Floral traits, Visitation rates and Phenology of *Luffa acutangula* Roxb. in the nature of Hinthada Township, Ayeyarwady Region

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Abstract

Luffa acutangula (L.) Roxb. is one of the common vegetables, widely grown in Myanmar. Pollination status of this species was studied at the Shan-taw village of Hinthada Township, Ayeyarwady Region. In this study, data collection of floral traits, visitation rates (VR) of significant pollinator and phenological studies were observed on a total of 228 flowers of 74 plants. In field techniques, observations of visitation rate and phenology were based on the experiments of Parrish (2004) and data collection of floral traits was based on Machado and Lopes (2004). From this study, it was found that the moth species as only significant pollinator. And this finding suggests that local gardeners should carry out hand pollination to promote yields of the fruits of *L. acutangula* Roxb.

Key words: Floral traits, visitation rates, phenology, Shan-taw village

Introduction

In recent years, the Convention on Biological Diversity (CBD) has recognized pollination as a key driver in the maintenance of biodiversity and ecosystem function. Pollination is vital for completing the life cycle of plants and ensuring production of fruit and seed whether they are agricultural crops or natural vegetation. Therefore, pollination is the most crucial process in the life cycle of plants and is essential for crop production and biodiversity conservation. Pollination is an ecological process based on the principle of mutual interactions or interrelationships between the pollinated plant and the pollinator (Collette, 2003).

Myanmar is one of the most biologically diverse countries in mainland Southeast Asia. There may be 273 families of flora comprising around 2,371 genera, 11,800 species, of which over 1,000 species are known to be endemic (Kress *et al*., 2003).

Most of our foods rely on successful pollination. Biotic pollination provides up to 80% of the world food and the rest is provided by abiotic pollination. Pollination is important for a country like Myanmar, an agricultural country. *L.acutangula* Roxb. is a common vegetable and its fibrous netting is an excellent sponge and also used in industrial application such as water filters (Min Kyaw Thu, 2008).

L. acutangula Roxb. is an annual climber. The fruits are eaten as vegetable. The fibrous material obtained from the dried fruits, is used as substitutes for bath sponges. They are known as vegetable sponge. Leaf decoction was used in Java for uremia and amenorrhea. Moreover, the fruit is sweet and used in anthelmintic, stomachic, antipyretic, cures biliousness, asthma, bronchitis, and the leaves are stomachic, antibilious, and antipyretic; cure bronchitis (Kirtikar & Basu, 1935).

In Hinthada area, no one has observed the pollination studies on this plant species. But, Min Kyaw Thu (2008) conducted as a pioneer research work on this species at Hlegu Township, Yangon Region. The present work became the second one but it was carried out in different localities with different approaching techniques. In fact, the knowledge of pollination studies is still relatively very little. Moreover, the knowledge of pollination among

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plant growers as well as even many entomologists, agriculturalists and horticulturists, is limited.

The pollination status of *L. acutangula* Roxb. is essentially needed to record for local gardeners in Hinthada in order to provide pollination awareness, and to value the natural mutualisms of each locality. The basic understanding of the natural pollination process will provide local people or gardeners with pollination knowledge and they will emphasize to value a beneficial mutualistic pathway of plants in their own nature.

Materials and Method

Observed plant species, the study site and the study period

The observed plant species of this paper was *L. acutangula* Roxb. (Kha-we) which belongs to the family Cucurbitaceae (Figure 2). The study site was located in the Shan-taw village of Hinthada Township, Ayeyarwady Region and the GPS position of this study site is 17˚40'. 898" N and 95˚24'. 919"E (Figure 1). The basic common techniques on pollination studies of *L. acutangula* Roxb. was carried out in 26th and 29th to 30th August 2011.

Floral traits

For observed species, floral traits of floral shapes, floral measurements, floral colours, floral rewards, landing platform, nectar guide present or absent, odour and floral symmetries were recorded. Flowers were classified according to floral types ("structural blossom classes") modified from Faegri and Pijl (1979) in accordance with Machado & Lopes (2004).

Seven floral types were considered: (1) bell-funnel; (2) tube; (3) dish-to-bowl; (4) gullet; (5) brush; (6) flag; and (7) chamber.

