SEED DISPERSAL AND PREDATION IN PRIMARY FOREST AND GAP ON DOI SUTHEP

ALICE SHARP

A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE
IN ENVIRONMENTAL RISK ASSESSMENT
FOR TROPICAL ECOSYSTEMS

GRADUATE SCHOOL
CHIANG MAI UNIVERSITY
MARCH 1995

SEED DISPERSAL AND PREDATION IN

PRIMARY FOREST AND GAP

ON DOI SUTHEP

ALICE SHARP

THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL

FULFILLMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF SCIENCE

IN ENVIRONMENTAL RISK ASSESSMENT

FOR TROPICAL ECOSYSTEMS

Examining Committee :

--CHAIRMAN

Dr. Stephen Elliott

--MEMBER

Mr. James F. Maxwell

--MEMBER

Assoc. Prof. Dr. Vilaiwan Anusarnsunthorn

Date 20 Month March Year 1995

ACKNOWLEDGMENTS

The author would like to express her deepest gratitude and respect to Dr. Stephen Elliott, her thesis supervisor and chairman of her thesis committee, whose generous support, advice, recommendations and suggestions have guided her throughout her graduate program to the final completion of this research.

She is sincerely indebted to Mr. James F. Maxwell her thesis co-supervisor for his help especially in identification of tree and seed species used in the study as well as suggestions and corrections.

The author also would like to express her thank to Assoc. Prof. Dr. Vilaiwan Anusarnsunthorn, her examining committee member for her suggestions and corrections.

The author is especially grateful to Ms. Kate Hardwick, post-graduate student, for her guidance and kindly help in the field work of this research.

Her heartfelt thanks and sincere appreciation are due to the German Society for Technical Cooperation (GTZ), for their generous scholarship support.

The author is grateful to the Faculty of Science, Chiang Mai University, particularly to the Environmental Risk Assessment for Tropical Ecosystems (ERA) Program and Department of Biology and all staff for a lot of assistance so that this study can be successful. Likewise, sincere thanks to all the staff of ERA program from Saarland University, Germany. Special thanks to CMU herbarium for the useful database and herbarium specimens.

Special thanks to all her ERA friends and colleagues, especially Mr. La Karimuna, Ms. Yupin Peetragorn, Mr. Sakchai Ovatnupat, Ms. Lei Zang for sharing the precious time and helping hands during the data collection.

Above all these, she is blessed with love, patience and encouragement of her parents and sisters for their understanding and mental support.

Alice Sharp

Author

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Thesis Title Seed Dispersal and Predation in Primary Forest and Gap on Doi Suthep.

Author Miss Alice Sharp

M.S. Environmental Risk Assessment for Tropical Ecosystems.

Examining Committee :

Dr. Stephen Elliott	Chairman
Mr. James F. Maxwell	Member
Assoc. Prof. Dr. Vilaiwan Anusarnsunthorn	Member

ABSTRACT

The study was carried out to determine the relative importance of seed dispersal and seed predation, compared with other site environmental conditions, as factors limiting some tree species from colonozing gaps.

Two sites, primary disturbed forest and gap were selected on Doi Suthep-Pui National Park. Seed traps were used to determine which species are able to disperse their fruits/seeds from forest into gaps. Seed predation was assessed by using three selected species and live trapping of potential mammalian seed predators were done.

The results from the seed traps showed that small, flat, light-weight and usually winged fruits/seeds could disperse farther into the gap, while bigger ones could disperse only a few meters from the parent trees. Seventy tree species could disperse their seeds into traps of which 21 were found only in the gap and 17 only in the forest, while the rest were found in both sites. The species diversity of fruits/seeds declined with distance from forest edge and was subject to high seasonal variability. This knowledge could possibly be used to choose tree species which cannot grow naturally because of the lack of dispersion and different fruiting phenologies for forest regeneration in different places and seasons. The rate of seed predation was determined for three tree species *Engelhardia spicata* Lechen. ex Bl. var. *spicata* (Juglandaceae), *Styrax benzoides* Craib (Styracaceae), and *Castanopsis acuminatissima* (Bl.) A. DC. (Fagaceae). Seed predation rate in the gap and forest did not differ significantly ($P>0.05$). Environmental conditions seemed to be more important than seed predation in limiting forest regeneration. Live trapping of potential fruit/seed predators showed a much higher density of small mammals in the gap than in the forest but the species found in both sites were not very different. Species common in both forest and gap were *Rattus rattus, R. surifer,* and *R. bukit,* but *Mus cookii* was found only in the gap.

ชื่อเรื่องวิทยานิพนธ์ การแพร่กระจายและการล่าเมล็ดในป่าและพื้นที่รกร้างบนดอยสุเทพ

ชื่อผู้เขียน นางสาว อลิส ชาร์ป

วิทยาศาสตรมหาบัณฑิต สาขาวิชาการประเมินความเสี่ยงทางสิ่งแวดล้อมในระบบนิเวศเขตร้อน

คณะกรรมการสอบวิทยานิพนธ์ :

ดร. สตีเฟน เอลเลียต

นาย เจมส์ เอฟ แมกซ์เวลล์

ร.ศ. ดร. วิไลวรรณ อนุสารสุนทร

บทคัดย่อ

การศึกษาถึงความสำคัญของการแพร่กระจายของเมล็ดและการล่าเมล็ดเปรียบเทียบกับสภาพทางสิ่งแวดล้อมต่าง ๆ เพื่อหาปัจจัยจำกัดของพืชบางชนิด ในการที่จะกลับมาเติบโตในพื้นที่รกร้างอีกครั้ง โดยทำการศึกษาเปรียบเทียบในสองพื้นที่คือ ป่าปฐมภูมิและพื้นที่รกร้างในเขตอุทยานแห่งชาติดอยสุเทพ-ปุย ในการวิจัยได้มีการวางกับดักเมล็ดในพื้นที่ทั้งสอง เพื่อศึกษาความสามารถในการแพร่กระจายเมล็ดของพืชจากป่ามาสู่พื้นที่รกร้างสำหรับการล่าเมล็ดได้ทำการศึกษากับพืชที่เลือกมา ๓ ชนิด นอกจากนี้ยังได้ศึกษาประชากรของผู้ล่าโดยการวางกับดัก

ผลการศึกษาจากกับดักเมล็ดพบว่า เมล็ดที่มีขนาดเล็กและน้ำหนักเบาสามารถแพร่กระจายเข้าไปยังพื้นที่รกร้างได้ไกลกว่าเมล็ดที่มีขนาดใหญ่ ซึ่งสามารถแพร่ไปได้เพียงไม่กี่เมตรจากต้นแม่ เมล็ดที่พบมีทั้งหมด ๗๕ ชนิด โดยที่ ๒๖ ชนิดพบได้เฉพาะในพื้นที่รกร้าง อีก ๑๖ชนิดพบได้เฉพาะในป่า ส่วนที่เหลือ ๓๓ ชนิดพบได้ในทั้งสองบริเวณ ความหลากหลายของเมล็ดที่พบจะลดลงตามระยะทางที่เพิ่มมากขึ้นจากต้นแม่ นอกจากนี้ยังแปรผันตามฤดูกาลอีกด้วย จากความรู้ในข้อนี้ สามารถนำไปใช้ในการเลือกชนิดของพืชเพื่อนำมาใช้ในโครงการปลูกป่าได้ อัตราการล่าเมล็ดระหว่างป่าและพื้นที่รกร้าง ที่ศึกษาจากพืช ๓ ชนิด คือ *Engelhardia spicata*, *Styrax benzoides* และ *Castanopsis acuminatissima* พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ (P.0.05) ดังนั้นปัจจัยที่มาจำกัดการฟื้นฟูสภาพป่าจึงน่าจะเป็นสภาพแวดล้อมของพื้นที่มากกว่าที่จะมาจากการล่าเมล็ด อย่างไรก็ตามการศึกษากลุ่มผู้ล่าเมล็ดโดยการวางกับดักพบว่าประชากรของผู้ล่า ในที่นี้คือสัตว์เลี้ยงลูกด้วยนมขนาดเล็ก จะสามารถพบได้มากกว่าในพื้นที่รกร้าง แต่ชนิดของผู้ล่าในทั้งสองพื้นที่ไม่มีความแตกต่างกันมากนัก โดยชนิดที่พบมากในทั้งสองแห่งได้แก่ *Rattus rattus*, *Rattus surifer* และ *Rattus bukit* ในขณะที่ *Mus cookii* พบได้เฉพาะพื้นที่รกร้าง

INTRODUCTION

The Royal Forestry Department (RFD) estimates that at the begining of this century, Thailand's forest covered 70 % of the country. However, the forest area has since been dramatically reduced. Between 1976 and 1980, Thailand had the second highest rate of forest depletion in Asia next to Nepal (Dankelman and Davidson, 1988). By 1985 only 29% of the country was forested with some estimates being as low as 17% (Water Conservation Bureau, 1989). Between 1961 and 1985 Thailand's average rate of deforestation was around three million rai per year (Phonesavanh, 1994). Although northern Thailand contains most of the remaining forest, it is also the region where the rate of reforestation is highest. Large portions of the northern region have been heavily logged or burnt and now consist of secondary scrub and open grasslands.

The factors contributing to forest loss and degradation in Thailand are both numerous and complex. Focusing on Doi Suthep - Pui National Park, upland deforestation is mostly due to land encroachment both by hilltribe folk, who have destroyed large areas of forest cover and newly arrived hilltribe families. Moreover, government agencies and agricultural research stations have occupied large areas of former forest. The remaining forest in the park has become fragmented into tiny patches which cannot support populations of large animals. The forest needs to be rapidly restored to connect these patches. Forest regeneration can be done by allowing natural succession to occur or accelerated by planting tree seedlings (Elliott, 1993).

In the past, reforestation efforts in the park relied heavily on *Pinus* and *Eucalyptus* species. Recently, however, the policy has changed and now there are some efforts to raise seedlings of a wide variety of native forest tree species in nurseries for forest restoration. However, there has been very little research on the effectiveness of tree planting as a forest restoration technique, in comparison with other methods such as fire control or encouraging natural sucession.

In this study, the relative importance of fruit/seed dispersal and fruit/seed predation, compared with other site conditions, were assessed as factors limiting some tree species from colonizing gaps. If seed predation or environmental conditions or both are found to limit seed germination in gaps, those species will not establish themselves naturally and can be regarded as candidates for propagation in nurseries and subsequent planting. If dispersal is the limiting factor, seeds or seedlings could be transfered into gaps to increase the rate of forest regeneration and also to increase species diversity of the forest.

Objectives of the Study:

1. To determine which tree species are able to disperse their fruits/seeds from the forest into gaps.

2. To determine if selected tree species are affected by fruit/seed predation.

3. To determine the relative importance of fruit/seed predation compared with other environmental factors as a factor limiting establishment of selected tree species in gap sites.

4. To determine which small mammal species are potential fruit/seed predators in gaps and forest.

5. To identify criteria by which appropriate tree species might be selected for reforestation projects.

LITURATURE REVIEW

Maxwell (1988) reported that there are two main kinds of forest in Doi Suthep-Pui National Park, namely deciduous and evergreen. Deciduous forests are found from the base of the mountain (c. 350 m) up to 900 - 1,000 m above sea level. They can be divided into two associations corresponding with Stott (1976), viz. deciduous dipterocarp - oak association and deciduous association. At about 1,000 m elevation, evergreen trees become commoner and deciduous ones rarer.

Deforestation in the tropics is an issue of global concern. Estimated annual rates of permanent deforestation in 1980, based on FAO- UNDP data, ranged from $3.0 * 10^6$ ha to $15.5 * 10^6$ ha. Recent estimates indicate that over the period 1981 - 1990 the rate of deforestation increased from $11.3 * 10^6$ ha to $17.0 * 10^6$ ha (Bruijnzeel, 1991). Satelite photographs made recently show that forest in Thailand is no longer a continuous belt, but is fragmented and much more reduced in area. In the past two decades huge expanses have been felled for timber or replaced by plantations of introduced cash crops such as coffee, cabbage, fruit trees, and others. Still larger areas have been cleared for "slash and burn" farming, a primitive system of agriculture that demands a perpetual supply of uncultivated land and primary forest.

Phoneaswanh (1994) mentioned that because of the reduction of the original forest cover, many countries in the world are countering decline of forests by forest restoration or rehabilitation projects, including Thailand. Such projects usually involve planting tree seedlings in degraded areas, an activity which involves large numbers of volunteers and a high budget. However, deforested areas (gaps) may recover to their previous state if left alone for a very long period.

Whitmore (1989) reported that differences in gap size result in different species composition of the next cycle. For example, in small gaps, seedlings which can survive under shade are found but in big gaps, only shade-intolerant seedlings are found. Because of the open canopy, environmental conditions will change such as incresing light intensity along with UV exposure and temperature. Not only are the gap environmental conditions limiting factors for forest regeneration, other factors such as competition between tree species, fruit and seed dispersal, herbivores, and seed predation are also important (Goldberg, 1985).

The study of forest dynamics includes measurements of fruit/seed dispersal (seed rain) in intact forest and in treefall gaps (Connell, 1989). Measurements of the abundance and species composition of both seed dispersal and germination from the seed bank in treefall gaps and measurements of regeneration from the seedling/sapling bank as compared to that of new seedlings that established after the gap was formed. A study on relationships between fruiting seasons and seed dispersal methods in a neotropical forest by Smythe (1970) showed that small-seeded fruits ripened rather evenly throughout the year, whereas large-seeded fruits tended to be seasonal. Small seeds which could pass unharmed through the guts of animals tend to be non-seasonal and thus easily for dispersed. Fruits with large seeds, destroyed by the animals eating them, fruit synchronously. Uhl *et al.* (1981) compared the contributions of the surviving soil seed bank and incoming seeds to seedling recruitment in burnt areas. Two study sites were observed, one burnt 16 months previously, with a full cover of vegetation and one freshly burnt. On each site two transects were set up along which were placed 30 seed traps. The difference in seeds caught provided an indication of the relative importance of local and long distance dispersal, since no seeds were found in the traps on the freshly burnt site whereas 197 seeds/m were dispersed into the vegetated site.

Foster and Janson (1985) studied the relationship between seed size and establishment conditions in tropical woody plants. They compared seed masses of 36 mature tropical forest tree species with differing light-gap requirements for establishment. They found that the 14 species that established beneath a closed canopy or in small gaps seemed to have higher mean seed masses than those that required large gaps or higher light intensity.

A study of the seedfall pattern of several species of bird-dispersed plants in an Illinois (USA) woodland by Hoppes (1988) showed that around individual fruiting plants, seedfall declined with distance from the seed source. Among fruiting species, small fruits and seeds were dispersed farther and were much more likely to be dispersed into adjacent treefall gaps than large fruits/seeds. Natural seedfall around treefall gaps was highest at the edge of the gap, lower in the center of the gap and lowest in undisturbed forest.

A study of seed arrival and survival in tropical treefall gaps by Augspurger *et al.* (1989) found that the degree of discrepancy in seedfall density between gap and beneath the forest canopy varies with seed size and dispersal agent. Large monkeys, toucans, and guans are unlikely to deposit large seeds in gaps. Instead, they drop seeds under canopy trees used as perches. They also found that wind may disperse fruits/seeds into gaps more efficiently than animals. Densities of fruit/seed of wind-dispersed species were 1.6 times greater in gaps than in paired adjacent canopy sites in a Panamanian forest. Augspurger and his colleague also reported that higher light and lower humidity in the forest openings are inimical to plant pathogens and faster growth in gaps reduced the period of susceptibility. Large seeds and seedlings are most vulnerable to predation in gaps where rodents seek shelter in thickets and predation of seeds by rodents was far greater than beneath the canopy.

Willson and Crome (1989) studied the pattern of the seed rain across a forest and clearing boundary. Four transects of seed traps were placed in the clearing and in the forest. Clearing traps were split into three distance categories: near (40 m), intermediate (40 - 80 m), far (>80 m). Forest wind dispersed species were dispersed further into field than *vice versa*, probably due to: height of release, higher wind speed in the field, and less physical obstructions in the field. Moreover, forest animal-dispersed seeds showed no distance effect into the clearing: vegetation structure may affect the movement of dispersal agents, e.g. availability of perch sites giving patchy patterns of dispersal.

Schupp (1988, 1990) studied seed dispersal, using 84 (1.0 m^2) seed traps randomly located. Seeds as well as immature and ripe fruits were counted and removed from the traps weekly. Quantifying the fall of full-sized immature fruits is important: they are readily consumed by seed predators. Viable seedfall differed significantly among years and insect damage made no difference in seedfall.

When fruits and seeds arrive in gaps, if the environmental conditions are suitable for germination, seedlings of those species will be found, but in some cases, seed predators that live in the gap or nearby will eat the fruit/seed before it can germinate.

Schupp (1988, 1990) studied the factors affecting post dispersal seed survival in a tropical forest. One part of the study was seed predation transects. He glued cleaned seeds to 30 cm pieces of 4.5 kg test nylon fishing line with epoxy cement. After attaching the opposite ends of the lines to wire stake flags, he dropped the attached seeds on to the leaf litter. His experiments suggested that disappearance of seeds from the lines was due to removal by vertebrates. Most seeds disappeared during the late wet to early dry season transition, a time of food shortage, when seeds are not generally hoarded.

Large-seeded tree species, the seeds of which are usually dispersed by mammals, are often readily dispersed but suffer large losses due to seed predation. Consequently, seedling establishment is influenced both by the impact of mammalian seed predators as well as by the ability of the seedling to survive where the seed is dispersed. Sork (1988) studied the effects of predation and light on seedling establishment in *Gustavia superba* (Lecythidaceae). She examined the relative rates of seed/seedling predation by mammals and the influence of the light environment in seedling establishment in three populations of this tropical American tree. One population was located in a semi-deciduous forest on Gigante Penninsula (GP), Panama and two were on Barro Colorado Island (BCI). Seedling density was significantly greater on GP than on BCI. A pattern was influenced by post-dispersal seed predation that was much lower on the GP than on BCI. Seedling transplant experiments, which measured the effects of light conditions (seeds were planted in gaps, edges, and in the understory) and protection from mammals (using tall cages, short cages, and no cages) showed that protection from mammals significantly increased all three measures of seedling performance: seedling survival, seedling height, and overall seedling success.

