Fruit productivity and other life history traits of *Maesopsis eminii* at a forest edge and in a closed habitat of Amani, East Usambara Mts.-Tanzania

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Abstract

The amount of fruits produced by tree species in tropical forest ecosystems depends on water availability, soil types, amount of insolation and structural features among other factors. Fruit productivity of the introduced invasive tree *Maesopsis eminii* at the edge and in closed habitats was investigated at three different study sites within Amani Nature Reserve (ANR), East Usambara Mountains -Tanzania. Fruits Productivity was assessed by visually estimating the amount of fruits in the tree canopies as well as by counting the fruits dropped on the forest floor. Additional variables namely leaf size, fruits weight, canopy diameter (m), canopy height (m), DBH and canopy cover of each tree were collected. Results show that there is no difference in the amount of fruits produced by *Maesopsis* trees between the edges and the closed habitats whereas edge trees had heavier fruits which may be related to the greater leaf biomass per unit space. It was detected that the canopy diameter of trees in closed habitats was larger than of those at the edges. The trees of the latter were found to have larger leaves. As the canopy volume in the two habitats is similar the crowns of edge trees are more packed and thus contain a greater leaf area index. This might be responsible for a greater leaf biomass per unit space (or relative assimilation rate) in the edge trees.

Keywords: *Fruits, Production, Maesopsis eminii, Forest Edge, Closed Habitat, Amani Nature Reserve (ANR).*

Introduction

The competitive ability of a plant species is closely linked to its efficiency of retrieving nutrients and water, trapping light and reproducing. In a forest habitat plants face a major challenge to reach the canopy and expose their photosynthetic organs to light. As vegetation patterns are the temporary results of an everlasting slow co-evolutionary process between competing species the sudden introduction of an alien can have devastating effects on such long established plant communities.

A tree that faces constraints from light limitations in a forest habitat might not be able to invest as much in productivity as one growing among conditions of ample light. Hence, a tree growing in the latter habitat could have an advantage and be favoured by evolutionary selection. The productivity of fruits and leaves is part of the key factors determining the competitive ability of a plant species. How to become successful is often a matter of how to use the limited resources in a more economical way and adapting to various habitats with different ecological variables.

The alien species of *Maesopsis eminii*, a member of the Rhamnaceae family, has been perceived as a potential threat to the diversity of indigenous, especially endemic, flora in the submontane forest of Amani Nature Reserve, East Usambara Mountains (Bineggeli and Hamilton, 1990). A native tree to West and Central Africa - its range spreading from Liberia as far as Northwestern Tanzania and Western Kenya – it was first planted at Amani Research Station in 1914 as a shade tree for near-endemic *Cephalospheira usambarensis*. *Maesopsis'* fast growth rates, prolific seed production and efficient dispersal notably by hornbills and blue monkeys account for its successful invasion, today being a very conspicuous tree species in the forests of Amani. Ecological impacts are thought range from floral impoverishment of the understorey scrub and herb vegetation, alteration of the canopy density to change of soil parameters including pH and water retention capacity. More recent studies, however, show that its invasive potential is far greater in disturbed areas such as forest edges and clearings than in pristine or near pristine forests, the latter hardly being encroached upon (Schulman *et al*, 1998; Newmark, 2002).

As *Maesopsis eminii* establishes itself as a pioneer species in treefall gaps it heavily depends on ample light although for its immediate germination the presence of sufficient water is the crucial factor (Binggeli and Hamilton, 1990). We investigated some life history traits of *Maesopsis* trees at the forest edge where there is ample light and in the forest interior where the limit of light probably is a constraint, and determined whether the number of fruits produced by trees in the two habitats was different and if the amounts correlated with light regimes. The fruit weight and leaf size were assessed within a comparative approach of the two different habitats. In addition, various structural features of the trees of the edge and the forest habitat, namely canopy cover; canopy diameter, canopy volume, diameter breast height and canopy height were examined.

The aim of this study is to investigate the amount of fruits produced by *Maesopsis* trees at the edge and in the closed habitats and how the structural features of the tree influence the reproductive output.

Specific Objectives were to:

1) Investigate fruits production of *Maesopsis* trees in the edge and closed habitats
2) Investigate fruits production of *Maesopsis* trees at three different sites
3) Investigate how structural features of *Maesopsis* trees influence fruits productivity

The Null-Hypothesis: There is no difference in the number of fruits produced by trees between the edge and the closed forest.

