Pollination Ecology of Ridged Gourd (*Luffa acutangula* Roxb.) in VFRDC, Hlegu

Min Kyaw Thu
Department of Botany, University of Yangon

Abstract

Luffa acutangula Roxb., a common vegetable, is widely grown in Myanmar to a certain extent. However the pollination status of this species has been still unknown in Myanmar recently. In this study, floral characteristics, flowering phenology, anthesis, pollen morphology, visitors, and their visitation rate of *L. acutangula* were recorded. In addition, pollination experiments such as selfing, crossing, bagging and single insect visit (SIV) were also carried out. Among pollinators, sphinx moths (*H. boerhaviae* and *T. silhetensis*) and *Trichoplusia* sp. might be main pollinators for *L. acutangula.*

Keywords: single insect visit (SIV); floral characteristics; flowering phenology; anthesis

Introduction

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. Ridged gourd, *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. The purpose of this work was to determine the pollination status of *L. acutangula* in Vegetables and Fruits Research and Development Centre (VFRDC), Yemon, Hlegu Township, Yangon Region.

Materials and methods

Plant materials

The pollination ecology of *Luffa acutangula* Roxb. cultivar '21 Giant' (Ridged gourd) was studied at Vegetable and Fruit Research and Development Centre (VFRDC), Yemon, Hlegu Township from 11th August 2007 to 15th October 2007.

Floral characteristics

Some floral characteristics such as floral sexual systems, floral symmetry, floral shape, floral colour, floral odour, floral rewards, landing platform, nectar guide and anther dehiscence were observed and recorded.

Flowering phenology

By observing flower development of 10 male flowers and 12 female ones, flowering phenology was recorded. In the evening, buds were numbered with marking tapes and bagged with fine nets. The development of buds was observed by checking marked flower buds every half an hour.

Pollen and ovule count

Pollen grains from 12 newly opened male flowers were collected, counted and measured by ocular with the help of microscope. Ovules from one day old 12 female flowers were collected and counted under microscope.

Pollinators and visitors

Almost all of the insects visited to *L. acutangula* were recorded by a digital camera and a few could be caught with insect net. In addition their foraging behaviors were also recorded. Some important pollinators were classified. Pollen load per visitor was recorded for some visitors by catching and immobilizing in ice and the pollen grains were extracted from their body parts by staining gelatin.

Visitation rate

Visitation rates were measured by using direct observation. Three 15 min. observations and ten 30 min observations were conducted.

Pollination experiments and seed setting

Six treatments—15 selfings, 15 crossings, 65 single insect visits (SIV), 15 baggings with fine mosquito net, 15 baggings with paper bag and 25 permanently open — were carried out. To conduct the experiments for selfing, crossing and SIV, the mature buds were covered with insect proof nets every evening. When the flower was open, the flowers were uncovered and then each experiment was conducted according to the procedures. Selfing and crossing were performed to determine if it is self- compatible. For selfing and crossing, the flowers were pollinated by hand and then they were re-bagged. Single insect visit (SIV) to previously bagged virgin flowers was employed to determine insect pollination ability. The bag was opened and watched for a potential SIV. After being visited by an insect, the flower was re-bagged again.

The two kinds of bagging experiment were done for *L. acutangula* whether it was apomixis or not. For that case, in the evening, the floral buds were permanently covered with fine insect proof nets and paper bags until the next week. Permanently uncovered 25 flowers were used for open pollination. The result of each treatment was recorded. And when the survived fruits were harvested, the viable seeds were counted.

Results

Floral characteristics

L. acutangula variety '21 Giant' was monoecius, with unisexual flowers and actinomorphic; pentamerous perianth; floral shape bowl; floral colour yellow; flower odour slightly sweet; floral reward nectar and pollen; anther dehiscence longitudinal; landing platform present; nectar guide absent. The male flowers had a long peduncle while the female flowers had short ones. The ratio of number of male flowers and female ones was 15:1. There were three stamens— two having large anthers and one had small one— in male flower. These anthers produced an average of 3012.83 ± 415.4 pollen grains. The stigma consisted of tri lobes, under which there was an inferior ovary containing an average of 158.42 ± 38.66 ovules. The pollen-ovule ratio was 19:1 (Table1).

Table 1. Floral diameter, number of pollen and ovule, and pollen-ovule ratio of *L. acutangula*

	♂ flower	♀ flower	♂:♀ Ratio
Flower diameter	4.8 ± 1.11	4.2 ± 0.85	
Number of Pollen	16734 ± 1613		
Number of ovule		144.5 ± 31.56	
Pollen-ovule ratio			116 :1

Pollen morphology

The pollen grain was round, pale yellow, 75-92.5 µm in diameter and trizonoporate i.e. having three pores. The grain had sticky oil but no spine (Fig. 1).

