

Analysis of some changes in vegetation structure caused by recreational activities:

Case study of tropical mountainous areas of Mount Tahan in Malaysia

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Abstract 本研究は、Mt. Tahan の熱帯山岳地帯におけるレクリエーション活動による樹木成長への影響を調査することを目的とした。レクリエーション活動の影響を生態-生理学的特性（クロロフィル蛍光および植生の成長）と木材の解剖学的特性の 2 つのパラメータを用いて評価した。測定には 2 つの優占種 *Tristaniaopsis fruticosa* と *Beackea frutescens* を用い、樹木の直径、高さ、葉面積、クロロフィル蛍光を測定した。各キャンプ場とトレッキング路に 20x20m のプロットを調査区として設定した。また、自然変化を識別するため、インパクトエリアとコントロールエリアを設定した。その結果、両プロット間で測定値に顕著な差が見られた。ただし、この結果はいくつかのインパクトが植生成長に影響したことを示し、ほとんどの測定において、インパクトエリアのパラメータの方がコントロールエリアよりも高い測定値を示した。この結果は、インパクトによる影響が様々なメリットとデメリットが複合して、植生状態への直接的な反応を引き起こしたことを示している。Mt. Tahan の場合には、レクリエーション活動によって引き起こされた植生へのダメージは深刻ではなかった。しかし、現在の状態を持続的に維持するには、継続的なモニタリングが今後必要であろう。

Keywords: クロロフィル蛍光、レクリエーション活動、樹木成長、タハン山

Abstract The purpose of this study is to evaluate some human recreational impacts on tree growth at recreational sites in tropical mountainous areas of Mount Tahan, Peninsular Malaysia. Impacts were quantified using two parameters which are eco-physiological characteristics (chlorophyll fluorescence and vegetation growth) and wood anatomical characteristics. Measurements were taken by assessing tree diameter, height, leaf area and chlorophyll fluorescence whereas two dominant species which are *Tristaniaopsis fruticosa* and *Beackea frutescens* were selected as representatives. Plot sized 20 x 20m were established in the most concentrated recreational site. As to identify the natural changes, the impact area was paired to another area, which is referred to as the control area. There were significant differences of value between the study areas where results showed that most values of parameters taken in impacted areas are higher than those in control areas. These contrasting results illustrated that disturbance triggers a dynamic response to the vegetation conditions including various positive and negative ways. In the case of Mount Tahan, the damage on vegetation caused by recreation activities is still not alarming but greater recognition is needed to maintain the sustainability.

Keywords: *chlorophyll fluorescence, recreational impacts, vegetation growth, Mount Tahan.*

1. INTRODUCTION

Conflict between recreation activities, resources and its impacts has caught the attention of researchers globally and locally. Previous studies claimed that human activity has been impacting environments and species for a long time (Leveque and Mounolou, 2004). Disturbances such as trail and campsite opening in the forest were said to significantly affect vegetation and tree growth.

However the actual productivity and ecological changes in term of vegetation and tree growth are not clearly described. In Malaysia locally, little is known on the relationship between recreational activities and its impact on mountain vegetation. Moreover, forest conservation, planning and treatment require ecological information such as the vegetation status in those specified area.

2. MATERIALS AND METHODS

2.1 Study area

The study was conducted in Mount Tahan (2,187 meter above sea level) which is the highest point (4°38'N, 102°14'E) in Peninsular Malaysia. It is located within the Pahang national park with an area of 1,677 square miles (4,343 km²). The elevation ranges from 1800 meter above and topography is hilly with slopes of 50 to 70 degrees. Mount Tahan has been a hot spot for local and international climbers since 1960's for its magnificent values of natural flora and fauna. In contrast, rapid visitation to Mount Tahan has been said in causing damages to the vegetation and reduced its aesthetical value. However, no study was done to evaluate current condition on the vegetation structure in the upper elevation of Mount Tahan.

2.2 Experimental design

This study was carried out by following a standard experimental procedure in recreation impact studies proposed by Cole and Bayfield (1993). In this study, six plots sized 20 x 20m were established in the most concentrated recreational areas. Plots were divided into two categories, one designated as the control site and the other as the impact site where the activity is hypothesized to have an influence. Parameters taken were chlorophyll fluorescence measurements, and wood anatomical characteristics. For wood anatomical studies, diameter of tree and wood sample were taken at about 10 cm above the ground. Data were analyzed and compared using independent t-test. The statistical analyses were performed using Statistical Package for Social Sciences (SPSS 12.0) and the significance level was set at 0.05. Graph and figures were carried out using CF handy Pea instrument package.

3. RESULTS

Chlorophyll fluorescence measurements

Chlorophyll fluorescence (CF) measurements were taken with an intention to early indications of plant stress. F_v/F_m value below 0.83 indicates that the plant is under stress condition. The results show that the mean values of F_v/F_m readings were found higher in most of disturbed plots than in control plots (Table 1). F_v/F_m which represents the maximum quantum yield of PSII (which correlated with the quantum yield of net photosynthesis) was significantly different between disturbed and control plot. The lowest mean values of CF were found in control trail area whereas F_o value shows a significant different for disturbed and control plots in camping area. However, The CF results revealed that *Tristaniopsis fruticosa* measured were not under severe stress as F_v/F_m values were below the level defined for threshold of concern 1 (0.83) but is still above the threshold of concern level 2.