The floral measurements were taken from approximately each 10 flowers of both male and female. Flowers were classified as (1) small, ≤10 mm; (2) medium, > 10 ≤ 20 mm; (3) large, > 20 ≤ 30 mm; and (4) very large, > 30 mm.

Seven categories of flower colours were considered with regard to the most conspicuous colour, (1) white; (2) red; (3) yellow; (4) purple(including blue and violet); (5) rose (including light and pink); (6) cream (including pale yellow and pale green); (7) orange.

Three classes of floral rewards were considered: (1) nectar (N); (2) nectar and pollen major source (NP); and (3) pollen major source (P).

For landing platform, this is a place to stay as a moment when pollinators and visitors visited flowers, was also recorded.

For nectar guide, it is a visual cue to point out the nectar source. If nectar guide is present, the data have to be present such as black bull's eye; light colour bull's eye; bull's eye surrounded by landing platform of red and yellow colours, etc.; streak; dots, lines and markings that occur on the petals of flowers (Knuth, 1906). If nectar guide is not present, the data has to present "absent" only.

Visitation rates

5 times of 2 hour interval observation was done on observed plant species. Total observation periods were 10 hours in field. Visitation rates of each visitor were watched and recorded into the data sheets. According to Parrish (2004), visitation rates of all visitors and significant pollinators were calculated.

In this observation, the visitors were grouped into 6 categories: (1) bee; (2) wasp; (3) butterfly; (4) fly; (5) beetle and (5) moth. A significant pollinator of a plant species was also chosen or matched by dichotomous key to pollination syndromes (Parrish, 2004) and their visitation rates.

Calculation of visitation rates (Parrish, 2004)

The following equation was used to record the visitation rates of all visitors and the significant pollinators per flower per day.

V= sum from i= 1 to n (v x b/p) / F, where:

i = each time interval in which there were observations (2 hours in observation period)

n= number of time intervals observed, 5 in each observation period (1600-1800, 1800-2000 etc.)

v= number of visits observed during observation period (10 minutes)

b= number of minutes in the time interval (120 per two hour interval)

p= number of minutes in an observation period (10 minutes)

F= number of observed flowers

Phenological study

In this study, at least 10 individual buds of both male and female flowers were selected and these selected buds were numbered with label cards in field. The phases or phenological states of each 1hr intervals from 01400 h to 0200 h were noted. And, the average longevity of a flower for insect visitation for all visitors and the significant pollinators to pollinate them were determined.

Identifications of plant, visitors and significant pollinators

Observed plant species were identified by matching with available literature (Burkill, 1935; Kirtikar & Basu, 1935; Pandey and Chadha, 1996; Kress, *et al*., 2003, Dafni, *et al*., 2005, etc.). The visitors and significant pollinators were also determined by using previous researches and some internet information.

