Chapter 2

Fruit bat as the major pollinator of semi-wild planted planted durian (*Durio zibethinus* L.) in southern Thailand.

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Abstract

The subtle difference of flower opening and fell off between commercial cultivars and semi-wild planted planted durian may influence their pollination biology. The floral biology and pollination experiments was carried out in eight semi-wild planted planted durian trees in mixed fruit orchards in southern Thailand between April-May 2003 and 2005. Flower is fully open at 1600-1630h and corolla drop around 2400-0100h. Anthesis occurs at 1930-2000h and stigma is already receptive when it is anthesis. All treatments set fruit at 7-10 days after pollination, however only open pollination (5.07%), cross pollination (13.96%) and emasculation (6.95%) result in substantial fruit set at 2 months after pollination. A very small percentage of fruit in self induced pollination suggests some degree of self-compatibility in this durian. Since its floral biology limit to nocturnal visitors, fruit bat is the major pollinator of this plant while insects were rarely observed. Bat visit durian flowers at the rate of 78.27± 62.10 times/ inflorescence and its peak was during 2000-2100h, number of visit was lower after but relatively stable till 0100 when corolla drop. Since this semi-wild planted durian depend on fruit bats for transferring pollen between trees, maintaining the fruit bat population and its roosting and foraging habitat are vital for long-term sustaining durian crop.

Keywords: durian, semi-wild planted planted, fruit bat, southern Thailand.

Introduction

Durian (*D. zibethinus* L.) is one of the most popular and economic important fruit crop in South East Asia. Thailand is the leading country for durian production of 746,642 ton in 1996 (Subhadrabandhu and Ketsa 2001). Durian has been introduced to Thailand for more than three hundred years. For such long period, it is not surprised that large number of varieties of this plant resulted from human selection has been recognised. During recent years, some varieties are going extinct due to land conversion from durian orchards to be urban area. In addition, some varieties are more popular and grow commercially in large scale and thus replace other varieties. In commercially-planted durian, all trees are cloned from vegetative part of a selected variety to keep the original characters. Some examples of these varieties are Mon Thong, Chanee, Karn Yaw. On the other hands, varieties that grow for household consumption is planted directly from seed, thus ultimately genetically diverse, since these seeds are resulted from open pollination. This group is known as Tu-Rian-Ban or semi-wild planted planted durian, which is appear to be more or less closer to wild durian than commercial one. In semi-wild planted planted ones, trees are large, robust, and relatively tall. It is known by farmers to stand drought condition, which currently occurs when climate largely changes, much better than those commercially popular varieties. Fertilizer, insecticide and weeding is not necessary, thus it requires relatively small investment. Since the market for healthy food (e.g. insecticide-free vegetable and fruit from organic farm) is growing, this semi-wild planted durian is more popular and its share in local and regional market is increasing. On the other hands, old durian trees die senescence, while the large number of old durian trees was also logged since legal permission does not required for this introduced species, thus the population of this semi-wild planted one is getting smaller. It is then growing concern to maintain population of this semi-wild planted durian, and consequently, investigation on pollination ecology is required.

Anecdotal information of the minor difference in floral biology related to pollination of commercial varieties and semi-wild planted ones indicated that flower of the latter open later (1800h) and fell off earlier (0400-0500h) compared to the former (1600h and morning respectively) (Kanchanasaka 1993). It is thus hypothesize that in semi-wild planted durian, the importance of bats as pollinator is much more pronounces than in commercial varieties. Late acting self-incompatibility was recognised in a

recent year (Honsho *et al.* 2004), thus those previous pollination experiments which did not take it into account can be doubtful, and more pollination experiments are needed. The objectives of the present study are to verify the hypothesis and also to include the late acting self incompatibility into pollination experiment.

Material and Methods

Study site

The present study was undertaken in traditional mixed fruit orchards or Suan-Som-Rom (in Thai) 3 km from Ton Nga Chang Wildlife Sanctuary (6° 56' N, 100° 14'E) . In these orchards, many species of edible plants are mixed planted in the way that their vertical stratification mimics plant community in tropical forest. Those top-canopy species are well spaced, while subcanopy and understorey species are selectively planted under top-canopy species. Durian and petai (*Parkia speciosa* Hassk.) are normally semi-wild planted as top-canopy species while longgong, banana, zingeber are predominated in subcanopy/understorey level. In these orchards, natural streams, if present, were maintained as source of water for plants. Farmers normally do not too often weed, and fertilizer is sometimes added. This kind of orchard is indicated to support high diversity of fauna and flora (Round *et al.* 2006). These studied orchards are surrounded mainly by rubber plantations, and other mixed orchards. Cultivated durians in the studied orchards vary in age from as young as 15 years to at least 80 years with a diameter of ca.1m.

