseudoanthidium lanificum
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa calens
Piper capense L.f.	*Ceratina ericia*
	Lipotriches aff welwitschi
	Thrinchostoma (Thrinchostoma sp. 1)
Piper umbellatum L.	*Allodape interruptus*
	Allodape macula
	Apis mellifera
	Braunsapis foveata
	Ceratina ericia
	Ceratina moerenhonti
	Ceratina sp. 2
	Ceratina sp. 3
	Colletes sp. 1
	Ctenoplectra sp. 1
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Heriades ?retifer (n sp.)
	Lasioglossum (Ctenonomia sp. 1)
	Lasioglossum (Ipomalictus sp. 1)
	Lasioglossum (Ipomalictus sp. 3)
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp.
	Lipotriches aff aurifrons
	Lipotriches aff panganina
	Meliponula ?denoiti
	Meliponula bocandei
	Meliponula lendliana
	Nomia aff hylaeoides
	Nomia orientalis
	Patellapis (Zonalictus sp. 2)
	Patellapis (Zonalictus sp. 3)
	Patellapis (Zonalictus sp. 6)
	Patellapis sp. 9
Plant sp. *A*	*Pachyanthidium aff bengualense*

	Pseudoanthidium (Micranthidium n. sp. 3)
	Ceratina ericia *Ceratina sp. 7*
Plant sp. B	*Halictus (Seladonia sp. 2)*
Plant sp. D	*Apis mellifera*
Plant sp. E	*Megachile ?semivenusta*
Plant sp. F	*Megachile ?niveicaula*
Plant sp. G	*Nomia viridiciacta*
Plant sp. H	*Nomia (Leuconomia sp. 2)*
Plant sp. I	*Allodape macula*
Plant sp. J	*Xylocopa (Xylomellisa sp. 1)*
Plectranthus barbatus	*Braunsapis foveata* *Ceratina ericia* *Nomia (Leuconomia sp. 2)*
Plectranthus sp.	*Ceratina sp. 2* *Nomia (Leuconomia sp. 2)* *Thyreus calceatus*
Pollia condensata C. B. Cl.	*Apis mellifera* *Braunsapis foveata* *Halictus (Seladonia sp. 2)* *Lasioglossum (Ctenonomia sp. 2)* *Megachile ?fulvitarsis*
Pseudarthia hookeri Wight & Arn. Var. hookeri	*Xylocopa calens*
Psidium guajava L.	*Apis mellifera* *Braunsapis angolensis* *Ctenoplectra antinorii* *Euapis abdominalis* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Heriades (Amboheriades n. sp. 1)* *Heriades sp. 101* *Lasioglossum (Ipomalictus sp. 3)* *Lipotriches tridentata* *Megachile ?fulvitarsis* *Megachile ?niveicaula* *Megachile basalis* *Megachile ciacta combusta* *Meliponula bocandei* *Meliponula erthyra* *Nomia (Leuconomia sp. 3)* *Patellapis (Zonalictus sp. 6)* *Pseudoanthidium lanificum* *Xylocopa (Xylomellisa sp. 1)* *Xylocopa (Xylomellisa sp. 2)* *Xylocopa calens* *Xylocopa flavorufa*

	Xylocopa imitator *Xylocopa incostans* *Xylocopa nigrita* *Xylocopa torrida*
Psychotria sp.	*Xylocopa calens*
Richardia brasiliensis Gomes	*Apis mellifera* *Braunsapis foveata* *Creigtoniella ithanoptera* *Ctenoplectra ?n sp.* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Heriades sp. 101* *Lasioglossum (Sellalictus sp. 4)* *Nomia viridiciacta* *Pseudoanthidium (Micranthidium n. sp. 3)*
Reichardia sp.	*Afranthidium sjoestdi* *Apis mellifera* *Ceratina ericia* *Lipotriches aff welwitschi* *Megachile ?polychroma* *Patellapis (Zonalictus sp. 2)*
Rotheca myricoides	*Amegilla aff langi* *Amegilla mimadvena* *Megachile polychroma* *Meliponula bocandei* *Xylocopa calens* *Xylocopa flavorufa* *Xylocopa imitator*
Rothmania sp.	*Meliponula bocandei*
Rubiaceae sp. 1	*Hyleus sp.*
Rubus sp.	*Ceratina sp. 2* *Halictus (Seladonia sp. 2)* *Megachile ?gratiosa* *Nomia orientalis*
Salvia sp.	*Xylocopa calens*
Senna didymobotrya (Fresen.) Irwin & Barneby	*Amegilla ?caelestina* *Xylocopa calens*
Sida sp.	*Amegilla mimadvena* *Anthophora (Heliophila aff. vestita)* *Braunsapis foveata* *Ceratina ericia* *Halictus (Seladonia sp. 2)* *Lasioglossum (Sellalictus sp. 2)* *Lasioglossum (Sellalictus sp. 3)* *Lipotriches aff panganina* *Lipotriches sp. 2* *Meliponula erthyra* *Meliponula lendliana* *Nomia (Leuconomia sp. 2)*
Solanum incanum L.	*Amegilla aff langi*

