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Distribution of *Castanopsis calathiformis* (Skan) Rehder & E.H.Wilson Seedlings Beneath Maternal Tree Crowns in Forest Restoration Plots

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Abstract

Castanopsis calathiformis (Skan) Rehder & E.H.Wilson is one of indigenous tree species in the Fagaceae that was planted in 1998 in a restoration plots in a deforested area near Mae Sa Mai village, Chiang Mai. Over time, *C. calathiformis* grew into large, healthy trees and have produced seeds into the plot. These have germinated and now dense carpets of *C. calathiformis* seedlings and saplings have formed dense under the maternal trees and no other plant species can grow in those areas. The objectives of this study are to (1) compare seeding populations of *C. calathiformis* with two other tree species in Fagaceae (*Quercus brandisiana* Kurz. and *Quercus semiserrata* Roxbin) Family within these restoration plots, and (2) determine seed predation and seed dispersal around the *C. calathiformis* maternal trees. The results showed that the seedling density of *Q. brandisiana* and *Q. semiserrata* was significantly lower than *C. calathiformis*. The density of *C. calathiformis* seedling declined significantly with increasing distances from the maternal trees and there was no relationship between characteristics of the maternal trees (height, GBH and crown width) and the density of C. calathiformis seedlings. The study of *C. calathiformis* seed destruction showed 14.1% of seed was destroyed (germinated seed = 4.31% and non-germinated seed = 9.76%) while intact and germinated seed = 82.7%. In the seed predation experiment no seed of *C. calathiformis* was removed from the plots. This study provided suggestion planting *C. calathiformis* in restoration sites should be considered carefully for each location to increase species diversity in the forest restoration efficiently.

Keywords: *Castanopsis calathiformis;* Seedling; Seed dispersal; Seed predation

1. Introduction

The Forest Restoration Research Unit (FORRU) initiated a research program in 1994 to develop appropriate methods for forest restoration forests in Northern Thailand (Elliott *et al.,* 2013). They started by propagating and planting a wide range of native forest tree species and assessing which ones might be most suitable useful for forest restoration (Elliott *et al.,* 2013). The approach being developed by FORRU is the "Framework Species" method for forest restoration that stimulates recovery of tree species richness. The "Framework Species" method involves planting 20-30 indigenous tree species, with the intention that they will attract seed-dispersing animals from nearby patches of natural forest hence accelerating natural forest regeneration (Elliott *et al.,* 2013). In this way, the tree species composition of the original forest should gradually be restored (FORRU, 2005).

This "Framework Species" method has been used in a deforested area near Mae Sa Mai village in the Doi Suthep-Pui National Park. Castanopsis calathiformis was one of the indigenous tree species that was selected for planting in this area in 1998. This species can be found in many areas such as Doi Inthanon National Park (Chiang Mai) or Doi Luang

National Park (Chiang Rai), however none of this species was recorded in Doi Suthep - Pui National Park. Over time, the seedlings and saplings of *C. calathiformis* have formed dense carpets under the maternal trees and no other plant species are found in that area. This phenomenon is different from other species which grew in the same plots. The question for this problem is Why do this seedling grow very densely and be different from other species in same area? The hypothesis tested in this study is that *C. calathiformis* seedlings in these restoration sites grow densely near maternal trees due to a lack of seed dispersal and/or seed predation. The study carried out under two main objectives; (1) compare seeding populations of *C. calathiformis* with two other tree species in Fagaceae (*Quercus brandisiana* Kurz. and *Quercus semiserrata* Roxbin) Family within these restoration plots, and (2) determine seed predation and seed dispersal around the *C. calathiformis* maternal trees. Consequently, the knowledge gained from this study could be a case study for selecting suitable species for forest restoration in specific areas

2. Materials and Methods

2.1 Study area

The study sites were located in three 22-year-old restoration plots near Baan Mae Sa Mai, Mae Rim District, Chiang Mai. The elevation of the plots was 1,100 m above sea level.

2.2 Seedling density and distribution

Three tree species of Fagaceae family were selected for the experiment: *Castanopsis calathiformis, Quercus semiserrata* Roxb. and *Quercus brandisiana* Kurz. The maternal tree in restoration plots planted in 1998 were chosen for the study. The number of maternal trees for each species was 10 trees for *C. calathiformis*, 10 trees for *Q. brandisiana* and 5 trees for *Q. brandisiana*. The number of *Q. brandisiana* tree sample was less than other species due to their small population size. The trees were cut off and died. The diameter at breast height (DBH), height and crown width of each tree were recorded. The seedling populations was determined under each tree using circular plots (5 m, 10 m and 15 m radius plot from the tree) were laid out around each maternal tree. Ten 1×1 m^2 quadrats were placed randomly in each subplot. Number of seedlings in each quadrat were recorded.

2.3 Seed survival after dispersing from maternal trees.

Seed production of *C. calathiformis* was determined by randomly placed 1×1 m^2 quadrats under 10 maternal trees (5 quadrats/ tree). The number of seeds was then counted and sorted into the following categories: intact or damaged seeds and the number of germinated or non-germinated seeds.

2.4 Seed predation

The percentage of seeds removed was assessed using permanent plots (1×1 m^2). One hundred seeds from each species were spread randomly on the ground. The number of seeds remaining in the plot were counted every two weeks. Seed predators were also monitored by camera traps that set up near the maternal tree throughout the fruiting season.