Study species

D. zibethinus is native to Borneo and Sumatra. There are approximately 30 species of Durio which is native to South East Asia, and durian by far the most common cultivated species in the genus. Durian is now widespread cultivated in south and south east Asia and northern region of Australia (Brown 1997). The literature indicated that durian has been growing in Thailand at least since 1676 (Brown 1997) As a tropical canopy tree, it attains height of 40 m, and diameter of 2-2.5m.

Floral Biology

Eight semi-wild planted durian trees or Tu Rian Ban (in Thai) which was 15-25 m high were accessed by climbing gears. Floral biology, including flower opening time,

nectar secretion rate, anthesis time, and stigma receptivity were determined. Nectar secretion rates were determined using 80 microlitre microcapillary tubes every hour from 1900h till midnight and again at 0700 h. Nectar concentration was measured with a pocket refractometer.

Pollination Experiments

The flowers are arranged in tightly packed groups ranging from 1-100 flowers per group. Each night some flowers in each packs open and after the corolla shed, the stigma remain. A typical cluster of 50 flowers will take 5-6 nights for all the flowers to open. When starting a pollination treatment, all open or previously opened flowers must be removed and the remaining flowers were counted. In order to control for the effect of number of flower on pollination success, flowers were cut until there were 15-30 flowers per inflorescences. The pollination experiments comprised of 1.) open pollination: all potential pollinators were allowed to access to the flower; 2.) spontaneous self pollination: all pollinators were excluded by bagging flowers from 1500-1800h, before anthesis occurred; 3.) insect pollination: capitula were covered with plastic nets (16mm mesh size) allowing access by insects but not bats; 4.) hand-crossed pollination: fertile flowers were rubbed directly with fertile ones from a different tree and bagged; e) self-induced pollination: pollen from same tree was rubbed to stigma and it was then bagged; f) emasculation pollination: the anthers were removed before anthesis with sharp scissors and the flowers are left uncovered allowing access by pollinators. In this treatment, it was to investigate the role of pollen vectors. Flowers were subjected to cross-pollination and self-induced pollination after 2000h when flower was anthesis. Large semi-permeable cloth bags (diameter 20 cm, 35 cm high) with a plastic net inside to stop the flowers touching the cloth were used for bagging flowers. In almost all sampling trees, three-six replicates were applied per treatment, and only one sampling tree that had a replicate per treatment since few packs were accessible. Fruit set was determined at 10, 20, 30 and 60 d after the experiments. The study was undertaken during April-May 2003 and 2005

Observation of flower visitors

Flower visitors were observed when possible. Nocturnal visitors were observed with night-shot video equipped with infrared light. Observation was undertaken between

28 April to 5 May 2003. Focal inflorescences in video field were observed from 1900-0100h, and divided into 30 minutes in each session. Number of visit was counted.

Results

Floral biology

Semi-wild planted durian has a short flowering duration but precisely at the same period between different years (from 3 years observation). Its main flowering period is during mid March to end of April, although flower bud is present since February. Its second flowering period which present in some years from some trees is around August-September. Flower is fully open at 1600-1630h and corolla drop around 2400-0100h. When fully open, most of studied trees bear a flower with slightly protrude style beyond anthers. One tree has style and anther at the same length. Nectar secrete after flower open for a short while, around 1630h. Anthesis occurs at 1930-2000h. Stigma is already receptive when it is anthesis.

Nectar secretion was accumulated since late afternoon, its average volume was 0.37 ml at 1900h. and its secretion rate was about 0.05ml/h till 0100h when corolla drops. Its concentration is provisional highest in the early evening, 21.92%, and gradually decreased till flower drop with average minimum of 13.29% (Fig. 1).

