A STUDY ON INSECT DIVERSITY AND ABUNDANCE IN MAZUMBAI FOREST RESERVE, TANZANIA.

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ABSTRACT

This study attempted to provide baseline data on the relationships between diversity, size of insect populations and habitat. Conducted in the Usambara Mountains of northeastern Tanzania, it concentrated specifically upon the forest gaps, closed forest, and edge forest of Mazumbai Forest Reserve. Three methods were utilised to collect the insects: interception traps, pit fall traps, and observation. Within a period of four weeks 1,014 insects in 32 super families and families were collected. The majority of both insect abundance and diversity were found in the forest gaps. The edge forest contained a different distribution of insects than the closed forest, and further energy needs to be concentrated on this vital area. Overall, the high diversity found in this short study indicates this is a rich ecosystem worthy of further research.

Key words: *insects, diversity, abundance, habitat*

INTRODUCTION

Insects are by far the most successful and diverse group of animals on earth, with more than 800,000 known species and over three million possibly more waiting to be discovered. They make up 70 percent of all animal life, and "can be found in almost every conceivable situation on the planet earth" (Skaife, 1994). For example, Coleoptera, has over 30,000 known species which "outnumber all the known species of vascular plants; there is six or seven described species for every one of vertebrates" (Harde, 1984). By virtue of their diversity and number, insects have a huge impact on ecosystems, however our knowledge of them is comparatively small. That is why studies on the ecology and distribution of insect populations are of great importance.

Insect populations in the tropical ecosystems are by far the richest, and the most vulnerable on earth (Wallner, 1987). In spite of this studies on the abundance and diversity of tropical insect populations have been lagging behind until recent years (Wolda and Fisk 1981; Wolda and Flowers 1985). Seasonal temperature and rainfall patterns constitute a major factor that determines the distribution and abundance of global organisms in space and time (Gray 1974; Wallner 1997). As well as directly affecting insects, weather factors also influence the growth and development of trees and so can affect them indirectly by influencing the timing and perhaps the amount of food available for insect at different places and different years (Dampster and Pollard 1981).

The Usambara Mountains in northeastern Tanzania are a prime location for the study of insects, due to their immensely diverse ecosystems and large amount of endemic species. The mountains "can be argued to be the richest forest in terms of biological diversity, endemism and scientific importance in tropical Africa" (Iversen, 1991) and therefore are of great biological interest. For example, there are 114 endemic trees and shrubs in the Usambara Mountains (Iversen, 1991), however, very little scientific research has been done on the area, and many more remain to be discovered. These mountains contain a rich genetic bank that has been virtually untapped. They are important water catchment area and a vital part of the Tanzanian economy (Mrecha, pers. Comm.). Unfortunately, due to pressure on the forests from the local people, at least 75 taxa are endangered (Iversen, 1991). The health and maintenance of these ecosystems is of importance to both science and the Tanzanian people.

Broadly this study concentrated on the insect populations of the Mazumbai Forest Reserve in order to gain a better knowledge on their distribution and responses to changes in habitat. This study intended to specifically ascertain the influence of habitat on the diversity and size of insect populations, comparing forest gaps, closed canopy forest, and edge forest along the border of the forest reserve.

METHODS

This study was conducted at Mazumbai Forest Reserve, which is located on the Eastern part of West Usambara Mountains between 5º 34' S and 38º 15' W and 1350msal and 1900 masl. Mazumbai has bimodal rainfall pattern, with short and long rains during November – Decmber and February –March respectively. The mean annual rainfall is 1500 mm with peak rains in April. Temperature ranges from 15ºC - 32º C with coolest period between June and August.

Mazumbai is considered to be a "well protected primeval forest island" (Mrecha, pers. Comm 2000) and one of the best examples of an intact forest at this altitude (Iversen, 60). However, 9 km of the 15 km border is exposed to deforested land, and due to its relatively small size the edge effect may have a significant impact on the forest (Iversen, 60). There are two types of forest classifications in the reserve, intermediate forest and montane rain forest. The montane forest is alternately classified as a montane moist forest (Hall, 6). The area is considered to be an important water catchment area for Tanzania.