In a comparative study of seed predation in tropical tidal forests on three continents, Smith *et al.* (1989) reported that significant differences were found in the amount of predation on four tree species. One species was consumed in greatest quantity where it was rarest in the forest canopy and the effect of seed predators on the forest was related to the type of tree and composition of the seed predators.

Osunkoya (1994) conducted a study on post-dispersal survivorship of north Queensland rainforest fruits and seeds. To identify and estimate the abundance of possible mammalian predators, line trapping was conducted over three days and nights. The traps were baited with a mixture of rolled oats and peanut butter. Trapped mammals were identified, counted, weighed, tagged, and released daily between 6.00 and 8.00 am. A total of 64 individual mammals of six species were trapped over three days. Of these mammals, only the Muridae (Rodentia) were considered to be major predators of fallen fruits and seeds.

A previous survey of small mammals on Doi Suthep indicated a fairly high population density of potential seed predators. Deciduous and evergreen forests supported very different small mammal communities. In deciduous forest the ground squirrel *Menetes berdmorei* is common and the ferret-badger *Melogale personata* is rare. In evergreen forest the tree shrew *Tupaia glis* and rats *Rattus rattus, R. surifer,* and *R. bukit* are common, while *R. bowersi* is rare. Only one species, *Rattus sabanus* was found in both habitats, but in very low numbers (Ua-Apisitwong,1989; Elliott *et al.*, 1989).

STUDY SITE DESCRIPTION

This study was conducted in Doi Suthep-Pui National Park, a few kilometers west of Chiang Mai city in northern Thailand. The study sites were located at approximately 18^0 50' N latitude, 99^0 0' E longitude. Doi Suthep rises to a hight of 1620 m above sea level, while the adjoining peak of Doi Pui is 1685 m high.

The bedrock of the mountain is mostly granitic but shales occur in a few places in the lowlands of the southern and western parts (Maxwell, 1988). Soils are generally deep and highly weathered. Rainfall varies from about 1,000 mm per year at the base of the mountain to 2,000 mm per annual near the summit, with a marked dry season from December to May when there is usually little or no rain (Elliott, 1989). Highest rainfall occurs in August at the base of the mountain and in August near the summit. Temperature also varies with elevation ranging from 15.1 ^{0}c (January) to 22.5 ^{0}c (March) near the summit and from 22.7 ^{0}c (December) to 29.2 ^{0}c (April) near the base of the mountain. It should be noted that the temperature from 1,000 m elevation to the summit of Doi Suthep-Pui is considerably less than in Chiang Mai city. Monthly rainfall and temperature of Doi Suthep is presented in Figure 3.1.

Thai people regard the whole mountain as sacred and it is renowned as the site of the highly revered Pra Taht Temple. In order to protect both the temple and its surrounding forest, the area was declared a National park on April 14th, 1981, covering 261 km^2 and is under the jurisdiction of the National Parks Division of The Royal Forestry Department. In recent decades, large portions of the original forest cover have been virtually destroyed due to encroachment by tourist resorts, government agencies, agricultural research stations, television relay stations, and more than 13,000 people which live in the park in several villages. A map of Doi Suthep-Pui National Park is presented in Figure 3.2.

There are two main kinds of forest in the park including deciduous forest (from the lowland, 350 m up to 950 m above sea level) and evergreen forest (from about 950 m above sea level to the summit of Doi Pui). There are two deciduous vegetation associations, viz. a deciduous dipterocarp-oak association and a mixed deciduous-evergreen association (Maxwell, 1988). The evergreen forest of Doi Suthep contains a very wide range of tree species. Although no species become dominant, trees of the family Magnoliaceae (e.g. *Talauma hodgsonii Hk. f. & Thoms., Michelia champaca* L.) and Fagaceae (e.g. *Castanopsis armata (Roxb.) Spach, Quercus lanata* J. Smith) are characteristic (Elliott,1992). The characteristics of each kind of forest are presented in Table 3.1.

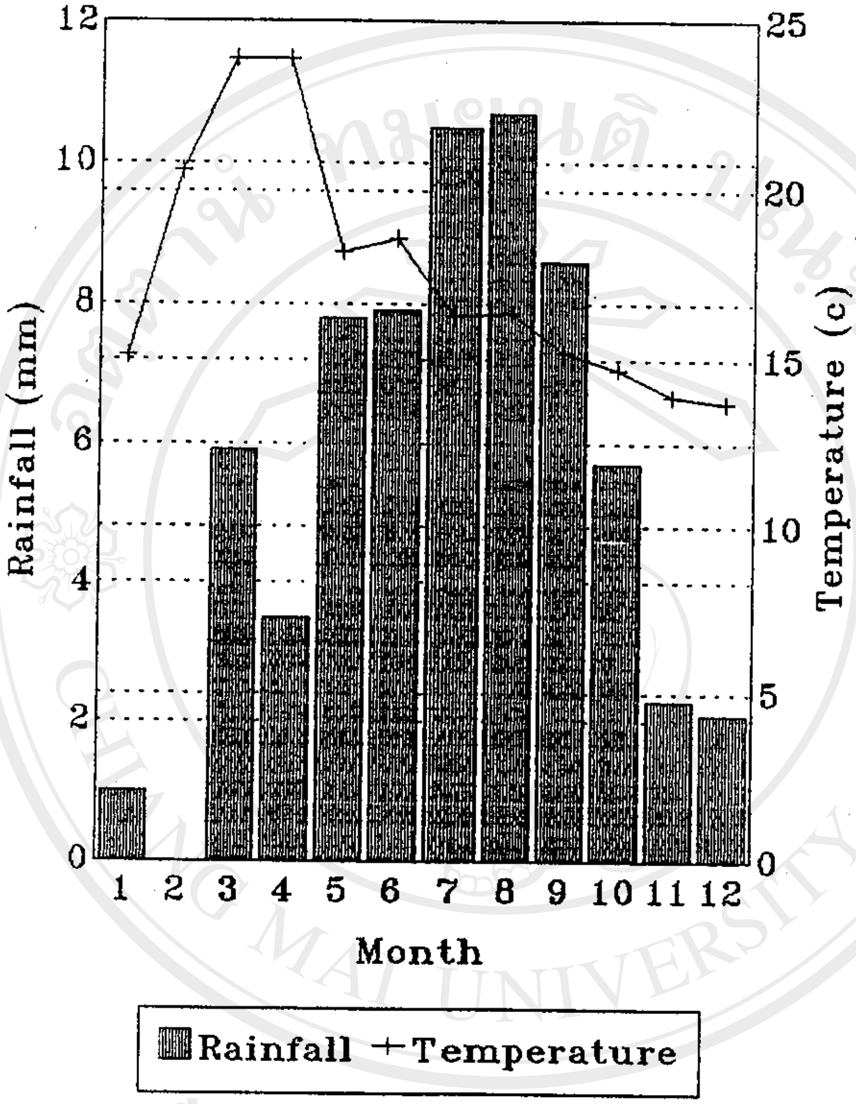


Figure 3.1 Mean monthly rainfall and temperature of Doi Suthep Pui National Park.Data from Doi Chiang Kian Meterological Station 1994.

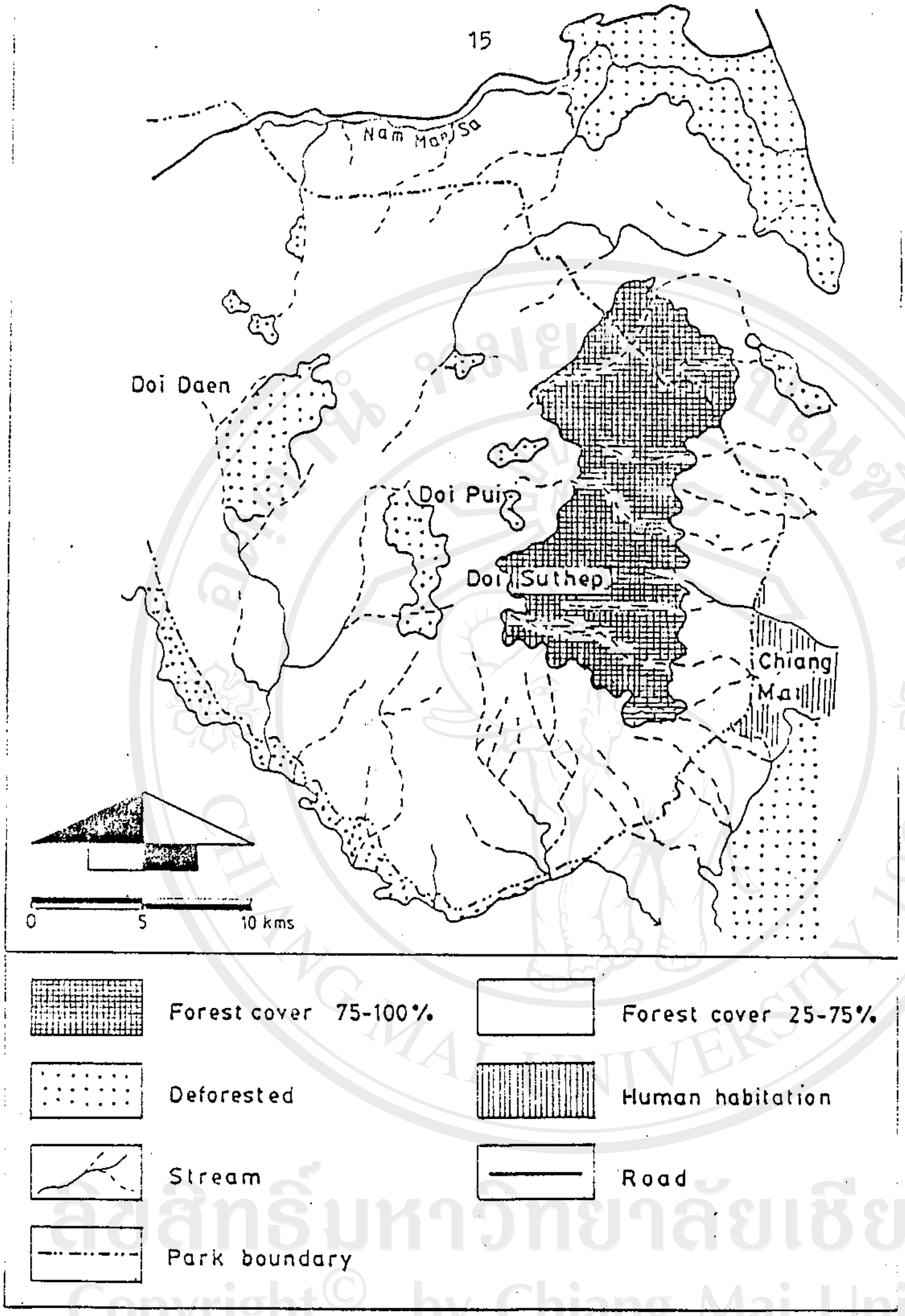


Figure 3.2 Doi Suthep-Pui National Park, Chiang Mai Province. Map traced from Royal Thai Survey Department, sheet 47461, series L7017 (Round, 1984).

Table 3.1 Characteristics of the Forest Types on Doi Suthep-Pui National Park.

Characteristic	Deciduous Dipterocarp Oak Forest	Mixed Evergreen and Deciduous Forest	Evergreen Forest
Tree height	short	taller	tallest
Canopy	sparse even in wet season.	more or less closed.	closed even in dry season
Spacing between trees	wide	closer	closest
Leaf phenology	almost completely deciduous	deciduous evergreen trees.	mostly evergreen trees
Common group	Dipterocapaceae, Fagaceae	none	Magnoliaceae, Fagaceae

Preliminary descriptions of the vegetation of Doi Suthep were provided by Hosseus (1908), Kerr (1911), Cockerell

(1929), and later Kuchler and Sawyer (1966) compiled a vegetation map of the mountain. Maxwell (1988) has provided the most recent and detailed description of the mountain. Elliott et al. (1989) carried out a transect survey (0.828 ha) through monsoon forest and reported that deciduous forest on Doi Suthep contains more tree species than any other similar forest yet surveyed. There are 90 species per ha for trees of diameter at breast height of 10 cm or more and the most species rich plant family found was the Leguminosae.

Animal species found on Doi Suthep include at least 326 birds (Round, 1984), 500 butterflies (Pinratana, 1977-85), 300 moths (Banziger, 1988), 61 mammals (Elliott *et al.*, 1989), 28 amphibians, and 50 reptiles (Nabhitabhata, 1987). Doi Suthep's streams also contain a diverse fauna. A survey by drift net at only two sites on one stream revealed the presence of 21 families of aquatic invertebrates, including no less than 10 new species of Ephemeroptera (Rajchappakdee, 1989).

The distance from Chiang Mai University to study area is approximately 25 km. Two adjacent sites were selected. Site 1 (1525 m) consists of disturbed primary evergreen forest with some pine and much secondary growth which forms a dense forest understory. The aspect is 25^0 southwest and the slope is 45%.

The bedrock is granite. The general soil characteristic is deep top soil, high organic matter content and high water holding capacity. Tree species include *Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae), *Schima wallichii* (DC.) Korth. (Theaceae), *Vaccinium sprengelii* (D.Don) Sleum. (Ericaceae), *Aporusa villosa* (Lindl.) Baill. (Euphobiaceae), and *Styrax benzoides* Craib (Styracaceae). Abundant herbaceous plants in clude *Microstegium vagans* (Nees ex Steud.) *A. Camus* (Gramineae), *Rubus blepharoneurus* Card. (Rosaceae), *Smilax ovalifolia* Roxb. (Smilacaceae), and *Polygonum chinensis* L. (Polygonaceae).

Site 2, a regenerating gap (1500 m), is located adjacent to the first site. It is a degraded open area with some secondary treelets and shrubs. The aspect is 65^0 northwest and the slope is 25%. The bedrock is granite. The general soil characteristic is a shallow top soil with less organic matter than in site 1 and low water holding capacity (Karimuna, pers. comm.). Treelets include *Debregeasia longifolia* (Burm. f.) Wedd. (Urticaceae), *Prunus persica* (L.) Bat. (Rosaceae, peach, planted), *Artocarpus heterophyllus* Lmk. (Moraceae, jackfruit, planted), and *Prunus cerasoides* D. Don (Rosaceae, planted). The most abundant herbaceous plants in this site are *Eupatorium adenophorum* Spreng. (Compositae), *Thunbergia similis* Craib (Acanthaceae), and *Clitoria mariana* L. (Leguminosae, Papilionoideae). Photographs of both sites are shown in Figures 3.3-3.4.

Figure 3.3 Disturbed evergreen forest, site 1 (Photo: La Karimuna).

Figure 3.4 Gap, site 2 (Photo: Alice Sharp).

MATERIALS AND EQUIPMENT

The materials and equipment used in this study are listed below:

4.1 Materials

a. plastic bags and elastic bands

b. form sheets

c. cotton

d. ether

e. bamboo poles

f. nylon fishing line

g. epoxy cement

h. fine mesh plastic window screen

i. metal wire

j. coarse metal screen

k. plastic sheet

l. paint brushes

m. milk bottles

n. vials

4.2 Equipment

a. binocular stereo microscope

b. forceps

c. petri dishes

d. mammal traps

e. trays

f. sieve

g. oven

h. needle

i. compass

j. altimeter

k. CMU plant database

l. specimens in CMU herbarium

METHODOLOGY

5.1 Study of Tree Species Composition

To learn about tree species found in the study sites, tree species in both the forest and gap were identified by collecting specimens, and comparing them with herbarium specimens, at the Department of Biology, Chiang Mai University and also use of the CMU database for Doi Suthep.

5.2 Study of Seed Dispersal

To determine which tree species were able to disperse their fruits and seeds from the forest into the gap, seed traps were made of plastic window screen fixed on a circular wire frame. Four points on circular wire were tied to bamboo poles. The traps had a diameter of 1.13 m or about 1 m^2 surface area (Figure 5.1). In site 1, twenty seed traps were placed randomly about 15-20 m far from forest edge, while in site 2, ten seed traps were placed near the edge of the forest and another ten traps were placed randomly in the centre of the gap. Seeds in the seed traps were removed, counted, and identified every month from March, 1994 to December, 1994. If identification was not possible and the seed was obviously different from any previously encountered, it was assigned a number.

5.3 Study of Seed Predation

To determine the impact of seed predation on selected tree species, following the methods of those of Schupp (1988), a hundred fruits or seeds of three selected species were glued with epoxy cement to the end of a nylon fishing line with the other end of the line fixed to a bamboo pole. Another hundred seeds of the same species were planted in the ground under a wire cage nearby the pole to prevent predation and to determine if they could germinate in the prevailing environmental conditions (Figure 5.2). The percentages of seeds of each species germinating and those lost due to predation were recorded every two weeks for four months (for each species). The three species selected were *Engelhardia spicata* Lechen. ex. Bl. var. *spicata* (Juglandaceae), *Castanopsis acuminatissima* (Bl.) A. DC. (Fagaceae), and *Styrax benzoides* Craib (Styracaceae) . *Engelhardia spicata* was found in the seed traps both in the forest and the gap, but was not recorded as seedlings in the gap, while *Castanopsis acuminatissima* did not appear in the seed traps in the gap and also was not recorded as seedlings in the gap. *Styrax benzoides* seeds were found only in the seed traps in the forest, but were recorded as seedlings in both sites (Karimuna, pers. comm.).