Results of this study might provide additional biological information that may be used in managing *Maesopsis eminii* especially in areas where it is thought to be very invasive.

Methods and Materials

Study Area

This study was conducted in Amani Nature Reserve (ANR, 83.8 km^2), which is part of East Usambara Mountains, in Tanzania. ANR lies at 5.6º S latitude and 38.38º E longitude (Hamilton and Bensted-Smith, 1989) at an altitude of 910m above sea level.

Its mean annual rainfall is 1918mm with peaks recorded from March to May and from October to December. The mean annual temperature is 20.6º. Hamilton and Bensted-Smith (1989) and Newmark (2002) have discussed comprehensively on soils, climate, rainfall regimes, and vegetation structure and composition of ANR and other fragments of East Usambara Mountains**.**

Three study sites were chosen for this study namely: Flood Plain (FP), Mbomole hill (MH), and the forest near Amani shops (hereafter referred to as Amani Shop Forest ASF). The flood plain site consists of a small permanent stream that enter the Amani pond, with a water channel of approximately 2m width, about 10-50m of aquatic vegetation, and the start of a forest edge of tall trees at the maximum level of flooding water. The Mbomole hill site is about 1-2km from the IUCN hostels towards the end of a trail following the base of the hill north-east of IUCN hostels to farms of bananas, cloves, Eucalyptus trees and cattle fodder. The habitat of FP and MH is less disturbed, and consists of tall trees sometimes associated with dense undergrowth. ASF is stretch of regenerating human disturbed habitat isolated from near-pristine Mbomole hill forest patch by a busy murram road.

Field Method

Data was collected from the forest edge and closed habitat of the three study sites. For this study the forest edge is the outside of a forest patch, about 0-5m into the forest where there is continuous exposure to light of the crowns and the upper parts of the trees. The closed habitat is the inside of a forest fragment, starting at about 20m-100m from the periphery of forest edge to the forest interior, where the crowns receive continuous insolation with the other parts remaining mostly unexposed.

Five pairs in total were chosen from the edge and closed habitat of the three sites. The method of selection was random since the trees tend to grow clumped together and thus only fairly isolated trees were chosen. Five *Maesopsis* trees were selected at the defined edge strip (0-5m). Five more trees were chosen at the defined closed habitat strip (20-100m). The distance between each selected pair (i.e the edge and forest tree) did not exceed 100m.

Fruits Productivity of trees was assessed by scanning both the tree canopy and at the forest floor. The amounts of fruits at the canopy was determined by estimating the number of fruits in one small branch, and multiplying with the number of branches of that size in one tree. The % of unripe and ripe fruits was estimated visually. At the forest floor under the trees, three 1m² plots were cleared off vegetation and litter, and were located away from the other covering the area of canopy above. After 48 hours the plots were checked and all fruits were counted. By multiplying the average number of fruits in plots under one tree with an area of its canopy spread, the amount of dropped fruits was estimated. To get the average weight of one seed, five undamaged fruits were selected from the plots and were weighed. For each tree the following additional variables were collected: Diameter at Breast Height (DBH), and Canopy Diameter were measured in metres using a tape measure. Using canopy radius and the height from the branching point of the tree, we calculated the canopy volume of the trees, by assuming the shape was cone shaped. The canopy cover of *Maesopsis* and other trees shading the chosen tree was estimated visually in %. Canopy height was measured in metres using a Clinometer. All measurements were taken by one observer to minimise bias in the data. For each chosen tree five leaves were collected on the forest floor close to the trunk; this is because most of the *Maesopsis* trees canopies occur at great heights (20m $\geq$ 40m). The leaves were sampled by picking the first one encountered without damaged parts, and the next one in that order.

Data Analysis

All data was analysed using ANOVA, specifically the General Linear Model for comparison of variables between the two different habitats and three sites respectively. Assumptions made in this Study are:

1) Fruits dropping on the ground plots were not removed by frugivores
2) The same conditions and factors contributed to fruits fall in all habitats and sites.