In this study two different altitudes were chosen, one along the main road at 1510 – 1530 m, and one on the southern border of the forest at 1400 – 1410m (Figure 2). In the higher altitude, a comparison between the forest gap and closed forest was attempted. The southern border of Mazumbai, at the lower altitude, is adjacent to maize and bean agriculture. For the purpose of this study, forest gaps were defined as an area of at least ten square meters with a crown cover from trees over five meters of less than ten percent. Closed forest was defined as an area of at least ten square meters with a crown cover of at least 75 per cent. At the lower altitude, edge forest is defined as closed forest within 15m of land used mainly for agriculture.

Three different trapping methods were utilised for the duration of the study: interception traps, pit fall traps and observation. The interception trap was designed with the intention of collecting flying insects. It consisted of a 0.5m x 0.5m transparent plastic sheet spread tightly between two 1.2m wooden poles. The sides of the plastic sheet were folded and sewn with dental floss to create loops to fit over the poles. Directly beneath the plastic sheet a funnel with a diameter of 0.5m at the mouth that constricts to a diameter of 0.05m at the base was attached. The funnel was constructed using steel wire, plastic sheeting, mailing tape and dental floss. At the base of the funnel, a collection bottle was attached with mailing tapes. One centimetre from the bottom of the bottle one-centimetre slits was made in order to promote water drainage. The bottle was attached to the funnel by means of the mailing tape.

The trap was checked and insects caught collected and counted after every other day. Debris occasionally blocking the base of the funnel was carefully checked for insects before removal. Insect specimens were identified in the field using identification keys, experience and or a combination of both. A X16 hand lens was used to assist in identification.

The second method in this study was baited pit fall traps. These consisted of a transparent plastic cone with the tip inverted twice to create a small cone in the bottom centre. Attached to the top of the cone was a 25-cm wide plastic circle with a 10-cm smaller circle removed from the centre to form a lip around the circumference of the pit fall. The trap was 15 cm deep. Each trap was buried in the ground until the lip was flush with the soil. The lip was lightly covered in leaf litter and soil. A larger leaf was placed over the mouth of the trap to limit flooding from rainwater and collection of debris. The traps were baited with sweet banana that had been fermenting for at least four days. The traps were checked every two days and the bait replaced. The trap would be removed from the soil and closely inspected through the opening and transparent sides for insects. Specimens were removed, counted and identified. Unfortunately, due to the dense vegetation layer in the forest gaps, pit fall traps were not able to be used and were only placed in closed forest.

The third method used was observation. A 0.5m x 0.5m plot was demarcated with twine. The plot was left to naturalise for two days before any observations were made. Once naturalised, the observer stood one meter away from the plot and observed the area for a period of five minutes within the plot, up to two meters high, for any flying insects. Following this a second five-minute time period was devoted to insects in or on the vegetation. This was a physical search for organisms by slowly lifting and turning over foliage, and inspecting the surface of the soil. This was done in all habitat types.

The placement of the traps was done as randomly as possible. In the higher altitude, the area was mapped and all forest gaps and closed forests noted. The numbers or letters were assigned to each and three forest gaps and three closed forests were randomly chosen. Each of three sites was broken down into smaller sections and one was randomly chosen. The first 15m from the road were excluded to limit the effects of disturbance. Within this plot the interception trap was placed in a breezeway. The observation plot was placed one meter from the interception trap in a randomly chosen direction. If in closed forest, the pit fall trap was placed five meters to the west of the interception trap. At the lower altitude, the intention was to study the edge forest, and therefore the area within 15m of the border was mapped. Otherwise, the rest of the methods were the same.

At each site, a 5m x 5m quadrant with the interception trap as the centre was used for a small vegetation analysis. Crown cover from trees over five meters, shrubs under five meters but over two meters, and herbaceous growth under two meters was estimated. The gradient was also estimated and recorded.

RESULTS

Throughout twenty days of data collection, including five trap checks per trap and two observations; a total of 1014 insects were either observed or collected and an attempt made on their classification. About 48.3% of insects were found in the interception traps, 29.8% were found in the pit fall traps, and 21.9% were observed in the observation plots. When considering the insects found in the interception traps and observation plots, 363 of insects were found in the forest gaps, compared to 244 in the edge forest and 110 in the closed forest (Figure 1). The majority of insects collected in the pit fall traps were in the edge forest with a total of 178 compared to 104 in the closed forest (Figure 2).

