
Distribution and Life History of Hawk Moths on Noni Plants in Thailand

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Kliangklaol, N., Tigvattananont, S., Bumroongsook, S. (2015). Distribution and Life History of Hawk Moths on Noni Plants in Thailand. *Journal of Agricultural Technology* 11(8): 2505-2513.

Noni plants are commonly grown in all parts of Thailand and it is known for various uses. There were four species of hawk moths found infested and damaged to the noni leaves: *Macroglossum gyrans*, *M. prometheus*, *M. sitiene* Walker and *Neogurelcahyas*. Nymphs and egg clusters of these hawk moths were collected from Pathumthani, Nakhonnayok, Ayutthaya, Bangkok, Khonkaen, Chaiyaphum, Uttaradit, Prachinburi, Chachoengsao, Rayong, Trat, Tak, Ratchaburi, Phetchaburi, Sakaeo, Nan, Prachuapkhiri Khan, Ranong and Chumphon province. The insect rearing was carried out in the entomological laboratory (27-35°C), King Mongkut's Institute of Technology Ladkrabang. Fresh young leaves of noni plants were used as food and changed every day. Developmental and morphological characteristics of eggs, nymphs and adults of the moths were recorded, measured and photographed (n=30). Host plants were identified and recorded including their distribution. The studies showed that *Macroglossum gyrans*, *M. prometheus*, *M. sitiene* and *Neogurelcahyas* belonged to family Shingidae and to become adult moths these insects have to go through 4 stages: egg, 5 successive larval instars, pupa and adults, respectively. The young larval instar preferred young noni leaves and the 4-5th larval instar consumed both young and mature leaves. The life cycle process took 37.09, 34.04, 31.97 and 32.80 days, respectively. Compared by using averaged body length, *M. prometheus* is the largest moth (30.12 mm) among these hawk moths and *M. hyas* (18.18 mm) is the smallest one whereas the sizes of *M. gyrans* and *M. sitiene* were not much different (26.00 and 27.25 mm, respectively). Adults of *M. prometheus*, *M. sitiene* and *N. hyas* were diurnal moths of which mating behavior and egg laying were carried by the adults occurred mostly during the daytime. Number of eggs laid was more than 120 eggs/female insect. Eggs of *M. gyrans* were found parasitized by wasps and the final instar was frequently attacked by Tachinid flies. *Trichogramma* sp. was an egg parasitoid of *N. hyas*. Normally, the female is larger than the male counterpart. Three morphological differences between male and female hawk moths: 1) antenna 2) lunulate fantail for a female and trilobite fantail for a male 3) a frenulum for a male and frenula for a female. The principal host plant was *Morinda citrifolia* in the family Rubiaceae and *M. sitiene* had more various host plants. It was a common insect and could be found during April-June and September-November. Spatial distribution of these hawk moths in Thailand was as follows: *M. sitiene* in Ayutthaya, Bangkok, Chachoengsao, Chumphon, Khonkaen, Nakhonnayok, Nonthaburi, Pathumthani, Phetchaburi, Prachinburi, Prachuapkhiri Khan, Ranong, Ratchaburi, Rayong, Tak, and Trat; *M. gyrans* in Chaiyaphum, Uttaradit and Bangkok; *M. prometheus* in Sakaeo, Uttaradit, Nan and Prachinburi and *Neogurelcahyas* in Bangkok.

Keywords: distribution, hawk moths, life history, noni plants

Introduction

Noni (*Morinda citrifolia* L.) is an indigenous plant known as an important herbal plant that used for diseases remedy and for local consumption (Fu *et al.*, 2013;). It is a shrub in the Rubiaceae family and can grow in wide variety of habitats. It is native to Southeast Asia and later spread all over India, small islands, in the Pacific Ocean, West Indies Islands and other tropical areas. This tree species shows flowering and fruiting throughout the year. Its multiple fruit is edible and consumed by locals has a very strong smell and bitter taste. The fruit of Indian mulberry contains a number of phytochemicals, including lignans, oligo- and polysaccharides, flavonoids, iridoids, fatty acids, scopoletin, catechin, beta-sitosterol, damnacanthol, and alkaloids. In addition, it contains a number of enzymes (proteins) and alkaloids that are believed to play a pivotal role in promoting good health.