	Lasioglossum (Sellalictus sp. 2)
	Lipotriches sp. 1
	Megachile rufipes
	Xylocopa calens
	Xylocopa (Xylomellisa sp. 2)
Solanum macrocalyx	*Apis mellifera*
Solanum mauritianum Scop	*Afranthidium sjoestdi*
	Amegilla (Megamegilla sp. 1)
	Anthophora (Heliophila aff. vestita)
	Apis mellifera
	Braunsapis angolensis
	Braunsapis foveata
	Ceratina sp. 2
	Ceratina sp. 3
	Colletes sp. 2
	Heriades sp. 101
	Lasioglossum (Sellalictus sp. 2)
	Lasioglossum sp. 2
	Lipotriches aff panganina
	Megachile bituberculata
	Megachile ciacta combusta
	Megachile decemsignata
	Megachile rufipes
	Patellapis (Zonalictus sp. 6)
	Pseudapis (Pseudapis gr anthidiodes)
	Pseudapis aff amoenula
	Pseudoanthidium lanificum
	Thyreus ?axillaris
	Thyreus pictus
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa (Xylomellisa sp. 2)
	Xylocopa (koptortotosoma sp. 1)
	Xylocopa calens
	Xylocopa flavorufa
	Xylocopa hottentota
	Xylocopa incostans
	Xylocopa nigrita
Solanum melongena	*Amegilla aff langi*
	Euapis abdominalis
	Meliponula bocandei
	Pseudapis aff amoenula
	Xylocopa calens
	Xylocopa incostans
Solanum microcalyx	*Apis mellifera*
	Ctenoplectra ?n sp.
	Lipotriches aff welwitschi
	Megachile ?niveicaula
	Meliponula bocandei
	Meliponula lendliana
	Nomia (Leuconomia sp. 1)
	Patellapis (Zonalictus sp. 2)
	Patellapis (Zonalictus sp. 6)
	Pseudoanthidium truncatum
	Xylocopa (Xylomellisa sp. 1)
	Xylocopa calens
	Xylocopa imitator
	Xylocopa nigrita

Solanum seafathianum	*Amegilla (Aframegilla sp. 1)*
Solanum sp.	*Apis mellifera* *Halictus (Seladonia sp. 1)* *Lipotriches (Lipotriches sp. 1)* *Thyreus interruptus* *Xylocopa (Xylomellisa sp. 1)* *Xylocopa calens* *Xylocopa incostans*
Solanum tuberosum	*Amegilla (Megamegilla sp. 1)* *Amegilla mimadvena* *Apis mellifera* *Euapis abdominalis* *Euapis erythros* *Halictus (Seladonia sp. 2)* *Megachile bituberculata* *Systropha sp.* *Xylocopa calens*
Spermacoce princeae	*Amegilla aff langi* *Apis mellifera* *Braunsapis aff luapulana* *Braunsapis angolensis* *Braunsapis foveata* *Ceratina ?eitriphila* *Ceratina ericia* *Ceratina sp. 1* *Ceratina sp. 3* *Ceratina viridis* *Halictus (Seladonia sp. 1)* *Lasioglossum (Sellalictus sp. 1)* *Lipotriches aff panganina* *Nomia aff hylaeoides* *Thrinchostoma (Eothrinchostoma sp. 1)*
Spermacoce princeae (K:Schum.) Verdc.	*Braunsapis leptozonia* *Ceratina ericia* *Ceratina moerenhonti* *Ceratina sp. 2* *Ceratina sp. 3* *Halictus (Seladonia sp. 1)* *Heriades (Pachyheriades sp. 1)* *Lipotriches aff panganina* *Patellapis (Zonalictus sp. 2)*
Stachytarpheta urtifolia	*Amegilla aff langi* *Xylocopa (Xylomellisa sp. 2)*
Stachytarpheta jamaicaensis	*Amegilla (Aframegilla sp. 1)* *Amegilla (Megamegilla sp. 1)* *Amegilla ?caelestina* *Amegilla aff langi* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis foveata* *Ceratina viridis* *Euapis abdominalis* *Heriades sp. 101* *Liotrigona bottegoi*

