ABIOTIC AND BIOTIC FACTORS AFFECTING THE OCCURRENCE OF THRIPS ON LOTUS FLOWERS

BUMROONGSOOK, S.

Department of Plant Production Technology, Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok 10520, Thailand
(e-mail: suvarin.bu@kmitl.ac.th)

(Received 13th Feb 2018; accepted 9th May 2018)

Abstract. *Frankliniella schultzei* Trybom and *Scirtothrips dorsalis* Hood are two important insect pests of lotus flowers (*Nulumbo nucifera* Gearn). Both are active throughout the year and are difficult to control during pre- and post- harvest management. This study is focused on factors that influence the relationship among the thrips, their host plants and abiotic factors. Therefore, the distribution of these thrips species within lotus flowers of different flower ages was assessed using randomly sampling from commercially growing areas in Bangkok, Thailand and investigated thrips abundance on these flowers every week from April to September, 2016. The results revealed that there was a higher thrips population on older lotus flowers. *S. dorsalis* was much more abundant in summer than in the rainy season. It was found mainly on the pedicel and the outer corolla of the flowers. In the summer and rainy season, *F. schultzei* occurred most often and were found on the distal parts of lotus petals and pollen areas. Hindu lotus and East Indian lotus could support more of *F. schultzei* and *S. dorsalis* than Album Plenum and Roseum Plenum. The correlation among abiotic factors (temperature, amount of rainfall and relative humidity) and population fluctuations of *S. dorsalis* and *F. schultzei* was assessed. The studies showed a positive correlation of temperature (r = 0.7918) and a negative correction of relative humidity (r = -0.7588) to population of *S. dorsalis* but no relation with amount of rainfall (r = 0.0260). Whereas, there were non-significant correlations among *F. schultzei* and temperature (r = 0.43650, relative humidity (r = -0.2113) and rainfall (r = -0.4164). Interactions between different temperatures, relative humidity and rainfall effects on the abundance of the thrips were seen here. Both fundamental and applied perspectives will provide better understanding the thrips population abundance, and help to develop management plans for thrips control.
Keywords: *F. schultzei, population fluctuation, S. dorsalis, relative humidity, rainfall*

Introduction

Currently, insect pests are an important factor in lotus farming that affect the quantity and quality of the agricultural product. Farmers use chemicals as the primary measure to prevent damage caused by insects. Thrips are major enemies of both vegetable crops and ornamental plants. They use their stylets to obtain water and liquid nutrients from various plant cells including shoots, flowers and leaves, which results in a pale color or dry edges of affected plant tissue. The insects are highly polyphagous. Both *Scirtothrips dorsalis* Hood (chilli thrips) and *Frankliniella schultzei* Trybom (common blossom thrips) are two important insect pests of lotus flowers (*Nulumbo nucifera* Gearn) grown for export (Mungnimitr and Bumroongsook, 2007). The chilli thrips is a serious insect pest of lotus, agricultural crops and various floral plants. It is most often found feeding on young shoots and leaves and causes scars on fruit surface (Seal and Klassen, 2008).

The common blossom thrips are abundant on sacred lotus in Thailand (Mound and Palmer, 1981). It is an anthophilous insect and often feed on the floral parts of its host plant (Kakkar et al., 2012b), and is capable of destroying parts of the lotus flower. Both larvae and adults usually stay at the base of the petals and feed on plant cells (Mungnimitr and Bumroongsook, 2007), but can feed on other plant parts such as petals and leaves (Milne et al., 1996). It is a highly polyphagous insect, infesting a wide range of vegetable

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

crops and ornamental plants (Moritz et al., 2013). The thrips aggregate and colonize on plant petals (Milne et al., 2002) and can also pollinate various host plants (Kirk, 1997), although they can disfigure ornamental flowers in the process. Heavy infestation can discolor of flowers and distort the growth of young shoots (Amin and Palmer, 1985). Both forms of *F. schultzei* (dark and pale forms) can also be insect vectors for virus transmission (Nagata and De Avila, 2000; Cho et al., 1988).

Abiotic and biotic factors work in combination to shape species distributions and abundance (Lewis et al., 2017). Temperature is one of the important abiotic factors that affects abundance, distribution and population dynamics of insects (Kang et al., 2009; Yadav and Chang, 2014). Thrips population had a positive correlation with temperature and showed a negative correlation with relative humidity (Shuaib et al., 2008). Climatic factors are important factors that significantly influence thrips density as well (Kirk, 1997; Waiganjo et al., 2008). High temperatures with no rainfall increased thrips populations, while high relative humidity and rainfall had a negative relationship (Hamdy and Salem, 1994).

