Effect of shade on leaf length, leaf area, stem diameter and coverage of *Lantana camara* under *Maesopsis eminii* and *Cinnamomum camphora* dominated sites in Amani Nature Reserve, East Usambara Mountain, Tanzania.

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Abstract:
Two adjacent sites, one dominated by *Maesopsis eminii* and the other by *Cinnamomum camphora* were selected for the study. During site selection we found the two sites looks a bit different in *L. camara* distribution and density and this study therefore investigated the effect of shade on leaf area, length, stem diameter and coverage of *Lantana camara*. Our results show that, shade is not the only limiting factor for *L. camara* distribution. The effect of shade on leaf area, length and stem diameter was very minimal at the ranges encountered.

INTRODUCTION:
In Amani Nature Reserve (ANR) many plants species were introduced from different parts of the world at different time of intervals for different purposes. Currently many of them are becoming invasive, such as *Clidemia hirta, Lantana camara, Maesopsis eminii, Phyllostachys bambusoides, Cordia alliodora, Stachyitapheta jamaicensis, Landolphia kleinii, Castila elastica, Arenga pinnata, Cedrela odorata, Rubus niveus* and *Rubus rosifolius*- (Mndolwa: Personal communication).

Invasive plants are becoming a threat to ecosystems all over the world. The most damaging invasive plants transform ecosystems by using excessive amount of recourses (especially water, light and oxygen), adding resources (especially nitrogen), promoting or suppressing fire, stabilizing sand movement and /or promoting erosion and accumulating litter, salt (Lecture notes by Pauline, TBA course 05/3) and allelochemicals. They can exert a profound influence on resident species. By modifying the soil and changing the environment near the ground, they can change the direction of succession. Plants such as *L. camara* are able to out-compete pre-existing native species and form new vegetation in few years.

The success of invasion is influenced by many factors. Niches must be available and the invader must be able to compete successfully for resources against species already present.

The invading species must be able to reproduce and establish a new generation with greater numbers of individuals. According to Given (1994) reproductive strategies is an important consideration in the success of invading species. Crawley (1989) in Given (1994) considered success of invasion as the result of interactions between the invading species and the targeted habitat.

The invasibility of the ecosystem and the invading power of the invaders need to be considered in parallel. Some habitats are more prone to invasion than others. Open habitats are particularly vulnerable to invasion by aggressive plants that can rapidly cover large areas. Communities that have widely spaced species where there are available niches for invaders to slip in will tend to be less resistant to invasions.

Amani Nature Reserve contains areas of highly disturbed forest and forest fragments of various sizes (Lecture note by Rosie, TBA Course 05/3). This fragmentation created open habitat that may provide opportunities for invaders to spread through the forest. Invasive plants such as *L. camara* are widely observed in such open disturbed habitats. It is not clear why invaders are more successful in open disturbed areas than in closed undisturbed areas. There would be many ecological parameters to be considered in this regard, but this study particularly focused on the determination of effect of shade on growth parameter of *L. camara*: leaf length, leaf area, stem diameter and ground cover.

Objective:

- To investigate relationship of leaf length, leaf area, stem diameter and coverage of *Lantana camara* to shading.

Methods:

Two adjacent forest sites, one dominated by *Maesopsis eminii* (site 1) and the other by *Cinnamomum camphora* (site 2) were selected in the Amani Nature Reserve. Six transects each at 30m apart were used at each site for sampling the target plant, *L. camara*. On each transect 11 sampling points each at 20m apart were marked for data collection from forest edge (at the road side) to the forest interior. At each sampling point, percentage shading, stem diameter just below the third pair of leaves from the shoot tip and coverage of *L. camara* within a 30×10m plot for sampling point 1 and within a 30×20m plot for sampling points 2-11 were recorded. The cover of *L. camara* were recorded in one of five cover classes: 5: very dense (75-100%), 4: dense (50-74 %), 3: moderate (25-49%), 2: sparse (1-24%) and 1: none

(0%). The third pair leaves from the shoot tip were collected from each sampled plant for measuring leaf length and area in the laboratory.

Materials:

A forester's densiometer was used for measuring percentage shade, acetate sheet graph paper for measuring leaf area, a 300mm ruler for measuring leaf length and vernier callipers for measuring stem diameter.