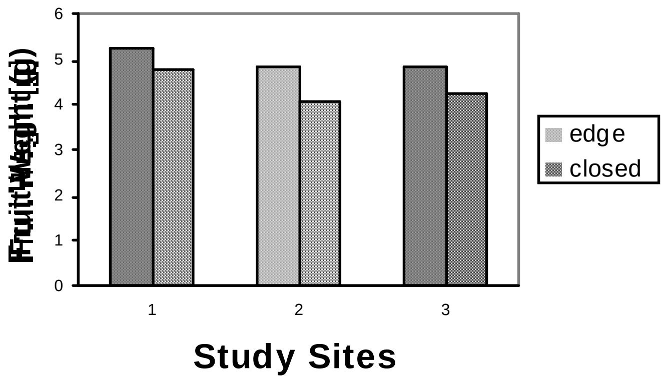
Results

Fruits Production at the Forest Edge and in the Closed Habitat

The number of fruits in the tree canopies and the amount dropped from the trees was the same at the edge and in the closed habitat (p>0.05, Anova). The average weight of fruits collected at the forest edge was greater (4.96g ± 0.1) than in the closed habitat (4.38g ± 0.1, p=0.009, Anova; fig. 1.).

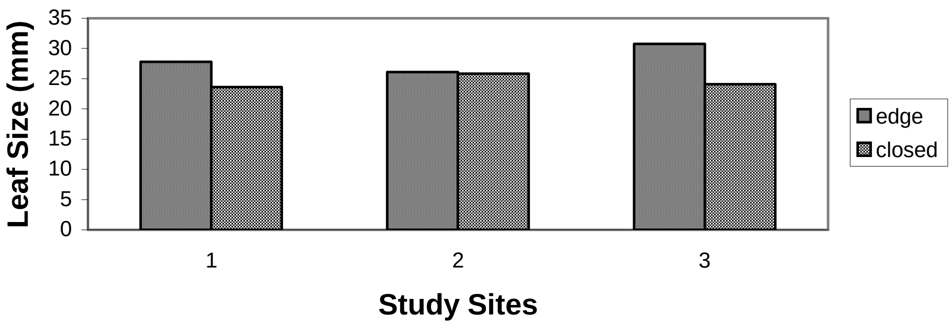
Fruits Production between the Sites

In all the three sites the number of fruits in the canopy of *Maesopsis* trees and those dropped on the tree floor was the same (p>0.05, Anova). The average weight of the



fruits collected under the trees was the same in all sites (p>0.05, Anova).

Figure 1. A bar graph showing the fruits weight of *Maesopsis eminii* at the edge and in



the closed habitats of our study sites.

Figure 2. A bar graph showing the leaf size of *Maesopsis eminii* in the two habitats.

Maesopsis eminii tree Canopy Structure and its Contribution to Fruits Quantity

The size of the leaves was the same in the three sites (p>0.05, Anova), but leaves at the forest edges were larger in size (28.2mm ± 0.7958), than leaves in the closed habitat (23.3mm ± 0.7958, p=0.022, Anova; fig. 2.). The DBH (1.66m ± 1.2) of trees at the three sites was different (p=0.023, Anova), but the same for the edge and closed habitats (p>0.05, Anova). All the sites had trees with the same canopy diameter (p>0.05, Anova), but trees at the forest edge had smaller canopy diameters (14.4m ± 1.4) than those in the closed habitat (22.8m ± 1.4, p=0.008, Anova). The canopy area of trees in all sites was the same, but trees in the closed habitat had a larger canopy area (384.5M^2 ± 47) than those at the edge (153.3 ± 47, p=0.024; fig.3.).

The canopy height of Maesopsis trees (33m ± 1.8) at the edge and closed habitat was the same (p>0.05, Anova), though it differed between the sites (p=0.04, Anova)**.**

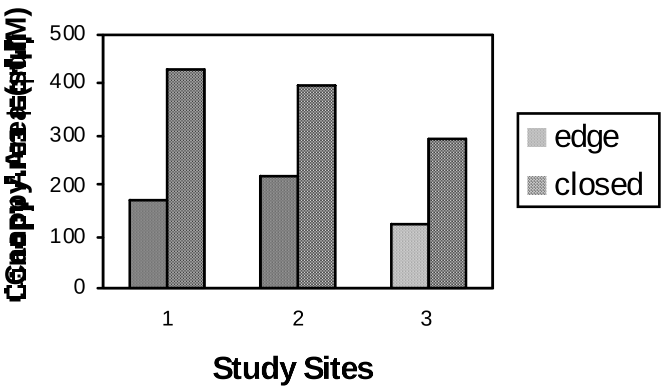


Figure 3. A bar graph showing the canopy area in *Maesopsis eminii* at the edge and in the closed habitats

Shading by other tree species was the same for trees in both habitats (p>0.05, Anova). The leaf size, DBH, shading, canopy diameter, area and volume and the canopy height did not influence the number of fruits produced by Maesopsis trees in all sites, and between habitats (p>0.05, Anova). But trees with higher canopy volume and area had more dropped fruits on the ground than trees with lower dimensions in the two variables (p=0.01, Anova).