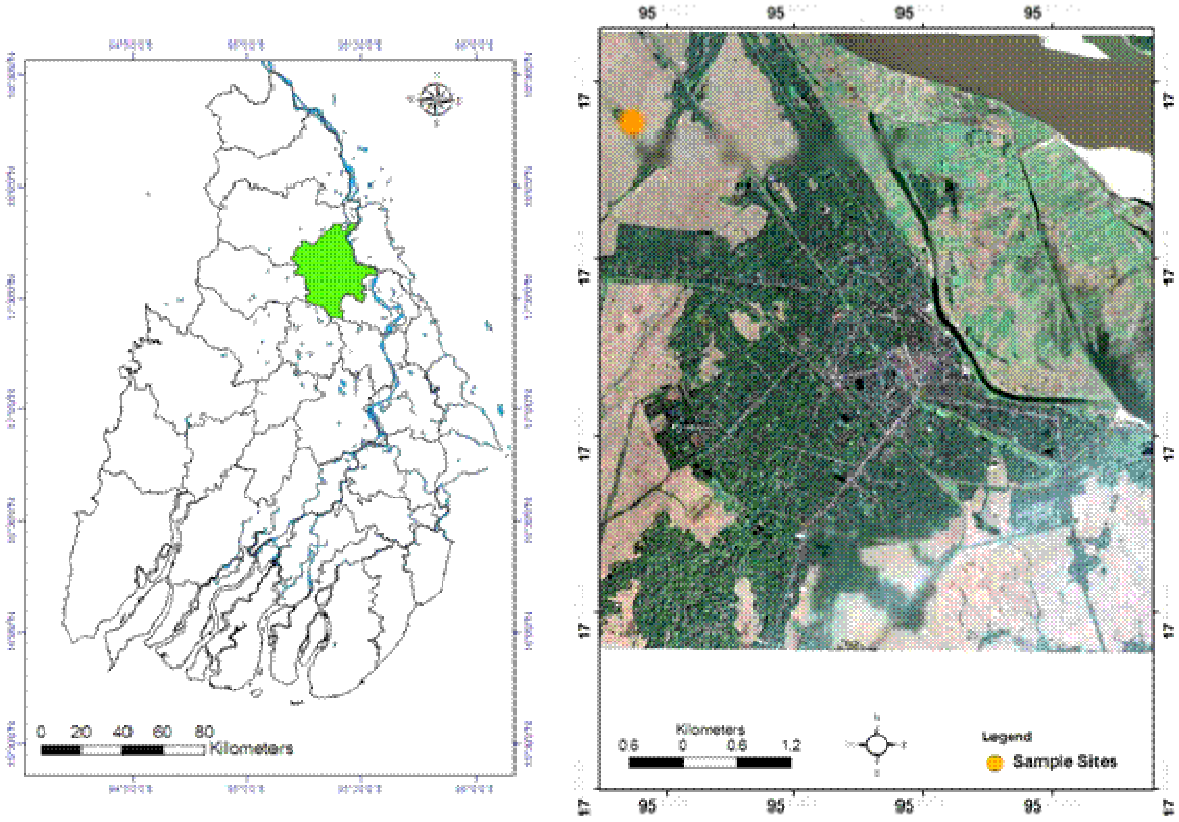


Figure (1) Hinthada Township in Ayeyarwaddy Region (Left) and the study site of Hinthada Township (Right)

Results and Discussions

Floral traits

Min Kyaw Thu (2008) described the floral traits of *L. acutangula* Roxb. as bowl shaped flower, the average diameter of flowers was 4.8 cm in male flower and 4.2 cm in female flower, yellow in colour, nectar and pollen sources (NP), landing platform present, nectar guide absent and slightly sweet smell. Some floral traits of above mentioned were similar to this observation which was floral shape, average floral diameter of female flower, floral colour, nectar guide absent and slightly sweet smell. But, there are little difference in floral traits between the two localities of Yemon, Hlegu Township and Shan-taw village, Hinthada Township which are average floral diameter in male flowers, floral rewards and landing platform. And, all of these floral traits were not represented in detail for all visitors of *L. acutangula* Roxb.

Min Kyaw Thu (2008) measured floral diameters of male and female flowers at Vegetable and Fruit Research and Development Centre (VFRDC), Yemon, Hlegu Township, Yangon Region and mentioned that the average diameter of male flower was 4.8 cm but observed flowers of the study area were 5.1 cm (Table 1). It can be noted that the male floral diameters of the study area were larger than in Yemon, Hlegu Township. The problems of this floral diameter may be dependent on the plant variety or one of the ecological problems such as air temperature, humidity, soil fertility, etc. In floral spatial pattern, some of the female flowers bloomed downwards because of their ovary weights and the male flowers bloomed upright in position. This is very important information for local gardeners because

the main pollinators (moth) cannot reach this downward floral surface. Female flowers will not probably be pollinated in this condition and it affects crop yields.

In floral rewards, nectar and pollen sources (NP) were not for all visitors. According to direct field observation, nectar and pollen sources (NP) were for bees and beetles, and nectar sources (N) were for the significant pollinator moth species, butterfly and fly.

Similarly, landing platform was also provided for visitors of bee, butterfly, fly and beetle but it was not for the significant pollinator moth.

Visitation rates and visitors

Visitation rates of visitors were observed with 5 times of 2 hour intervals (totally 10 hours observation). Visitor groups were classified as bees, wasp, butterfly, fly, beetle and moth. A total of five species of visitors was found in direct observation in field and they were bee, butterfly, fly, beetle and moth (Figure 3). Among these species, beetle species were abundantly found. Only one time of fly visit was found.

