



INFLUENCE OF DISTURBANCE REGIMES ON FIG-WASP RELATIONSHIPS AND SYCONIAL CHARACTERISTICS OF *Ficus tinctoria* (MORACEAE) IN SOME SELECTED SITES OF KANDY AND MATALE DISTRICTS

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The fig–fig wasp interaction is an obligate mutualistic relationship. *Ficus tinctoria* (Moraceae) is a hemi-epiphytic dioecious fig tree species. The present study investigated the influence of vegetation disturbance regimes on the fig–fig wasp relationship and syconial characteristics of *F. tinctoria* across two study sites and was conducted from October 2024 to February 2025. Study sites were selected based on the difference of disturbance level in their vegetation after calculating the percentage vegetation cover. The study sites were the less disturbed Nattarampotha area which belongs to the Kandy District (Site 1) and the more disturbed urban core within Matale city (Site 2). Mature syconia were collected, their diameter measured, cut into two halves and reared until the complete wasp emergence. The number of galls and florets per syconia, pollinator fig wasps (PFWs) and non-pollinator fig wasps (NPFWs) were counted and recorded according to their sex. Percentage contribution of galls in the syconium for fig wasp production was higher in Site 1 (89.00%) than Site 2 (79.85%). Mean values of syconial diameter (DS), volume (VS) and number of florets per syconium (Fl/S) were comparatively higher at Site 2 (DS = 9.46 ± 0.40 mm; VS = 473.23 ± 63.67 mm³; Fl/S = 134.60 ± 21.6). The sex ratio of PFWs in Site 1 was 0.06 and in Site 2 was 0.30, indicating that Site 1 is more female-biased. The pollinator ratio of Site 1 (0.40) was significantly higher ($p=2.14 \times 10^{-8}$) than Site 2 (0.10). At site 1, there was a strong positive correlation between total non-pollinator fig wasps and pollinator male fig wasps (PMFWs) ($r = 0.785$) and between non-pollinator male fig wasps and PMFWs ($r = 0.824$), whereas there was no strong correlation found at Site 2. Overall, Site 1 showed higher pollinator ratio, proportion of female wasps and wasp abundance within the syconia, indicating a stable mutualistic relationship. This study reveals the significant effects of disturbance on the relationship between *F. tinctoria* and its associated fig wasp species. The findings support the conclusion that increased disturbance negatively impacts syconial characteristics and fig–fig wasp relationships.

Keywords: galls, pollinators, non-pollinators, florets

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INTRODUCTION

According to the systematic classification, fig trees belong to Family Moraceae and Genus *Ficus* (Corner, 1965). Fig trees (*Ficus* spp., Moraceae) are essential parts of tropical and subtropical ecosystems in the world. They are frequently referred to as keystone species because of their year-round fruiting patterns, which offer a steady supply of food for a wide variety of frugivores, such as birds, bats, primates, and insects (Ma et al., 2009).

There are approximately 750 tropical and extra-tropical fig species that are pollinated by highly specific chalcidoid wasps (Hymenoptera: Agaonidae) (Compton & Hawkins, 1992). *Ficus* associated fig wasp species not only include pollinators but also non-pollinators (West et al., 1997). Pollinator fig wasps have an obligatory relationship with *Ficus* species.

The study species of this research is *Ficus tinctoria* and its' English common name is "dye fig". It is also known as "humped fig". *Wal-ehetu*, *Gas-netui* and *Gas-anguna* are the Sinhala vernacular names of this species. In Sri Lanka, *Ficus tinctoria* is distributed low country to 1000 m altitude (Dassanayake, 1981). The pollination of *Ficus tinctoria* is facilitated by a specialized wasp species, *Liporhopalum rutherfordi indicum* (Family Agaonidae) (Priyadarsanan, 2000).

The research question was, how do disturbance regimes affect fig-wasp interactions and the syconial characteristics of *Ficus tinctoria*?

The general objective of this study was aimed to examine how different disturbance regimes influence fig-wasp relationships and syconial characteristics of *Ficus tinctoria* populations in some selected sites of Kandy and Matale Districts.

METHODOLOGY

Based on the difference of disturbance level in their vegetation, the occurrence of the study species and after a number of pre-visits to the different locations, two study sites were selected and one of them was from Kandy District and the other one was from Matale District of the Central Province of Sri Lanka. Accordingly,



Nattarampotha area which belongs to the Kundasale Divisional Secretariat as a less disturbed area (Site 1) and an urban core within Matale Municipal Council Area as a disturbed area (Site 2) were selected preliminarily. Vegetation density was taken as the measure of degree of disturbance to the vegetation (Wijetunga et al., 2015), it was calculated using satellite images from the Google Earth Pro. For each site, four circular plots with approximately 50 m radii were selected randomly and analyzed them for the percentage vegetation cover using ruler option and draw polygon option in the Google Earth Pro. Mean percentage vegetation cover for each site was calculated and One-way ANOVA test showed that, it was significantly different ($p=0.014$, $f=11.93$, $n=8$) among two study sites.

The study was conducted from October 2024 to February 2025. Samples were collected from 5 *Ficus tinctoria* trees per each study site. For each syconium, diameter of syconium (DS) was measured. Then, assuming that the syconium is a regular sphere, volume of syconium (VS) was calculated. Afterwards, the syconia were cut into two halves and reared for 1 to 3 days, until the completion of wasp emergence. With minor adjustments, the syconia rearing technique used by Priyadarsanan (2000) was used for this research. Then, both fig wasps and fig halves were preserved in 80% isopropyl alcohol. For preserved wasps, identification and sex determination were done. Then, they were counted separately, according to their sex. For preserved syconia, number of galls and number of parthenocarpic seeds were counted and recorded.