Table 1. Summary of results for variables of *Maesopsois eminii* at the edge, in the closed habitat as well as in the three study sites**.** > and < indicates a significantly greater or lesser value for a variable in this habitat compared to the other habitat, respectively; = is no difference for a given variable between the two habitats and the sites respectively; ≠ indicates that the variable shows significant difference between the sites

No.	**Variable**	**Edge Habitat**	**Closed Habitat**	**All Sites**
1	Number of Fruits	=	=	=
2	Fruit Weight	>	<	=
3	Leaf Size	>	<	=
4	Canopy Area	<	>	=
5	Canopy Diameter	<	>	=
6	Canopy Volume	=	=	=
7	DBH	=	=	≠
8	Canopy Height	=	=	≠

Discussion

The amount of fruits present on trees was similar at the edge and in the closed habitats in all sites. This might be because the trees in both habitat types had the same canopy volume. The fruit weight of the edge trees was larger than of the forest trees. It can be concluded that larger fruits contain larger seeds. Seedlings from larger seeds have a competitive advantage in a dense population (Black, 1957a,b). The difference in fruit weight between the two habitats suggests that the trees at the edge have a greater potential to invest in reproduction.

The edge trees had smaller canopy areas than the forest trees. Since there was no difference in the canopy volume between the two habitats the trees at the edge seem to have more packed crowns. As forest trees receive less insolation from the side they tend to place their assimilatory organs in a more widely spread area while the distance from the lowest branching point to the uppermost canopy is smaller than in trees of the open habitat.

Leaves play a crucial role in providing energy that sustains the plant’s tasks. The leaf size of trees at the forest edge was larger than of those in the closed habitat. Crawley

(1997) observed that leaf morphology in tropical forest was highly plastic, since juvenile leaves were large and thin, but became smaller and thicker as the leaves emerged into the full sunlight of the upper canopy. According to Begon, Harper and Townsend (1990) the leaf area index (LAI) is defined as the surface area of leaves per unit surface area on ground. Leaf size contributes to leaf area index. An increase in LAI may be expected to lead to greater productivity. This, however, is only the case where the tree under story receives sufficient light as the lower leaves might be shaded upon by the upper canopy and respire more than they produce. Beyond a certain LAI the trees productivity might decrease (Begon, Harper and Townsend, 1990). As earlier mentioned the canopy area of trees in the closed habitat is more spread out than edge trees with the canopy volume remaining the same. As edge trees containing significantly more layers of leaves do not face the same threat of decreasing their productivity they might have a higher LAI. The trees at the edge may thus be more efficient in producing leaf biomass per unit space, and hence show a more efficient relative assimilation rate. Although this advantage has not influenced the amount of fruits it might be responsible for the increased fruit weight of edge trees. Producing a greater amount of leaves might be a requirement in a habitat where competition between neighbouring Maesopsis is fiercer than in the forest where a lower species density - among other factors mentioned earlier - contributes to allowing a wider spread of the canopy. There is much evidence (referring to own observations) that Maesopsis densitiy patterns behave in the way assumed above, however, in order to have solid proof we would encourage an additional study assessing tree densities in our three study sites.

The forest edge and the forest interior both were invaded by Maesopsis, a similarly high fruit production could be maintained even under constraints of reduced light exposure. However, due to increased leaf sizes and additional architectural features of edge trees it may be concluded that trees at the forest edge had a more efficient relative assimilation rate (as they have a higher LAI) or leaf biomass per unit space than forest trees. This might explain the increased fruit weight of the edge trees.

Acknowledgments

We are very grateful to Dr. Rosie Treverlyn, Dr. Claire Monzancourt, Anthony Kuria, Prof. Brian Moss, Dr. Thomas Wagner for their constant support and enthusiasm during planning, data collection, analysis and write up. Our thanks go to Bruno and Johari from Amani Forest Station who would never hesitate to assist us with their profound knowledge. Not to be forgotten is the daily morale and energising word we received from all TBA participants. Thanks a lot for being alive and kicking.

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