Kearns and Inouye (1993) state a visitor with highest visitation rate may be assumed as the significant pollinator among other visitors because insect visitation rates affect the overall likelihood of effective pollination. Therefore, moth had a highly significant visit and could be selected as a significant pollinator for *L. acutangular* Roxb. Their visitation rates were 11.86 per flower per day. Their visits started from 1800 h to 0200 h. The highest visitation rates occurred between 2000 h and 2200 h. The lowest visitation rates were between 2400 h and 0200 h because most flowers closed and some fell off at this time (Table 2 and Figure 4).

Total visitation rates of all insect visitors were 19.14 per flower per day. Visitation rates of all visitors were mentioned in tables (4) and (5). Phillipe (1991) mentioned that most of the members of Cucurbitaceae are mainly pollinated by bees but bees cannot be pollinated in *L. acutangula* Roxb. because their visits were before the maturation of reproductive organs. From this point of view, bees cannot be a significant pollinator for the observed plant species. Bees were in the third position of visitation rates. Beetles were also found in the second position of the highest visitation rate but they only visited flowers and they do not perform to transfer pollens. Especially, their flight activities occurred between 1600 h and 1800 h before the maturation of reproductive organs of both male and female flowers but this activity did not occurr at night. At night, most of beetles landed on petals and ate nectar, pollen and floral tissues only. Most of flowers were destroyed by beetles. It was found at about 0100 h. Pollination was almost exclusively performed by many moth species in *L. acutangula* Roxb. (Min Kyaw Thu, 2008). In the study area of Hinthada Township, only one visiting species of moth was found to pollinate the observed plant species. This moth species was *Theretra silhetensis.* In their foraging pattern, they use their proboscis which were inserted into the base of corolla while they were hovering.

Phenological study

A total of both male and female flowers each 10 individuals were examined. *L. acutangula* Roxb. was monoecious, with unisexual flowers. Numbers of male flowers were higher than female ones and the ratios was 15:1 as found in Min Kyaw Thu (2008). Field data were mentioned in Table 3 and 4.

From this observation, most male flowers of *L. acutangula* Roxb. began to open at 1700 h mostly and some flowers, at 1800 h. The flowers closed between 2400 h to 0200 h of the following day. This was about one hour late than Min Kyaw Thu's findings. The petals fell off mostly at about 0200 h. The average longevity of male flowers of *L. acutangula* Roxb. was 8.3 hr for significant pollinators and others. The male flowers opened for 6 to 7 h

(Min Kyaw Thu, 2008). But, the male flowers of the study area opened for 8.3 hr. The anthesis time (pollens shed from anthers) started from 1800 h to 2000 h (Table 3 and 4).

Female flowers opened at about 1800 h mostly. Their average longevity was 6.8 hr. The average longevity of male flowers was higher than that of female flowers. Min Kyaw Thu (2008) mentioned that the petals of female flowers persisted until next morning if the female was not successfully pollinated. But, the petals of some female flowers withered and fell off at about 0200 h by rain and beetles although they were not successfully pollinated. The maturation of stigma can be tested by fingers easily. A total of 8 out of 10 female flowers were sticky at about 1900 h (Table 3 and 4).

Table (1) Floral diameters of male and female flowers of *L. acutangula* Roxb.

Flowers / diameters	Male flower (mean)	Female flower (mean)
Floral diameter (cm)	5.1 (n=10)	4.2 (n=10)
Floral diameter (mm)	50.99 (n= 10)	41.99 (n= 10)

Table (2) Visitation rates of visitors of *L. acutangula* Roxb. on a total of 188 observed flowers.