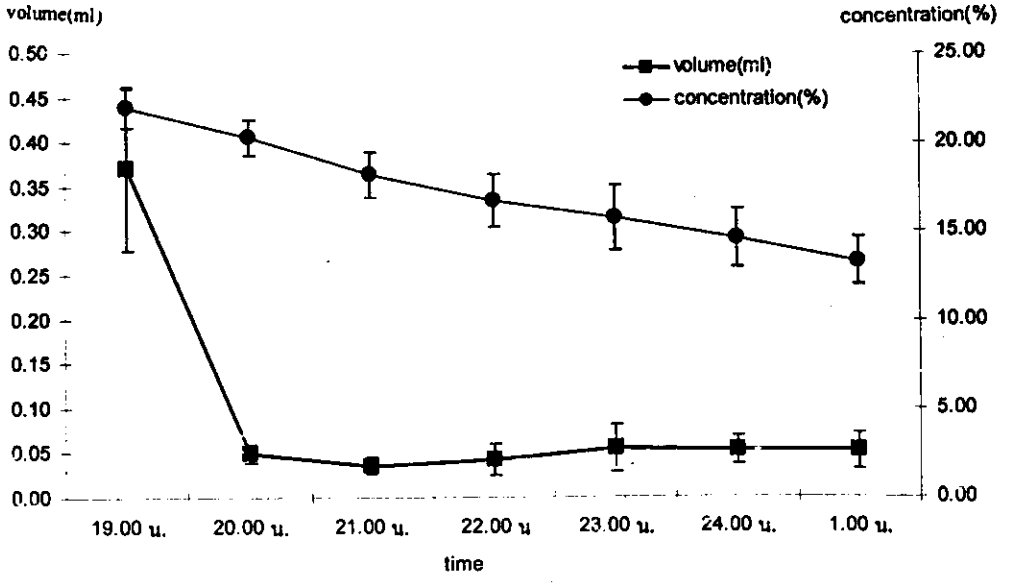

Figure 1. Average nectar volume (ml) and sucrose concentration (%) of durian (n=18) from. Standard deviation of concentration is shown.

Pollination experiment in *Durio zibethinus*

From pollination success observed at 7-10 days after the pollination experiments, although all treatments set fruit, cross pollination was the most successful(76.19%), follow by open pollination (56.43%), emasculated pollination (61.42%), self-induced pollination (38.53%), insect pollination (26.12%) and self pollination respectively (12.13%), Fig. 2). After the period of 20, 40 and 60 days, set fruits of all treatments are declined. At two months period, only open pollination (5.075), cross pollination (13.96%) and emasculation (6.95%) result in more than 5% fruit set (fig. 2). Self induced pollination also yield very small percentage of fruit (0.87 %,). This result indicated that this semi-wild planted durian has some degree of self compatibility, but its fruit set is very low. Generally, durian bears a very small number of fruit per inflorescence from natural pollination (5-7 % of all flowers). In the present study, fruit bat appears to contribute of all fruit set in this type of durian.

