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# Diversity and abundance of litter insects within some exotic tree species in the arboretum of Ruhande, Rwanda.

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***Abstract***

*Insects are the most diversified animals, equivalent to 55% of all identified and named species on earth and play great role in ecosystem functions. This has motivated to study insect diversity in the arboretum of Ruhande where they were not yet studies. Three tree plantation species were selected for the study including Pinus patula, Grevillea robusta, and Cedrela serrata. Litter insects were hand collected, and transported in the laboratory for identification. Results indicated the predominance of three orders, including Hymenoptera, Coleoptera, and Lepidoptera. Classification at family level obtained 29 families, and Formicidae family was the largest. Biodiversity analysis indicated that insects were the most diversified in the litter of Grevillea robusta followed by Cedrela serrata plantations. It is suggested that the abundance and diversity of insects were related to habitat conditions such as litter cover, shade, and soil chemical conditions. This study provides baseline information on litter insect population as affected by plantation species. Further studies are needed in order to investigate the most suitable tree plantation species for insect diversity conservation in Rwanda.*

***Keywords**: Insects; Insect abundance; Insect diversity.*

## 1. Introduction

Insects are the most diversified organisms on earth (Daly et al., 1998), totalizing between 800,000 and 1,000,000 named species, equivalent to 55% of all known species on earth (Picker et al., 2004) and almost three quarters of all described animals (Mc Gavin, 1997). They are the most successful and enduring life forms that have ever existed on earth (Mc Gavin, 2007).

Insects exhibit a great degree of biological adaptations and are sensitive indicators of habitat quality and richness and may be considered key stone species (Kimsey, 1985; Samwey, 2005), and play vital roles in processes such as pollination (Costanza et al., 1997), soil formation and fertility, and plant productivity (Fittkau and Linge, 1973), and the regulation of populations of other organisms through predation and parasitism (Greenwood, 1987; Daily, 1997). Insects are more sensitive to environmental perturbations than plants and vertebrates due to their rapid breeding rates and relatively short generation times (Kremen et al., 1993; Hilty and Merenlender, 2000), thus are used as good indicators to monitor toxicity, bioaccumulation, and response to pollution and contamination (Rosenberg et al., 1986; Mauricio da Rocha et al., 2010). Characteristics of certain insects make them useful models for understanding general biological process (Gullan and Granston, 2010).

The diversity of litter insects still remains poorly studied particularly for the sake of biodiversity conservation (Cowling, 1989), and particularly in Rwanda. Therefore, the objective of this study was to investigate the abundance and diversity of litter insects in some exotic tree plantations at the arboretum of Ruhande. It is hypothesized that the diversity and abundance of litter insects in this forest plantation is influenced by tree species that have created microhabitats due to their long-term establishment on one soil type and under similar climatic conditions.

## 2. Materials and Methods

### 2.1. Study site

Arboretum of Ruhande is situated in Southern Rwanda, near the National University of Rwanda (lat. 2°36´S and long. 29°44´E; altitude: 1,638–1,728 m). The arboretum of Ruhande was initiated in 1934 and covers an area of 200ha, counting 529 monospecific plots, composed of over 207 native and exotic tree species. The size of plots is 50 x 50m and intercalated with alleys of 6m wide (Stanga, 1991; Nsabimana et al., 2008).

The mean annual rainfall is 1,232 mm and mean annual temperature is 19.6°C (ISAR, 1987; Burren, 1995). The soil in the Arboretum of

Ruhande is classified as a Ferralsols (FAO, 1998; Nsabimana et al., 2008). Such forest diversity established on one soil type give an opportunity to study effects of tree plantation species on inhabiting insect biodiversity. Three replicated plantation species were selected for the study including Pinus patula (Plot No. 92, 211, 410), Grevillea robusta, (Plot No. 104, 150, 203) and Cedrela serrata (Plot No. 111, 112, 159). The age of each plantation plot is more than 30 years, and understory vegetation is annually cut and left on the ground. This plantation is only used for seeds production and it is never cut down.

## 2.2 Insects collection and classification

Litter insects were collected in March 2012 using the square pick-up point technique (Bakenga, 1985; Lamotte, 1969), and were hand searched and collected (McGavin, 2007). All grasses were removed on an area of $1m^2$, selected randomly within the plot and then dwelling insects were collected into jars which contained the killing agent, 10% formal solution. Collected insects were transported to the laboratory for subsequent classification using identification keys in the literature (Borror, 1970; Picker et al., 2004).

## 2.3 Statistical analysis

Collected data were entered into Excel sheets before being used for analysis by Biodiversity Professional software to calculate the diversity indices such as Shannon and Evenness indices (Weaver and Shannon, 1949; Equation 1).

$$H' = -\sum_{i=1}^{s} (p_i \ln p_i) \quad , \quad p_i = \frac{n_i}{N} \qquad \text{(Equation 1)}$$

Where: $n_i$ is the number of individuals in a species i (the abundance of species i). S is the number of species. N is the total number of individuals in a community. $p_i$ is the relative abundance of each species, calculated as the proportion of individuals of a given species i to the total number of individuals in a community. A rich ecosystem with high species diversity has a large H′ value, while an ecosystem with little diversity has a low H′ (Weaver and Shannon, 1949).

