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RESEARCH NOTE

PHENOLOGICAL PATTERNS OF SELECTED *Ficus* SPECIES IN TASIK CHINI, MALAYSIA

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One of the important keystone plant species in tropical forests are figs as they are food sources for frugivores (Lambert & Marshall 1991; Turner 2001; Llamas 2003). *Ficus* fruits or syconiums are preferred by most frugivores because of their readily availablity and wide distribution. Frugivores also rely on *Ficus* in times of relative food scarcity. *Ficus* also has high calcium content compared to other fruits (Turner 2001). Since figs are known to bear fruits all year round (Janzen 1979; Weiblen 2002), they are a potential species to be planted in disturbed forests and rehabilitation projects. However, basic information on the flowering and fruiting patterns of the *Ficus* has not been well documented.

Amongst the few studies on *Ficus* includes the leaf phenology of *Ficus fulva* in Lambir Hills National Park, Sarawak. Leaves of *F. fulva* dropped during drought and new leaves were initiated at the onset of the rainy season. Before production of large syconium the tree shed all of their leaves and then new leaves and syconium were initiated (Harrison *et al.,* 2000). Another study in neotropical forest, *Ficus citrifolia* trees became deciduous during cold and dry months. The flowering (syconium initiation) was asynchronous among individuals, but with some synchronous during hot and raining months. There was a correlation between flowering (syconium initiation) and vegetative (leaf) phenology, with significantly higher crop initiation in individuals with full leaf canopy. The fig development was longer in cold months. The ripe fig production occurred year-round and was not correlated with climate (Pereira *et al.,* 2007).

This study aims to determine the phenological patterns of nine selected *Ficus* tree species in the Chini watershed forests. The trees were *Ficus fistulosa*, *F. glandulifera*. *F. crassiramea*, *F. consociata*, *F. obpyramidata*, *F. hispida*, and *F. vasculosa*. The specific study objectives were to determine the relationship amongst the species on whether they synchronized their flowering or fruiting patterns and to investigate the relationship between the phenological patterns of *Ficus* species with the micro-climate conditions. The UKM Pakarunding (2012) reported that the increment of land use development in Chini has change the environmental characteristic such as rain, humidity and temperature. Since the climate in Chini is changing due to anthropogenic developments the effects on keystone species must be investigated.

Observations on phenology of *Ficus* species leaves and syconium were made every month, for 18 months, using a binocular. Rainfall data was from January 2010 until February 2012 from four weather stations established by the UKM-PPTC. The seasons were divided into three categories which were dry season from October 2010, February 2011 and June 2011 to August 2011 (total monthly rainfall is less than 60 mm) (Schaik *et al.,* 1993; Toma 2000), wet season from July 2010, December 2010 to January 2011, May 2011, September 2011 and November 2011 to January 2012 (total monthly rainfall is between 60 mm to 100 mm), rainy season from June 2010, August 2010 to September 2010, November 2010, March 2011, April 2011 and October 2011 (total monthly rainfall is more than 100 mm) (Toma 2000).

Monthly phenology censuses from 28 June 2010 until 26 February 2012 were presented in this paper. At each census, the abundance of syconium was estimated by using the proportion of the crown having syconium using an ordinal scale of 1 to 5, with 1 representing the canopy branches have no syconium at all, 2 where only 1-3 canopy branches have syconium, 3 where half of canopy branches have syconium, 4 representing 3/4 canopy branches having syconium and 5 where every canopy branch has syconium) (modified from Marzalina (1995)).

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Two litter traps were used to collect the ripe fruit and dry leaves for each tree individual. The traps were made of a wooden frame (1 x 1 m) supported by short PVC legs with nylon netting of 1 mm mesh size (modified from Newton (2007)). The syconium and leaves were collected and dried for five days in separate envelopes at a constant temperature in a drying oven and the dry weight of the samples were measured. The fallen leaves and syconium that were collected in the trap were assumed as the amount of litter from the previous month.

To analyse the differences of the leaf and syconium phenology between selected *Ficus* species in each month, we used one-way ANOVA followed by a multiple comparison test. The dry weight of leaves and syconium were analysed with the monthly rainfall from January 2010 until January 2012 by using the Bivariate Correlation Test. This analysis is to determine the relationship between the micro-climate and phenology. We also determined the relationship between the seasons with phenology by analysing the three seasons with the syconium abundance scale by using the Chi-Squared Test.