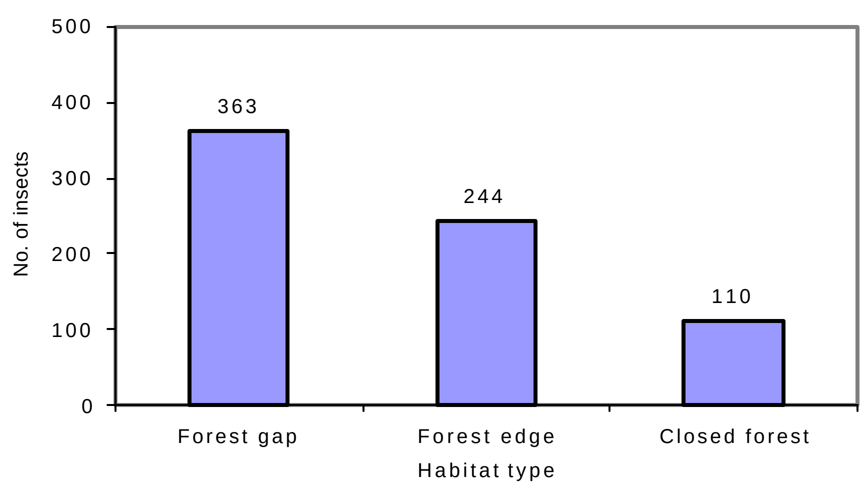

Fig.1 Size of insect populations in each habitat type, excluding pit fall traps

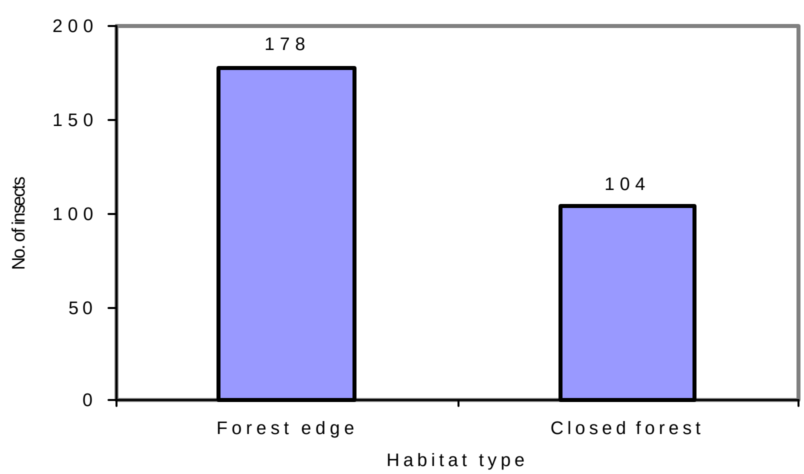

Fig. 2 Number of insects found in pit fall traps

The greatest diversity was found in the forest gaps, with a total of 32 super families and families, compared to 17 in the edge forest and closed forest (Table 1, Figure. 3). Certain families were found in only one habitat type (Table 2). In the forest gaps, 18 families were particular to that habitat type, which is significantly greater than the three found in the edge forest and the two in the closed forest (Figure. 4). Different orders were prominent in each habitat, (Figures. 5, 6 & 7) however, Odonata was only found in the forest gaps, and the Blattodea only in the edge forest. In the forest gaps, the Diptera and Coleoptera had the densest populations (Figure. 5). Conversely, the greatest number of insects was in the Coleoptera and Hymenoptera orders in the edge forest (Figure 6). The closed forest consisted the majority of Coleoptera Hemiptera and Diptera orders (Figure. 7