Data analysis

Data were analysed using the Statview program

Results:

Percentage shade variation between the two sites

The mean percentage shade in *Maesopsis*-dominated site was higher (66.0%) than the mean percentage shade in *Cinnamomum*-dominated site (57.8%) (df= 130 t=3.56 P=0.0005) (Figure1)

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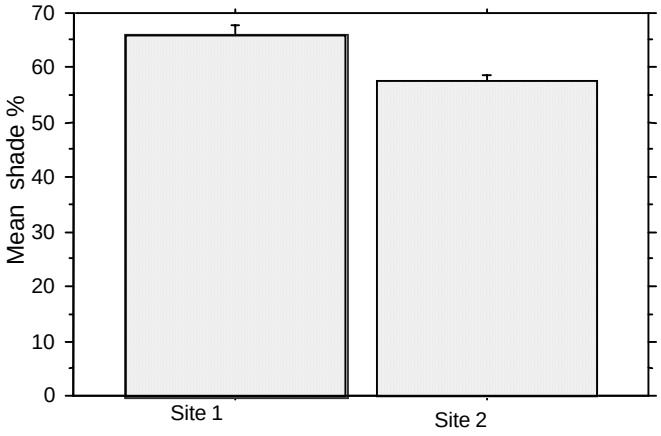

Figure 1. Mean percentage shade in *Maesopsis*-dominated site and *Cinnamomum*-dominated site

Mean coverage of *L. camara* over the two sites

Coverage in *Maesopsis*-dominated site (3.0) was higher than in *Cinnamomum*-dominated site (2.0), (df=130 t=5.71 p<0.0001)(**fig 2).**

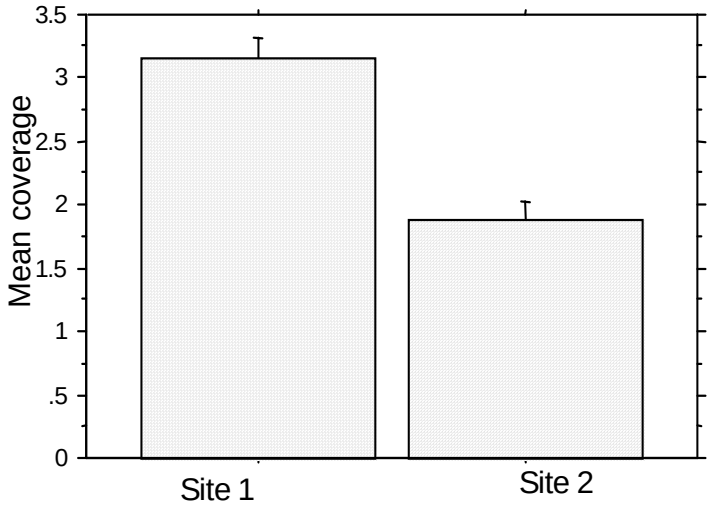

Figure 2. Mean coverage of *L. camara* between *Maesopsis*-dominated site and *Cinnamomum*-dominated site

Average leaf area (mm^2) and length variation between the two sites

The average leaf area in *Maesopsis*-dominated site (1541.6) was lower than in *Cinnamomum*-dominated site (1866.1) (df=77, t=-2.200, P=0.0308) (**fig 3**). Similarly the average leaf length in *Maesopsis*-dominated site (61.02) is smaller than in *Cinnamomum*-dominated site (68.14) (df=77, t=-1.994, P=0.0497) (**fig 4**).

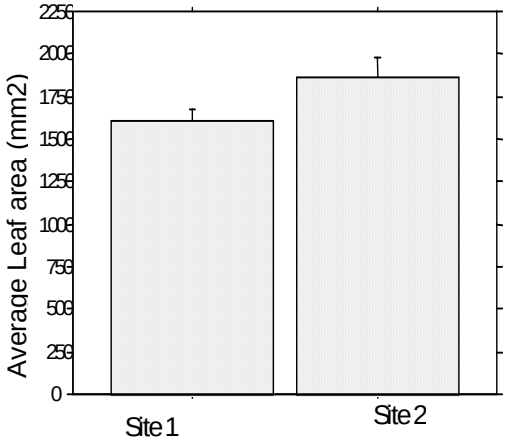

Figure 3. Average leaf area at site 1 and site2.