All of the selected *Ficus* species showed variation on the leaf fall phenology. The highest peak of leaf fall was shown by *F. vasculosa* II (215.14 g) in April 2011, followed by *F. fistulosa* II (194.67 g) in November 2011 and *F. hispida* (184.33 g) in January 2012 (Fig. 1). There were several significant differences ($p < 0.05$) of monthly leaf fall between species from October 2010 to November 2010, January 2011 to April 2011, July 2011 and August 2011 to September 2011 (Fig. 1).

For both *F. fistulosa* stands they showed different patterns in leaf fall phenophase. *Ficus fistulosa* II had a clear leaf fall peak in November 2011 but not with *F. fistulosa* I. *Ficus fistulosa* I showed a constant value of dry weight leaf fall with small increment and decreased value. In February 2011, *F. fistulosa* II showed an increment of leaf fall of 68.5 g and this value start to decrease in April 2011 (61.27 g). For monthly comparison between *F. fistulosa* I and *F. fistulosa* II, there were significant differences ($p < 0.05$) in November 2010, January 2011, April 2011, August 2011 and January 2012. For overall comparison, both *F. fistulosa* I and *F. fistulosa* II showed significant differences ($p < 0.05$) for leaf fall phenophase.

Ficus vasculosa I and *F. vasulosa* II showed an increment in September 2010 and was the highest peak for *F. vasculosa* I (129.65 g). Both values start to decrease in December 2010. The value of *F. vasculosa* I remained constant but *F. vasculosa* II started to increase again until the peak in April 2011 (215.14 g). In May 2011, *F. vasculosa* II values decreased drastically to 15.71 gram. In June 2011 both of the *F. vasculosa* showed small increment in the amount of leaf fall value until August 2011. For monthly comparison only two significant differences of leaf fall between *F. vasculosa* I and *F. vasculosa* II ($p < 0.05$) which were in October 2010 and April 2011.

Almost all of the species did not show a significant correlation of leaf fall phenology with monthly rainfall except *F. hispida* ($p < 0.05$) that showed an intermediate association between leaf fall ($r = -0.47$) and low amount of monthly rainfall. From all of the selected species, *F. hispida* has wider leaves (5.5 – 35 x 2.5 – 17.5 cm) and white hairs on its surface (Ng 1978). With these characteristics, the tree may undergo higher water loss during low rainfall periods. The *F. hispida* significantly shed its leaves during dry period (Schaik *et al.,* 1993) to adapt with the environment factors and increase the leaf fall rate to overcome water loss.

Similar to our findings of *F. hispida*, Harrison *et al.* (2000) reported that drought caused a significant increase in *F. fulva* leaf fall at Lambir Hill Sarawak. These phenomena caused water stress to the plant and forced it to drop its leaves. Due to

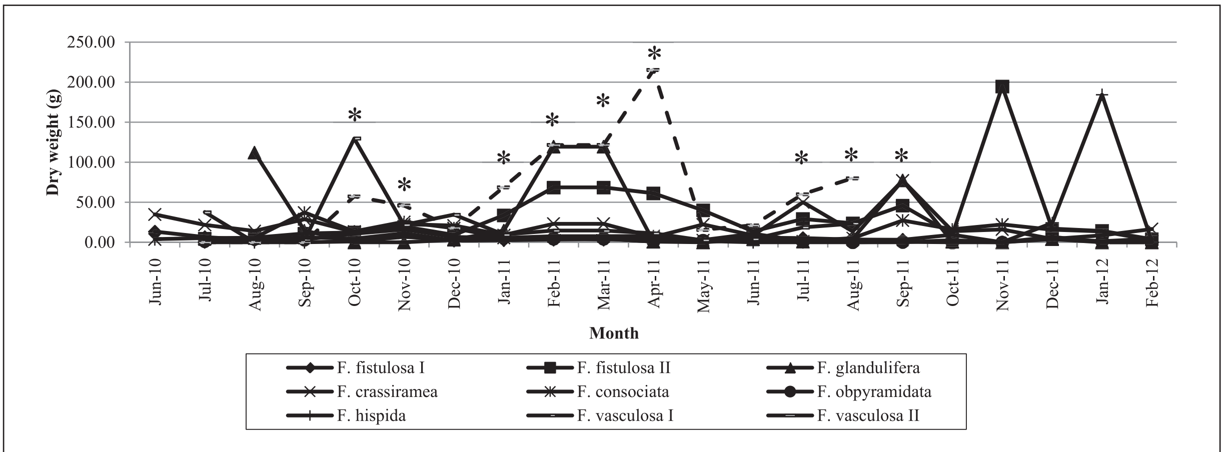

Fig. 1. Monthly mean dry leaves of the nine individuals of seven *Ficus* species from June 2010 to February 2012 at Chini forest *significant at $p < 0.05$.