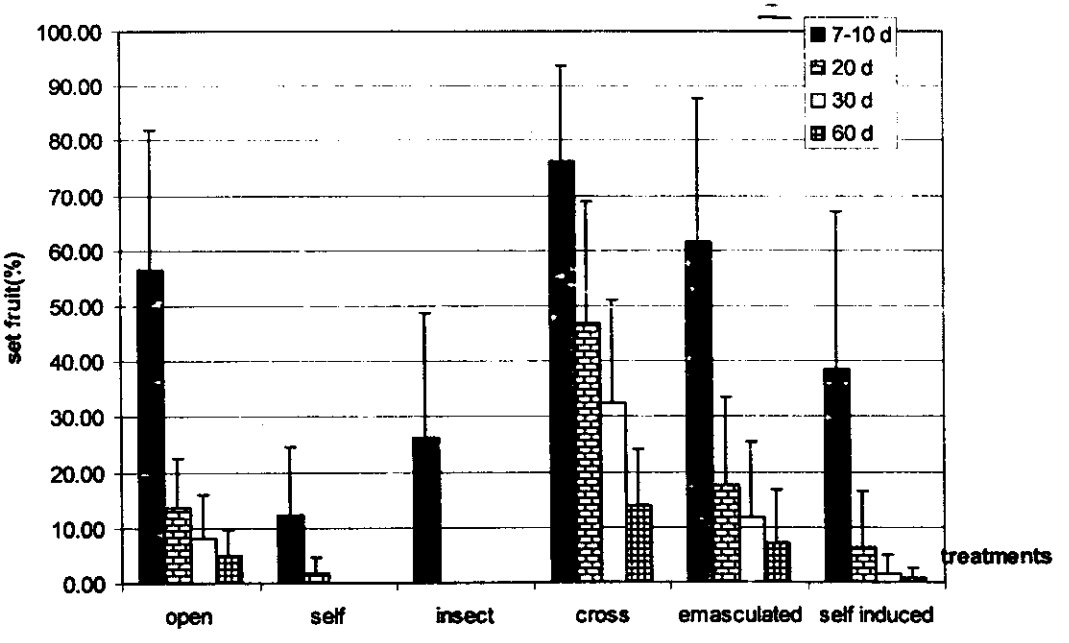

Fig. 2 Percent fruit set (+ SE) of durian at different periods after pollination in 6 pollination treatments carried out in 8 durian trees during April-May 2003, and 2005.

Observation of flower visitors

Flower visitors were observed when possible. Nocturnal insects are rarely observed including beetles and moths. Some nectarivorous birds (flower peckers) were found

feeding on nectar during late afternoon. Major and reliable visitors were nectarivorous bats, probably *E. speleae* from size and 'queet' noise. Bats came in flowering trees as a flock, up to 20 bats when trees were in full broom. From 11 inflorescences observed (3-10 flowers per inflorescence), bat visit 78.27± 62.10 times/ inflorescence (mean ± SD) (range 18-216). The peak of visit was during 2000-2100h (Fig. 3), after 2100 h, number of visit was lower but relatively stable till 0100 when corolla drop.

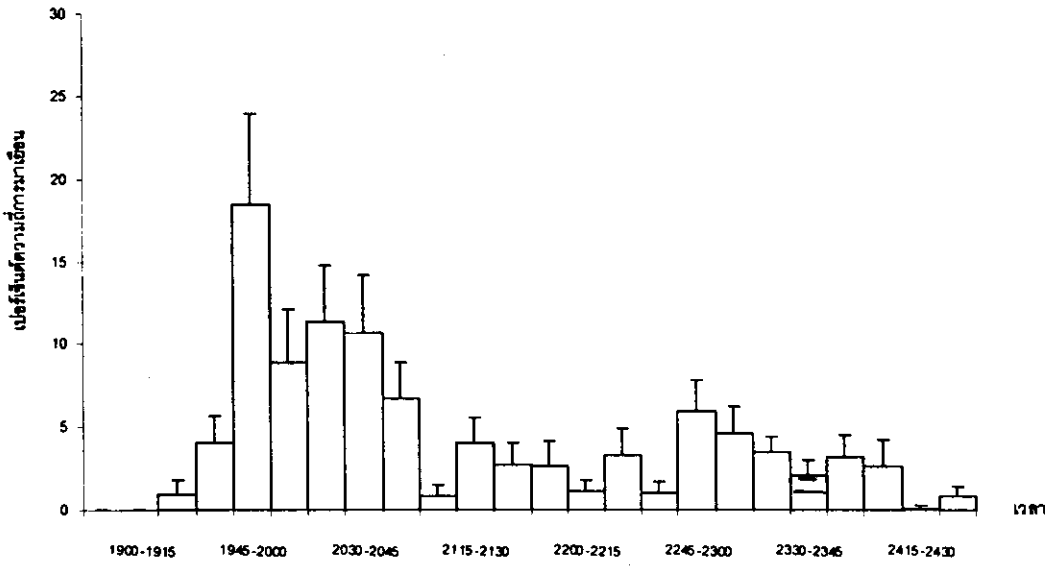

Fig. 3 The percentage frequency of bat visit at inflorescence (n=11) of durian. On average, fruit bat visit 78.27± 62.10 (SD) times/ inflorescence.