5.4 Survey of Potential Seed Predators.

To determine which species of potential seed predators were present, 30-33 live-capture traps(12*12*30 cm wire mesh traps and 8*9*25 cm Folding Havahart traps) were placed in lines about 10 m apart in each site . The bait used in this study was a mixture of sticky rice, banana, roasted crushed peanuts and banana essence (Elliott *et al.*, 1989). Traps were checked and rebaited at 9.00-12.00 hr. Trapped animals were described, sexed, weighed, and anaesthetized with ether before being measured and marked by hair cuttings on different parts of their bodies (Figure 5.3). The relative abundance of small mammals were estimated from the trap rate.

$$\text{Trap Rate} = \frac{\text{total no. of small mammal trapped}}{\text{total no. of night observed* no. of traps set each night}}$$

During the study period, mammal trapping was carried out 3 times to compare between different seasons. Mammal trapping was carried out in the middle of the hot season, rainy season, and cool season.

In the last trapping, three different species of the mammals trapped were left in separate cages overnight for a "cafeteria test". Twenty fruits or seeds of each of the three selected tree species were put in each cage together with the animal to observe which fruits or seeds were eaten by the mammals and which were prefered the most.

5.5 Study on the Effect of Glue.

Since the germination rate of fruits/seeds glued to nylon fishing line was measured, it is important to know if glue inhibits germination. Therefore, a hundred fruits/seeds with one spot of epoxy cement and another hundred without glue were planted in a shade house to test the germination and to see if glue could inhibit the germination of the fruits/seeds glued on nylon lines. The germination rates of each species with and without glue were compared. The statistical significance of the results of germination tests was determined using the procedure developed by Roberts (1963). The test on the effect of glue on fruits/seed germination was carried out in a shade house in San Sai District, Chiang Mai. The shade had 30% light penetration i.e. 70% shade. The seeds were watered daily for four months and germination was recorded every two weeks.

Figure 5.1 Seed trap.

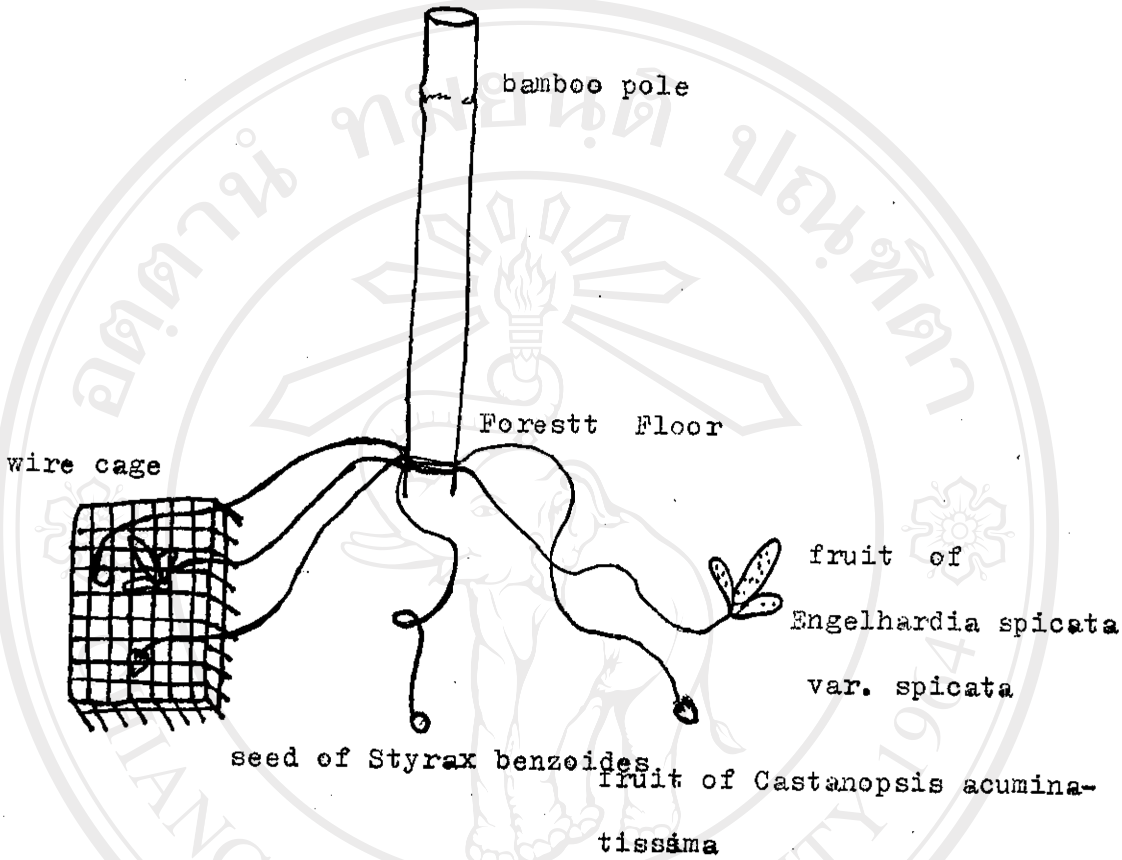


Figure 5.2 Diagram of seed predation test.

Figure 5.3 Live trap in the field.

RESULTS

1. SEED DISPERSION

Of the seeds falling into the traps during the study, 70 species were found ; 48 species from 43 genera and 28 families were actually identified (Table 6.1). Out of 70 species, 21 were found only in the gap (30%) while 17 were found only in the forest (24%) (Figure6.1) . The remainder, 32 species, were found in both sites. The species composition is shown in Figures 6.2-6.4. In different seasons, the species diversity of seeds differed due to fluctuating fruiting phenology. The highest species diversity of seeds was recorded in August (28 species). Figure 6.5 shows variation in species diversity for each month.

The species diversity of seeds declined with distance from the forest edge. Out of 37 species which can be found in the traps near the edge of the forest, 5 could not be found in the traps in the centre of the gap. For those species which could be found in seed traps in both the edge and the centre, many of them were found lesser in the centre (e.g. *Betula alnoides, Dalbergia discolor*, and *Rubus blepharoneurus*). Figures 6.6-6.7 show the abundance of seeds dispersed in each site. Small, flat, light-weight, and winged fruits/seeds could disperse farther into the gap, while bigger ones could disperse only a few meters from parent trees. Figures 6.6-6.7 show size and shape of somes fruits/seeds usually found in the forest and in the gap, respectively.

Animal-dispersed seeds were also found in the seed traps, mostly from bird droppings. In this case usually only tiny seeds were found (e.g. three species of *Ficus*). The different patterns of fruiting

Table 6.1 List of species found in seed traps.

FAMILY NAME	BOTANICAL NAME	FOREST	GAP		HABIT	FRUIT TYPE
			E	C		
BETULACEAE	*Betula alnoides* Ham. ex D. Don	F	VA	A	tree	achene
COMPOSITAE	*Eupatorium adenophorum* Spreng.	-	VA	VA	shrub	achene
	Eupatorium odoratum L.	VF	VA	VA	shrub	achene
	Vernonia parishii Hk. f.	M	M	VF	treelet	achene
DIOSCOREACEAE	*Dioscorea alata* L.	VF	-	-	vine	capsule
ELAEOCARPACEAE	*Elaeocarpus prunifolius* Wall.ex C. Muell.	-	-	VF	tree	drupe
EUPHOBIACEAE	*Antidesma sootepense* Craib	VF	A	F	tree	capsule
	Aporusa villosa (Lindl.) Baill.	-	VF	-	treelet	capsule
	Glochidion kerrii Craib	M	M	F	treelet	capsule
	Sapium baccatum Roxb.	M	F	F	tree	drupe
FAGACEAE	*Castanopsis acuminatissima* (Bl.) A. DC.	F	-	-	tree	nut
	Castanopsis diversifolia King ex. Hk.f.	F	-	-	tree	nut
GNETACEAE	*Gnetum leptostachyum* Bl.	F	-	-	tree	drupe
JUGLANDACEAE	*Engelhardia spicata* Lechen ex. Bl. var. *spicata*	A	A	F	tree	achene
LAURACEAE	*Litsea cupeba* (Lour.)Pers.	-	F	-	tree	berry
LEGUMINOSAE, PAPILIONOIDEAE	*Crotalaria pallida* Ait.	F	-	-	shrub	pod
	Dalbergia discolor Bl.ex Miq.	M	A	M	tree	pod
	Desmodium floriobundum (D. Don) Sweet	F	A	A	shrub	pod
	Lespedeza parviflora Kurz	A	-	-	treelet	pod
	Shuteria involucrata (Wall)Weight & (*S. suffulta* Bth.var. *sinensis* (Hemsl.) Niyo.)	F	F	F	vine	pod
MAGNOLIACEAE	*Manglietia garrettii* Craib	M	F	-	tree	capsule
MELASTOMATA-CEAE	*Melastoma normale* D.Don var. *normale*	-	F	F	treelet	berry
	Memecylon plebejum Kurz	M	F	-	treelet	berry

Table 6.1 (Continued)

FAMILY NAME	SPECIES NAME	FOREST	GAP E	GAP C	HABIT	FRUIT TYPE
MORACEAE	*Ficus fistulosa* Reinw. ex Bl. var. *fistulosa*	A	F	A	tree	utricular
	Ficus geniculata Kurz	A	A	A	tree	utricular
	Ficus microcarpa L.f. var *microcarpa*	M	A	A	tree	utricular
	Ficus superba (Miq.) Miq. var. *japonica* Miq.	M	A	A	tree	utricular
	Morus macroura Miq.	F	F	VF	tree	utricular
MYRTACEAE	*Maesa montana* A.DC.	-	A	M	tree	berry
MYRSINACEAE	*Eugenia albiflora* Duth. ex Kurz	M	-	-	tree	berry
	Decaspermum fruticosum J.R. & G. Forst.	A	M	M	tree	berry
PINACEAE	*Pinus kesiya* Roy. ex Gord.	F	-	-	tree	achene
POLYGONACEAE	*Polygonum chinense* L.	VA	M	F	herb	berry
RANUNCULA-CEAE	*Clematis acuminata* DC. var. *sikkimensis* Hk.f.& Th.	-	A	A	vine	achene
ROSACEAE	*Prunus cerasoides* D.Don	M	-	-	tree	drupe
	Rubus blepharoneurus Card.	M	A	M	tree	berry
RUBIACEAE	*Tarennoidea wallichii* (Hk.f.)Tirv.& Sastre	M	VF	-	tree	drupe
SCHISANDRA-CEAE	*Kadsura heteroclita* (Roxb.) Craib	-	M	VF	shrub	berry
SOLANACEAE	*Solanum toruum* Sw.	A	M	M	herb	berry
STYRACACEAE	*Styrax benzoides* Craib	M	-	-	tree	capsule
THEACEAE	*Adinandra integerrima*	-	F	-	tree	capsule
	Eurya acuminata DC. var. *wallichiana* Dyer	M	M	F	tree	capsule
	Schima wallichii (DC.)	M	VF	VF	tree	capsule
	Korth.	-	VA	VA	shrub	nut
TILIACEAE	*Triumfetta pilosa* Roth	VF	VA	VA	shrub	nut
	Triumfetta rhomboides Jacq.	F	M	M	treelet	berry
VERBENACEAE	*Clerodendrum serratum* (L.)					
	Spr. var. *wallichii* Cl.	M	VF	VF	vine	berry
VITACEAE	*Cayratia trifolia* (L.) Dom.	F	VF	-	vine	berry
	Cissus assamica (Laws.) Craib					

Notes : VA = very abundant; M = common; VF = very few; A = abundant; F = few

Table 6.1 (Continued)

CODE	FOREST	GAP (EDGE)	GAP (CENTRE)
No. 1	-	F	VF
No. 2	-	F	VF
No. 3	-	VF	-
No. 4	-	-	-
No. 5	-	-	-
No. 6	VF	-	-
No. 7	A	A	M
No. 8	-	VF	-
No. 9	F	-	-
No. 10	-	F	F
No. 11	M	-	-
No. 12	VF	-	-
No. 14	F	VF	-
No. 15	-	F	VF
No. 16	A	-	-
No. 17	M	M	VF
No. 18	VA	A	F
No. 19	-	VF	VF
No. 21	M	-	-
No. 22	M	-	-
No. 23	-	VF	VF
No. 30	VF	-	-
No. 31	F	-	-

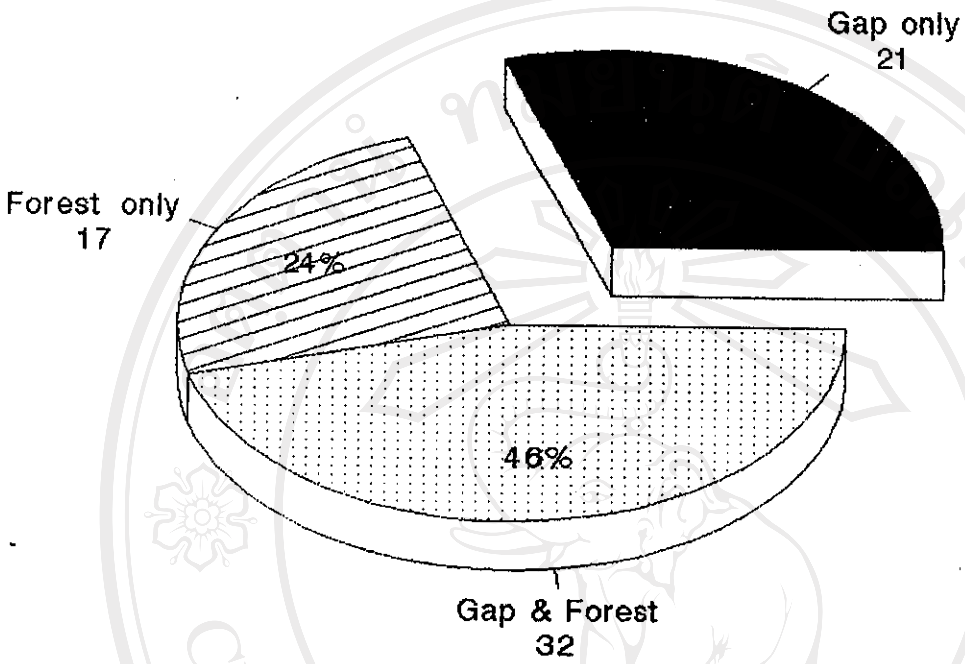


Figure 6.1 Seeds found in gap and forest of Doi Suthep.

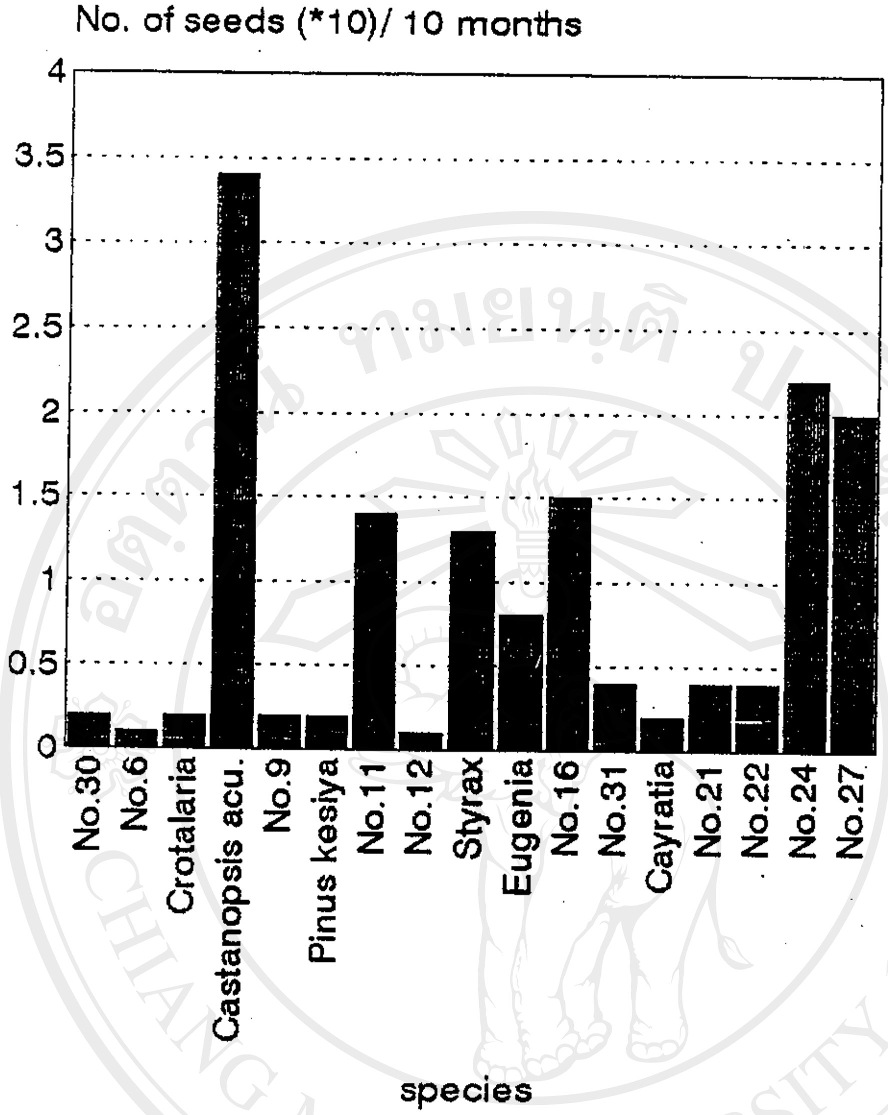


Figure 6.2 Species found in seed traps of forest site.