this situation, two of his study samples died. Another study on a deciduous *F. citrifolia* in Southern Brazil found out that the leaf fall phenology was negatively correlated with the current month average temperature (Pereira *et al.,* 2007).

Deciduous phenology characteristic was observed in one of our study samples of *F. glandulifera*. It showed massive leaf shedding in August 2010, February 2011 and September 2011. The *F. glandulifera* tends to shed all its leaves and stay in leafless stage for almost one week. The development of the tree from leaf shedding to leaf flushing and finally in full canopy took almost one month. But, syconium initiation did not occur at the same time as leaf flushing. The syconium phenology was initiated when canopy was 100% in cover.

Syconium initiation is also called flowering onset (Pereira *et al.,* 2007). Most of the studied species except *F. crassiramea* showed continuous trends of syconium initiation. *Ficus crassiramea* did not show syconium initiation phenophase during the 18 months of observations, suggesting that this species show supra-annual trend (Newton 2007).

Ficus fistulosa II syconium initiation had a significant positive correlation with rainfall but *F. fistulosa* I and *F. hispida* had significant negative correlation with rainfall. Similarly with *F. fulva* in Lambir National Park, its syconium initiation showed negative correlation with rainfall (Harrison *et al.,* 2000).

The highest value of ripe syconium production was displayed by *F. vasculosa* II in October 2010 (266.89 g), followed by *F. fistulosa* II (223.49g) in April 2011 and *F. fistulosa* II (194.69 g) in November 2011 (Fig. 2). There were significant differences ($p < 0.05$) of ripe syconium phenology between some species in August 2010, September 2010 to November 2010, January 2011, June 2011, August 2011 to September 2011 and November 2011 to December 2011 (Fig. 2).

Ficus fistulosa II showed multiple peaks of syconium production in December 2010 to January 2011, April 2011, July 2011, November 2011 and January 2012. Whereas *F. fistulosa* I showed constant low productivity of ripe syconium production. For overall comparison, both *F. fistulosa* I and *F. fistulosa* II showed significant differences ($p < 0.05$) in ripe syconium production. Both trees grow in different localities. *Ficus fistulosa* I grow in an open area which face high disturbance whereas *F. fistulosa* II grows in an enclosed area, but the level of maturity of both trees are the same.

Ficus vasculosa I and *F. vasculosa* II showed similar ripe syconium production. Both had peaks in October 2010 but *F. vasculosa* I had lower ripe syconium production. The production of ripe syconium in other months for both *F. vasculosa* showed constant low value but in July 2011 *F. vasculosa* I showed a slight increase in ripe syconium production. The similar trend does not proof that both *F. vasculosa* had significant difference ($p > 0.05$) in overall ripe syconium production.

The comparison of the ripe syconium phenophase for individuals in months showed significant differences ($p < 0.05$) by using LSD multiple comparison tests. By this analysis, we only found differences in October 2010, November 2010, January 2011, February 2011, March 2011, April 2011, July 2011 and October 2011. All of the species did not show significant correlations between the ripe syconium productions with monthly rainfall.