	Lipotriches (Lipotriches sp. 1) *Megachile ?gratiosa* *Megachile ?montibia* *Megachile ciacta combusta* *Meliponula erthyra* *Pseudoanthidium (Micranthidium n. sp. 3)* *Thrinchostoma wissmani* *Thyreus pictus* *Xylocopa calens*
Tagetes minuta L.	*Apis mellifera* *Meliponula lendliana* *Xylocopa torrida*
Teclea nobilis Del.	*Meliponula erthyra*
Tephrosia sp.	*Apis mellifera* *Megachile ciacta combusta* *Xylocopa (koptortotosoma sp. 1)*
Terenna pavettoides	*Apis mellifera* *Ceratina ericia*
Thurnbergia alata Sims	*Allodape interruptus* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis foveata* *Ceratina ?eitriphila* *Ceratina sp. 1* *Ceratina sp. 3* *Ceratina viridis* *Ctenoplectra ?n sp.* *Ctenoplectra antinorii* *Halictus (Seladonia sp. 1)* *Heriades sp. 101* *Heriades sulcatulus* *Lasioglossum (Ipomalictus sp. 2)* *Lasioglossum (Ipomalictus sp. 3)* *Lasioglossum sp.* *Megachile ciacta combusta* *Meliponula erthyra* *Pseudoanthidium (Micranthidium n. sp. 3)* *Systropha sp.* *Thyreus ?axillaris* *Thyreus calceatus*
Thurnbergia sp.	*Halictus (Seladonia sp. 1)*
Tithonia diversifolia (Hemsl.) Gray	*Allodape interruptus* *Amegilla (Megamegilla sp. 1)* *Amegilla aff langi* *Amegilla sierra* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis aff luapulana* *Braunsapis angolensis* *Ceratina ericia* *Ceratina sp. 2* *Ceratina sp. 8* *Ceratina viridis* *Chalicodoma rufipes*

	Coelioxys sp. 1
	Coelioyxs sp. 1
	Ctenoplectra antinorii
	Halictus (Seladonia sp. 1)
	Halictus (Seladonia sp. 2)
	Hypotrigona gribodoi
	Lasioglossum (Sellalictus sp. 2)
	Megachile ?gratiosa
	Megachile aff rufipes
	Megachile bituberculata
	Megachile ciacta combusta
	Megachile felina
	Megachile maxillosa
	Megachile obtusodentata
	Megachile rufipennis
	Megachile torridum
	Meliponula ?denoiti
	Meliponula bocandei
	Meliponula erthyra
	Meliponula lendliana
	Nomia (Leuconomia sp. 2)
	Patellapis (Zonalictus sp. 2)
	Pseudapis ?tshindica
	Pseudapis aff amoenula
	Pseudoanthidium (Micranthidium n. sp. 3)
	Thyreus ?axillaris
	Thyreus interruptus
	Thyreus pictus
	Xylocopa calens
	Xylocopa flavicollis
	Xylocopa hottentota
	Xylocopa imitator
	Xylocopa nigrita
	Xylocopa torrida
Triumfetta rhomboidea Jacq	*Anthophora (Heliophila aff. vestita)*
	Ceratina sp. 2
	Ceratina sp. 5
	Coelioxys verticalis
	Ctenoplectra sp. 1
	Megachile torridum
	Thrinchostoma telekii
Triumfetta tomentosa	*Braunsapis sp. 1*
	Meliponula bocandei
Turraea holstii Gueke	*Meliponula lendliana*
	Ceratina sp. 2
	Halictus (Seladonia sp. 1)
	Lasioglossum (Dialictus sp. 1)
	Lipotriches (Lipotriches sp. 1)
	Meliponula lendliana
Urena lobata L.	*Apis mellifera*
	Ceratina ericia
	Halictus (Seladonia sp. 2)
	Heriades sp. 101
	Meliponula lendliana
	Nomia (Leuconomia sp. 3)
	Patellapis (Zonalictus sp. 6)