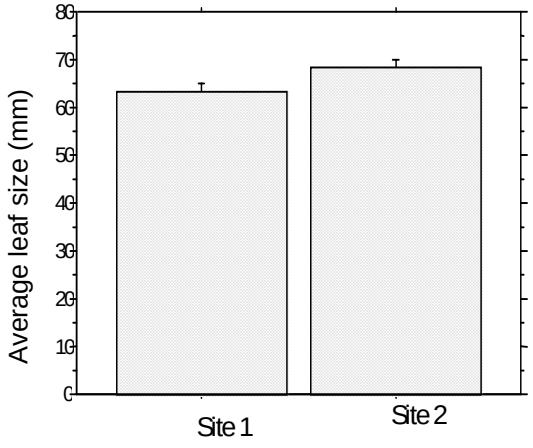

Figure 4. Average leaf length at site1 and site2.

Average stem diameter variation between the two sites

There was no significant difference in stem diameter variation between the two sites (t=0.136 df=77 P=0.8920).

Coverage of *L. camara* in relation to percentage shading at sites 1 and 2.

A weak negative correlation was shown between cover of *Lantana camara* and percentage shading (P=0.0016, r^2 =0.146) and (P<0.0001, r^2=0.252) at *Maesopsis*-dominated site and *Cinnamomum*-dominated site respectively. **(Figure 5 and 6)**

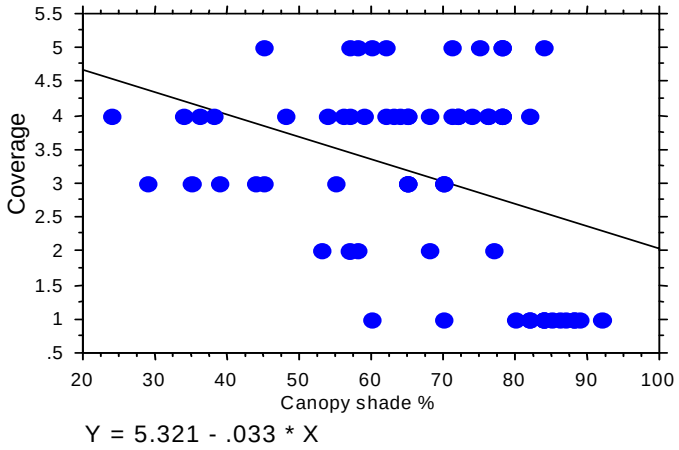

Figure 5. Relationship between cover of *L. camara* and percentage shading (*Maesopsis*-dominated site).

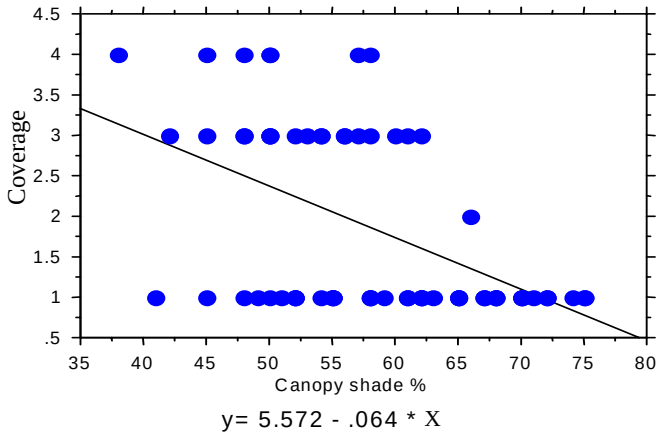

Figure 6. Relationship between cover of *L. camara* and percentage shading (*Cinnamomum*-dominated site).

Average leaf area (mm2) in relation to percentage shading at sites 1 and *Cinnamomum*-dominated site

Average leaf area for *Maesopsis*-dominated site showed a weak negative relationship with percentage shading (P=0.02944 r^2=0.022) (**Figure 7**). The effect was non-significant at *Cinnamomum*-dominated site (P=0.1345, r^2= 0.091).

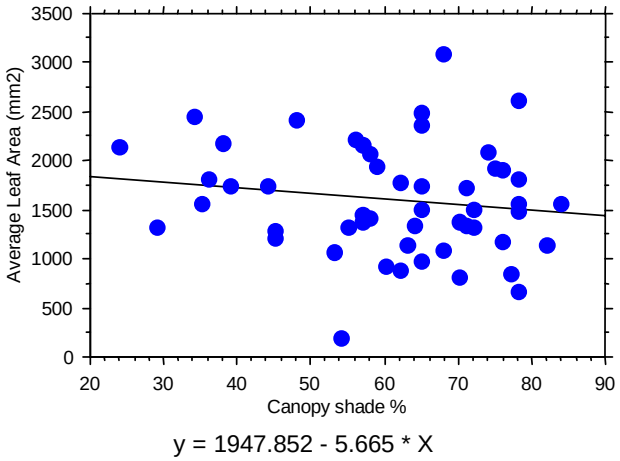

Figure 7. Relation between average leaf area and percentage shading (*Maesopsis*-dominated site).