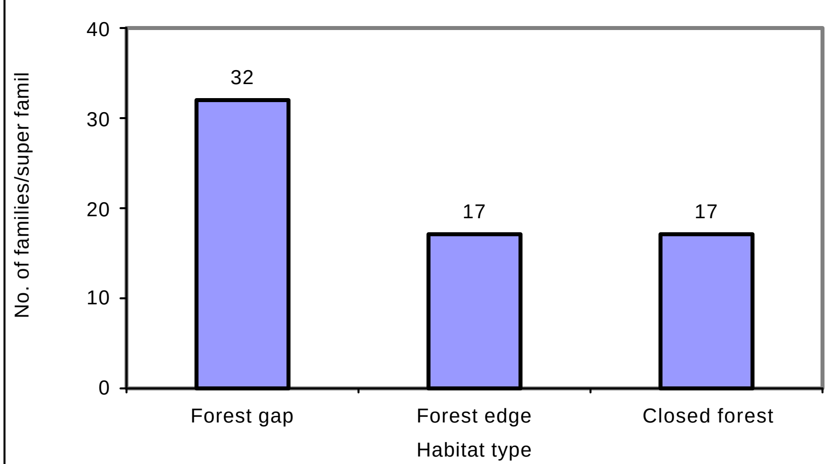

Fig. 3 Number of insect families and super families found in each habitat type

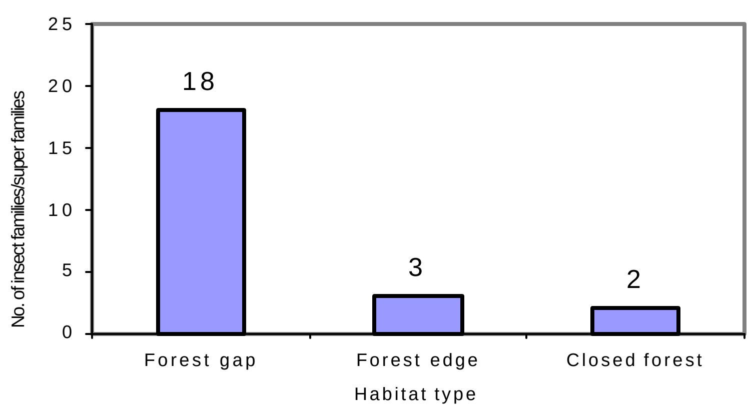

Fig. 4 Number of insect families found only in a particular habitat type

Table 1: Complete List of Insects from the Observation Plots and Collected in Interception Traps and Their Classification.

CLASSIFICATION:	Forest Gap	Closed Forest	Edge Forest
BLATTODEA	0	0	1
COLEOPTERA	15	5	14
> Adephaga	0	0	0
*Carabidae	1	0	0
> Polyphaga	7	3	6
*Curculionidae	2	3	1
*Chrysomelidae	1	0	0
*Coccinellidae	1	0	0
*Dermestidae	1	0	0
*Elateridae	1	0	0
*Hydrophilidae	1	0	0
*Lycidae	2	0	1
*Meloidae	0	0	1
*Muscidae	5	0	0
*Scarbaeidae	0	1	3
*Staphylinidae	41	13	23
DIPTERA	5	2	6
>Brachycera	3	0	0
*Bombyliidae	1	0	0
*Stratiomyiidae	3	0	0
*Tabanidae	1	0	0
>Cyclorrhapha	17	3	2
*Chloropidae	42	3	16
*Diopsidae	1	0	0
*Drosophilidae	0	0	5
*Lonchpteridae	3	2	2
*Muscidae	5	0	0
*Syrphidae	1	0	1
>Nematocera	35	7	2
*Mycetophildae	7	0	0
*Pschodidae	0	1	0
*Tipulidae	8	2	1
HEMIPTERA	11	1	6
>Heteroptera	1	0	0
+Coreoidea	1	0	0
+Lygaeoidea	4	1	0
+Pentatomoidea	0	5	0
>Homoptera	0	2	8
+Aphidoidea	7	4	4
+Cicadelloidea	0	3	1
+Fulgoroidea	1	1	0
+Sternorrhycha	0	2	0
HYMENOPTERA	0	0	0
>Apocrita	3	0	1
+Apoidea	3	0	0
+Chaleidoidea	1	0	0
+Formicoidea	0	0	0
*Formicidae	46	3	49
>Symphata	1	0	0
LEPIDOPTERA	0	2	0
>Ditrysia	7	1	4
>Zeugloptera	0	0	0
*Micropterygidae	4	0	0
ODONATA	0	0	0
>Anisoptera	2	0	0
ORTHOPTERA	1	0	2
>Caelifera	0	0	0
+Acridoidea	1	1	2
+Tetrifoidea	1	0	0
>Ensifera	0	2	2
+Tettigonoidea	0	3	2
+Grylloidea	1	3	4
UNIDENTIFIED	65	31	73
TOTAL	363	110	244