Fig. 1. Pollen morphology of *L. acutangula*

Flowering phenology and anthesis

Both flowers of *L. acutangula* began to open between 1605 and 1715 h. The flowers closed between 2300 and 0200 h and later the petals fell off. Opening and closing of the male flower occurred about 30 min and 2 h respectively before that of the female flower. If the female flower was not successfully pollinated, the petals will persist until next morning (Fig. 2).

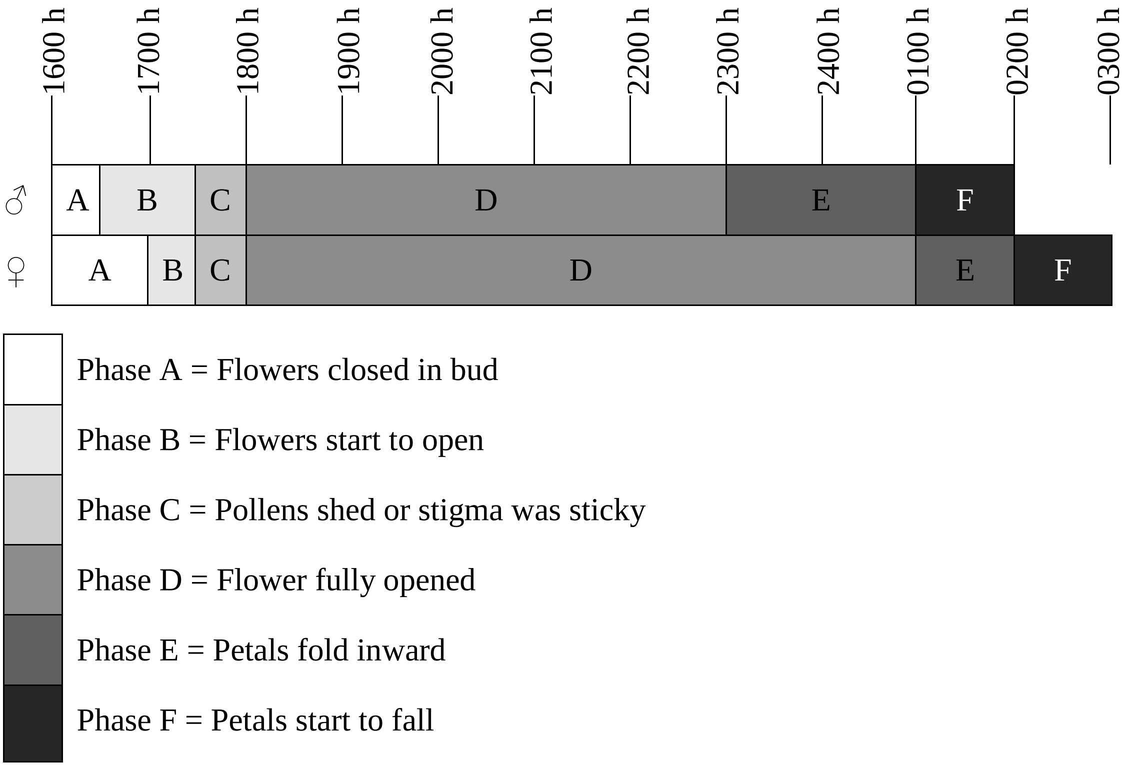

Fig. 2. Flowering phenology of *Luffa acutangula* Roxb.

Pollination

Pollinators and their foraging time

Pollination was almost exclusively performed by moths; only a few cockroaches were observed visiting the flowers of *L. acutangula* . *Xylocopa* sp. acted as a nectar thief. It visited the flowers of *L. acutangula* at about 1500 h. It made a hole at the base of corolla of flower and drank nectar. Some skippers also visited to the flowers at about 1700 h.

Hummingbird-hawk moth (*Macroglossum* sp.) and sphinx moths (*Theretra silhetensis* and *Hippotion boerhaviae,*) visited soon after the flowers open and reached a maximum between 1830 and 1900 h. Male flowers were visited more than female flowers.

Generally, the first minutes of pollination was occupied by Hummingbird hawk moth then sphinx moths. Small moths and cockroaches started pollination from about 1930 h to till the end of anthesis i.e. 2400 h. Most of the moth searched mainly for nectar while cockroaches looked for both pollen and nectar.