All plant parts has health benefit and contains nutrition and vitamins., Noni is known to have antibacteria, anti-inflammation, and antioxidation activities properties. Huang *et al.* (2014) stated its fruit extracts control the mechanism of inflammatory responses caused by *H. pylori* infection. There are quite a number of insect pest damage to indian mulberry plant. Insect pests of Noni are the melon aphid, *Aphis gossypii*, the green scale, *Coccus viridis*, weevils leaf miners the Kirkaldy whitefly, *Dialuerodes kirkaldyi*, caterpillars (e.g., croton caterpillar, *Achaea janata*, and the greenhouse thrips, *Heliothrips haemorrhoidalis*) (Nelson, 2006). Noni stem borer (*Lamprosema chagalis*) are a *devastating* pests identified for the first report on noni in Micronesia. Infected branches are found larva feeding inside and caused damage to plant tissue (Agricultural Experiment Station, 2008). In Fiji, it is the principal larval host of the hawk moth, *Macroglossum hirundovitiensis* (Stamps fiji.com 2002). *Macroglossum* is a family of hawk moth, they are moderate to large in size. The larval stages are very destructive to Noni leaves.

Macroglossum is a hawk moths genus in the Sphingidae family. It has been described more than 110 species (Wikipedia, 2015). Likewise *Macroglossum*, *Neogurelca* is a genus of hawk moth. Hawk moths was known as effective flower pollinators (Frankie, 1989). Its body, mouth parts and proboscis carried pollen along distances between host plants. It required nectar as energetic resource and flight dispersal (Casey 1976; O'Brien, 1999). A cibarial pump to get nectar up and then put into its esophagus (Gibson,

2001). The hawk moth as a pollinator was reported more in tropical regions than elsewhere (Grant, 1983; Opler, 1983). *Macroglossum* hawkmoth species are quite abundant in southeast Asia. A host plant of *Macroglossum gyrans*, *M. prometheus*, *M. coeythus* and *N. hyas* was *Morinda*. (Hollaway, 1987; Pittaway and Kitching, 2010) These 4 insect species were not recorded on the checklist of 176 species of hawk moths in Thailand (Inoue *et al.*, 1997). Only *M. sitiene* larva fed on *Morinda citrifolia* L in Bangkok (Pittaway and Kitching, 2010) Few studies have been worked on the biology of these Hawk moths especially growth and developmental aspects. Therefore, in this paper, distribution and life history of hawk moths on noni plants was investigated.

Objectives: This study is to work on distribution, growth and development of Noni hawk moths in Thailand.

Materials and methods

Sample collection

Nymphs and egg clusters of the hawk moths were collected from noni plants from Pathumthani, Nakhonnayok, Ayutthaya, Bangkok, Khonkaen, Chaiyaphum, Uttaradit, Prachinburi, Chachoengsao, Rayong, Trat, Tak, Ratchaburi, Phetchaburi, Sakaeo, Nan, Prachuapkhiri Khan, Ranong and Chumphon province. Then, they were placed in plastic boxes sized 19×28.5×10 cm. The date and places of collection were recorded. Egg and larva parasitization was observed and recorded.

Insect rearing in the laboratory

The nymphs and egg were all reared at room temperature (27-35°C) at the entomological laboratory, King Mongkut's Institute of Technology Ladkrabang. The noni leaves were provided as food for both adults and nymphs. Developmental and morphological characteristics of eggs, nymphs and adults of the moths were recorded, measured and photographed (n=30).

