Plant reproductive phenology and general flowering in Lambir Hills

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General flowering in Asian dipterocarp forests is one of the most spectacular and mysterious phenomena in tropical biology. General flowerings occur at irregular intervals of less than a year to several years and during an event most dipterocarp trees and many other plants, from shrubs to emergent trees to epiphytic orchids, flower, over roughly a three-month period. Conversely, flowers are scant between general flowering events. This type of community-wide masting has only been documented from aseasonal tropical forests in Asia.

Since 1993 we have observed plant phenology from tree towers and walkways constructed in an 8 ha study plot and another tower constructed for tourists. We chose 576 individual plants of 305 species in 56 families to monitor phenology at the community level in 1993. Plant phenology is monitored twice a month and in this paper we report results from July 1993 up to the end of September 2003. At each census, reproductive organs (flower buds, flowers, and fruits) are observed and the intensity of reproductive activity for each individual is recorded according to the following five grades: non-reproductive or very few flowers or fruits (covering <1% of the crown); >1% and <50% of the crown covered with flowers or fruits; >50% and <80% of the crown covered with flowers or fruits; flowers or fruits covering the whole crown.

Two hypotheses have been proposed to explain the timing of flowering in SE Asian forests; drought and temperature drop, both of which may be associated with the El Niño Southern Oscillation (ENSO). Prolonged droughts or an increase of solar radiation associated with dry conditions have repeatedly been reported to occur in general flowering years. On the other hand, Ashton et al. (1988) argued that a drop in the daily minimum temperature always preceded flowering events.

From our studies in Borneo over a ten-year period we conclude that drought is the most plausible trigger for general flowering. We recorded a large general flowering in early 1996 and smaller flowering events in late 1996, 1997, 1998, and 2001. All flowering peaks were preceded by dry periods and every drought (30-day rainfall total <40mm) was followed by a flowering (Fig. 1). Conversely, neither temperature nor solar radiation had any clear correlation with flowering. Moreover, minor droughts were found to trigger leaf flushing in several species. Flower induction is basically the transformation of leaf buds to flower buds. Thus, these results suggest plants initiate buds when dry conditions start and produce either leaves or flowers depending on the severity of the drought.

In the aseasonal forests of SE Asia droughts tend to occur during transition periods from La Niña to El Niño, or at the beginning of an El Niño episode. Therefore, there is an irregular 6-7 year cycle involving a dry period with several droughts and a wet period without droughts. The magnitude of a flowering event also depends on the timing of droughts associated with the ENSO cycle, with the largest events occurring after an interval several years with little or no flowering. As most plant species can only reproduce successfully during large flowering events, changes in the ENSO cycle, as a result of global warming, may have serious ramifications for forest regeneration in this region.

REFERENCES

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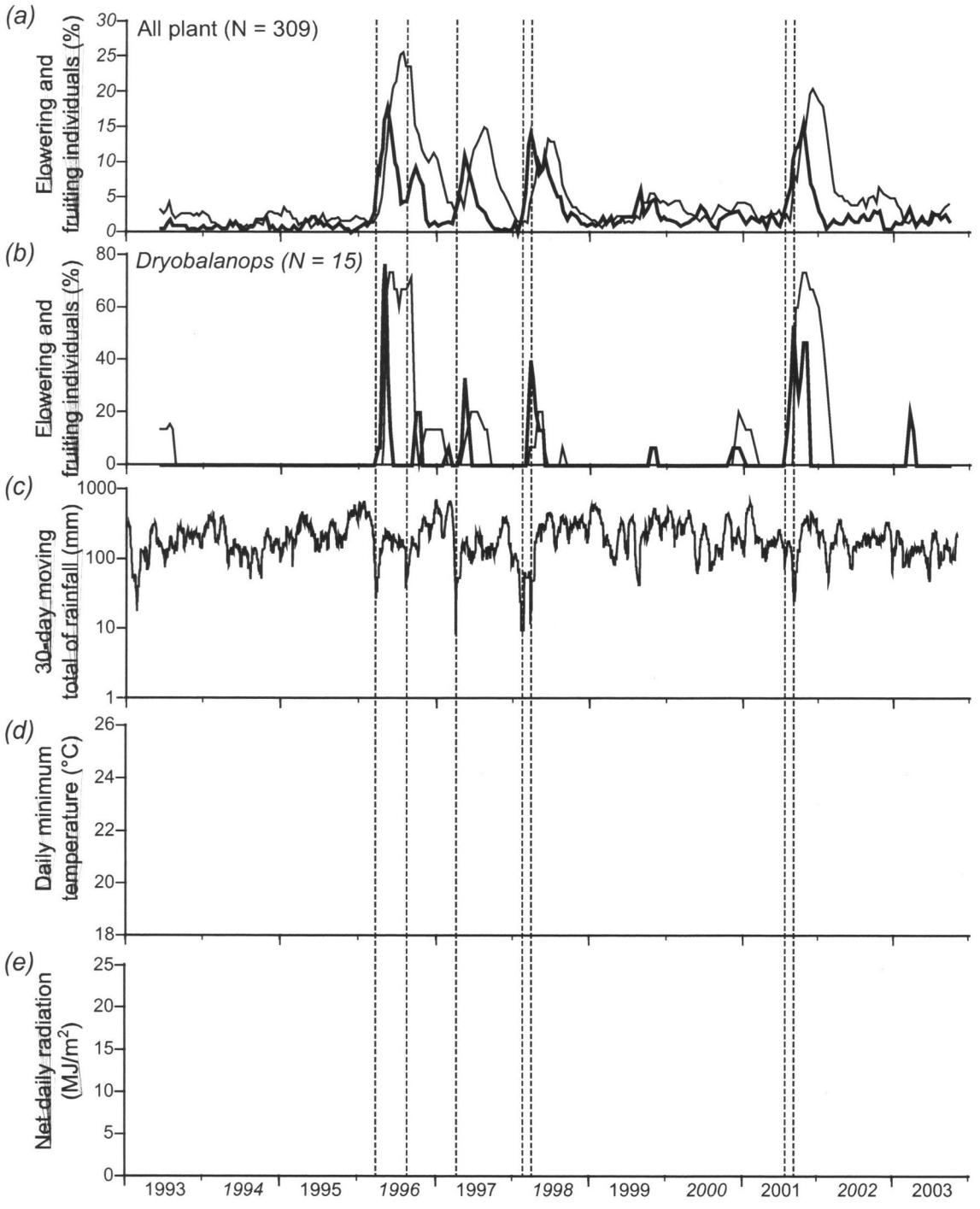

Fig. 1 Plant reproductive phenology over 10 years at Lambir Hills National Park, Sarawak, Malaysia and climatic variables. (a) Temporal changes in the proportion of flowering (thick red line) and fruiting (thin line) in all individuals. (b) Changes in the proportion of flowering (thick red line) and fruiting (thin line) individuals of *Dryobalanops aromatica* and *D. lanceolata* (Dipterocarpaceae) (N = 15). (c) Changes in total rainfall over the proceeding 30-day period starting from the day of observation. The horizontal line indicates 40 mm, our definition of drought. (d) Daily changes in minimum temperature. (e) Daily changes in average net daily radiation over a 10-day period starting on the day of observation.