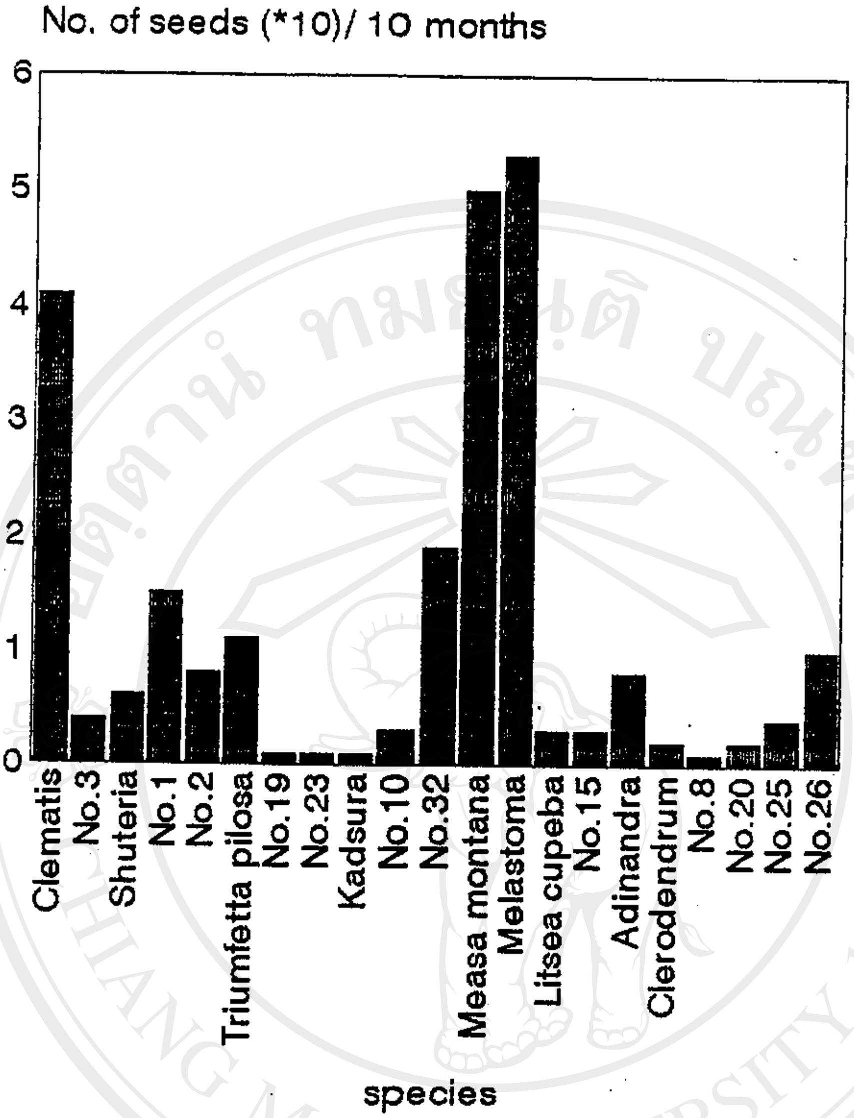
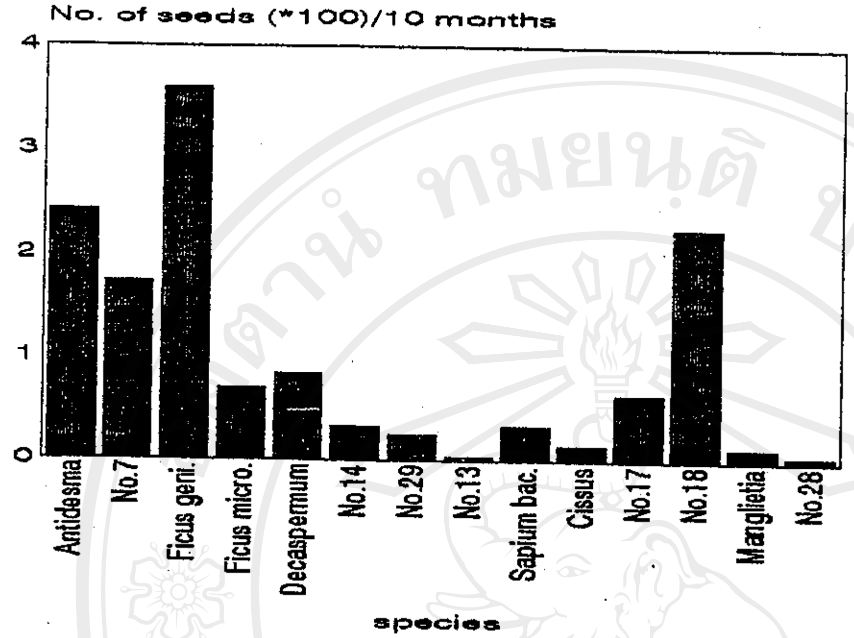


Figure 6.3 Species found in seed traps of gap site



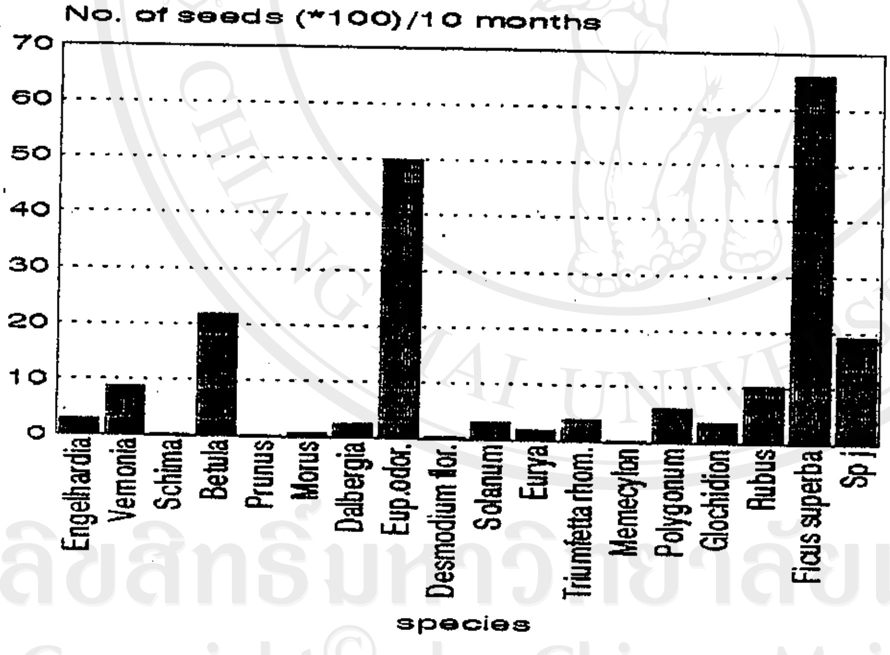


Figure 6.4 Species found in seed traps shared by boyh sites.

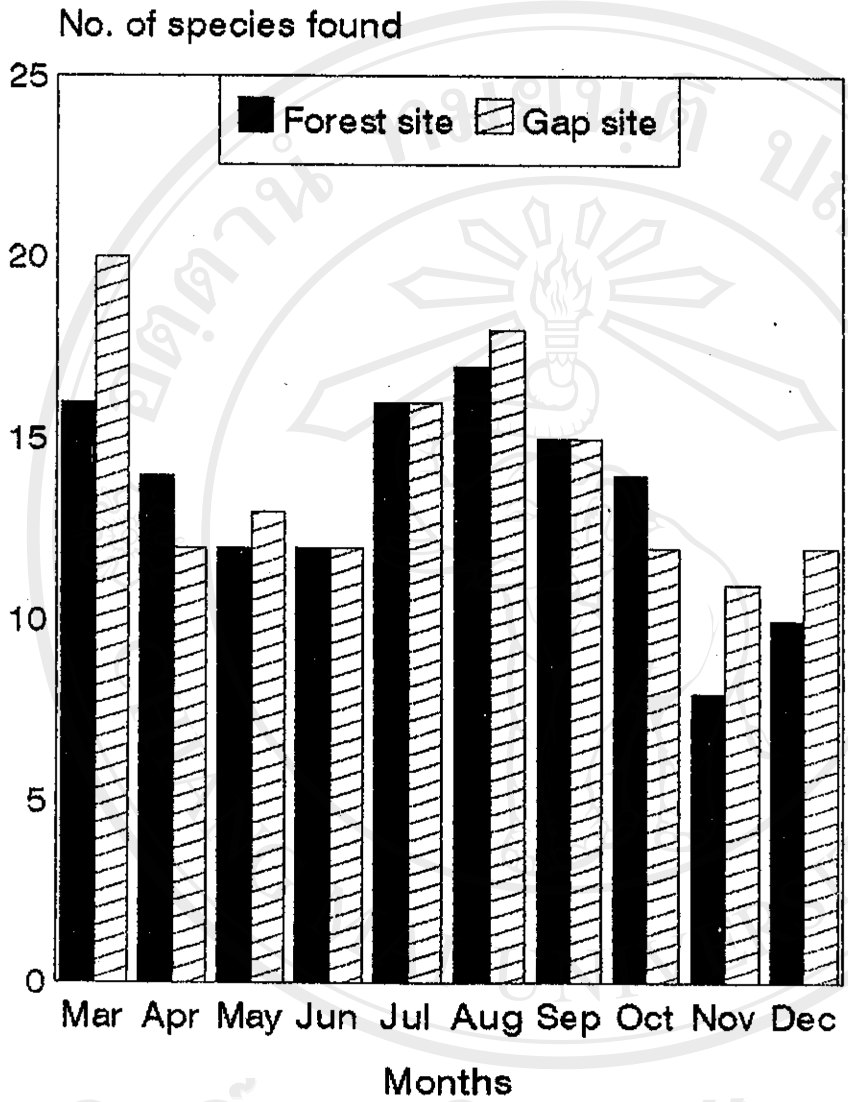


Figure 6.5 Species diversity of seed in each site.

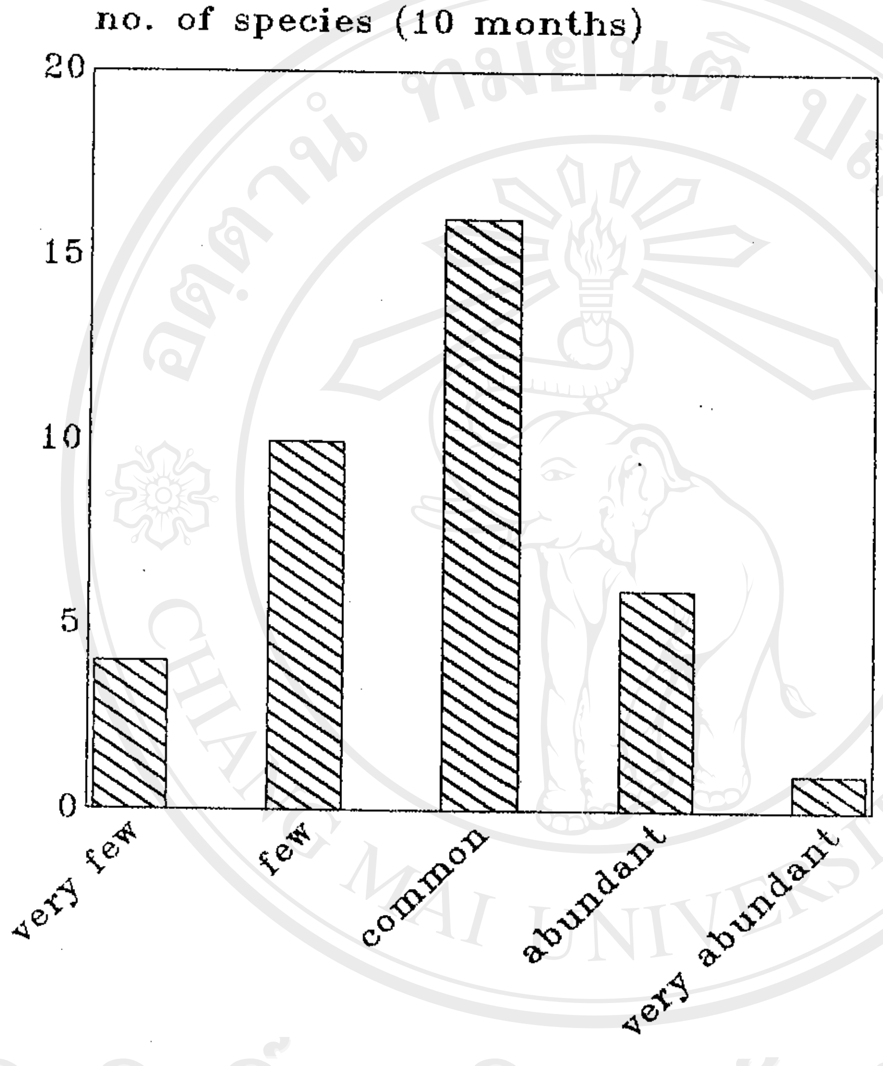


Figure 6.6 Abundance of seeds dispersed in the forest.

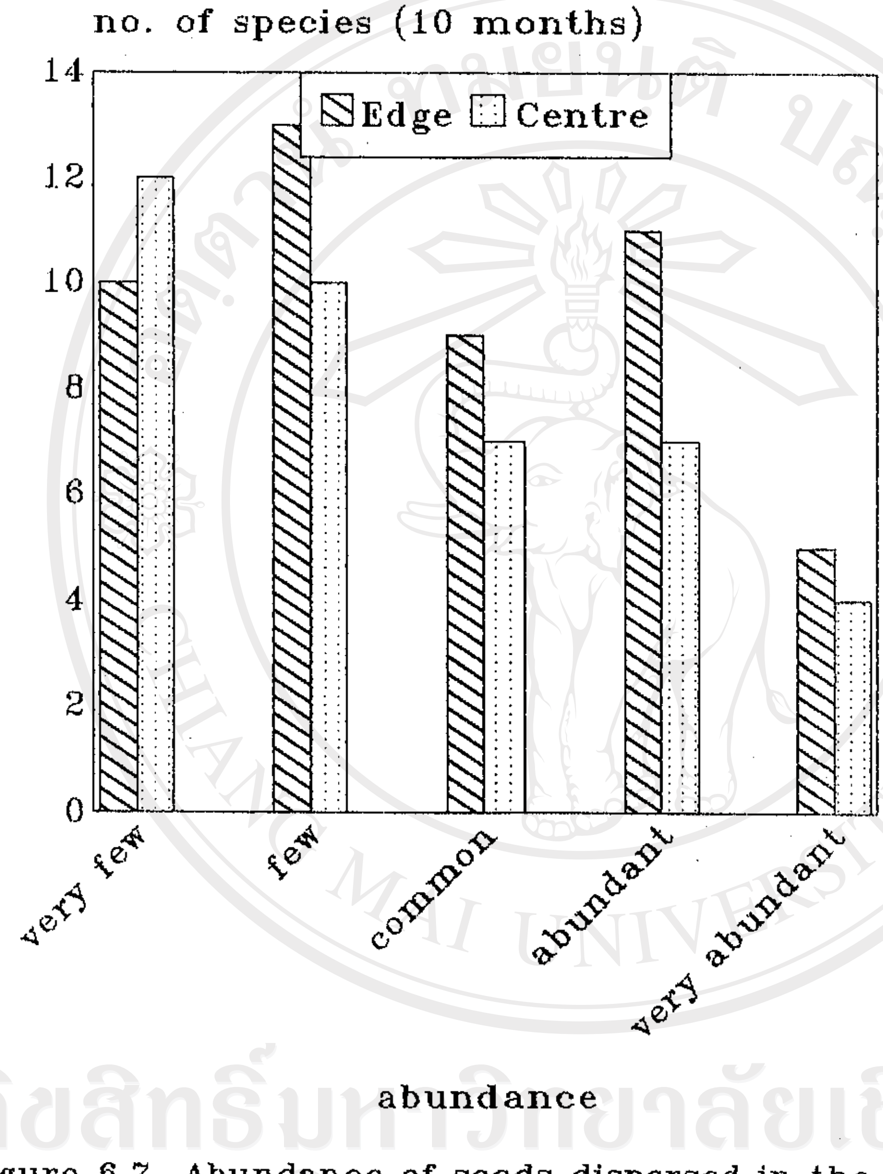
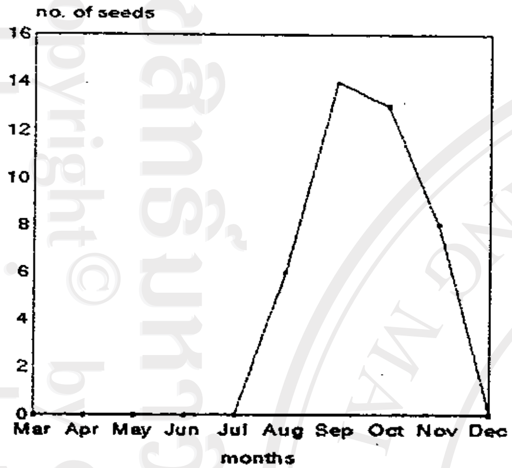
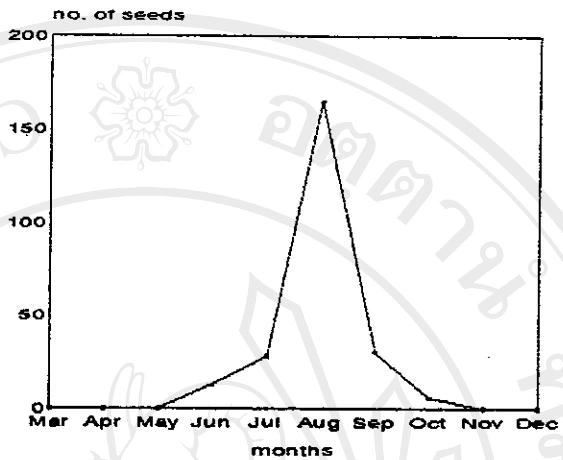


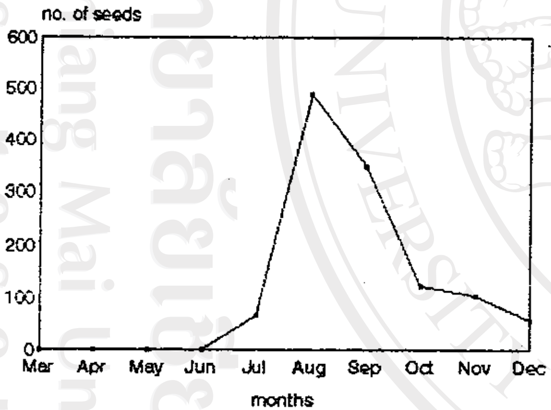
Figure 6.7 Abundance of seeds dispersed in the gap.