The statistical software MINITAB, version 22, was used to perform the statistical analyses.

RESULTS AND DISCUSSION

A total of 76 figs (syconia) were collected from two study sites and 36 out of them were from Naththarampotha, Kandy Site (Site 1) and rest of the 40 figs were from the Matale Site (Site 2).

Syconial parameters

As syconial parameters, the diameter of the syconium (DS) and the volume of the syconium (VS) were calculated. Mean diameter of syconia was calculated at 95% confidence interval. It was found to be 8.75 ± 0.72 mm ($\pm$ SEM) at Site 1 and 9.46 ± 0.40 mm ($\pm$ SEM) at Site 2, respectively. Similarly, the mean volume of the syconia at Site 2 (473.23 ± 63.67 mm³) ($\pm$ SEM) was higher than at Site 1 (451.51 ± 121.06 mm³) ($\pm$ SEM). One-way ANOVA test showed that there was no statistically significant difference in both diameter ($p=0.404$, $F=0.72$, $n=27$) and volume ($p=0.878$, $F=0.02$, $n=27$) of syconia between the two study sites. This can happen due to the similarity in the environmental conditions of the two study sites because both sites are fallen under the same agro-ecological region of the intermediate zone.



Galls and florets

To compare the medians of galls per syconium, Mood's Median Test was used. The two study sites do not have any significant impact on the number of galls that occur in a syconium ($X^2=1.9$, $p = 0.168$, $n=27$). However, the median number of florets of both sites are significantly different ($X^2=4.46$, $p = 0.035$, $n=27$). These results reveal that floret production is largely influenced by the environment or ecological factors. In addition to that, higher floret count of Site 2 suggests the possibilities that it offers better floral development conditions like nutrient availability, higher moisture content, or especially less floral herbivory.

The percentage contribution of galls in a syconium for wasp production was $89.00 \pm 16.00\%$ ($\pm$ SEM) at Site 1, with a standard deviation (SD) of 50.8, showing a relatively high variation in the data. Conversely, at Site 2, the mean percentage contribution was lower at $79.85 \pm 6.08\%$ ($\pm$ SEM), with a standard deviation (SD) of 19.22, proposing more uniform values across samples collected from Site 2.

Fig wasps

Out of the 76 figs collected from both sites, fig wasps were emerged only from 27 figs. A total of 432 fig wasps were collected from those 27 figs. 7 different morpho-species of wasps were collected including the pollinator wasp species and 6 non-pollinator wasps species.

The pollinator wasps at Site 1 had an extremely low sex ratio of 0.06. This result indicates an extreme female biased, which is a common adaptation in fig wasps to maximize the number of dispersing females under conditions of local mate competition (Patel, 1998). The sex ratio of pollinator wasps, was significantly higher at 0.30 in Site 2. This less extreme ratio, while still female-biased, could indicate an adaptive response to various ecological conditions, like resource distribution or fig tree density. The sex ratio of the non-pollinator wasps at Site 1 was 0.2. Remarkably, there were no males among the non-pollinator wasps at Site 2 (sex ratio = 0).

Site 1 had a pollinator ratio of 0.4, while Site 2 had a ratio of 0.1. The higher pollinator ratio at Site 1, suggesting a stable fig-wasp mutualism, in which a greater number of pollinators improves efficient pollination and consequent seed production.

Relationships among different categories of fig wasps

Seven relationships between various fig-wasp categories were taken into consideration: viz. (1) between total non-pollinator fig-wasps (TNPFW) and total pollinator fig-wasps (TPFW), (2) TNPFW and pollinator female fig-wasps (PFFW), (3) TNPFW and pollinator male fig wasps (PMFW), (4) non-pollinator female fig-wasps (NPFFW) and PFFW, (5) NPFFW and PMFW, (6) non-pollinator male fig-wasps (NPMFW) and PFFW and (7) NPMFW and PMFW. To determine whether there were significant differences between the various fig-wasp categories mentioned



above, Pearson's Correlation Coefficient test was used. According to the results, notably, in Site 1, a significant relationship between the two groups was indicated by the strong positive correlation ($r = 0.785$, $p=0.001$) that was found between the total number of non-pollinator fig wasps and pollinator male fig wasps. Likewise, a significant positive correlation ($r = 0.824$, $p<0.001$) was discovered between pollinator male fig wasps and non-pollinator male fig wasps, indicating a close relationship between the two species' abundances. For Site 2, there was no any strong correlation found between any groups of wasps.

CONCLUSIONS

In the less disturbed site (Site 1), higher rates of successful pollination and greater wasp abundance within syconia indicated a stable and well-balanced mutualistic relationship. Also, in that site, strong female-biased wasp population revealed that more advantageous as it enhances pollination efficiency and it ensures greater reproductive success for *Ficus tinctoria*. In the disturbed site (Site 2), reduced wasp numbers, lower pollination success and an increased presence of non-pollinating wasps indicated that reduced reproductive success. Overall, this study emphasizes that increased disturbances negatively impact syconial characteristics, pollination efficiency and reproductive success of both *Ficus tinctoria* plant and associated fig wasp species.

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