Biotic factors associated with host plants can affect species distributions and abundance. Plant aging increased mortality and influenced larval development of thrips (Campos et al., 2003). A nutrient supplement (nectar/pollen) is essential for insect survival in the absence of prey, or a modified microhabitat which can protect it against severe abiotic conditions (Xiao et al., 2011). Asian lotus flower is a concave shape and without nectar, having a cavity surrounded by petals and stamens and releasing scent. The flower has a thermoregulation process that can control temperature during anthesis and an optimum temperature between 30 and 36 °C when the environmental temperature is between 10 and 45 °C (Seymour et al., 1998; Seymour and Schultze-Motel, 1996; Xiao et al., 2011). Thrips are a lotus flower pollinator. The level of plant damage is dependent on *S. dorsalis* density (Mannion et al., 2014).

The objectives of this research are to determine seasonal population fluctuation and within lotus flower distribution of *F. schultzei* and *S. dorsalis*. The correlation of abiotic factors: temperature, relative humidity and amount of rainfall and population abundance of thrips on lotus flowers were evaluated. Understanding the influence of these abiotic and biotic factors on thrips abundance can help to further develop more efficient management programs for thrips control.

Materials and methods

Location of the sample sites

The experimental sites were located in Ladkrabang district of Bangkok province. Eleven sites of sample collection were chosen based on lotus varieties and non pesticide-treated areas (*Fig. 1*). GPS coordinates for location and the distance from sample sites to the data logger including the lotus plant variety were illustrated in *Table 1*. S1 and S2 are the experimental sites for collection of Hindu lotus (a single white flower); S3 and S4 for Album Plenum (a double white flower); S5-S6 for East Indian lotus (a single pink flower); and S7-S11 for Roseum Plenum (a double pink flower, *Table 1*).

Population density of S. dorsalis and F. schultzei on different stages of lotus flowers

Differently aged lotus flowers (*N. nucifera* var. Roseum Plenum), i.e., small bud, standard bud and full bloom (5, 9 and 13 days above water level, respectively; n = 30),

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

were collected weekly from non-chemical lotus farms in Ladkrabang area, Bangkok, Thailand. Direct thrips count was performed using a stereomicroscope and total number of thrips found on each type of flower was recorded.

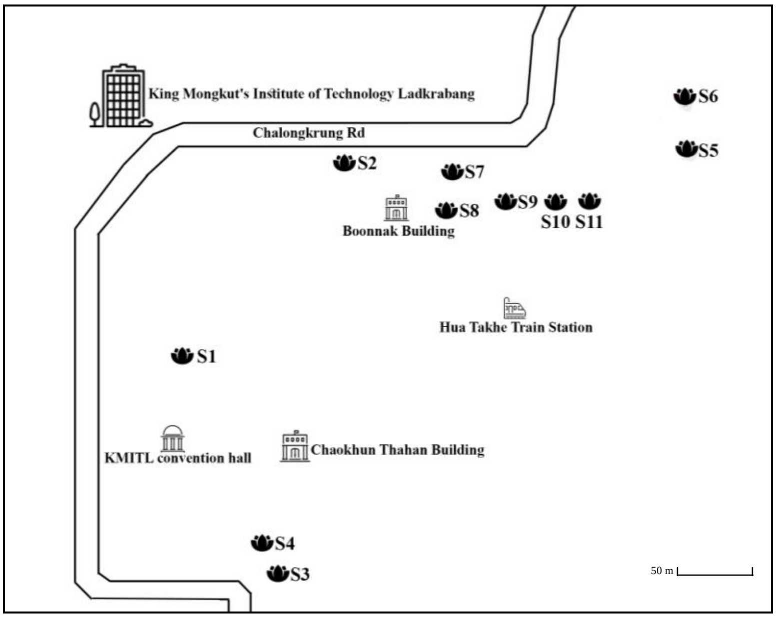

Figure 1. *Location of the sample sites in Ladkrabang district*

Table 1. *Description of eleven sample sites located in Ladkrabang district, Bangkok, Thailand*