2.5 Data analysis

Data was analyzed in Excel and the R Statistical Environment (R Core Team, 2018) and. A Generalized Linear Model (GLM, function 'glm') was used to determine the effect of distance from maternal trees on number of seedlings. The percentage of both seeds removed, and seeds destroyed were analyzed using analysis of variance ('function 'aov').

3. Results and Discussion

3.1 Seedling density and distribution

The seedling densitiesof *C. calathiformis, Q. semiserrata* and *Q. brandisiana* showed significantly distribution at the three distances (p-value < 0.001). *Q. brandisiana* seedlings were not detected and very few *Q. brandisiana* seedlings were found (2 ± 1 only within the 0-5 m distance.

Although all of 3 species were planted at the same time, each species may possibly have a different growth rate. If this is so, seed productivity of *Q. semiserrata* and *Q. semiserrata* may be affected.

The seedling density of *C. calathiformis* is markedly affected by distance from the maternal tree (Figure 2), seedling number is greater close to the maternal trees. Seed dispersal distance is affected by seed size and structure, small, flat, lightweight, and usually winged fruits/seeds disperse farthest, and larger ones like this species (Fresh weight = 8.87 ± 1.17 g, Length = 29.21 ± 1.13 mm.) usually spread only a few meters from the parent trees (Sharp, 1995).

In addition, there was no significant relationship between the density of *C. calathiformis* and the DBH, height and crown spread of the maternal trees.

3.2 Seed survival after dispersing from maternal trees.

The highest percentage was the intact and germinated seed (82.7%) while the lowest percentage was intact, but non-germinated seed (3.22%) (Figure 3). Hence, *C. calathiformis* seed in non-recalcitrant and has a very high germination rate. Moreover, very few were destroyed in this study. Together these results explain of the high seedling density of this species in the study area.

Figure 1. General characteristics of *C. calathiformis* in forest restoration sites (a) maternal trees (b) seedling carpet and (c) *C. calathiformis* seeds.

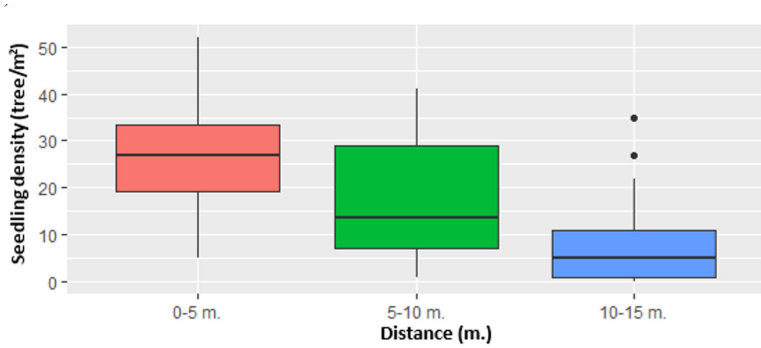

Figure 2. The relationship between seedling density of *C. calathiformis* and distance from maternal trees.

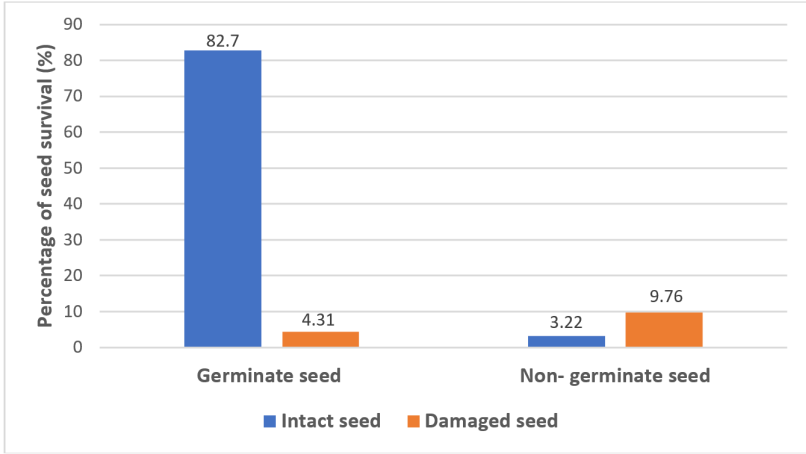

Figure 3. Percentage of Seed survival of *C. calathiformis* (%) after dispersal from maternal trees.

3.3 Seed predation

In the nine study plots, no seeds of *C. calathiformis* were removed throughout the period of data collection. Camera traps set up near the *C. calathiformis* maternal trees did not record any seed predator. However, some herbivorous species such as the Large Indian Civet (*Viverra zibetha* Linnaeus) have recorded in this restoration site. The result showed that seed predation rate of *C. calathiformis* negligible.

4. Conclusions

The seedling density of *C. calathiformis* in these restoration sites is very dense due to rapid germination of fallen seeds, and a lack of seed dispersal and seed predation. The covering of *C. calathiformis* on the ground can omit natural seed germination and tree seedling growth of other tree species that will be the barrier for increasing of species diversity in reforestation plot. In future restoration plantings the use and placement of *C. calathiformis* should be considered carefully in each location. Finally, it's important to survey nearby forests and select tree species that found in the area.

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