Pollen load per visitors

Pollen load per visitor was recorded for Hummingbird-hawk moth (*Macroglossum* sp.) and sphinx moths (*T. silhetensis*), and *Trichoplusia* sp. (Notuidae). Average of 22.88 ± 44, 87.5 ± 14 and 62.13 ± 59 pollen grain was collected from *Macroglossum* sp. (n=5), *T. silhetensis* (n=7) and *Trichoplusia* sp. (Notuidae) (n=7), receptively.

Foraging patterns

Hummingbird-hawk moth (*Macroglossum* sp.) and sphinx moths (*T. silhetensis* and *H. boerhaviae*) introduced their tongues into the base of corolla while they were hovering. The other pollinators (moths and cockroaches) landed on the flower and introduced their proboscis into the corolla base (Fig. 3).

A. *Macroglossum* sp.

B. *Hippotion* sp.

C. *Theretra silhetensis*

D. *Blattella* sp.

E. Unidentified sphingid moth

F. *Diaphania hyalianata*

Fig. 3. Insect visitors on the flowers of *Luffa acutangula* Roxb.

G. Unidentified green moth

H. *Nausionae pueritia*

I. *Trichoplusia* sp.

J. Unidentified noctuid moth

Fig. 3. Insect visitors on the flowers of *Luffa acutangula* Roxb. (contd.)

Visitation rate

The visitation rates could be conducted only for the first hour of anthesis (Fig. 4). There were three 15 min observations and ten 30 min observations were performed. For *L. acutangula* , generally the first pollinator within 30 min observation was Hummingbird-hawk moth (*Macroglossum* sp.), the second visitor was the sphinx moth *H. boerhaviae* and the last visitor was also a sphinx moth *T. silhetensis*.