	Lasioglossum (Sellalictus sp. 2)
Vernonia auricrofolia	*Meliponula bocandei*
Vernonia lasiopus	*Amegilla ?cymatilis* *Amegilla aff langi* *Amegilla fallax* *Apis mellifera* *Megachile (Paracella sp. 1)* *Megachile ?polychroma* *Meliponula ?denoiti*
Vernonia ouristella	*Ceratina viridis*
Vernonia sp.	*Amegilla capensis* *Anthophora (Heliophila aff. vestita)* *Apis mellifera* *Braunsapis foveata* *Ceratina ericia* *Coelioxys odin* *Creigtoniella ithanoptera* *Halictus (Seladonia sp. 1)* *Halictus (Seladonia sp. 2)* *Heriades sulcatulus* *Lipotriches orientalis* *Lipotriches sp. 4* *Megachile ?polychroma* *Megachile postaigra* *Megachile rufipennis* *Megachile torridum* *Meliponula bocandei* *Meliponula erthyra* *Nomia (Leuconomia sp. 2)* *Nomia (Leuconomia sp. 3)* *Nomia orientalis* *Nomia sp. 1* *Pachyanthidium (Pachyanthidium sp. 2)* *Pseudoanthidium (Micranthidium n. sp. 3)* *Pseudoanthidium lanificum* *Thrinchostoma torridum* *Thyreus calceatus* *Xylocopa imitator*
Zea mays	*Apis mellifera* *Ceratina viridis* *Creigtoniella ithanoptera* *Megachile ?dariensis* *Megachile aff rufipes* *Megachile polychroma* *Meliponula bocandei* *Pseudoanthidium lanificum* *Serapista denticulata* *Meliponula ?denoiti* *Meliponula erthyra*
Zehneria scabra	*Apis mellifera* *Ceratina ericia* *Heriades (Amboheriades n. sp. 1)*

Appendix 8.3: A list of forest dependent bee species in Kakamega Forest.

Families	**Species**
Apidae	*Allodape ?chapini*
Apidae	*Allodape derufata*
Apidae	*Allodape macula*
Apidae	*Allodape* sp. 1
Apidae	*Allodope* n. sp.
Apidae	*Amegilla (Aframegilla* sp. 1)
Apidae	*Braunsapis* sp. 1
Apidae	Ceratina penicillata
Apidae	*Ceratina* sp. 4
Apidae	*Megaceratina sculpturata*
Apidae	*Tetraloniella* sp. 1
Apidae	*Tetraloniella* sp. 3
Apidae	*Thyreus* sp. 2
Apidae	*Xylocopa ?hottentota*
Apidae	*Xylocopa ?senior*
Apidae	*Xylocopa aff sicheli*
Apidae	*Xylocopa erythrina*
Apidae	*Xylocopa varipes*
Halictidae	*Lasioglossum (Sellalictus sp. 4)*
Halictidae	*Lasioglossum (Sellalictus sp. 5*)
Halictidae	*Lasioglossum sp. 1*
Halictidae	*Lipotriches (Lipotriches sp. 1*)
Halictidae	*Lipotriches (Nebenomia sp.)*
Halictidae	*Lipotriches aff aurifrons*
Halictidae	*Lipotriches sp.*
Halictidae	*Nomia aff hylaeoides*
Halictidae	*Nomia tshindica*
Halictidae	*Patellapis* (*Homalictus* sp. 1)
Halictidae	*Patellapis* (*Zonalictus* sp. 5)
Halictidae	*Patellapis* (Zonalictus sp. 7)
Halictidae	*Patellapis* sp. 9
Halictidae	*Patellapis* sp. 7
Halictidae	*Pseudapis* sp. 1
Halictidae	*Pseudapis* sp. 2
Halictidae	*Steganomus* sp. 1
Halictidae	*Thrinchostoma* n sp.
Megachilidae	Coelioxys odin
Megachilidae	*Coelioxys* sp. 3
Megachilidae	*Heriades ?sulcatulus*
Megachilidae	*Heriades* n sp. 1
Megachilidae	*Heriades retifer* (n.sp.)
Megachilidae	*Megachile* (*Eutricharea* sp.)
Megachilidae	*Megachile ?mitimia*
Megachilidae	*Megachile basalis*
Megachilidae	*Megachile decemsignata*
Megachilidae	*Megachile postaigra*
Megachilidae	*Megachile semivenusta*
Megachilidae	*Megachile sp. 1*
Megachilidae	*Megachile* sp. 2
Megachilidae	*Megachile* sp. 3
Megachilidae	*Megachile* sp. 4
Megachilidae	*Megachile* sp. 5
Megachilidae	*Megachile* sp. 6
Megachilidae	*Pachyanthidium aff bengualense*

Appendix 8.4: A list of *farmland* dependent bee species around Kakamega Forest.