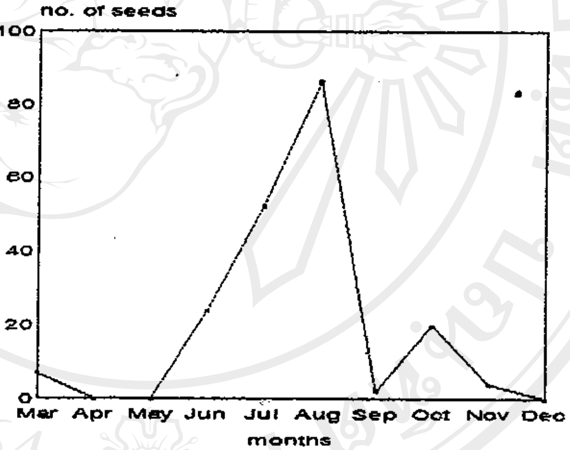
Fruiting phenology of Sapium baccatum



Fruiting phenology of Antidesma sootepense

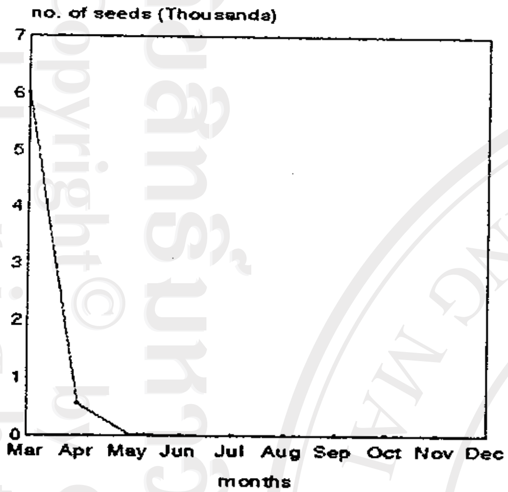


Fruiting phenology of Rubus blepharoneurus.

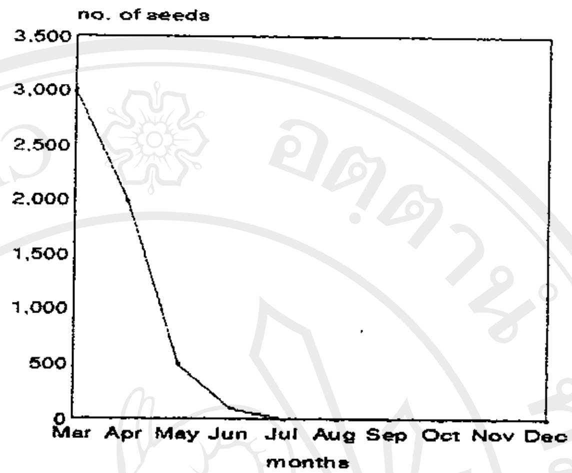


Fruiting phenology of species J

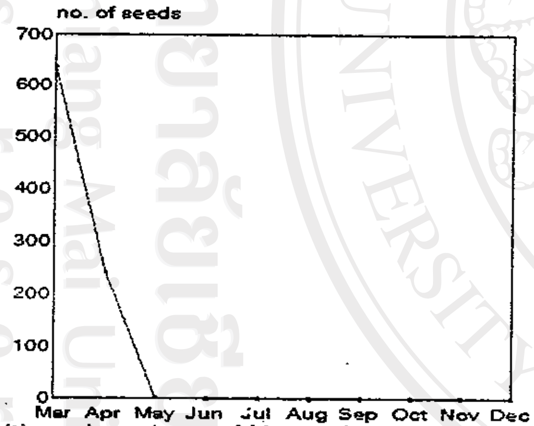
Figure 6.8.1 Pattern of fruiting phenology.



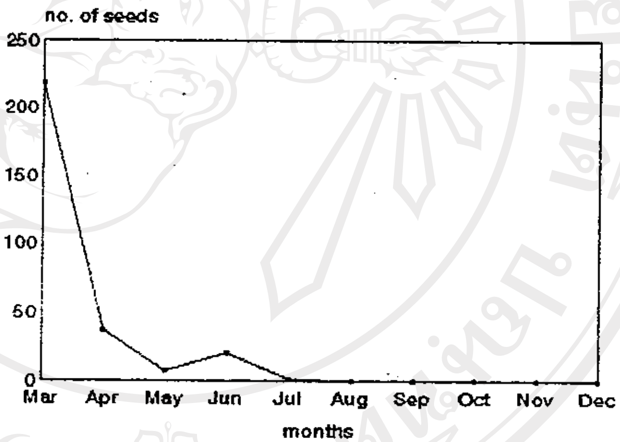
Fruiting phenology of Ficus superba



Fruiting phenology of Eupatorium odoratum

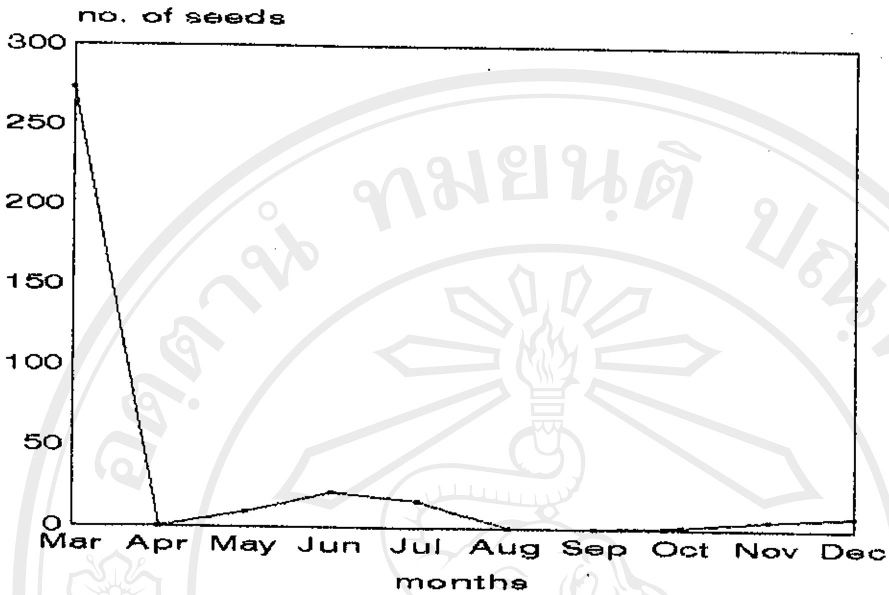


Fruiting phenology of Vernonia volkameriifolia var. volkameriifolia.

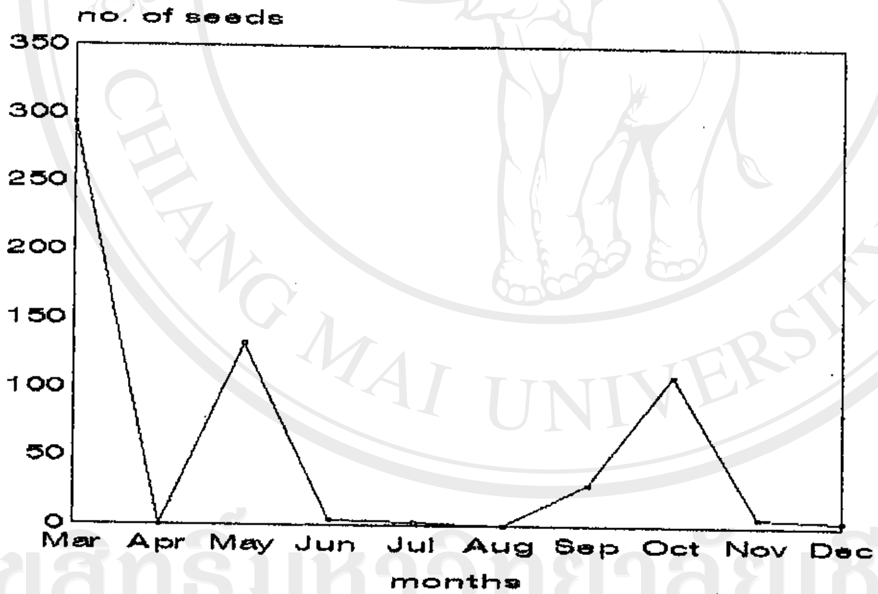


Fruiting phenology of Engelhardia spicata

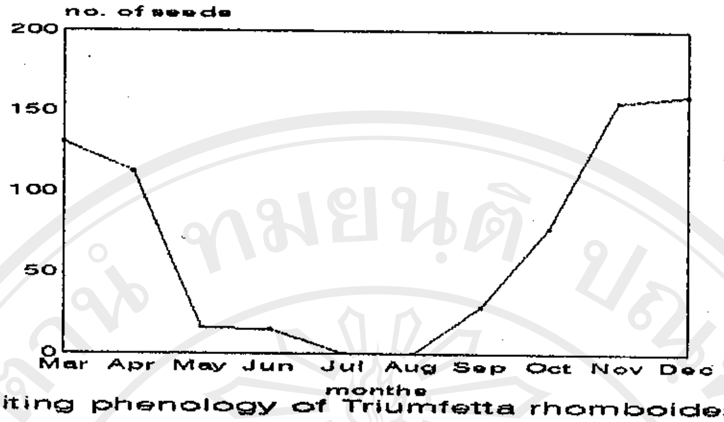
Figure 6.8.2 Pattern of Fruiting Phenology



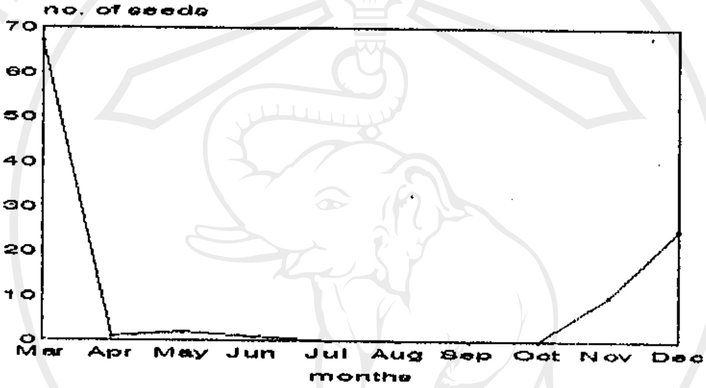
Fruiting phenology of species No.7



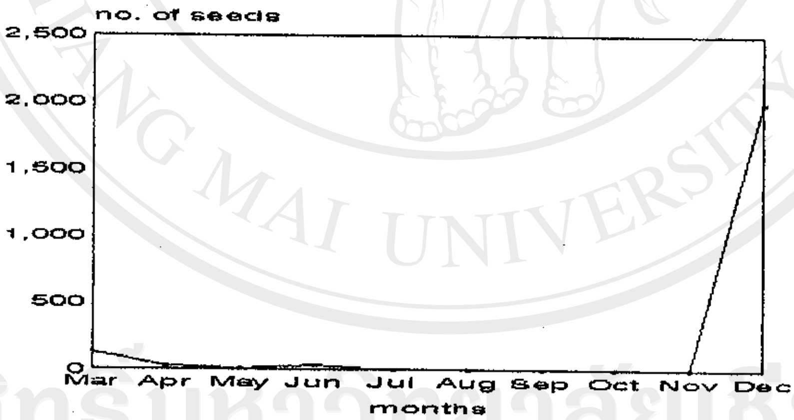
Fruiting phenology of Solanum torum.
Figure 6.8.3 Pattern of fruiting phenology.



Fruiting phenology of Triumfetta rhomboides



Fruiting phenology of Morus macroura



Fruiting phenology of Betula alnoides

Figure 6.8.4 Pattern of fruiting phenology

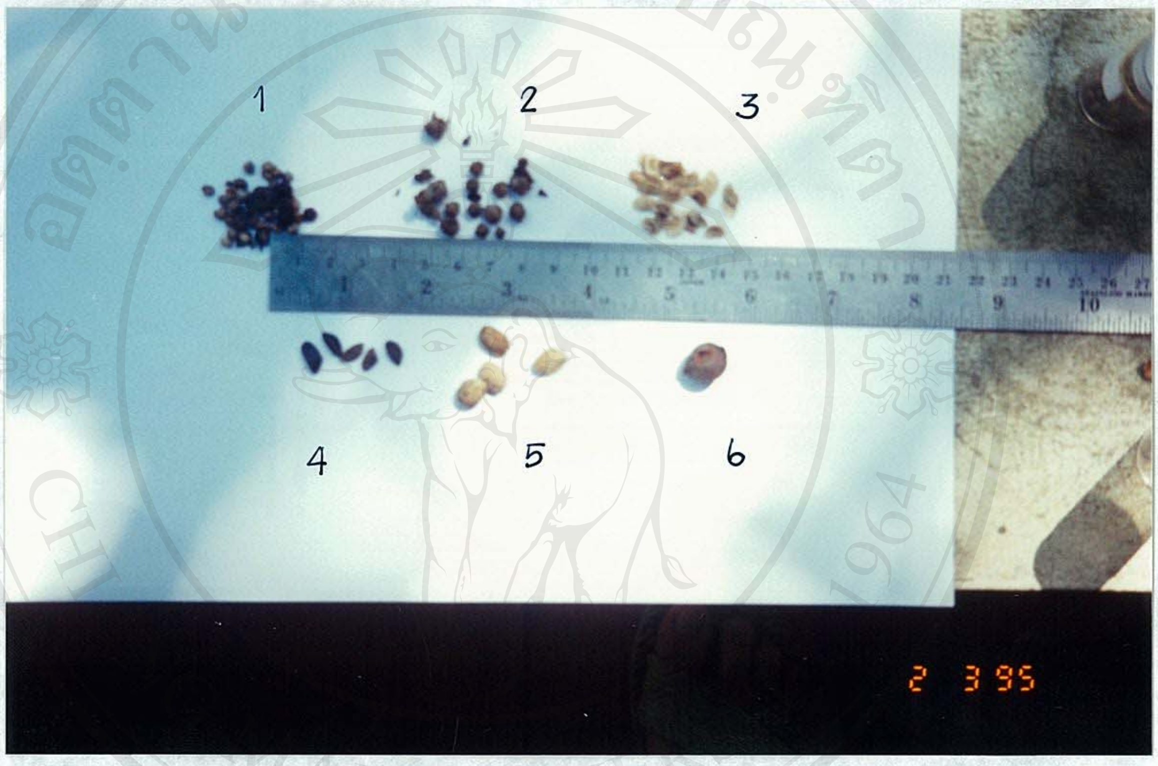


Figure 6.9 Seeds usually found in forest.

1 = *Decaspermum fruticosum* J.R. & G. Forst. (MYRTACEAE)

2 = *Castanopsis acuminatissima* (Bl.) A. DC. (FAGACEAE)

3 = *Schima wallichii* (DC.) Korth (THEACEAE)

4 = *Manglietia garrettii* Craib (MAGNOLIACEAE)

5 = *Prunus cerasoides* D. Don (ROSACEAE)

6 = *Eugenia albiflora* Duth. ex Kurz (MYRTACEAE)

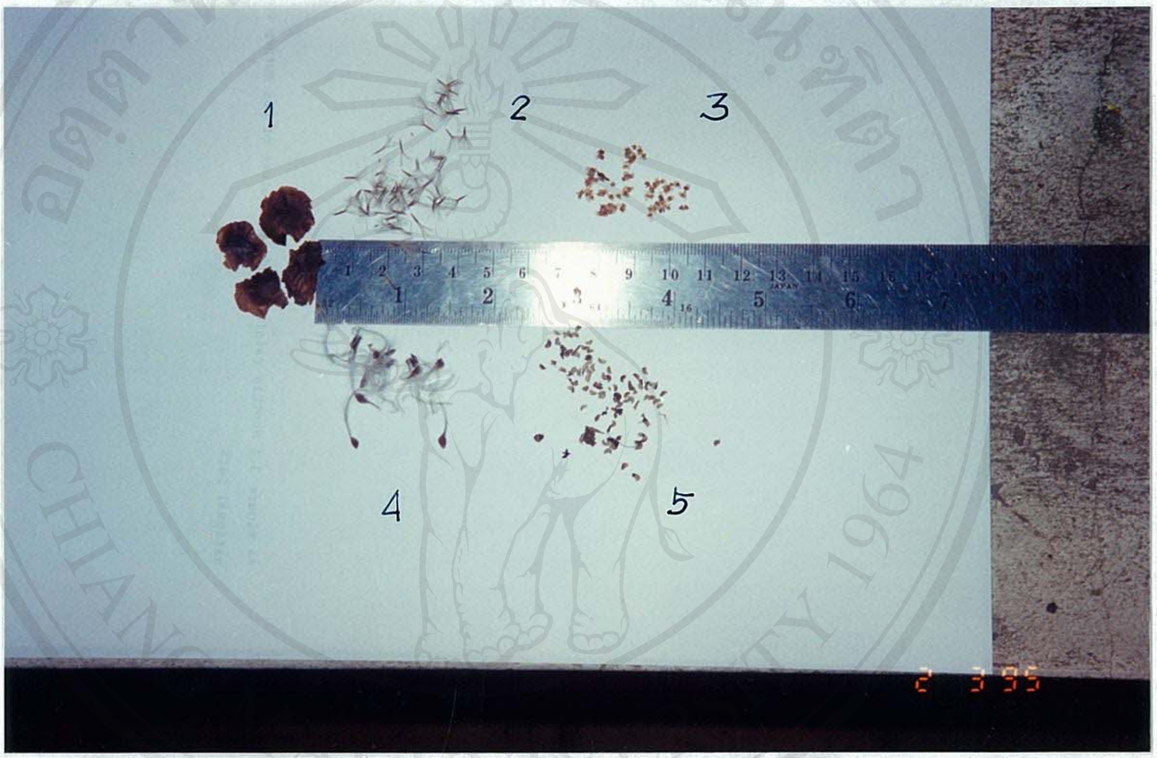


Figure 6.10 Seeds usually found in gap.