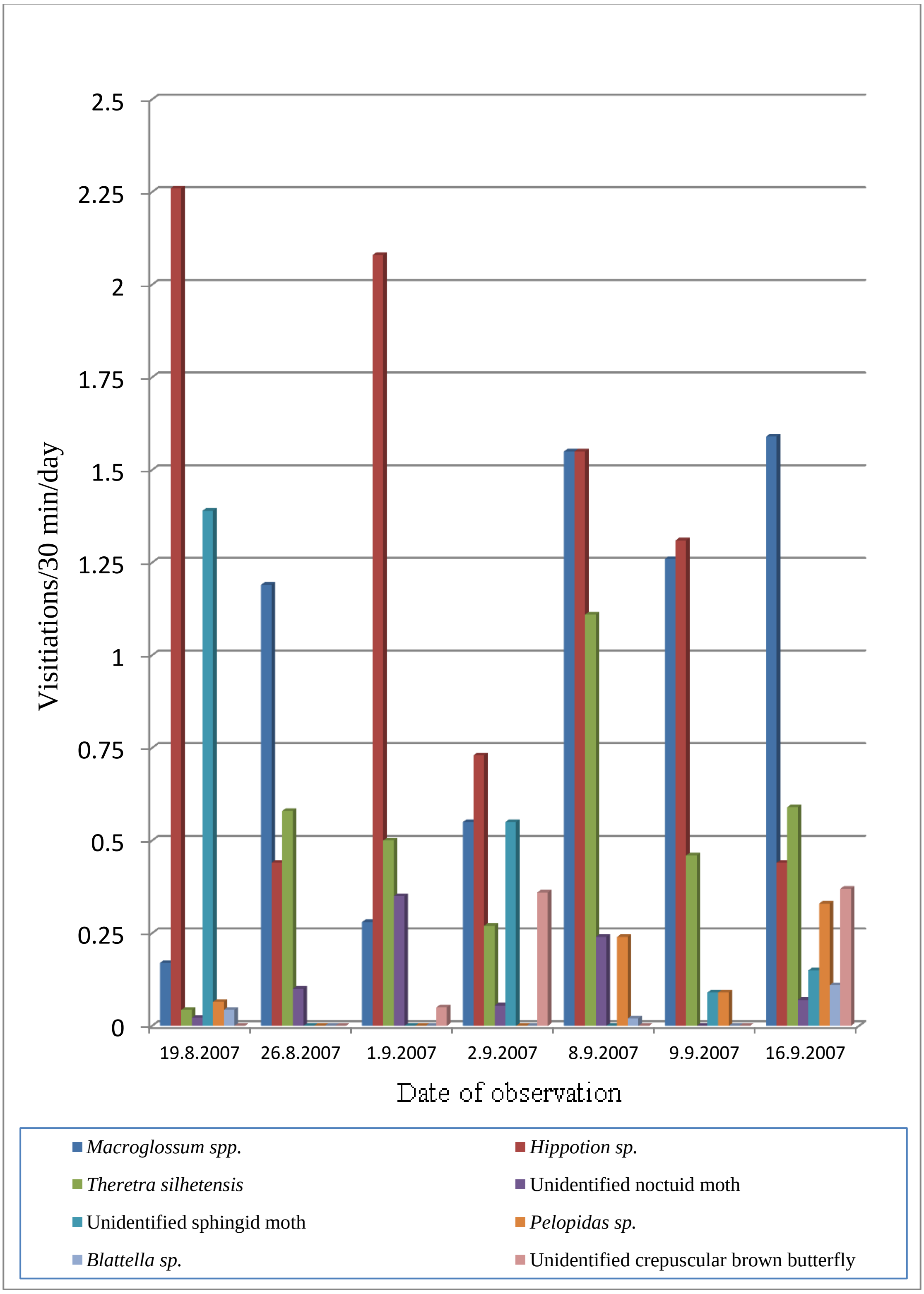

Fig. 4. Visitation rate of some active crepuscular moth species for *L. acutangula* on 9th September, 2007

Pollination experiments

Selfing and crossing produced average of 103.58 ± 20.59 and 100.9 ± 26.46 viable seeds receptively. No flower was pollinated and fertilized by both bagging experiments. In open pollination, 17 out of 25 flowers pollinated and fertilized but only 15 flowers survived and which gave average of 46.4 ± 30.59 viable seeds (Table 2).

Table 2. The results from various pollination treatments to *L. acutangula*

Pollination Treatment	#Flower initiated for each treatment	#Flower with fertilized ovary	#Fruit resulted from each treatment that survived until harvest	#Average viable seeds/fruit (Mean ± S.D.)	Fruit set %	Seed set %
Selfing	15	15	12	103.58 ± 20.59**	100	65.38
Crossing	15	15	10	100.9 ± 26.46**	100	63.69
Bag with fine net	15	0	0	0	0	0
Bag with paper bag	15	0	0	0	0	0
Open	25	17	15	46.4 ± 30.59	68	29.67

(** P < 0.01)

Single insect visit (SIV)

Out of 30 flowers, Hummingbird-hawk moth (*Macroglossum* sp.) could successfully pollinate 12 flowers. But only 11 fruit survived and average of 31.73 ± 7.05 viable seeds were harvested. Out of 17 flowers, *H. boerhaviae* pollinated 13 flowers and made all of them fertilize. Average of 30 ± 5.08 viable seeds was harvested. *T. silhetensis* visited 18 flowers and could make 12 flowers to fertilize but 10 flowers survived and average of 29.2 ± 4.85 viable seeds were recorded (Table 3).

Table 3. The results from SIV (Single Insect Visit) experiment for some pollinators to *L. acutangula*

Pollinators	#Flower initiated for each SIV	#Flower with fertilized ovary	#Fruit resulted from each SIV that survived until harvest	#Average viable seeds/fruit (Mean ± S.D.)	Fruit set %	Seed set %	Efficiency of pollination
Macroglossum sp.	30	12	11	31.73 ± 7.05	20	40	800
Hippotion boerhaviae	17	13	13	30 ± 5.08	18	76.5	1377.9
Theretra silhetensis	18	12	10	29.2 ± 4.85	18.4	67	1232.8

Discussion and Conclusion

Anthesis

The length of anthesis in angiosperms varies from a few hours to several weeks (Nepi & Pacini, 1993). The beginning of anthesis was marked by opening of the flower, irrespective of the type of pollination. On the other hand the end of the anthesis occured with the closing of the flowers, ending the receptivity of one or both sexes. For *L. acutangula* the opening and closing of the male and female flowers occured in the same manner but out of phase by about 30 min and 2 hours respectively. This might facilitate cross-pollination especially at the beginning of anthesis. According to the anthesis time of *L. acutangula*, it was visited by crepuscular moths and nocturnal moths.

The length of anthesis time of *L. acutangula* was shorter than that of *Lagenaria siceraria* which had 15 hours i.e. 1730 to 0800 h (unpublished data), but it was longer than that of *Cucurbita pepo* which had 6 hours i.e. 0530 to 1130 h (Nepi & Pacini, 1993).

Pollen

The surface of pollen grain of *L. acutangula* was the same that of *L. siceraria* i.e. unidentified. *Cucurbita pepo*, however, had the pollen grain with short spines (Nepi & Pacini, 1993). Both *L. acutangula* and *Cucurbita pepo* had the pollen grain with the same shape of spherical, but former had 3 pores but the latter had 12 operculated pores.