Time intervals	Bees	Wasp	Butterfl	Fly	Beetle	Moth	Total visits
1600-1800	34		7	1	72		114
1800-2000						32	32
2000-2200						76	76
2200-2400						72	72
2400-0200						6	6

Calculation of visitation rates of significant pollinators

V = Sum from i = 1 to n; (v x b/p) / F
= (v x b/p) / F + (v x b/p) / F + (v x b/p) / F + (v x b/p) / F + (v x b/p) / F
= (114 x 120/10) /188 + (32 x 120/10) / 188 + (76 x 120/10) / 188 + (72 x 120/10) / 188 + (6 x 120/10) / 188
= 7.28 + 2.04 + 4.85 + 4.59 + 0.38
= 19.14
Visits per flower per day by all visitors (V) = **19.14**

$\mathbf{V_m}$ = Sum from i = 1 to n; (v x b/p) / F
= (v x b/p) / F + (v x b/p) / F + (v x b/p) / F + (v x b/p) / F + (v x b/p) / F
= (0 x 120/10)/ 188 + (32 x 120/10)/ 188 + (76 x 120/10)/ 188 + (72 x 120/10)/ 188 + (6 x 120/10)/ 188
= 0 + 2.04 + 4.85 + 4.59 + 0.38
= 11.86
Visits per flower per day by the significant pollinator (V_m) = **11.86**

Table (3) Flowering phenology of *L. acutangula* Roxb. (Male flowers)

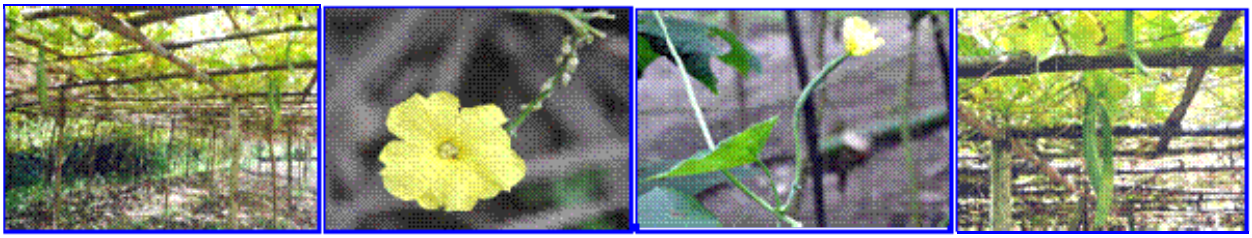
No. of flower	29-8-2011											30-8-2011		Longevity of each flower (hrs)
	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	
1	A	A	A	B	C	C	C	D	D	D	E	E	A	9
2	A	A	A	B	C	C	C	D	D	D	E	E	A	9
3	A	A	A	B	C	C	C	D	D	D	E	A	A	8
4	A	A	A	A	B	C	C	D	D	D	E	E	A	8
5	A	A	A	B	B	C	C	D	D	D	E	E	A	9
6	A	A	A	B	B	C	C	D	D	D	E	A	A	8
7	A	A	A	A	B	B	C	D	D	D	E	E	A	8
8	A	A	A	A	B	B	C	D	D	D	E	A	A	8
9	A	A	A	B	B	C	C	D	D	D	E	E	A	9
10	A	A	A	B	B	B	C	D	D	D	F	F	F	7
Total hours of flower longevity from phase B to E														83
Average longevity of a flower (hrs) to visit and pollinate for visitors														8.3 hr

Table (4) Flowering phenology of *L. acutangula* Roxb. (Female flowers)

No. of flower	29-8-2011													Longevity of each flower (hrs)
	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	
1	A	A	A	A	B	C	D	D	D	E	E	F	F	7
2	A	A	A	A	B	B	C	D	D	D	E	F	F	7
3	A	A	A	A	A	B	C	D	D	D	E	F	F	6
4	A	A	A	A	B	C	D	D	D	D	F	F	F	6
5	A	A	A	A	B	C	D	D	D	E	E	F	F	7
6	A	A	A	A	B	B	C	D	D	E	E	F	F	7
7	A	A	A	A	B	C	D	D	D	D	E	F	F	7
8	A	A	A	A	B	B	C	D	D	D	E	F	F	7
9	A	A	A	A	A	B	C	D	D	D	E	F	F	6
10	A	A	A	A	B	C	D	D	D	D	E	E	F	8
Total hours of flower longevity from phase B to E														68
Average longevity of a flower (hrs) to visit and pollinate for visitors														6.8 hr

Phase keys for both male and female flowers

A	Flowers closed in bud
B	Flowers start open
C	Pollens shed for male flowers (or) stigma is sticky for female flowers
D	Flowers fully opened
E	Petals fold inward slightly
F	Petals fold inward deeply and some fall off in male flowers or fruit set period in female flowers.



