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Sapling dynamics along an altitudinal gradient in Doi Suthep-Pui National Park, Northern Thailand

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Abstract

Recently, climate change has been a topic involving considerable argument, particularly in relation to the adaptation and migration of plants in mountain ecosystems. This study aimed to clarify forest dynamics, particularly in the sapling stage, as they relate to micro-climate changes, by using a permanent plot along an altitudinal gradient (in the range 900–1,100 m above sea level). A permanent transect plot (30 m × 600 m) was established in the forest ecotone between deciduous dipterocarp forest (DDF) and lower montane forest (LMF). All trees with diameter at breast height (DBH) greater than 1 cm were tagged, measured and identified. The monitoring was done every 2 yr from 2012 to 2016. The micro-climatic factors were automatically recorded and the amount of rainfall was based on meteorological station data. Only saplings (DBH < 4.5 cm) were analyzed to detect the dynamics relating to micro-climate changes.

The results showed that the 175 species of saplings belonged to 118 genera and 59 families. In the forest ecotone, species that co-existed between evergreen and deciduous species had high abundance based on the importance value index. A higher mortality rate was detected in the second period (2014–2016) than in the first period (2012–2014), with values of 0.96%/yr and 9.97%/yr, respectively. In addition, the high mortality rate was mostly found in the dominant species from LMF and was positively and significantly related to decreased rainfall and increased temperature, indicating drought conditions had a strong influence on saplings of evergreen species. The deciduous species will replace the forest ecotone based on drought occurrence.

Introduction

Plant regeneration, particular in the seedling and sapling stages is highly sensitive to environmental changes (Frelich, 2002). Environmental changes are mostly found in mountain ecosystems based on an altitudinal gradient, especially along the forest ecotone between deciduous and evergreen forests (Tang and Ohsawa, 1997). Recently, many researchers have reported that mountain ecosystems make good representative study areas for detecting the influences of climate changes on tree regeneration dynamics (Frelich, 2002; Marod et al., 2015). Long-term ecological research (LTER) based on permanent plots is useful for forest dynamic research (Frelich, 2002). LTER plots in Thailand have displayed important outputs such as changes in forest recovery during successional stages, the dynamics of forest structure and the species composition related to environmental factors (Bunyavejchewin et al., 2001). However, there is less documentation available particularly on the adaptation and mitigation of sapling tree species related to climate change in montane forest (Marod et al., 2015). Thus, the current study aimed to clarify the forest dynamics, particular in the sapling stage, related to micro-climatic changes along altitudinal gradients.

Materials and Methods

Data collection

All studies were conducted in the forest ecotone between deciduous dipterocarp forest (DDF) and lower montane forest (LMF) at latitude 18° 47' 4"N and longitude 98° 54' 58"E in the Doi Suthep-Pui National Park, Chiang Mai province, Thailand. A transect permanent plot, 30 m × 600 m (1.8 ha), was established in 2012 which covered an altitudinal range of 900–1,100 m above sea level. The area was divided into 180 subplots (10 m × 10 m). All tree species with diameter at breast height (DBH) larger than 1 cm were tagged, DBH was measured, identified and analyzed only for sapling trees (DBH < 4.5 cm). Monitoring was done every 2 yr from 2012 to 2016. In addition, micro-climatic factors (temperature and light intensity) were automatically measured since 2012 using Hobo Data Loggers. The data loggers were set up in three lines with 50 m between each logger in each line (a total of 36 loggers). In addition, the amount of rainfall was also analyzed based on the data from the Doi Suthep-Pui National Park Meteorological Station.

Data analysis

The importance value index (IVI) was used to evaluate the dominance of sapling tree species in the area (Whittaker, 1975). The forest dynamics were characterized using the annual mortality rate (M) and recruitment rate (R) (Sherman et al., 2012) of selected species which had more than 100 individuals, using generalized linear model analysis in the R software package, version 3.2 (R Core Team, 2013) to detect the relationship between micro-climatic changes.

Results and Discussion

Species composition

The results in 2016 showed that there were 3,035 sapling trees across the permanent plot comprised of 175 species in 118 genera and 59 families. Sapling density was 1,686 individuals/ha. The dominant families based on species number were the Rubiaceae, Fagaceae and Lauraceae with species number of 14, 13 and 12, respectively. The dominant sapling tree species based on the IVI were *Castanopsis tribuloides* (34.17%), *Quercus brandisiana* (28.33%), *Litsea martabarnica* (27.54%), *Lithocarpus garrettianus* (26.35%) and *Dipterocarpus obtusifolius* (20.35%), respectively. These dominant species were composed of both evergreen and deciduous species, which indicated the establishment of coexisting sapling species in the forest ecotone. Similar findings were also observed among mature tree species of DDF and LMF (Marod et al., 2015).

Forest dynamics related to micro-climatic changes

The species number varied among periods with the highest number in 2016. Sapling density tended to increase during the study period based on the high recruitment rate in both periods (6.24%/yr for 2012–2014 and 6.21%/yr for 2014–2016). The recruitment rate in the first 2 yr was positively related to increased rainfall ($p < 0.001$) and was negatively affected by low light intensity ($p < 0.05$). In contrast, a high variation in the mortality rate was detected, particularly in the second period which increased more than seven-fold, from 0.96%/yr to 9.97%/yr. This showed the high positive relationship to decreasing rainfall ($p < 0.001$) and to increasing light intensity and temperature ($p < 0.05$). In addition, more rain-free days in the rainy season (May to October) during 2015 to 2016 were observed, in contrast with the average temperature changes (Doi Suthep-Pui Meteorological Station data). As a result, there was a higher mortality rate in the evergreen species of LMF than in the deciduous species of DDF, especially for the dominant species of *Castanopsis tribuloides* (22.18%/yr), *C. acuminatissima* (14.72%/yr), *Lithocarpus garrettianus* (10.09%/yr) and *Persea gamblei* (8.80%/yr). However, the general list species were consistent with Marod et al. (2015) such as *Quercus brandisiana, Schima wallichii* and *Wendlandia paniculata* which were not significantly related, indicating the micro-climatic changes induced severe drought conditions and strongly

influenced the high sapling mortality. In contrast, a high amount of rainfall might motivate a high recruitment rate and reduce the mortality rate of saplings.

Thus, the climatic conditions are the main environmental factors for plant regeneration, especially in the sapling stage which is sensitive to such changes (Frelich, 2002). The results of the current study also clarified that changes in rainfall and temperature were the key factors in the survival of saplings for coexisting species of LMF and DDF along the altitudinal gradient, similar to the conclusion of Martin et al. (2007).

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