Average leaf length- percentage shading relationship at site 1 and 2

At both sites the relationship between average leaf length and percentage shading was not significant (P=0.1811, r^2=0.036) and (P=0.263, r^2= 0.052) for *Maesopsis*-dominated site and *Cinnamomum*-dominated site respectively.

Stem diameter (mm) - percentage shading relationship at sites 1 and 2

There was no significant relationship between stem diameter and percentage shading for *Maesopsis*-dominated site (P=0.5986, r^2=0.006), and *Cinnamomum*-dominated site. (P=0.363, r^2= 0.035).

Discussion:

Percentage shading and *L. camara* coverage

Our study shows that the *Maesopsis*-dominated site had higher shading than the *Cinnamomum*-dominated site. There was also more dense *L. camara* coverage at the *Maesopsis*-dominated site compared with *Cinnamomum*-dominated site. This compares with

Binggeli and Hamilton (1993) in Newmark (2002) have observed that *Maesopsis* stands have more open canopy compared to stands of native species.

According to work done by Frances & David. (2002) *L. camara* density was not correlated with canopy openness in two out of three sites examined, and also it was found that *L. camara* density is related more strongly to distance from forest edge than to canopy openness. Conversely, our study showed that *L camara* density was correlated with shade although this was a weak relationship indicating that shade is not the only limiting factor.

Leaf area, length, stem diameter and percentage shading.

Relationships of leaf area to shade revealed weak negative correlation at *Maesopsis*-dominated site where there was high shade, and showed non-significant association in the *Cinnamomum*-dominated site. The mean leaf area was larger in *Cinnamomum*- dominated site where percentage shading was comparatively low. This result indicates that leaf area is more influenced, by shade in the shadier site.

Leaf length between the two sites was significantly different. The mean average leaf length was larger in *Cinnamomum*-dominated site where percentage shade was lower. Leaf length was not significantly correlated to the shade. From the results of comparison of the two sites, it seems that leaf length is influenced by some other ecological factors than by shade. Difference in stem diameter between the two sites was non-significant. Association of stem diameter to percentage shading in both sites was also non- significant, indicating that percentage shading has no effect on stem diameter.

Plant species interactions:

The two sites were different in terms of plant species composition. *Maesopsis*-dominated site was mainly dominated by invasive plant species such as, *L. camara Clidemia hirta* and *Rubus spp.*. Native species: *Parinari excelsa, Makaranga campensis, Cinchona ciccibru* and *Polyscia fulva* were sparsely observed. In contract, at the *Cinnamomum*-dominated site other shrubs such as *Psidium cattleianum*, and *stombosia scheffleri* were found in abundance.

A study conducted by Binggeli and Hamilton (1993) in Newmark (2002), indicated that *Maesopsis eminii* has caused ecological changes and alteration in plant species composition under its canopy. They found the regeneration of native plant species reduced, while

abundance of non-native forest trees such as *L. camara, Clidemia hirta* and *Rubus rosifolius* increased. From this observation it seems that those invasive plants can share the same habitat, and the appearance of one invasive plant species in one habitat may provide opportunity to other invaders.

Conclusion:

Shade is not the only limiting factor for *L. camara* distribution. Leaf area is more influenced, as shade gets larger and larger. From the results of comparison of the two sites, it seems that leaf length is influenced by some other ecological factors than by shade. Percentage shading has no effect on stem diameter.

L. camara grew more abundantly, although leaf area was slightly reduced under the more shaded environment provided by *Maesopsis*. It is likely that *Maesopsis* provides more suitable environment for growth of *L. camara* and other invasive species.

Recommendation:

The effect of shading on germination, responses of *L camara* seedlings to nutrient and light competition with other plant species as well as the effect of other plant species should be considered. In addition, giving attention to ecological factors such as soil moisture, soil pH, plant interactions and the effect of different plant leaf litters on *L. camara* should help to clarify the situation.

From the observation of the mutual association of the invaders in the *Maesopsis*-dominated site, we suggest that, an investigation of the relationship of invaders might assist in a management programme for those invaders.

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