## 3. Results

### 3.1. Species abundance and richness

In total, 456 insect individuals belonging to 10 orders and 29 families were collected (Table 1). The largest orders were Hymenoptera, Coleoptera, and Lepidoptera with 315, 70 and 32 individuals respectively (Fig. 2) and the largest number of Hymenoptera was found in Pinus patula (Fig. 2). The orders of Mantodea, Isoptera and Plecoptera were absent in both Grevilla robusta and Pinus patula. The best represented families were Formicidae followed by Cerembycidae with 315, and 41 individuals respectively. Myrmicaria natalensis from Formicidae was the best represented species but it varied greatly across plots. Grevillea robusta stand had the highest insect diversity belonging to 21 families followed by Pinus patula counting 16 families (Table 1). Analyses done with Biodiversity Professional indicated that Grevillea robusta had the highest diversity index followed by Cedrela serrata (Table 2).

**Table 1: Distribution of sampled insect individuals (mean ± SE) in orders and families from aboveground litter of Grevillea robusta, Pinus patula, and Cedrela serrata plantations at the Arboretum of Ruhande.**

| Order | Family | Grevillea robusta | Pinus patula | Cedrela serrata |
|---|---|---|---|---|
| Hemiptera | Tingidae | 1 ± 1 | _ | _ |
| | Reduviidae | 1 ± 1 | _ | 0.33 ± 0.33 |
| | Pentatomidae | 0 | 0.33 ± 0.33 | _ |
| | Flatidae | 0 | _ | _ |
| | Cydnidae | 0.33 ± 0.33 | _ | _ |
| | Miridae | 0.66 ± 0.66 | _ | _ |
| Lepidoptera | Noctuidae | 4 ± 2 | _ | _ |
| | Papilionidae | 0.66 ± 0.66 | _ | _ |
| | Lycaenidae | _ | 0.66 ± 0.66 | _ |
| | Nymphalidae | 2 ± 1.15 | 1 ± 1 | 0.66 ± 0.66 |
| | Tortricidae | 0.33 ± 0.33 | _ | _ |
| Hymnoptera | Formicidae | 28.7 ± 10.8 | 53 ± 14.7 | 32.6 ± 18.5 |
| Coleoptera | Coccinellidae | 0.66 ± 0.66 | _ | _ |
| | Tenebrionidae | 0.33 ± 0.33 | 3 ± 0.57 | 4.33 ± 1.8 |
| | Staphylinidae | 2.33 ± 0.33 | 1.66 ± 1.2 | 1.33 ± 0.33 |
| | Silvanidae | 0.33 ± 0.33 | 0.66 ± 0.66 | 0.33 ± 0.33 |

| | | | | |
|---|---|---|---|---|
| | Cerambycidae | 1.66 ± 0.66 | 5.66 ± 2.3 | 2.33 ± 0.64 |
| | Scarabidae | _ | 1.33 ± 0.88 | _ |
| | Carabidae | 1 ± 0.57 | _ | _ |
| Orthoptera | Gryllidae | 1.33 ± 0.88 | 0.33 ± 0.33 | _ |
| | Tettigoniidae | _ | 0.33 ± 0.33 | _ |
| | Acrididae | _ | 0.33 ± 0.33 | _ |
| | Euschmidtiidae | 1.66 ± 1.66 | 0.33 ± 0.33 | _ |
| Blattodea | Blabelidea | 0.33 ± 0.33 | 0 | _ |
| | Blattidae | 0.33 ± 0.33 | _ | _ |
| Mantodea | Mantidea | 0 | _ | _ |
| Isoptera | Termitidae | 0 | _ | _ |
| Plecoptera | Notonemouridae | 0 | _ | _ |
| Uknown | Uknown | 1 ± 1 | 1.33 ± 0.66 | 1 ± 1.2 |