Table 1: Mean values and standard error of chlorophyll fluorescence parameters of *Tristaniopsis fruticosa* with significant level at $p < 0.05$.

| | Parameters | | Camping area | | |
|------|------------|---|----------------|----------------|---------|
| | | | Disturbed | Control | F-value |
| Wood | F_o | ! | 248.45 ± 4.56 | 216.79 ± 4.12 | 8.13* |
| | F_m | ! | 993.86 ± 22.80 | 795.13 ± 19.09 | 12.41* |
| | F_v | ! | 745.43 ± 20.1 | 578.34 ± 16.56 | 7.25* |
| | F_v/F_m | | 0.74 ± 0.005 | 0.71 ± 0.007 | 0.02* |
| | ! | ! | ! | ! | ! |

anatomical characteristics

The growth characteristics and vessel area for wood anatomical examination of *B. frutescens* are summarized in Table 2. Diameter of tree and wood sample were taken at about 10 cm above the ground.

Tree diameter (D) and height (HT) had shown a significant difference where mean values in the disturbed plots are higher than in the control plots. Results also showed that *B. frutescens* grew in the disturbed plots had higher vessel areas (A_v) compared to the control plots with the mean value of 177.06 μm^2 and 106.40 μm^2 respectively (Table 2).

Table 2: Mean value and standard error of each parameter of *Beckea frutescens*. Significant level at $p < 0.05$.

| Parameters | Camping area | | |
|------------------------------------|---------------|---------------|---------|
| | Disturbed | Control | F-value |
| D (cm) | 2.25 ± 0.72 | 1.83 ± 0.26 | 0.17* |
| HT(cm) | 88.50 ± 7.2 | 82.65 ± 4.15 | 2.29* |
| A _v (μm^2) | 177.06 ± 0.14 | 106.40 ± 1.58 | 2.89* |

Remark: Diameter of tree and wood sample were taken at about 10 cm above the ground.

4. DISCUSSIONS

In this study, the mean values of F_v/F_m parameters for *T. fruticosa* were found higher in the disturbed plots than the control plots for all study sites (Table 1). CF readings were low on impacted areas which are under stresses. Control plots received direct exposure of sunlight, wind and high intensity of radiation receipt at high altitudes especially on clear summer days. This situation makes the area have higher light intensities and uneven temperature which localized plants under severe water stress. According to Dickinson and Murphy (2007), high mountain ecosystems have cold and high winds that will combine to stress the plants by coupling low metabolic activity being called physiological drought produced by the desiccating effect of the wind. At temperature too high or too low the photosynthetic yields decrease steadily until CO_2 uptake ceases (Schulze and Caldwell, 1993). Lower value of F_v/F_m indicated that there is a decreasing in PSII production which means that the tree is under stress condition. From our observation, we could see that most tree in control plots seem to have chlorosis and stunting effect where yellowing of leaves were caused by the reducing of chlorophyll synthesis. Leaves seemed to be particularly sensitive indicators of mineral deficiency, tending to reduce in size, abnormal in shape or structure, pale in colour and even develop dead areas on the tips or margins.

Table 2 showed that wood samples of *B. frutescens* from the control plots had lower vessel area and smaller in size (tree diameter and height) compared to those from the disturbed plots. Previous studies by Falster and Westoby (2005) suggested that low vessel area is a characteristic of slow growing species which is similar to those found growing on nutrient- poor dry soils. In contrast, higher vessel area reflects a healthier and fast growing species. Canopy opening and activities done by recreationist created more exposure to disturbance (Photo 2a). Nevertheless, higher moisture and soil minerals derived by human waste and disposal in camping sites probably contributed to the contrasting results. The supply of nutrients from the environment varies continuously within time and spaces and affect vegetation growth and wood development. The optimum supply of nutrients will allow maximum growth while lack of them will lead to the inhibiting growth. In contrast to that, eroded soil in disturbed plots released more soil organic matter, nutrients and minerals downhill. Erosion especially on steep slopes may form gullies which will encourage breakdown and release soil particles contained minerals and nutrients to the lower area (Photo 2b). Chemicals dissolved in water flowing through the soil have reacted with the underlying rocks to release the mineral nutrients plants need in which the process called chemical weathering (Allaby, 2006).

5. CONCLUSION

The study shows two contrasting result which concluded that recreation activities is not a major factor of disturbance and growth stresses in mountain areas which are originally a sensitive ecosystem. Generally, human impacts cause damaging change to ecosystems more frequently than normal processes. In Mount Tahan, some vegetation communities are relatively benefited from these activities which added and decomposed minerals and nutrients availability in those areas. As conclusion, disturbances affect ecosystems by different characteristics; type (physical and biological), and patterns of occurrence (spatial distribution, frequency, intensity, duration). In the case of Mount Tahan, the rate of changes and disturbance is still not yet alarming. However, further research on vegetation condition should be done to maintain the sustainability and conservation.

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Photo 1: Overview of main camping site in Botak Hill with the elevation of 1897 m.



(a)



(b)

Photo 2: Areas impacted by recreation activities (a) Bare ground of camping site in Botak Hill, and (b) Gullies erosion along trekking trail from Botak Hill to the Summit