Habit Male flower Female flower Fruits

Figure (2) *Luffa acutangula* Roxb.

Bee Fly A significant pollinator (moth), *Theretra silhetensis*

Beetle (1) Beetle (2) Beetle (3)

Figure (3) Visitors and a significant pollinator of *Luffa acutangula* Roxb.

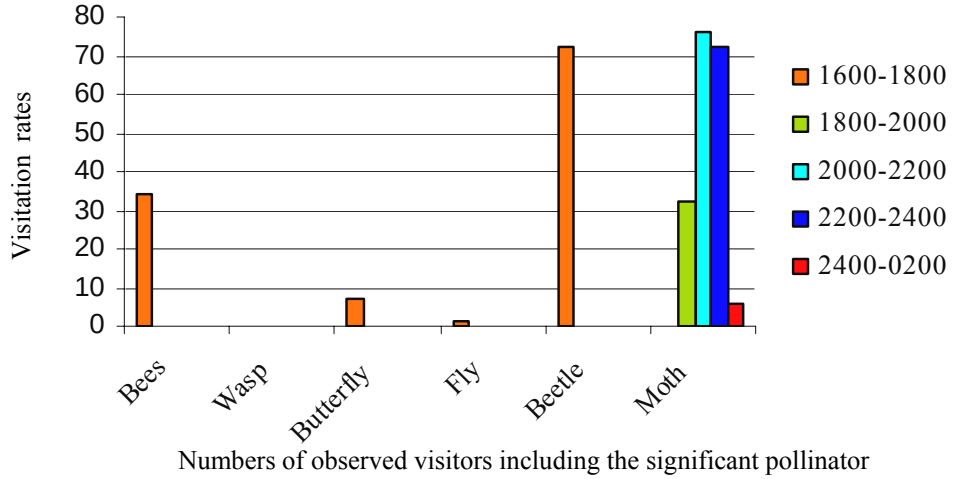


Figure (4) Visitation rates of visitors and significant pollinators (moths)

Conclusion

Most people in the study area were gardeners and farmers. They grow vegetables of Cucurbitaceae mostly and sell their crops in the market of Hinthada. From an interview with some local people during the field trip, it was known that they have no awareness on pollination process.

According to field data, the floral traits of *L. acutangula* Roxb. were dish-to-bowl in floral shape, very large (>30mm) in floral diameter, yellow in colour, nectar (N) for the significant pollinator (moth) and both nectar and pollen (NP) for the rest of visitors in floral rewards, landing platform (petals) absent for the significant pollinator (moth) and present for the rest of visitors, nectar guide absent and slightly sweet smell in floral odour at night.

With regard to visitation rates and visitors, a single moth species (*Theretra silhetensis*) possessed in the highest visitation rates and was the significant pollinator for *L. acutangula* Roxb. Their visitation rates were 11.86 per flower per day among the total visits of all visitors (19.14). Therfore, it can be said that flowers of *L. acutangula* Roxb. in the study area were naturally pollinated by moth species (*Theretra silhetensis*).

In phenological observation, most of the male flowers began to open at 1700 h mostly and closed between 2400 h and 0200 h of the following day. The average longevity of male flowers of *L. acutangula* Roxb. was 8.3 hr for significant pollinators (moths) and other visitors to transfer the pollens. Although the flowers opened at 1700 h, anthesis time occurred in 1800 h. Female flowers opened at about 1800 h mostly and their average longevity was 6.8 hr to receive the pollens for pollination. The maturation of female organs or stigmatic surface of the female flowers started at 1900 h mostly. The average floral longevity of male flowers is higher than that of the female flowers.

From this study, it was found that the moth species as only significant pollinator. And this finding suggests that local gardeners should carry out hand pollination to promote yields of the fruits of *L. acutangula* Roxb. According to the study of phenology, hand pollination should be done between 1900 h and 2300 h. Moreover, the female flowers were opened downward because of their ovary weights. This floral spatial pattern made these female flowers difficult to pollinate. All of these female flowers should be made upright by hand before the significant pollinators visited.

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