Table 2: Distribution (%) of insect orders in different habitats at Mazumbai Forest Reserve, Tanzania

Order	Forest gaps	Forest edge	Closed forest
Coleoptera	20.7	20.0	20.7
Hymenoptera	14.9	20.5	2.7
Heteroptera	6.9	8.6	17.2
Lepidoptera	3.0	1.6	2.4
Orthoptera	1.1	4.9	8.2
Odonata	0.5	-	-
Diptera	3.5	14.3	18.2
Unidentified	17.9	30.0	28.0

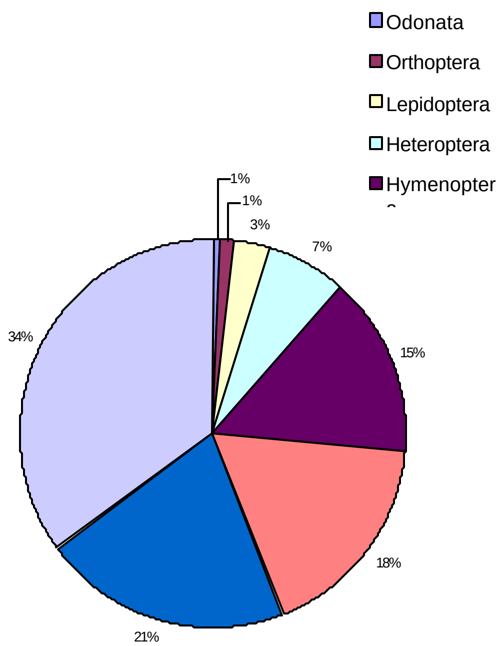

Fig.5 Distribution of insects found in forest gaps by order

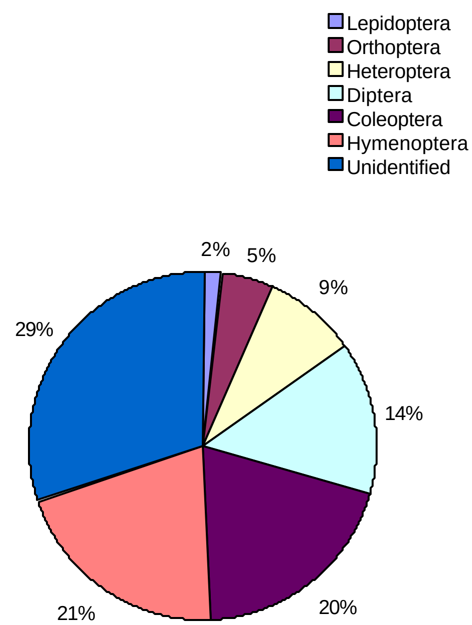

Fig.6 Distribution of insects found in edge forest by orders

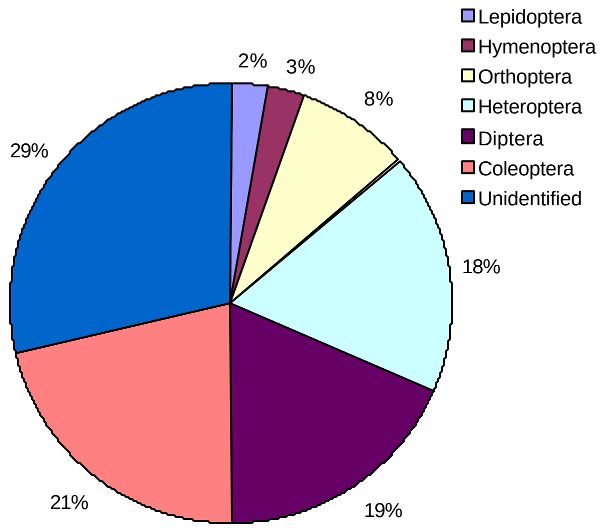

Fig 7 Distribution of insects found in closed forest by orders

The majority of insects were identified, however, 17.9% in the forest gaps, 30.0% in the edge forest and 28.0% in the closed forest remain unidentified. Of those identified in the forest gaps, 65.4% were identified to family or super family. In the edge forest 69.0% and in the closed forest 63.3%, were identified to family or super family.