There were 35 occurrences of scale 1 syconium abundance in the wet season which meant that most species did not produce syconium in the wet season. For scale 5, the highest occurrence was in the wet season with 10 occurrences followed by the rainy season with 8 occurrences. There was no significant relationship between seasonality with the syconium abundance in the canopy (P=0.486, df=8). In the dry

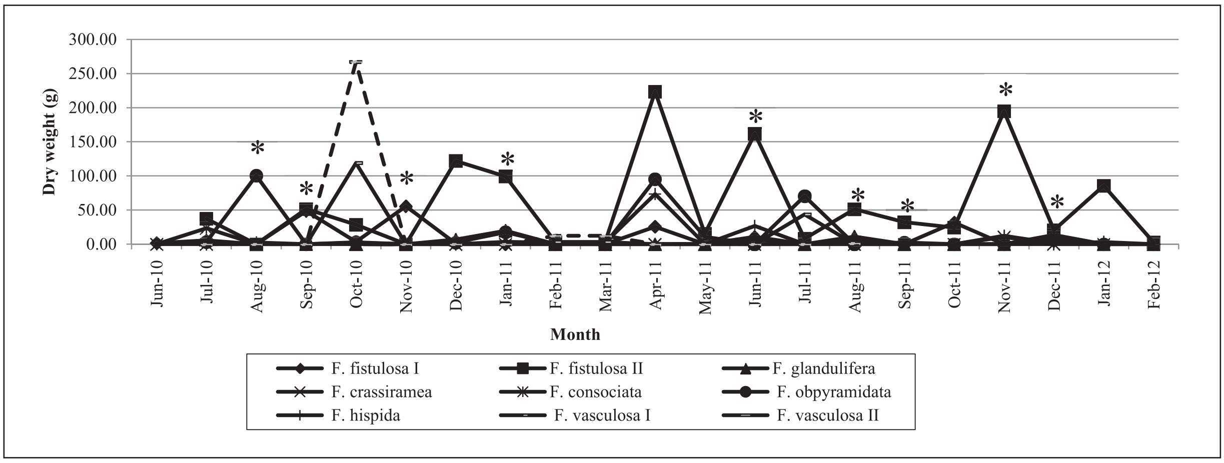

Fig. 2. Monthly mean dry weight of ripe syconium of the nine individuals of seven *Ficus* species from June 2010 to February 2012 at Chini forest *significant at $p < 0.05$.

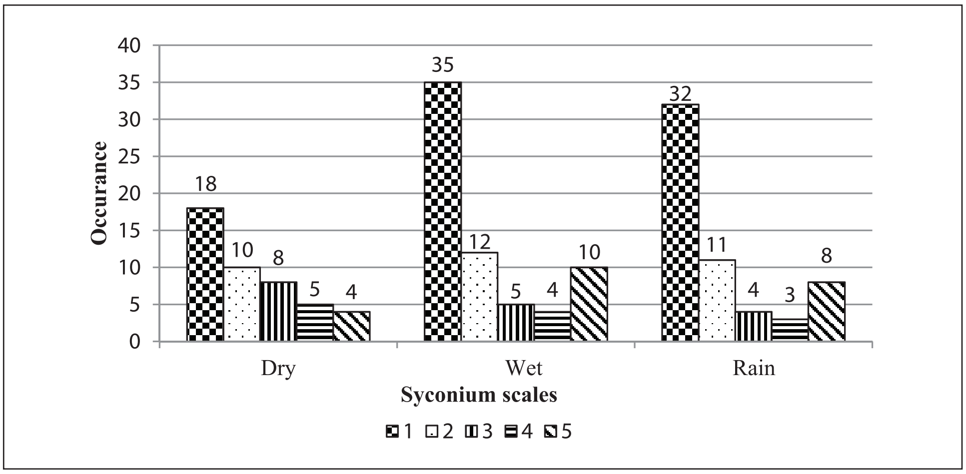

Fig. 3. Seasonal and syconium abundance in the *Ficus* species canopy at Chini forest (1, the canopy branches have no syconium at all; 2, only 1-3 canopy branches have syconia; 3, half of canopy branches have syconia; 4, 3/4 canopy branches have syconia; 5, every canopy branch has syconia)

season, the number of occurrences of syconium decreased from scale 1 to 5 (Fig. 3).

Previous studies postulated that *Ficus* trees bear their fruits all year round. On the contrary, we conclude that not all of the individuals amongst the species studied follow the above trend. *Ficus glandulifera* displayed a deciduous characteristic. Our results also indicated that there was no correlation between leaf fall with rainfall, and ripe syconium with rainfall except for the negative correlation between *F. hispida* leaf fall with rainfall. There was no relationship between the three climatic seasons (wet, rainy and dry) and the *Ficus* syconium abundance in Chini. Further examination on the *Ficus* phenology in relation to the local temperature variation in a longer temporal observation is proposed for future studies.

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