Pollen-ovule ratio

The pollen-ovule ratio of *L. acutangula* was smaller than that of *Cucurbita pepo* which had 317:1 (Nepi & Pacini 1993).

Pollination

Moths play an essential role in the pollination of *L. acutangula* although most of the members of Cucurbitaceae are mainly pollinated by bees (Phillipe, 1991). According to the anthesis of *L. acutangula*, it was a moth-pollinated species. Hummingbird-hawk moth (*Macroglossum* sp.) and sphinx moths *H. boerhaviae* and *T. silhetensis* were pollinators for the first pollinating hour. According to the pollen load of some major visitors, pollen carrying capacity of T. *silhetensis* and *Trichoplusia* sp. were significantly higher than *Macroglossum* sp. According to the experiments of selfing and crossing, *L. acutangula* was self-compatible. No flower was pollinated and fertilized by both bagging experiments. Therefore, *L. acutangula* could not produce viable seeds by apomixis.

Nectar might be the main reward for pollinators since many necterivorous insect species visited to the flowers. For *L. acutangula, Xylocopa* sp. could be regarded as nectar thief although it sometimes pollinates the flowers. It agrees with Faegri and Van der Pijl (1979) who stated that *Xylocopa* are indispensable pollinators, had a very strong tendency to rob blossoms of their nectar by stealing and in adapted species are often punctured.

For pollination experiment, there was a highly significance between both of selfing and crossing and open pollination ($p < 0.01$). So, it was clear that hand pollination was more efficient than natural pollination. For SIV, there was no significance between pollination efficiency of studied pollinators. Taken together, among pollinators, sphinx moths (*H. boerhaviae* and *T. silhetensis*) and *Trichoplusia* sp. might be main pollinators for *L. acutangula.*

Further study

Measurement of nectar sugar composition, female receptivity, pollen load per visitor for more visitors and pollen germination on stigma will be carried out near future.

Acknowledgements

The author is much indebted to Professor Dr. Maung Maung Gyi, Retired Head of the Department of Zoology, University of Yangon, Professor Dr. Khin Maung Swe, Head of the Department of Zoology (Retied), Dagon University, Professor Dr. Thanda Aye, Department of Botany, University of Yangon, U Hla San, Project Manager (VFRDC, Hlegu), Daw Tin Tin Cho, Deputy Project Manager (VFRDC, Hlegu), Daw Lai Lai Mon, Supervisor (VFRDC, Hlegu), and Daw Phyu Phyu Win, Manager, Plant Protection Division (MAS) for their help in the study. Special thanks go to Professor Dr. Khin Nantha Oo, Head of the Department of English, Maubin University for her kind review for language accuracy.

References

Faegri, K., and L. Van der Pijl. 1979. *The Principles of Pollination Biology*. 3rd edition. Oxford: Pergamon.

Hooker, J. D. 1879. *The Flora of British India*. Vol II. L. Reeve & Co. Ltd. The Oat House, Brook, NR. ASHFORD, KENT, England.

Kearns, C.A. and D.W. Inouye. 1993. *Techniques for Pollination Biologists*. University Press of Colorado, Niwat Co. 571pp.

Kress, W.J., R. A. DeFilipps, E. Farr and D Y. Y. Kyi. 2003. *A Checklist of the Trees, Shrubs, Herbs, and Climbers Recorded from Myanmar*. United States National Herbarium, National Museum of Natural History, Smithsonian Institution, Washington DC, USA.

Nepi, M. and E. Pacini. 1993. *Pollination, Pollen Viability and Pistil Receptivity in Cucurbita pepo*. Annals of Botany **72**:527-536

Maung, N. 2002. Taxonomy of Angiosperms. Department of Botany, University of East Yangon, Myanmar

Parrish, J. 2004, posting date. *Pollination Ecology: Field Studies of Insect Visitation and Pollen Transfer Rates*. Teaching issues and Experiments in Ecology, Vol. 2: Experiment #3 [online] http://tiee.ecoed.net/vol/v2/experiments/pollinate/abstract.html

Philippe, J. M. 1991. *La pollinisation par les abeilles.* Aix-en-Provence: Edisud.

Wist, T. J. 2005. *Pollination Biology of Echinacea angustifolia and E. purpurea (Asteraceae) in Saskatchewan*. M.Sc thesis, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. [online] library2.usask.ca/theses/available/etd-10282005-002406/ unrestricted/ TylerWist_2005_ MSc_ Echinacea.pdf