Discussion

Floral Biology

The present study, some detail of floral biology in semi- wild durian which differ from those commercial cultivars. Previous author mentioned that by morning, the calyx, corolla and staminal group have absconded, leaving just pistil attached to receptacle (Lim and Luders 1998, Brown 1997). Specifically, that time is around 2400-0100h in this semi-wild planted durian. Although stigma of some Thai cultivar is receptive from 24h before flower open to at least at noon of the following day (Salakpetch *et al.* 1992) and anthesis is about 1900h, such early period that corolla and male sexual organs drop limit its natural pollination to nocturnal visitor only. In contrast to semi-wild planted durian, flower of those commercial cultivars open early in the late afternoon, and flower drop in the morning after sunrise (Kanchanasaka

1993) or around 1100h (Lim and Luders 1998), thus diurnal pollinators may play some role in these cultivars.

Pollination experiments

From the present study, it is clear that fruit bat is the only legitimate pollinator of durian in the study area. Although nectarivorous bird have seen visiting flowers, but it is diurnal visitor which unlikely to be an actual pollinator. Although our study did not support Ferazzi (1995) who stated that bees (*Apis dorsata*, *A. cerana*, *A. mellifera*) pollinate durian flower in Thailand, it is possible that *A. dorsata* which is able to forage nocturnally, is potentially a pollinator of durian in some localities when this bee is abundant. Similarly, moths are also a potential candidate (Soepadmo and Eow 1977). In a recent study, moths and *A. dorsata* is quite likely the pollinator of chiropterophilous plant, Parkia speciosa (Bumrungsri *et al.* unpublished manuscript). In this species, insect contribute 20% of all pollination success.

There are a few species of fruit bat that reported to visit this plant, including *E. spelaea*, *Macroglossus sobrinus*, *M. minimus*, *Cynopterus brachyotis*, *C. sphinx*, and *Pterpus vampyrus* (Gould 1977, Kanchanasaka 1993, review by Brown 1997). From this list, *E. speleae* seems to be the major pollinator since it is the most common nectarivorous species, and travel as far as 38km a night, while *M. sobrinus* usually found feeding on banana flowers and *M. minimus* on Soneratia spp. (Start and Marshall 1976). *Cynopterus* and *Pterpus* are mainly fruit eating bat, and opportunistically feed on flower when available. Further investigation is needed to determine how much pollination success contributed by each species.

Previous studies reported a different degree of self compatibility in different durian cultivars (review by Brown 1997). In consistence with a recent study in 4 most popular Thai cultivars that self- induced pollination yield a lower fruit set or no fruit set at all compared to cross pollination (Honsho *et al.* 2004), cross pollination is necessary for this semi-wild planted durian regard its final yield. Since this semi-wild planted durian depend on fruit bats for transferring pollen between trees, maintaining the fruit bat population and its roosting and foraging habitat are vital for long-term sustaining durian crop. It has been suggested that commercial durian orchards closer to forest having higher pollination success than distant plantations (Kanchanasaka

1993). Though bear a large number of flower, durian has a very short flowering period, reliable visit by fruit bat during flowering period can be aided by mixing other bat-pollinating plants in durian orchard. It is recommend to plant particular plants such as *Parkia* sp., wild banana, *Eugenia* spp., *Cieba pentandra* or *Oroxylum indicum*, since these species are shown to be a major food source of *E. spelaea* in this area (Bumrungsri et. al. unpublished report).

On the other hands, open pollination reported to yield very low fruit set (0-1.4%) in durian plantations in Chantaburi Horticulture Research Center (Honsho *et al.* 2004), and fruit drop is rapid, within 2 weeks. This evidence suggests that pollinator population is very small. In this area of Thailand, most farmers treated fruit bats as pest, so they were hunted or punish to death when the colony was found (S. Bumrungsri, pers. observ.). Theoretically, such open pollination failure could be predicted when pollinator population is too small.

Although fruit set were observed in every treatments at 7-10 days, only some treatments that the fruit is present when it mature at 60 days. From a comparable speed of pollen tube growth in the style of self and cross pollinated durian flower, Honsho *et al.* (2004) suggested that self incompatibility in durian occur after pollen tube reach ovary, known as 'late acting self incompatibility'. They suggested it occurred within 4 weeks after pollination. From our evidence, it probably that such phenomenon is occur from 7-20 days after pollination since the actual fruit set was decline sharply during this period. It is still not clear this late acting self incompatibility occur at which step of fertilization indicated by Seavey and Bawa (1986).

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