Results and discussion

Four species of hawk moths were found mainly on Noni (*Morindacitrifolia*) and other host plants were recorded in Table 1. They are *Macroglossumgyrans* Walker, *M. Prometheus* Boisduval, *M. sitiene* Walker and *Neogurelcahyas* (Walker). They are Sphingidae and belonged to order Lepidoptera. A female adult laid egg singly on a noni leaf. When egg hatching, the larva showed a dorsal horn on the eighth abdominal segment at the rear end. After the pupation stage, the adult moth became apparent. The adult moths of these insects have to go through 4 stages: egg, 5 successive larval instars, pupa and adults, respectively. The young larval instar preferred young noni leaves and the 4-5th larval instar consumed both young and mature leaves. The caterpillar was difficult to find due to well camouflaged on host plants. The life cycle process took 37.09, 34.04, 31.97 and 32.80 days, respectively. The growth and development of these four moths was summarized in Table 2-5. By using an averaged body length, *M. prometheus* is the largest moths (30.12 mm) among these moth hawks and *N. hyas* (18.18 mm) is the smallest one whereas the sizes of *M. gyrans* and *M. sitiene* were not much different (26.00 and 27.25 mm, respectively) (Table 6). *N. hyas* were attracted by flowers low down on the tree and approaching closely to the ground about 30 cm from the ground for nectar. It has a cibarial pump to get nectar up and then put into its esophagus (Gibson, 2001)

Adults of *M. prometheus*, *M. sitiene* and *N. hyas* were diurnal moths of which mating behavior and egg laying were carried by the adults occurred mostly during the daytime. Number of eggs laid was more than 120 eggs/female insect. Adults of *M. prometheus*, *M. sitiene* and *N. hyas* were diurnal moths of which mating behavior and egg laying were carried by the adults occurred mostly during the daytime. Solomon Rajuet *al.* (2015) stated that *N. hyas*' foraging period was during the day or twilight period. Number of eggs laid was more than 120 eggs/female insect. Eggs of *M. gyrans* were found parasitized by wasps and the final instar was frequently attacked by Tachinid flies. *Trichogramma* sp. was an egg parasitoid of *N. hyas*.

Table 1 Host plants of noni hawk moths

Hawk moth species	Host plant	Plant family
<i>M. gyrans</i>	<i>Morindacitrifolia</i>	Rubiaceae
<i>M. sitiene</i>	<i>Morindacitrifolia</i> , <i>M. tomentosa</i> , <i>Paederialinearis</i>	Rubiaceae
	<i>Caladium bicolor</i>	Araceae(Leuvanich, 1991)
	<i>Duabangagrاندiflora</i>	Sonneratiaceae(Leuvanich, 1991)
<i>M. prometheus</i>	<i>Morindacitrifolia</i>	Rubiaceae
<i>Neogurelcahyas</i>	<i>Morindacitrifolia</i>	Rubiaceae
	<i>Paederialinearis</i>	
	<i>Paederiascandens</i>	(Pittaway and Kitching,2010)
	<i>Paederiafoetida</i>	(Pittaway and Kitching,2010)
	<i>Serissafoetida</i>	(Pittaway and Kitching,2010)

Table 2 Developmental stages of *M. gyrans*¹

Growth stages	Duration time (days)	Head capsule width (mm)	Dorsal horn length (mm)
egg	3.31±0.10		
1 st instar	1.68±0.15	0.48±0.02	0.74±0.01
2 nd instar	1.39±0.16	0.72±0.04	1.48±0.01
3 rd instar	1.65±0.30	1.23±0.05	2.23±0.32
4 th instar	4.17±0.63	1.91±0.13	3.08±0.21
5 th instar	10.27±0.75	2.76±0.17	3.81±0.46
pupa	9.37±0.90		
adult	5.25±1.73		

¹Values are means of thirty replicates ± SD**Table 3** Developmental stages of *M. prometheus*¹

Growth stages	Duration time (days)	Head capsule width (mm)	Dorsal horn length (mm)
egg	3.12±0.07		
1 st instar	1.67±0.15	0.61±0.01	2.12±0.25
2 nd instar	1.71±0.27	1.03±0.03	4.03±0.31
3 rd instar	1.77±0.30	1.67±0.06	6.55±0.65
4 th instar	2.27±0.26	2.48±0.02	9.86±0.75
5 th instar	4.88±0.64	3.55±0.18	11.01±0.71
pupa	13.15±1.15		
adult	5.50±1.67		

¹Values are means of thirty replicates ± SD

Table 4 Developmental stages of *M. sitiene*¹

Growth stage	Duration time (days)	Head capsule (mm)	Dorsal horn (mm)
egg	2.83±0.07		
1 st instar	1.52±0.21	0.59±0.03	1.72±0.20
2 nd instar	1.30±0.16	0.99±0.02	3.15±0.21
3 rd instar	1.73±0.26	1.47±0.04	5.02±0.52
4 th instar	2.11±0.26	2.08±0.75	7.68±0.65
5 th instar	4.81±0.30	3.16±0.22	8.24±0.99
pupa	11.42±1.12		
adult	6.25±1.67		