1 = *Dioscorea alata* L. (DIOSCOREACEAE)

2 = *Vernonia volkameriifolia* DC. var. *volkameriifolia* (COMPOSITAE)

3 = *Betula alnoides* Ham. ex D. Don (BETULACEAE)

4 = *Clematis acuminata* DC. var. *sikkimensis* Hk. f. & Th. (RANUNCULACEAE)

5 = *Rubus blepharoneurus* Card. (ROSACEAE)

phenology are shown in Figures 6.8.1-6.8.4.

2. SEED PREDATION

The rate of predation and germination of the three selected species are shown in Table 6.2. The three selected species were *Engelhardia spicata var. spicata*, *Styrax benzoides*, and *Castanopsis acuminatissima*. *E. spicata* was selected because its fruits could be found in seed traps both in the forest and gap, but was not recorded as seedling in the gap then it might be limited by either gap environmental conditions or seed predation or both of the factors. *Styrax benzoides* seeds were found only in the seed traps in the forest, but was recorded as seedlings in both site. To test whether seed predation might reduce the seedlings establishment of *S. benzoides* so this species was selected. The last species, *Castanopsis acuminatissima*, did not appear in the seed traps in the gap and also was not recorded as seedlings in the gap. Assume that seed dispersion is not a factor limiting seedlings establishment, if fruits or seeds could possibly dispersed into gap, does the gap environmental conditions and/or seed predation are the factor limiting the establishment of seedlings of this species.

For *Engelhardia spicata* var. *spicata* the number of fruits lost in the forest (51%) was higher than in the gap (43%). There was no seed germination in the gap and 4 seeds germinated in the forest.

Both *Styrax benzoides* and *Castanopsis acuminatissima* showed the opposite results i.e. more seeds were lost in the gap than in the forest (*Styrax* 69 % lost in the gap, *Castanopsis* 64 % lost in the gap), but the germination rates in the forest were higher than in the gap for both species.

Predation rates were higher in the gap for *S. benzoides* and *C. acuminatissima*, but was higher in the forest for *E. spicata var. spicata*. Seed germination rate in the gap did not differ significantly from that in the forest (P>0.05). The main factors limiting seed germination seemed to be environmental conditions in the gap since higher seed germination occurred in the forest. Figures 6.11-6.13 show the progression of seed predation and seed germination with time.

Table 6.2 Rates of seed predation and seed germination for three selected species (P>0.05).

SPECIES	% PREDATION		% GERMINATION		% GERMINATION	
	Forest	Gap	Forest	Gap	Glue	No-Glue
Engelhardia spicata var. *spicata*	51	43	4	0	10	13
Styrax benzoides	45	69	1	0	24	21
Castanopsis acuminatissima	52	64	5	2	35	28

Statistical significances of results of germination tests were determined by using the procedure developed by Roberts (1963). The germination rate of glued seeds and non-glued seeds did not differ significantly (P>0.05), so it is safe to assume that glue had no effect on seed germination. For *Engelhardia spicata* var. *spicata* the germination rate of non-glued seeds was higher than that of glued seeds (13 % in non-glued and 10 % in glued groups). For *Styrax benzoides* and *Castanopsis acuminatissima* the germination rates of glued seeds were higher than those of non-glued seeds, (glued : *Styrax* 24 %, *Castanopsis* 35 %) but the difference were not statistically significant. The change in germination rate of glued and non-glued seeds in the forest and seeds in the gap are shown in Figures 6.11-6.13. The fruiting phenologies of these three species are shown in Figure 6.14. Photos of the fruit or seeds of each species are shown in Figures 6.15-6.17.

In the predation test one important aspect which must be considered is, are the seeds attrative as food for small mammals. As shown in photo 6.15, bracts of *Engelhardia spicata* var. *spicata* are three-lobed, with an indurated or crustaceous endocarp (nut) inside which makes *E. spicata* var *spicata* difficult to be eaten. *Styrax benzoides*, photo 6.16, is usually one-seeded (or rarely few-seeded) with a broad hilum, hard pericarp and endosperm can be eaten by rats. The best food in this study was *Castanopsis acuminatissima.* It was eaten the most because the pericarp is more easy to remove and there is a lot of endosperm inside.

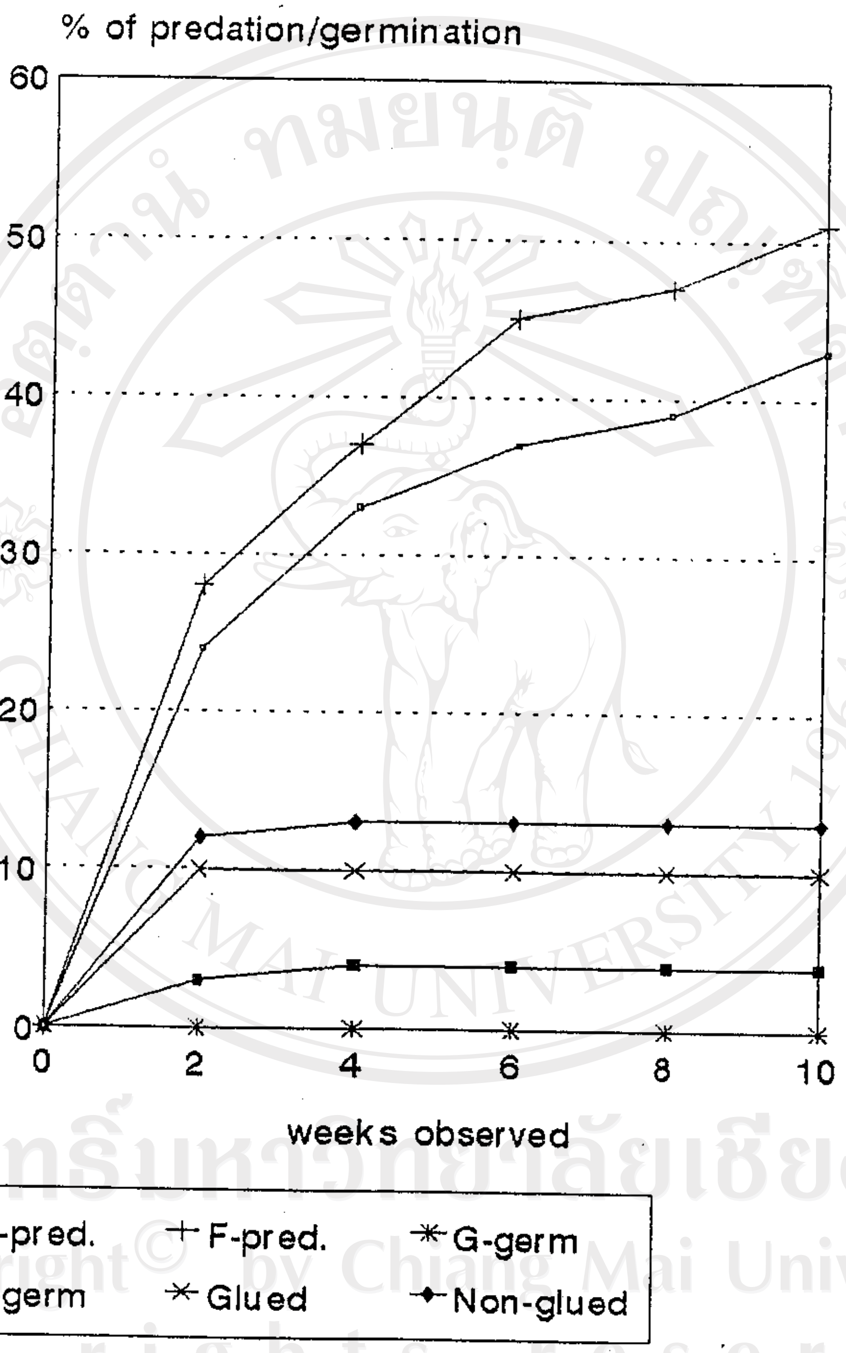


FIGURE 6.11 Rates of predation and germination of <u>Engelhardia spicata</u>

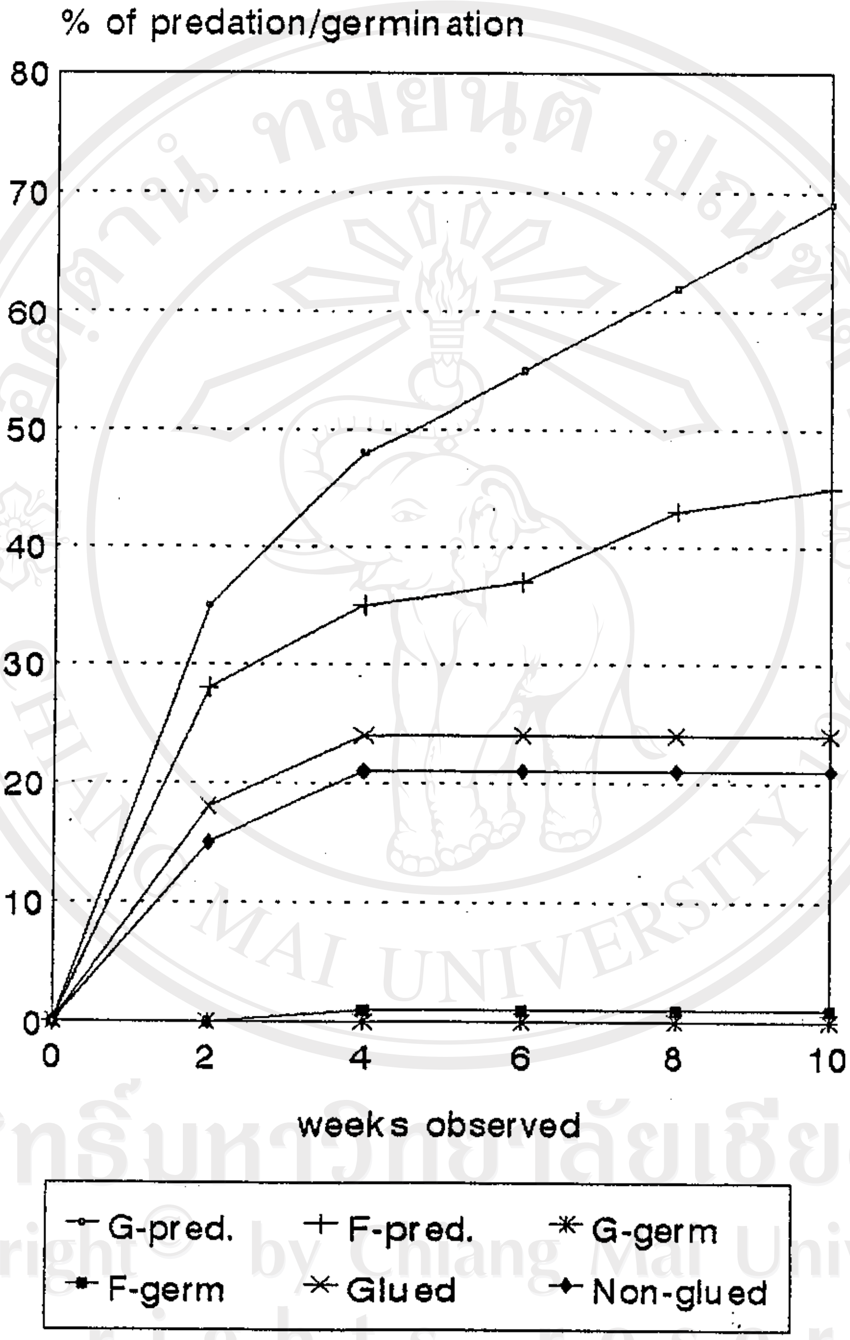


FIGURE 6.12 Rates of predation and germination of *Styrax benzoides*

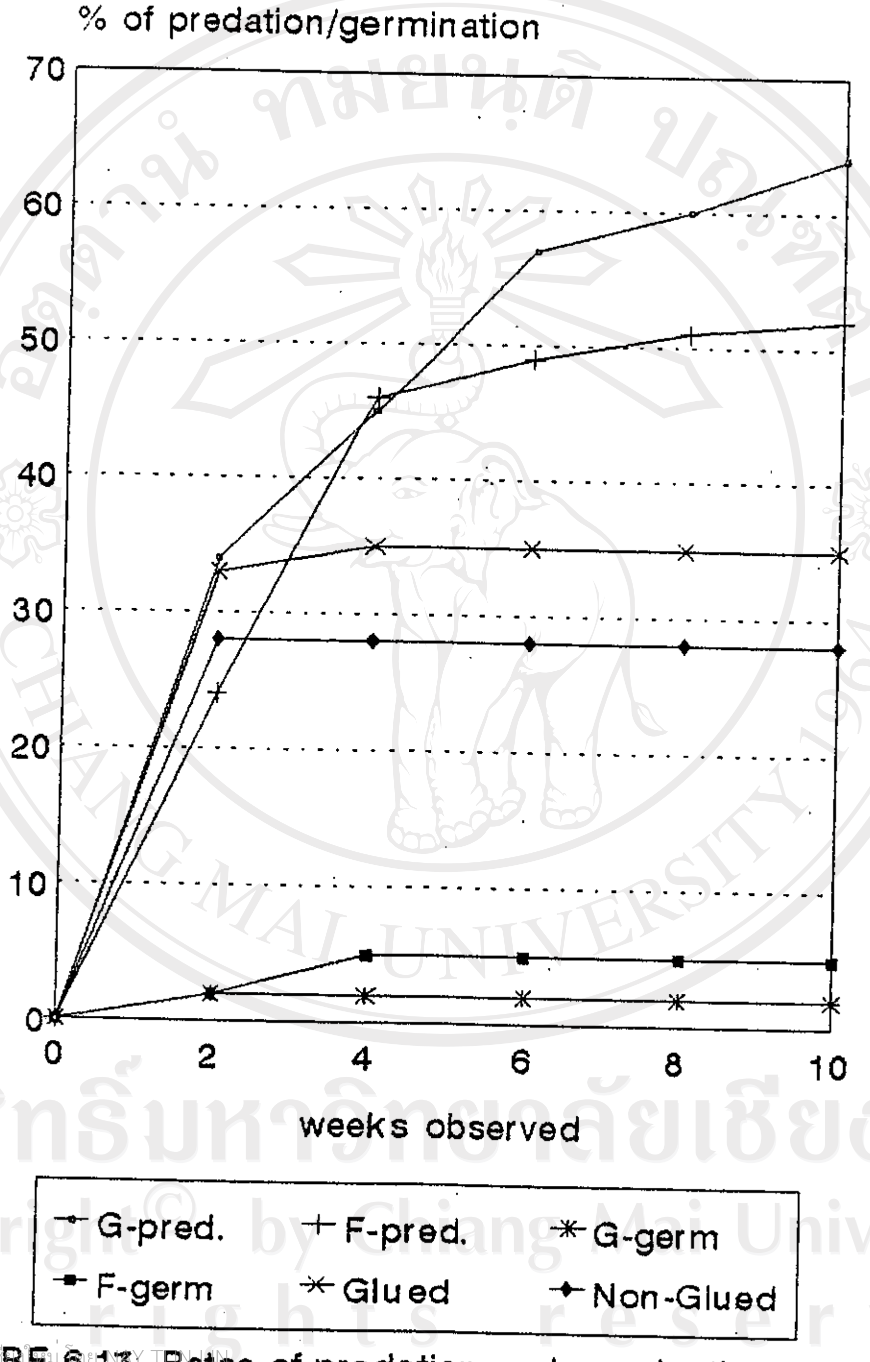
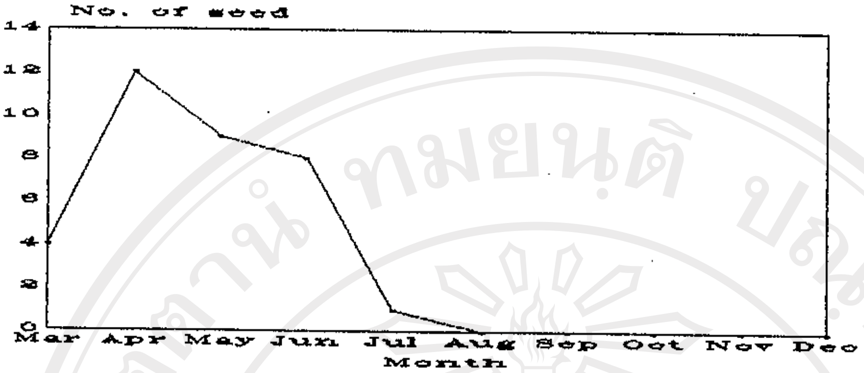
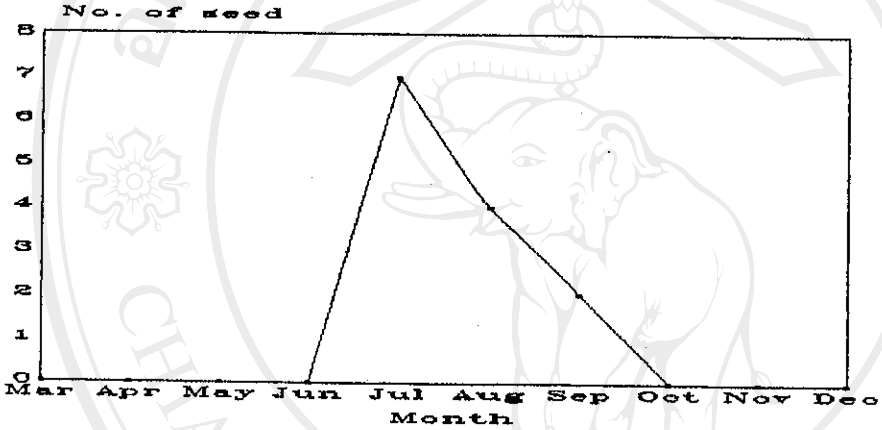


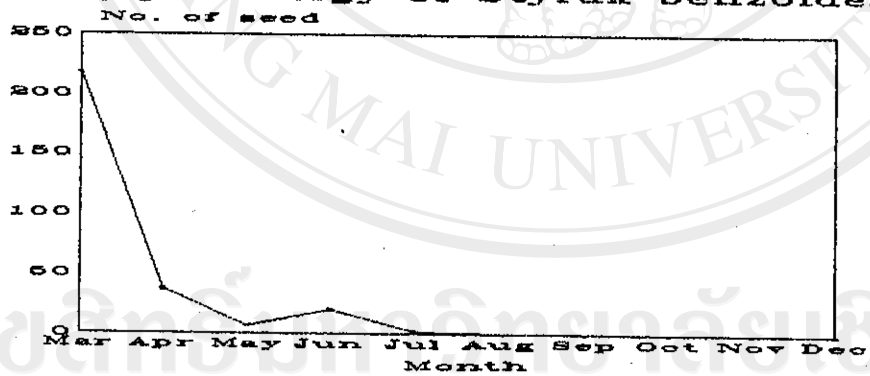
FIGURE 6.13 Rates of predation and germination of C. acuminatissima



Fruiting phenology of Castanopsis acuminatissima.