Family	**Species**
Apidae	*Ceratina ? viridis*
Apidae	*Ceratina* sp. 8
Apidae	*Ceratina* sp. 9
Apidae	*Ctenoplectra* sp. 1
Apidae	*Ctenoplectra* sp. 2
Apidae	*Ctenoplectra* sp. 5
Apidae	*Pasites* ? *humectus*
Apidae	*Liotrigona bottegoi*
Colletidae	*Hylaeus* sp. 1
Halictidae	Halictid 34
Halictidae	Halictus sp.
Halictidae	*Lasioglossum (?Rubrihalictus* sp.)
Halictidae	*Lasioglossum (Rubrihalictus sp. 2)*
Halictidae	*Lipotriches* (*Trinomia* sp. 1)
Halictidae	*Lipotriches* (*Trinomia* sp. 2)
Halictidae	*Lipotriches* sp. 2
Halictidae	*Lipotriches* sp. 3
Halictidae	*Lipotriches* sp. 4
Halictidae	*Nomia* (*Leuconomia* sp. 4)
Halictidae	*Nomia* sp. 1
Halictidae	*Pseudapis* ?sp. 1
Megachilidae	*Megachile* (*Paracella* sp. 1)
Megachilidae	*Megachile crakokensis*
Megachilidae	*Megachile maxillosa*
Megachilidae	*Megachile obtusodentata*
Megachilidae	*Megachile sinuata bokanica*
Megachilidae	*Pachyanthidium (Pachyanthidium* sp. 1)
Megachilidae	*Pachyanthidium (Pachyanthidium* sp. 2)
Megachilidae	*Pachyanthidium* sp. 1

Appendix 8.5. Pearson coefficient correlation values of niche overlap values calculated from the 15 most abundant bee species and 10 most important plant species.

	Al (1)	Am (2)	Bf (3)	Ce (4)	C2 (5)	Cv (6)	H1 (7)	H2 (8)	Md (9)	Mb 10)	Me (11)	Ml (12)	Xx1 (13)	Xc (14)	Xn (15)
Al (1)	1	0.1715	-0.1452	-0.3678	-0.2811	0.056	-0.4669	-0.413	-0.2192	-0.0712	0.0951	-0.4813	**0.9683**	0.8334	-0.02031
Am (2)		1	0.6845	0.7492	0.7376	0.5026	0.6667	0.6668	0.7565	0.4061	0.1002	0.6002	0.1916	-0.1957	**0.8303**
Bf (3)			1	0.6827	0.6721	0.5712	0.6883	0.6198	0.7621	**0.9154**	-0.3425	0.6925	-0.0999	-0.4964	-0.4799
Ce (4)				1	0.7839	0.4842	**0.9673**	0.966	0.9228	0.1958	-0.5454	0.7886	-0.3393	-0.6662	-0.6731
C2 (5)					1	0.5794	0.7414	0.6719	0.7797	0.1684	-0.461	**0.8171**	-2689	-0.5047	-0.7386
Cv (6)						1	0.4198	0.3186	**0.5288**	-0.2754	0.0165	0.4578	0.0007	-0.2194	-0.3976
H1 (7)							1	**0.9792**	0.9092	0.1395	-0.6373	0.8043	-0.4398	-0.7181	-0.5653
H2 (8)								1	**0.8849**	0.1018	-0.602	0.7298	-0.3699	0.6791	-0.6039
Md (9)									1	0.0507	-0.4542	**0.8474**	-0.2196	0.5715	-0.7722
Mb 10)										1	**-0.1954**	0.0275	0.0506	0.0632	-0.0409
Me (11)											1	-0.6708	0.8564	**0.8858**	0.0727
Ml (12)												1	-0.4972	**-0.7054**	-0.6827
Xx1 (13)													1	**0.7849**	-0.1744
Xc (14)														1	-0.1433
Xn (15)															1

Al (1).-*Amegilla aff langi*, **Am (2)**- *Apis mellifera*, **Bf (3)**- *Braunsapis foveata*, **Ce (4)**- *Ceratina ericia*, **C sp 2 (5)**- *Ceratina* sp 2, **Cv (6)**- *Ceratina viridis*, **H1 (7)**- *Halictus (Seladonia sp 1)*, **H2 (8)** – *Halictus* (*Seladonia* sp 2), **Md (9)** – *Meliponula ?denoiti*, **Mb (10)** – Meliponula bocandei, **Me (11)** – *Meliponula erthyra*, **Ml (12)** – *Meliponula lendliana*, **Xx sp 1 (13)** – *Xylocopa (Xylomellisa sp 1)*, **Xc (14)**– *Xylocopa calens*, **Xn (15)** – *Xylocopa nigrita*

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ERKLÄRUNG

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DECLARATION

I, Mary Wanjiku Gikungu, do hereby declare that this thesis is my original work and has not been presented for a degree in any other university. Passages of the thesis that have been literally or logically cited from other publications are marked as such and properly referenced.

Signed……………………… Date………………….