Sample sites	Location	Distance to the data logger (km)	Lotus varieties
S1	13°43'38.0"N 100°46'46.9"E	0.200	Hindu lotus
S2	13°43'48.6"N 100°46'53.4"E	0.126	Hindu lotus
S3	13°43'30.1"N 100°46'49.7"E	0.286	Album Plenum
S4	13°43'30.8"N 100°46'49.3"E	0.578	Album Plenum
S5	13°43'49.2"N 100°47'09.3"E	0.318	East Indian lotus
S6	13°43'51.7"N 100°47'09.2"E	0.340	East Indian lotus
S7	13°43'48.3"N 100°46'58.2"E	0.020	Roseum Plenum
S8	13°43'46.9"N 100°46'57.7"E	0.047	Roseum Plenum
S9	13°43'47.6"N 100°46'59.5"E	0.043	Roseum Plenum
S10	13°43'47.6"N 100°47'00.7"E	0.074	Roseum Plenum
S11	13°43'47.6"N 100°47'01.5"E	0.101	Roseum Plenum

Comparison of the abundance of S. dorsalis and F. schultzei on different parts of lotus flower

Standard buds of Roseum Plenum lotus flowers (n = 30) were collected and thrips count on its pedicel, petals and pollen areas of lotus cut flower were performed. Thrips density of *S. dorsalis* and *F. schultzei* from these flower parts was identified and recorded.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

Number of thrips on the different corolla of lotus flowers

Roseum Plenum lotus flowers are composed of six corolla: the first corolla are the outermost petas, and the innermost petals are the sixth corolla. Standard lotus flowers var. Roseum Plenum (n = 30) were collected weekly. Thrips count on each corolla were investigated.

Thrips abundance on different varieties of lotus flowers

A total of 30 lotus flowers were randomly selected from each of four varieties of *N. nucifera*: Hindu lotus (a single white flower), Album Plenum (a double white flower), East Indian lotus (a single pink flower) and Roseum Plenum (a double pink flower). Number of thrips found on lotus was investigated and recorded.

Correlation among thrips population abundance and temperature, relative humidity and rainfall

A total of 30 Roseum Plenum lotus flowers were randomly selected. Thrips counts of *S. dorsalis* and *F. schultzei* on each flower and its pedicel was performed. For the temperature and relative humidity dataset, a data logger (DT172-CEM G M Electronics) was used to record air temperature and relative humidity every hour The weather data (daily average observation for air temperature and relative humidity) was computed. The data logger was placed on the wall of the storage house (5 m from S7) at 1.5 m above the ground with protective roof. The amount of rainfall at Ladkrabang area obtained from the Thai Meteorological Department.

Data collection and statistical analysis

The experimental period was spread out across two seasons: summer (April-May, 2016) and rainy season (June-September, 2016). Samples were collected once a month for six months and processed independently for each experiment. To reduce light intensity variation effect on thrips population, all samples were collected between 7 and 9 am. Thrips were collected from plant parts, then transferred in 70% ethanol for later analysis. They were identified to species using a stereomicroscope. The SPSS statistical software was used to perform data analysis. Population density of thrips were analyzed separately for each experiment using the paired sample t-test to determine the mean difference between density of *S. dorsalis* and *F. schultzei*. ANOVA was applied to assess the mean difference of thrips occurrence among lotus varieties. Linear regression analysis was used to assess correlation among thrips occurrence and abiotic factors**.**

Results

Population density of S. dorsalis and F. schultzei on different stages of Roseum Plenum lotus flowers

Thrips counts on the same type of flower buds were compared and the results showed that the older the flower buds were, the more thrips were found. In the small flower buds, no difference was found in the density of *F. schultzei* detected than *S. dorsalis* (t-value = 1.29 and p = 0.1125). *F. schultzei* were found more than *S. dorsalis* in the standard-sized buds (t = 2.19 and p = 0.0264) and the full bloom lotus flowers

APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH 16(3):2827-2836.
http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

(t = 3.11 and p = 0.0054; *Table 2*). *F. schultzei* was found the most on full bloom lotus flowers.

Comparison of the abundance of S. dorsalis and F. schultzei on diffirent parts of Roseum Plenum lotus flowers

S. dorsalis was found on flower pedicel and petals and none were detected in the middle area of flowers (containing pollen and stamen). Comparing *S. dorsalis* and *F. schultzei* occurrence on flower pedicels, the result showed no significant difference (t = 1.46 and p = 0.0869). *F. schultzei* were detected more than *S. dorsalis* on lotus flower petals (t = 2.82 and p = 0.0091), as well as stamen and pollen areas (t = 2.56 and p = 0.0141; *Table 3*).