Fruiting phenology of Styrax benzoides



Fruiting phenology of Engelhardia spicata var. spicata

Figure 6.14 Fruiting phenologies of selected species from seed traps of the forest site.

Figure 6.15 Fruits of *Engelhardia spicata* var. *spicata*

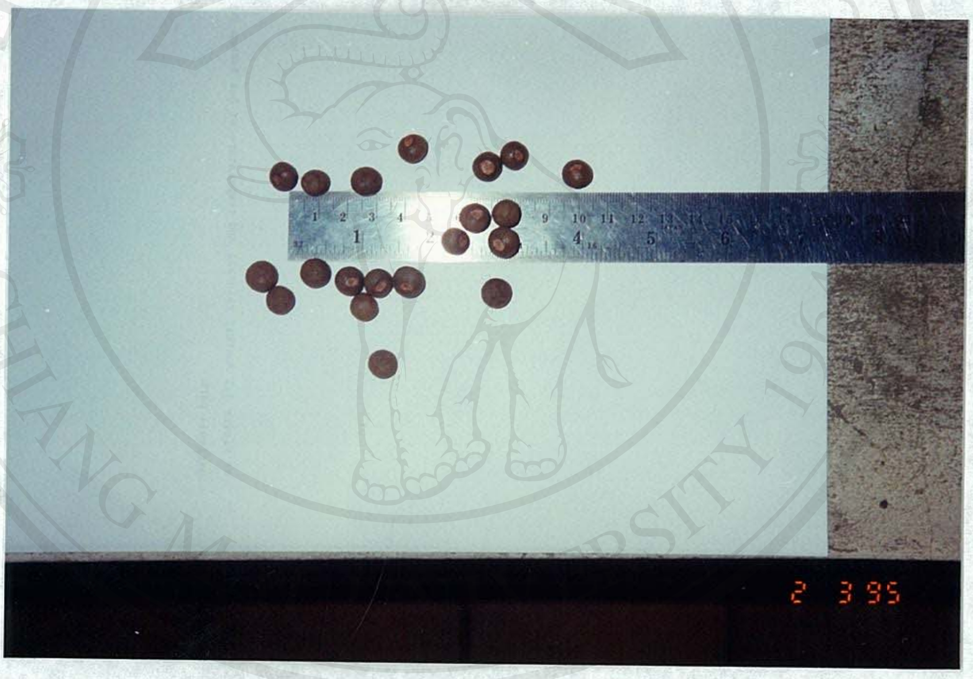


Figure 6.16 Seeds of *Styrax benzoides*

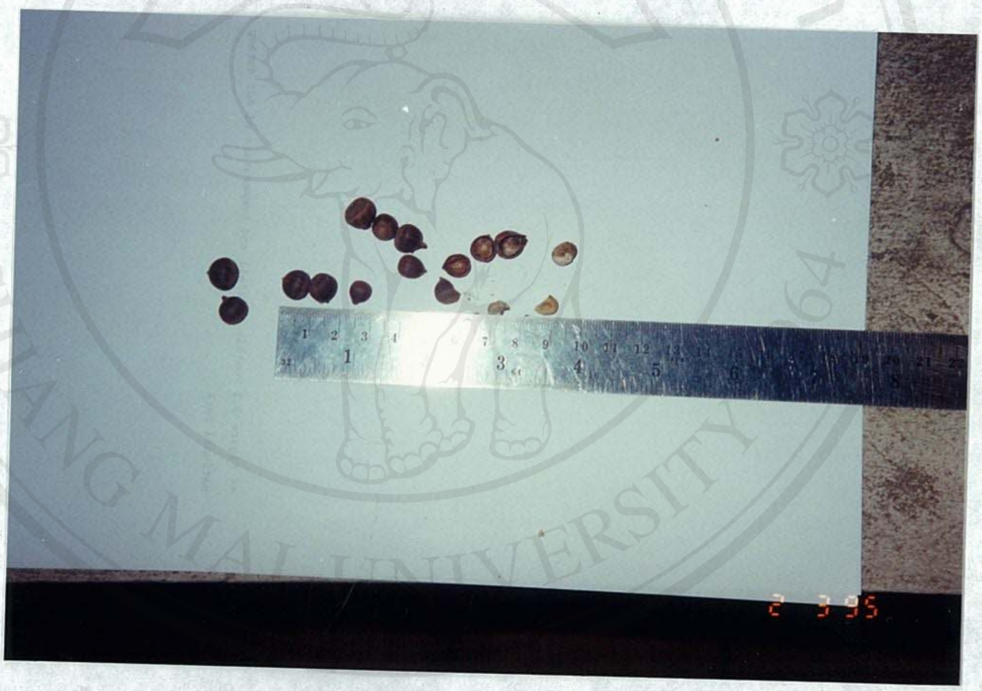


Figure 6.17 Fruits of *Castanopsis acuminatissima*

3. MAMMAL TRAPPING

Live trapping of potential seed predators showed a much higher density of small mammals in the gap than in the forest, but the species found in both sites were not very different. Species common in both forest and gap are *Rattus rattus, R. bukit,* and *R. surifer,* but *Mus cookii* was found only in the gap. Photographs of the first three species of rats trapped are shown in Figures 6.18-6.20. The trap rate in the gap was a lot higher than that in the forest as shown in Table 6.3.

Table 6.3 Trap rate in forest and gap in each trapping for each species.

SPECIES	4-9/APR/1994 F	4-9/APR/1994 G	11-16/AUG/1994 F	11-16/AUG/1994 G	18-23/NOV/1994 F	18-23/NOV/1994 G
Rattus rattus	*0.02*	*0.007*	*0.015*	*0.023*	*0.015*	*0.056*
R. surifer	*0*	*0.007*	*0*	*0.046*	*0.007*	*0.078*
R. bukit	*0*	*0.053*	*0.016*	*0.015*	*0.015*	*0.056*
Mus cookii	*0*	*0.022*	*0*	*0*	*0*	*0*
Total	0.02	0.089	0.031	0.084	0.037	0.190

From the "cafeteria test", the three species of small mammals used in the experiment were *Rattus rattus, R. surifer,* and *R. bukit.* The results of the test are shown in Table 6.4

Table 6.4 Result from "cafeteria test".

SPECIES	% OF FRUITS/SEEDS EATEN BY MAMMALS OVER NIGHT		
	Engelhardia spicata	*Styrax benzoides*	*Castanopsis acuminatissima*
Rattus rattus	0.0	35.0	75.0
Rattus surifer	0.0	20.0	85.0
Rattus bukit	0.0	15.0	85.0

All the mammal species tested prefered to eat *C. acuminatissima.* None of *E. spicata* fruits were eaten.

Rattus rattus ate more *S. benzoides* seeds than the other two species, but *C. acuminatissima* were eaten more by *Rattus surifer* and *Rattus bukit*.

Figure 6.18 *Rattus rattus.*

Figure 6.19 *Rattus surifer.*

Figure 6.20 *Rattus bukit.*

DISCUSSION

1. SEED DISPERSAL

Dispersal of fruits/seeds from the forest into gaps is affected by many factors such as distance from parent trees, wind speed/direction, shape and size of seeds, kind of fruit/seed, means of dispersal, and seasonal variation.

Distance from seed source Smythe (1970), Uhl *et al.*(1981), and Willson and Crome (1989) reported that around individual fruiting plants, seedfall declined with distance from the seed source which agrees with the results reported here. As shown in Table 6.1, many species which appeared in the gap were found only in the seed traps placed near the edge of the forest and not in the seed traps in the centre of the gap. For example *Vernonia psrishii* Hk. f. (Compositae) was common in the traps in the forest and traps along the edge, but very few fruits were found in the traps in the centre of the gap, the same situation also occurred with *Engelhardia spicata var. spicata, Morus macroura* Miq. (Moraceae), and *Rubus blepharoneurus* Card. (Rosaceae). As shown in Figure 6.7, the no. of species found in the seed traps in the gap mostly decreased from edge to centre of the gap while in the forest, the no. of species found common in the seed traps was the highest. This might be due to farther distance from seed sources of traps in the centre of the gap. So if wind speed is quite low, seeds of these species might not possibly disperse their seeds into the centre of the gap.

Shape and size of seeds Foster and Janson (1985) reported that species established beneath a closed canopy or in small gaps seem to have higher mean seed masses than those that require large gaps or higher light intensity.

Small seeds are dispersed farther and are much more likely to be dispersed into adjacent treefall gaps than large seeds (Hoppes, 1988). These two studies show that the shape and size of seeds affect seed dispersal. Results reported here show that small, flat, light-weight and winged fruits/seeds could disperse farther into gaps while bigger ones can disperse only few meters from the parent tree. Big fruits/ seeds like *Castanopsis acuminatissima*, *Manglietia garrettii* Craib (Magnoliaceae), and *Gnetum leptostachyum* Bl. (Gnetaceae) could not be found in the traps in the gap because of the bigger fruit/seed size which wind could not blow the fruits/seeds into gap.

Dispersal agent The result also showed that animals can be seed dispersal agents e.g. birds may excrete small undamaged seeds into the gap (e.g.*Ficus fistulosa var. fistulosa, Ficus superba var. japonica*) when flying across the gap. Similar results were reported by Smythe (1970) and Augspurger *et al.*(1988).

Fruiting phenology Tropical forests are characterized by a broad interplay among seasonal variations in gap characteristics and climate. Thus, arrival of seeds in gaps, as well as survival of seedlings, have to be evaluated relative to the seasonal phenology of tree species (Runkle, 1989). In different seasons, seeds caught in the seed traps were different this must be the result of a different fruiting period for each species. Figures 6.8.1-6.8.4 show the different patterns of fruiting phenology. These Figures show the availability of seed of each species and can be used for planning of seed collection programs.

Fruiting patterns vary from a single peak (e.g. *Antidesma sootepense* Craib, *Rubus blepharoneurus* Card.) to double peaks (e.g. *Solanum toruum* Sw., *Engelhardia spicata* var. *spicata*).

These factors are just a few of the factors which might limit seedling establishment in gaps. In any reforestation projects, research about seed dispersion methods needs to be done to decide on species selection. For example, if we know which species can disperse their seeds into gaps and germinate there we can allow those species to recolonize the gap naturally. For species which can not disperse their seeds into gaps, we may have to collect the seeds from the forest, germinate them in a nursery and transplant them as seedlings. Knowing the seed dispersal method could save money and labour.

Species of seeds found in the traps can be compared with species of tree seedlings known to occur in the study sites. Species present in the seed rain and the seedling community are obviously not limited by lack of dispersal, seed predation, or environmental conditions, whereas those recorded in the seed traps but failing to establish as seedlings could be limited by either or both of these two factors.

Data from seed traps were compared with results of a survey of tree seedlings in both sites carried by Karimuna (pers. comm.) during March-November, 1994 in Table 7.1.

Table 7.1 Comparison of seed rain and tree seedling communities in both sites.

SPECIES	SEED RAIN		SEEDLING COMMUNITY	
	Forest	Gap	Forest	Gap
Adinandra integerrima T. And. ex Miq.	0	few	0	0
Albizia odoratissima (L.f.) Bth.	0	0	few	0
Antidesma acidum Retz.	0	0	few	0
Antidesma sootepense Craib	rare	abundant	0	0
Aporusa villosa (Lindl.) Baill.	0	rare	0	0

Table 7.1 (Continued)

SPECIES	*SEED RAIN* Forest	*SEED RAIN* Gap	*SEEDLING COMMUNITY* Forest	*SEEDLING COMMUNITY* Gap
Beilschmiedia sp.	0	0	0	rare
Betula alnoides B.-H.	few	abundant	few	rare
Castanopsis acuminatissima (Bl.) A. DC.	few	0	0	0
Castanopsis diversifolia King ex Hk. f.	few	0	abundant	common
Castanopsis tribuloides (Sm.) A. DC.	0	0	common	0
Cayratia trifolia (L.) Dom.	common	few	0	0
Cissus assamica (Laws.) Craib	few	rare	0	0
Dalbergia discolor Bl. ex Miq.	common	abundant	0	0
Debregeasia longifolia (Burm.f.) Wedd.	0	0	0	few
Decaspermum fruticosum J.R.& G. Forst.	abundant	common	0	0
Elaeocarpus prunifolius Wall. ex C. Muell.	0	rare	0	0
Engelhardia serrata Bl.	0	0	abundant	common
E. spicata Lechen. ex Bl. var. *colebrookeana*	0	0	common	0
E. spicata Lechen. ex Bl. var. *spicata*	abundant	abundant	0	0
Eugenia albiflora Duth. ex Kurz	common	0	common	0
E. fruticosa (DC.) Roxb.	0	0	common	0
E. tetragona Wight	0	0	abundant	0
Ficus fistulosa Reinw. ex Bl. var. *fistulosa*	abundant	abundant	0	0
F. geniculata Kurz	abundant	abundant	0	0
F. microcarpa L.f. var *microcarpa*	common	abundant	0	0
Glochidion kerrii Craib	common	common	0	0
Gnetum leptostachyum Bl.	rare	common	0	0
Helicia nilagirica Bedd.	0	0	abundant	0
Heliciopsis terminalis (Kurz) Sleum.	0	0	abundant	0
Litsea cupeba (Lour.) Pers.	0	rare	rare	common
Litsea sp.	0	0	common	rare
Manglietia garrettii Craib	common	rare	0	0
Millettia pubinervis Kurz	0	0	few	0
Morus macroura Miq.	few	rare	0	0
Olea salicifolia Wall. ex G. Don	0	0	abundant	0
Phoebe lanceolata (Nees) Nees	0	0	rare	rare
Phoebe sp.	0	0	rare	rare
Planconella punctata Flet.	0	0	rare	0
Rauvolfia ophiorrhizoides (Kurz) Kerr	0	0	rare	0
Rhus chinensis Mill.	0	0	rare	0
Sapium baccatum Roxb.	common	few	0	0
Styrax benzoides Craib	common	0	rare	few
Trema orientalis (L.) Bl.	0	0	0	rare

There were some species which were found in the seed traps, but were not present as seedling such as *Solanum torum* Sw., *Elaeocarpus* *prunifolius*, and *Engelhardia spicata* var. *spicata* so either environmental conditions (such as higher temperature and fire) or seed predation or both might affect seedling establishment of these species. Some species were found in the seed traps and were also present as seedlings such as *Styrax benzoides* and *Betula alnoides* which obviously not limited by lack of dispersal, seed predation, or unsuitable environmental conditions.

2. SEED PREDATION

Of the three selected species, only *Engelhardia spicata* var. *spicata* had a higher rate of seed predation in the forest than in the gap and 4 seeds germinated in the forest. This result agrees with a survey carried out by Karimuna (pers. comm.) who found seedlings of *E. spicata* only in the forest. A lower predation rate in the gap, but no germination and an absence of seedling, shows that environmental conditions limited seedling establishment in the gap. Moreover, *E. spicata* is known as a primary tree species. Usually the germination of seeds of primary tree species occurs below the canopy, so although *E. spicata* fruits could disperse into gaps, these open disturbed places were not suitable for the seeds to germinate or for seedling establishment. While the results from the "cafeteria test" showed that no *E. spicata* fruits were eaten, it could not be concluded that small mammals will not take *E. spicata* fruitss as their food, because in the test three species of seed were left in the same cage, so the mammals had a chance to choose the food they liked to eat the most. In nature, fruits of *E. spicata* would be dispersed in March while the peak of *C. acuminatissima* and *S. benzoides* fruiting were in April and July respectively (Figure 6.14) . So in the real situation, if small mammals do not have any choice for their food, they may eat *E. spicata* seeds.

C. acuminatissima and *S. benzoides* both showed the opposite result i.e. more seeds were lost in the gap than in the forest, but the germination rates in the forest were higher than in the gap. *C. acuminatissima* was not present as seedlings in the gap because like *E. spicata* it is primary tree species, which is limited by both gap environmental conditions and means of dispersal. Seeds usually germinate below the canopy and seedling also can survive below canopy (Whitmore, 1990). The results from the "cafeteria test" showed that *C. acuminatissima* was eaten the most. It can be concluded that both environmental conditions and seed predation must be two of the factors limiting *C. acuminatissima* from colonizing gaps.