DISCUSSION

Habitat was found to have an influence on insect abundance and diversity in Mazumbai Forest Reserve. The data indicates that forest gaps contain the most diverse and abundant insect populations, second being the edge forest, with closed forest the least abundant and diverse. The large number of families that were found only within the forest gaps indicates a relatively distinct environment suited for particular types of insects, and capable of absorbing an immense diversity of species. The vegetation composition of forest gaps is perhaps the most influential factor. There is a known relationship between the diversity of fauna and the responding increase in insect diversity (Young, 1982). Forest gaps contain a greater diversity and density of herbaceous vegetation than in the closed forest, which may provide a greater number of niches for different species to occupy.

Temperature can be a factor in the distribution of insect populations as well. A greater diversity of insects and larger populations can be found in higher temperatures, even of only a degree or two centigrade higher than in a cooler environment (Wolda, 1987). This is not true to the extreme; however, in a forest such as Mazumbai the closed forest may be slightly cooler because of the heavy canopy cover than the open forest gap. It may play a small, yet significant role for the insects, concentrating them in the forest gaps.

The second most diverse and numerous populations were found in the edge forest. A possible explanation is the proximity to the agricultural and provided an environment similar to that of forest bordering a gap. The transitional habitat is recognised as providing a variety of niches for different species (Madoffe 1993). Plant and animal populations in fragmented habitats are exposed to abiotic and biotic changes associated with artificially induced edges or adjacent environment conditions (Klevin 1989, Laurence 1991, and Angelstan 1992). Edge effect include changes in microclimate, light conditions, and wind-shear forces which can alter forest structure and composition (Young and Mitchell 1994) and, subsequently, alter assemblages of small mammals, birds and insects (Klein 1994, Lawrence 1994). There may have been also an increase in temperature and density of vegetation, which would lead to greater numbers of insects. However, the higher number of insects in the edge forest largely due to the prominence of Hymenoptera order, or ants. This is of interest because the majority of ants are omnivores and therefore capable of invading secondary successional stages and disturbed habitats (Young, 1982). The same is true for the order Blattodea, or cockroaches, that was only found in the edge forest. This suggests the area may be affected by the presence of the agriculture, and disturbance could actually be increasing the populations of particular taxes. Information on the influence of edge effects is essential in forest conservation programs (Maeto *et a*l. 1999)

A different order responded as well to particular habitats, namely the Diptera. They were most prominent in the forest gaps, and this is most likely a result of an environment better suited for flying insects, as compared to the closed forest. However, the patchiness of insect populations is a noted phenomenon in the tropics (Wolda 1978, Madoffe 1993. Particular types of insects may be concentrated in small pockets, due to vegetation changes. For example, “Phytophagous insects are expected to be patchy in species rich habitats, while generalist predators, scavengers, and parasites may be less patch since much of their foraging and feeding is opportunistic” (Young, 1982). It is therefore difficult to make a conclusion on the concentrations of particular groups of insects without several trials and traps. It is possible that when only observing a few traps, one is studying particular patches, or microclimates, not the habitat type as a whole.

CONCLUSIONS

Due to the short length of this study, and probably limited number of trap types and baits, no concrete conclusions can be drawn upon the insect populations of Mazumbai Forest Reserve. Overall, though there were a great number of limitations in this study, a definite relationship between habitat and insect distributions can be noted. A list of insect families and orders provides useful information on the forest reserve, and the great diversity found in such a short time period indicates that this is a rich ecosystem worthy of much future monitoring of these diverse populations. The effect of the border on insect populations is still uncertain, though the data suggests selection for certain insect populations. This is a vital issue, as the forest reserve is exposed to an increasing extent of deforested land and agricultural crops, such as maize and beans. The accepted use of insect populations as bio-indicators and the relative ease of collecting statistically viable information encourage further research. Mazumbai Forest Reserve is an extremely rich ecosystem, and the more knowledge that can be gained on the edge effect, the greater chance we have on protecting it.

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