¹Values are means of thirty replicates ± SD**Table 5** Developmental stages of *Neogurelca hyas*¹

Growth stage	Duration time (days)	Head capsule (mm)	Dorsal horn (mm)
egg	3.14±0.08		
1 st instar	1.81±0.07	0.55±0.02	0.75±0.02
2 nd instar	2.02±0.35	0.79±0.05	1.81±0.18
3 rd instar	2.01±0.08	1.24±0.02	3.19±0.29
4 th instar	2.32±0.34	1.72±0.06	5.07±0.71
5 th instar	3.89±0.63	2.50±0.16	5.93±0.62
pupa	8.91±0.92		
adult	8.70±2.57		

¹Values are means of thirty replicates ± SD**Table 6** Sizes in mm of adult hawk moths¹

<i>Hawk species</i>	<i>Body length</i>	<i>Wingspan length</i>	<i>Antenna length</i>	<i>Proboscis length</i>
<i>M. gyrans</i>	26.00±0.82	44.50±5.32	11.15±1.29	21.50±2.45
<i>M.prometheus</i>	30.12±5.89	57.30±2.98	13.16±0.75	27.60±1.97
<i>M. sitiene</i>	27.30±2.10	47.61±2.89	11.83±0.76	28.73±1.78
<i>N. hyas</i>	18.18±1.18	37.00±2.46	7.75±0.64	17.05±0.71

¹Values are means of thirty replicates ± SD

Normally, the female are larger than the male counterpart. Three morphological difference was found between male and female hawk moths: 1) antenna 2) lunulate fantail for a female and trilobite fantail for a male 3) a frenulum for a male and frenula for a female. The principal host plant was *Morinda citrifolia* in family Rubiaceae and *M. sitiene* had more various host plants. It was a common insect and could be found during April-June and September-November. Spatial distribution of these hawk moths in Thailand was as follows: *M. sitiene* in Ayutthaya, Bangkok, Chachoengsao, Chumphon, Khonkaen, Nakhonayok, Nonthaburi, Pathumthani, Phetchaburi, Prachinburi, Prachuapkhirikhan, Ranong, Ratchaburi, Rayong, Tak, and Trat; *M. gyrans* in Chaiyaphum, Uttaradit and Bangkok; *M. prometheus* in Sakaeo, Uttaradit, Nan and Prachinburi and *N. hyas* in Bangkok (Table 7).

Table 7 Distribution of noni hawk moth in Thai provinces from observation and recorded in foreign countries from literature review

Hawk moth species	Thailand	Foreign countries
<i>M. gyrans</i>	Bangkok, Chaiyaphum and Uttaradit	Southeast Asia and Madagascar (Wikipedia, 2014)
<i>M. prometheus</i>	Nan, Prachinburi and Uttaradit	Australia, China, Indonesia, Malaysia, New Guinea (Holloway, 1987)
<i>M. sitiene</i>	Ayutthaya, Bangkok, Chachoengsao, Chumphon, Khonkaen, Nakhonayok, Nonthaburi, Prachinburi, Pathumthani, Phetchaburi, Prachuapkhirikhan, Ranong, Ratchaburi, Rayong, Tak, and Trat	Sri Lanka, eastern India, Bangladesh, Myanmar, southern China, Taiwan, southern Japan, Vietnam, Malaysia and Indonesia (Wikipedia, 2015; Pittaway and Kitching, 2010)
<i>N. hyas</i>	Bangkok	India, Nepal, Myanmar, central and southern China, Taiwan, southern Japan, Vietnam, Malaysia, Indonesia and the Philippines (Wikipedia, 2014; Pittaway and Kitching, 2010)

Acknowledgement

We would like to thank Faculty of Agricultural Technology, KMITL for research facilities. Thanks go to Mr. Jakkrit Sangsawang, Ms. Pratanit Charoenratnaprapa, Ruedeemas Deesorn and Suparat Ladwong for insect rearing assistance and data collection.

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