Styrax benzoides was the only pioneer tree species used in the study. Some of the main characters of pioneer tree species are that seed germination can occur only in gaps open to the sky which receive full sunlight. Seedlings of pioneer tree species cannot survive below the canopy in shade. So gap conditions were probably suitable for *S. benzoides* seeds to germinate then even some seed predation occurred (from the cafeteria test) the seedlings of this species were recorded in the gap. Since the result from seed traps showed that there was no *S. benzoides* seed found in the traps in the gap, but from Table 7.1 the seedlings of *S. benzoides* were recorded in the gap so it can be concluded that for *Styrax benzoides* seed dispersal, gap environmental conditions and seed predation are not the factors limiting it from colonizing gap. The reason why seeds of *S. benzoides* could not be found in the seed traps in the gap might be because there were so few seeds can dispersed into gap while there were only 20 seed traps placed in the gap. In the forest, *S. benzoides* seeds were found in the seed traps and also present as seedlings. Since the forest was disturbed in the past so there are some small gap around the area then the conditions of the forest site are also suitable for *S. benzoides* seeds to germinate.

All the results agree with those of Sork (1988) who found that seedling establishment is influenced both by the impact of mammalian seed predators as well as by the ability of the seeds to germinate and survive where they are dispersed.

From Figures 6.11-6.13, predation rates of the selected species in both sites increased sharply during the first month and decreased after two months while the germination rates, the seeds germinated only in the first month and no germination at all after that. The sharply increasing predation rate might be due to the freshness of the seeds (i.e. smell of fresh seeds may be attractive to mammals). The germination of seeds which occurred only in the first months might be the result of seed dormancy. Normally seeds of primary tree species have little capacity for dormancy. For *S. benzoides*, a pioneer tree species which is capable of dormancy has a 3-10 weeks dormancy period (Elliott *et al.*, 1993). Germination occured in the first month of the test because after collection seeds were kept for nearly two weeks before sowing in the field because the time was limited for the researcher at that time.

The germination rates of glued and non-glued seeds did not differ significantly. So it can be assumed that epoxy resin had no effect on seed germination. However, the germination rates of both glued and non-glued seeds in the shade house were higher compared with the germination rates of the control groups in the field. It can, therefore, be assumed that the conditions in shade house were more suitable for seed germination than in nature. The highest rate of germination was in the first two weeks for *E. spicata* and *C. acuminatissima* and in the first four weeks for *S. benzoides* which shows a longer dormancy period. As already mentioned above, pioneer tree species sometimes have a capacity for dormancy. Thus the results from the study supports the fact that *S. benzoides* is a pioneer tree species.

3. SEED PREDATORS

Seed predators destroy the majority of seeds produced annually in many plant communities and post dispersal mortality on the ground is often in excess of 75 % (Howe *et al.*, 1989). That is why the importace of seed predators needs to be taken into consideration. Ua-Apisitwong (1989) and Elliott *et al.*, (1989) reported that in evergreen forest on Doi Suthep-Pui the tree shrew *Tupaia glis* and rats *Rattus rattus* , *R. surifer* and *R. bukit* were common. The results of this study also found that *R. rattus*, *R. surifer* and *R. bukit* were common in both sites. *Mus cookii* was found only in the gap in the first trapping.

The trap rates for all species were higher in the gap which means the population density of small mammals in the gap was higher than in the forest.

Small mammals were about three times more abundant in the gap than in the forest. This might be because the natural habitat in the gap is more suitable for small mammals to live there safely such as the ground vegetation of the gap are mostly dense grasses and scrubs so it is safe for them to move and hide from predators. Another reason is the higher primary productivity at ground level in the gap so it is a lot easier for small mammals to find their foods , while in the forest the primary productivity is higher in the canopy than on the forest floor. The higher population density of small mammals in the gap may responsible for the higher seed predation rate of *C. acuminatissima* and *S. benzoides*.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this study it can be concluded that :

1. Small, light-weight fruits/seeds are able to be dispersed farther from forest into gap better than bigger ones.

2. Distance from parent tree, dispersal agent, and environmental conditions are factors limiting seedling establishment.

3. Environmental conditions seem to have more influence on seedling establishment than seed predation.

4. The species composition of the mammal communities in both sites was not very different, but the population density in the gap was higher.

5. Appropriate tree species for planting as seedlings in reforestation projects might be :

- those which cannot disperse their seeds into gaps i.e. *Gnetum leptostachyum* Bl., *Manglietia garrettii* Craib, *Castanopsis acuminatissima* (Bl.) A. DC..

- those which are affected by seed predation i.e. *Castanopsis acuminatissima* and

- those which are limited by gap environmental conditions i.e. *Engelhardia spicata* var *spicata, C. acuminatissima*.

Species which satisfy one or more of these criteria might be selected for germination in shade a house and transplanting in gaps for reforestation projects to preserve biodiversity.

For the three selected species, it can be concluded that *Engelhardia spicata* and *Castanopsis acuminatissima* need to be germinated and planted in the gaps because they are primary tree species while *Styrax benzoides* can grow in gaps naturally.

Recommendations

1. More research should be continued concentrate on species which fail to establish in deforested areas such as those primary tree species.

2. Database of species found is very important and useful for reforestation projects. We should use the database (if that place had been studied) in species selection, the data of fruiting phenology can be used in seed collection programs.

REFERENCES

Augspurger, K.C., Schupp, E.W., Howe, H.F. and Levey, D.J. (1989). Arrival and survival in tropical treefall gaps. Ecology 70(3) : 562-564.

Banziger, H. (1988). How wildlife is helping to save Doi Suthep : Buddhist sanctuary and national park of Thailand. Symb. Bot. Ups. 28(3) : 255-267.

Bruijnzeel, L.A. (1991). Hydrological impacts of tropical forest conservation. Nature and resources 27(2) : 36-46.

Cockerell, T.D. (1929). The flora of Doi Sutep, Siam. Torreya 29 : 159-162.

Connel, J.H. (1989). Some processes affecting the species composition in forest gaps. Ecology 70(3) : 560-562.

Dankelman, I. and Davidson, J. (1988). Woman and environment in the third world. Earthscan, London.

Elliott, S., Maxwell, J.F. and Beaver, O. (1989a). A transect survey of monsoon forest in Doi Suthep-Pui National Park. Nat. Hist. Ball. Siam Soc. 37(2) : 137-171.

Elliott, S., Ua-Apisitwong, S.and Beaver, O. (1989b). The small mammals communities of Doi Suthep-Pui National Park. Proc. 10th Ann. Wildlife Symp., Kasetsart University, Bangkok.

Elliott, S., and Beaver, O. (1992). The importance of Doi Suthep-Pui National Park for Wildlife conservation, Scientific research and education. Tiger paper 19(3) : 1-6.

Elliott, S., Hardwick, K., Tupacz, E.G., Promkutkaew, S. and Maxwell, J.F. (1993). Forest restoration for wildlife conservation : some research priorities. Seminar paper.

Foster, S.A. and Janson, C.H. (1985). The relationship between seed size and establishment conditions in tropical woody plants. Ecology 66(3) : 773-780.

Goldberg, E.D. (1985). Effects of soil pH, competition, and seed predation on the distributions of two tree species. Ecology 66(2) : 503-511.

Hoppess, W.G. (1988). Seedfall pattern of several species of bird-dispersed plants in an Illinois woodland. Ecology 69(2) : 320-329.

Hosseus, C.C. (1908). Beitrage Zur Flora der Doi Sutap. In J.F. Maxwell (ed.) Vegetation of Doi Suthep-Pui National Park, Chiang Mai, Thailand. Tiger Paper.

Howe, H.F., Schupp, E.W., and Westly, L.C. (1985). Early consequences of seed dispersal for a neotropical tree (*Virola surinamensis*). Ecology 66(2) : 781-791.

Kerr, A.F.G. (1911). Contributions of the Flora of Siam I : sketch of the vegetation of Chiang Mai, Bull. Misc. Info. Kew. 1 : 1-6.

Kuchler, A.W. and Sawyer, J.O. (1967). A Study of the vegetation near Chiang Mai, Thailand. Trans. Kansas. Acad. Sci. 70(3) : 281-348.

Maxwell, J.F. (1988). The vegetation of Doi Suthep-Pui National Park, Chiang Mai Province, Thailand. Tiger paper. 15 :7-8.

Nabhitabhata, J. (1987). Wildlife in Doi Suthep-Pui National Park. Kog-Ma Watershed Rsch. Bull. 48 : 42 pp.

Osunkoya, O.O. (1994). Postdispersal survivorship of North Queensland rain forest seeds and fruits : Effect of forest, habitat and species. Australian Journal of Ecology 19 : 52-64.

Phonesavanh, B. (1994). Effect of irrigation on the phenology and seedling community of a deciduous dipterocarp forest at Huai Hong Khrai. M.S. Thesis submitted to Graduate School, Chiang Mai University.

Price, M.V., Waser, N.M. and Bass,T.A. (1984). Effects of moonlight on microhabitat use by desert rodents. J. Mammal. 65 : 353-356.

Roberts, E.H. (1963). The effects of inorganic ions on dormancy in rice seed. Physiol. Plant. 16 : 732-744.

Round, P. (1984). The status and conservation of the bird community in Doi Suthep-Pui National Park, Northwest, Thailand. Nat. Hist. Bull. Siam Soc. 32(1) : 21-46.

Runkle, J.R. (1989). Synchrony of regeneration, Gaps and latitudinal differences in tree species diversity. Ecology 70(3) : 546-547.

Schupp, W.E. (1988). Factors affecting post dispersal, seed survival in a tropic forest. Oecologia 76 : 525-530.

Schupp, W.E. (1990). Annual variation in seedfall, postdispersal predation, and recruitment of a neotropical tree. Ecology 71(2) : 504-515.

Smith, J.T., Chan, T.H., McIvor, C.C., and Robblee, M.B. (1989). Comparison of seed predation in tropical tidal forest from three continents. Ecology 70(1) : 146-151.

Smyth, N. (1970). Relationships between fruiting seasons and seed dispersal methods in a neotropical forest. Amer. Nat. 104 : 25-35.

Sork, L.V. (1988). Effects of predation and light on seedling establishment in Gustavia superba. Ecology 60(2) :1341-1350.

Stott, P.A. (1976). Recent trends in the classification and mapping of dry deciduous dipterocarp forest in Thailand. In Ashton, P. and Ashton, M., editors, the classification and mapping of Southeast Asian ecosystems (IV Trans-Aberdeen-Hull Symposium on Malesian Ecology), Hull. 22-56.

Ua-Apisitwong, S. (1989). The small mammal communities of Khao Yai National Park. B.S. Special Project. Chiang Mai University.

Uhl, C., Jordan, K.Clark, H. Clark, and R. Herrera.(1981). Ecosystem recovery in Amazon caatinga forest after cutting, cutting and burning, and bulldozer clearing treatments. Oikos 38 : 313-320.

Water Conservation Bureau (1989). Report from meeting of source of Water Conservation Bureau. Department of Water Resources, Bangkok.

Whelan C.J., Willson M.F. Tuna, C.A. and Souza-Pinto I. (1991). Spatial and temporal patterns of post-dispersal seed predation. Can. J. Bot. 69 : 428-436.

Whitmore, T.C. (1989). Canopy gaps and the two major groups of forest trees. Ecology 70(3) : 536-538.

Willson, M.F. and Crome F.H.J. (1989). Patterns of seed rain at the edge of a tropical rainforest, Queensland. Journal of Tropical Ecology 5 : 301-308.

APPENDICES

Appendix A : Fruits/Seeds Found in each Month.

FAMILY	BOTANICAL NAME	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
BETULACEAE	*Betula alnoides* Ham. ex D. Don	*	*	*	*	*					*
COMPOSITAE	*Eupatorium adenophorum* Spreng.		*	*	*	*					
	Eupatorium odoratum L.	*	*	*	*						
	Vernonia parishii Hk. f.	*	*	*							
DIOSCOREACEAE	*Dioscorea alata* L.						*				*
ELAEOCARPACEAE	*Elaeocarpus prunifolius* Wall.ex C. Muell.			*							
EUPHOBIACEAE	*Antidesma sootepense* Craib				*	*	*	*	*	*	*
	Aporusa villosa (Lindl.) Baill.						*				
	Glochidion kerrii Craib	*			*	*	*	*	*	*	
	Sapium baccatum Roxb.						*	*	*		
FAGACEAE	*Castanopsis acuminatissima* (Bl.) A. DC.	*	*	*	*	*					
	Castanopsis diversifolia King ex. Hk.f.						*			*	
GNETACEAE	*Gnetum leptostachyum* Bl.	*	*	*	*	*					
JUGLANDACEAE	*Engelhardia spicata* Lechen ex. Bl. var. *spicata*										

Appendix A (Continued)

	BOTANICAL NAME	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LAURACEAE	*Litsea cubeba* (Lour.)Pers.					*	*				
LEGUMINOSAE, PAPILIONOIDEAE	*Crotalaria pallida* Ait.	*									
	Dalbergia discolor Bl.ex Miq.	*	*	*							
	Desmodium floriobundum (D. Don) Sweet	*	*	*		*					
	Lespedeza parviflora Kurz	*	*								*
	Shuteria involucrata (Wall)Weight & (*S. suffulta* Bth.var. *sinensis* (Hemsl.) Niyo.)	*	*					*	*		
MAGNOLIACEAE	*Manglietia garrettii* Craib					*					
MELASTOMATA-CEAE	*Melastoma normale* D.Don var. *normale*			*	*	*					
	Memecylon plebejum Kurz										
MORACEAE	*Ficus fistulosa* Reinw. ex Bl. var. *fistulosa*	*	*								
	Ficus geniculata Kurz				*	*	*				
	Ficus microcarpa L.f. var *microcarpa*	*	*		*	*	*	*		*	
	Ficus superba (Miq.) Miq. var. *japonica* Miq.	*	*	*	*						
	Morus macroura Miq.										

APPENDIX A (Continued)

	BOTANICAL NAME	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MYRTACEAE	*Maesa montana* A.DC.					*					
MYRSINACEAE	*Eugenia albiflora* Duth. ex Kurz						*				
	Decaspermum fruticosum J.R. & G. Forst.				*	*	*	*		*	*
PINACEAE	*Pinus kesiya* Roy. ex Gord.		*							*	
POLYGONACEAE	*Polygonum chinense* L.			*	*	*	*	*	*	*	*
RANUNCULA-CEAE	*Clematis acuminata* DC. var. *sikkimensis* Hk.f.& Th.	*									
ROSACEAE	*Prunus cerasoides* D.Don	*	*								
	Rubus blepharoneurus Card.					*	*	*	*		
RUBIACEAE	*Tarennoidea wallichii* (Hk.f.)Tirv.& Sastre									*	*
SCHISANDRA-CEAE	*Kadsura heteroclita* (Roxb.) Craib						*				
SOLANACEAE	*Solanum toruum* Sw.	*		*	*	*		*	*	*	*
STYRACACEAE	*Styrax benzoides* Craib					*	*	*			
THEACEAE	*Adinandra integerrima*	*	*	*	*		*				
	Eurya acuminata DC. var. *wallichiana* Dyer	*	*	*	*						
	Schima wallichii (DC.) Korth.			*							
TILIACEAE	*Triumfetta pilosa* Roth	*		*	*	*		*	*	*	*
	Triumfetta rhomboides Jacq.						*				
VERBENACEAE	*Clerodendrum serratum* (L.) Spr. var. *wallichii* Cl.						*	*	*		
VITACEAE	*Cayratia trifolia* (L.) Dom.										
	Cissus assamica (Laws.) Craib										

APPENDIX A (Continued)

Code	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
No. 1	*									
No. 2	*	*								
No. 3	*									
No. 4	*		*	*						
No. 5										
No. 6	*									
No. 7	*	*	*	*						
No. 8			*	*	*	*		*		
No. 9		*	*							
No. 10			*							
No. 11			*							
No. 12				*	*	*	*	*		
No. 14			*	*	*	*	*	*	*	*
No. 15					*		*			
No. 16						*	*			
No. 17						*	*	*		
No. 18					*		*	*		
No. 19						*				
No. 21						*	*			
No. 22								*	*	*
No. 23							*	*		
No. 30								*	*	
No. 31								*	*	*

APPENDIX B : Simple procedure for determining statistical significance of results of germination tests (E.H. Roberts, 1963).

The alternative percentage values (y) which are significantly different from a value (x) when using 100 seeds in each treatment. The table includes Yates' correction

x	y	y	x	y	y	x	y	y	x	y	y
0	6	-	-	-	-	-	-	-	-	-	-
1	8	-	26	41	13	51	66	36	76	88	62
2	10	-	27	42	14	52	67	37	77	89	63
3	12	-	28	43	15	53	68	38	78	90	64
4	13	-	29	44	16	54	69	39	79	91	65
5	15	-	30	45	17	55	70	40	80	91	66
6	16	0	31	46	18	56	71	41	81	92	67
7	18	0	32	47	18	57	72	42	82	93	68
8	19	1	33	48	19	58	73	43	83	93	70
9	20	1	34	49	20	59	74	44	84	94	71
10	21	2	35	50	21	60	75	45	85	95	72
11	23	2	36	51	22	61	75	46	86	96	73
12	24	3	37	52	23	62	76	47	87	96	75
13	25	4	38	53	24	63	77	48	88	97	76
14	27	4	39	54	25	64	78	49	89	98	77
15	28	5	40	55	25	65	79	50	90	98	78
16	29	6	41	56	26	66	80	51	91	99	80
17	30	7	42	57	27	67	81	52	92	99	81
18	32	7	43	58	28	68	82	53	93	100	82
19	33	8	44	59	29	69	82	54	94	100	84
20	34	9	45	60	30	70	83	55	95	-	85
21	35	9	46	61	31	71	84	56	96	-	87
22	36	10	47	62	32	72	85	57	97	-	88
23	37	11	48	63	33	73	86	58	98	-	90
24	38	12	49	64	34	74	87	59	99	-	92
25	40	13	50	65	35	75	87	60	100	-	94

CURRICULUM VITAE

Name : Alice Sharp

Date of Birth : March 17, 1970

Place of Birth : Bangkok, Thailand

Educational Background:

Secondary : Dara Academy, Chiang Mai Thailand

Higher Educ. : B.S. Biology
Faculty of Science, Chiang Mai University
Chiang Mai, Thailand.

Scholarship : German Society for Technical Cooperation (GTZ)