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The phenology of dioecious *Ficus* spp. tree species and its importance for forest restoration projects

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ABSTRACT

Ficus spp. are keystone tree species in tropical forest ecosystems and therefore, it is vital to include them in tree planting for forest restoration programs. However, lack of knowledge about critical aspects of their reproductive ecology currently limits their use, particularly optimal seed collection times and potential interruption of their highly specialized pollination mechanisms. Therefore, the reproductive phenology of seven dioecious *Ficus* species (*Ficus auriculata*, *F. fulva*, *F. hispida*, *F. oligodon*, *F. semicordata*, *F. triloba* and *F. variegata*) was studied at Doi Suthep–Pui National Park, Northern Thailand, in order to provide useful data to support forest restoration projects. The fig crops on male and female trees of each species were quantified monthly over a full annual cycle (March 2008–February 2009), using the canopy density method. At the population-level, most species produced figs all year round, but fig abundance varied seasonally. Maximum production of ripe figs by female (i.e. seed-producing) trees of most species occurred in the rainy season (May–August, except for *F. triloba*), while the main fig crop of male (i.e. wasp-producing) trees peaked 1–3 months before female trees. Four species *F. auriculata*, *F. fulva*, *F. oligodon*, and *F. variegata* presented critical bottleneck periods for wasp survival, especially during the rainy season, when the wasp-producing figs of male trees were least abundant. The study generated scientifically-based recommendations that will be useful for development of efficient forest restoration programs that maintain keystone resources in tropical forest ecosystems such as (i) optimum time and place for seed collection, (ii) recommendations on the propagation of dioecious fig species, (iii) optimum planting sites for each species and (iv) forest restoration plans to sustain the obligate ecological relationships between fig-trees and their pollinators.

1. Introduction

Forest restoration for biodiversity conservation, watershed protection and carbon sequestration requires detailed knowledge of plant phenology (FORRU, 2006). This is especially so for forest restoration programs based on the 'framework tree species method' which involves planting 20–30 carefully selected indigenous forest tree species (both pioneer and old growth simultaneously) to re-establish a basic forest structure that catalyzes the recovery of biodiversity (Goosem and Tucker, 1995). Indeed, propagation of a diverse crop of native forest tree species requires careful planning of seed collection and nursery work programs (FORRU, 2008). Furthermore, phenological data can be used to indicate the habitat preferences of tree species, provide information about pollination and seed dispersal mechanisms, and enable the identification of keystone tree species (Gilbert, 1980).

Due to their status as keystone species for frugivorous seed dispersers (Lambert and Marshall, 1991; Shanahan et al., 2001b), *Ficus* spp. have been promoted as framework species for tropical forest restoration (Goosem and Tucker, 1995; FORRU, 1998). *Ficus* produce figs that attract numerous seed-dispersing animals year-round, and they also grow very dense root systems that are excellent for preventing soil erosion and stabilizing river banks (FORRU, 2006). In addition, many species of *Ficus* are drought-resistant, pest-resistant and fire-resilient, which enable them to survive and grow well under the harsh, hot, dry, sunny conditions that prevail in most degraded sites (Condit, 1969; FORRU, 2006). Therefore, figs play an important role in supporting high biodiversity in the tropical forest ecosystems (Rønsted et al., 2008). Hence, dioecious *Ficus* species that thrive in secondary growth may have role in facilitating the regeneration of disturbed habitats (Shanahan et al., 2001a).

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