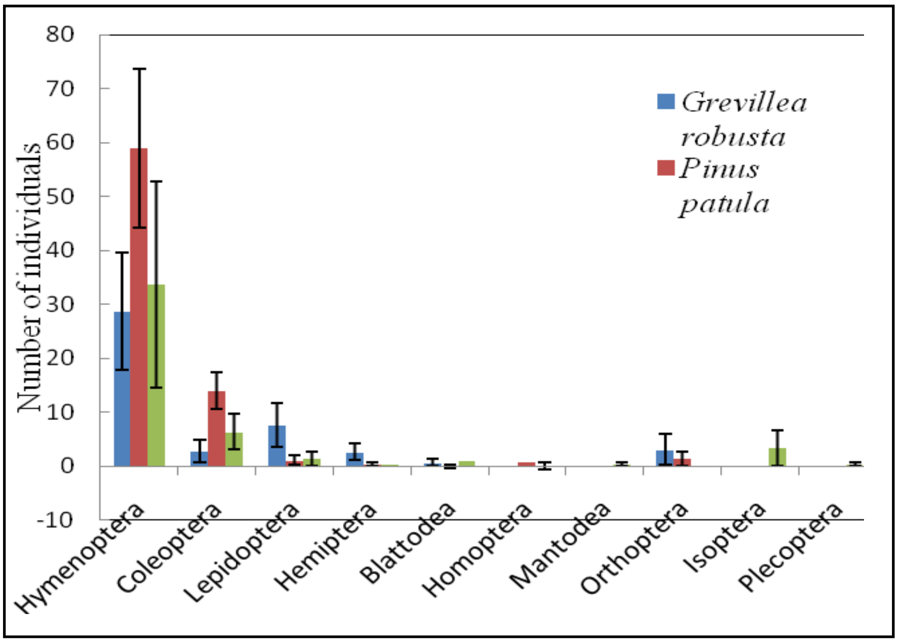


**Figure 2**: **Abundance of litter insect individuals (mean ± SE per m$^2$) classified in different orders per plantation type at the Arboretum of Ruhande**

**Table 2: Insect diversity indices in aboveground litter of Grevillea robusta, Pinus patula and Cedrela serrata plantations**

| Plantation type | SHANNON INDEX | Evenness |
|---|---|---|
| Grevillea robusta | 0.796 | 0.612 |
| Pinus patula | 0.421 | 0.378 |
| Cedrela serrata | 0.501 | 0.449 |

## 4. Discussion

The results showed that Formicidae family was the most abundant and widely distributed across the studied plots (Table 1). Dominance of Formicidae family has also been observed in native forest in Western Ghats, India (Sabu et al., 2008) and can be explained by the fact that Formicidae is one of the largest insect families worldwide (Chavhan et al., 2011). Furthermore, it has been noted that opportunity patterns of Formicidae are expected when nest sites and food sources are abundant and evenly distributed in their habitats (Levings and Traniello, 1982).

Lepidoptera larvas were found in a relatively high amount within the studied plots. Lepidoptera also called the wood borers (Uniyal and Mathur, 1998) can explain their presence in our sites.

Grevillea robusta plantation had the highest indices of insect diversity and abundance (Table 2). This can be explained by the fact that Grevillea robusta is one of agroforestry species with whom a large number of crops and plantation species can grow (Sheikh, 1993; Karanja et al., 1998; Schulze et al., 2004). This plant species generate a large amount of litter that can provide habitat to large animal diversity (Muthuri, 2005), including litter insects (Anu et al., 2009). The highest diversity of litter insects in G. robusta plantation can also be explained by both relatively high soil pH and soil nutrient richness in comparison to those of other plantations investigated by Nsabimana et al., (2008). The latter conditions may favor the proliferation of insects in that habitat (Muthuri et al., 2005). The abundance and diversity of insects in the studied sites may also be a result of both light and shade conditions (Almeida and Câmara, 2008), provided by G. robusta which allow the growth of diverse undercover vegetation, and thus increasing the probability to shelter more litter insects (Watson and Abbey, 1989).

Termitidae family play a central role as mediators of nutrient and carbon fluxes (Bignell et al., 1997; Lawton et al., 1998), their presence increase soil permeability and may improve soil structure, aeration, nutrient cycling and soil fertility (Attignon, 2004). Therefore, the abundance of termites and their active organic matter mineralization (Collins, 1984) may explain the highest soil carbon content found within the Cedrela serrata plots in comparison to other plantation types investigated (Nsabimana et al., 2008).

Pinus patula plantations had the least litter insect diversity (Table 2). The lowest insect species in Pinus patula can be explained by the fact that P. patula secretes a resin which is a toxin to undercover vegetation thus impacting the presence of animal diversity (Poynton, 1979; Tisdale and Nebeker, 1992). Furthermore, Pinus patula may consume higher amount of water from the soil which does not facilitate biodiversity to inhabit its aboveground litter (Bregje, 2002), which may have resulted in lower litter insects diversity within P. patula plots in this study. Such lower species richness has also been observed in tree plantations in Ethiopia (Lemenih et al., 2004). In addition, lower soil pH has been observed in Pinus patula plots, suggesting that the decomposers are unable to live within this soil type consequently it also has low carbon content as it was measured by Nsabimana et al., (2008) which may consequently result in lower insect diversity (Ehrenfeld, 2003).

## 4. Conclusions

This study indicated that the largest insect individuals were observed in Hymenoptera, Coleoptera, and Lepidoptera orders. The largest families were Formicidae followed by Cerembycidae. Grevillea robusta stand was the most suitable habitat for litter insects, and had representatives of 21 insect families. Pinus patula stand showed to shelter less litter insects among the studied sites mainly due to its low soil pH and the toxins secreted by that tree species. These results confirm that the diversity of litter insect species can significantly be influenced by the nature of microhabitat provided by diversity of tree plantations. It is recommended to continue similar studies in other plantation types, other land uses and in other regions in order to explore the insect richness and abundance in all land uses in Rwanda. Therefore, provide enough data for insect conservation measures in Rwanda.

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