Table 2. *Population density of S. dorsalis (S) and F. schultzei (F) on different stages of Roseum Plenum lotus flower*

Months (2016)	Thrips density[1] on different stages of flower					
	Small bud		Standard bud		Full bloom	
	S	F	S	F	S	F
April	0.16	3.42	1.20	3.04	7.09	14.31
May	0.68	2.03	2.55	16.03	2.75	48.70
June	0.44	0.49	0.96	7.73	0.68	20.69
July	1.18	0.90	0.63	1.78	0.35	16.58
August	1.08	0.91	0.08	9.01	0.01	30.51
September	0.00	0.00	0.00	0.00	0.73	2.867

Table 3. *Number of S. dorsalis (S) and F. schultzei (F) found on different parts of Roseum Plenum lotus flowers*

Months (2016)	Thrips density					
	Flower pedicel		Petal		Pollen and stamen	
	S	F	S	F	S	F
April	1.87	0.00	1.29	0.86	0.00	4.99
May	0.38	0.42	0.52	7.24	0.00	17.43
June	0.37	0.05	0.87	0.78	0.00	3.02
July	0.09	0.00	0.96	2.94	0.00	3.48
August	0.30	0.00	0.08	7.01	0.00	6.46
September	0.00	0.00	0.22	6.69	0.00	1.21

Number of thrips on the different corolla of Roseum Plenum lotus flowers

S. dorsalis were found from the first to the third corolla of Roseum Plenum flowers (*Table 4*). *F. schultzei* could be located from the outermost to the innermost corollas (*Table 5*). Density of *F. schultzei* appeared higher than *S. dorsalis* on different corolla.

Thrips abundance on different varieties of lotus flowers

S. dorsalis occurrence peaked in April and decreased gradually from May to September. They preferred Hindu lotus and East Indian lotus followed by Album Plenum and Roseum Plenum (*Table 6*). *F. schultzei* was found most in East Indian lotus during April and May, 2016 and its population was highest in Hindu lotus from June to

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

September, 2016 (*Table 7*). *F. schultzei* was detected more in Roseum Plenum in May and June than Album Plenum.

Table 4. *Population density of S. dorsalis on different corolla of Roseum Plenum lotus flowers*

Months (2016)	Population density of *S. dorsalis* on the corolla no.					
	1	2	3	4	5	6
April	5.98	1.93	1.35	0.00	0.00	0.00
May	1.40	0.62	0.73	0.00	0.20	0.00
June	0.22	0.11	0.04	0.00	0.00	0.00
July	0.62	0.15	0.33	0.00	0.00	0.00
August	0.04	0.00	0.00	0.00	0.00	0.00
September	0.11	0.02	0.02	0.00	0.00	0.00

Table 5. *Population density of F. schultzei on different corollas of Roseum Plenum lotus flowers*

Months (2016)	Population density of *F. schultzei* on the corolla no.					
	1	2	3	4	5	6
April	0.02	.0.31	0.00	0.00	0.00	0.00
May	0.31	2.24	0.47	1.80	0.82	0.91
June	0.18	9.40	0.04	5.44	0.71	0.91
July	0.15	22.58	0.31	8.56	2.27	2.24
August	0.20	19.27	0.13	7.56	1.91	0.78
September	0.00	8.04	0.00	3.31	1.49	0.02

Table 6. *Population density of S. dorsalis on different varieties of lotus flower*

Months (2016)	Number of *S. dorsalis*[1]			
	Hindu lotus	Album Plenum	East Indian lotus	Roseum Plenum
April	21.80b	16.04b	36.04a	3.60c
May	21.75a	3.91bc	9.04b	2.07c
June	6.51a	1.02b	1.42b	3.27ab
July	6.62a	1.02b	1.42b	3.27ab
August	0.47a	0.09a	2.71a	0.44a
September	0.00b	0.18b	1.69a	0.35b

[1]Within rows, means followed by the same letters are not significantly different (P = 0.05, DMRT)

Table 7. *Population density of F. schultzei on different varieties of lotus flower*

Months (2016)	Number of *F. schultzei*[1]			
	Hindu lotus	Album Plenum	East Indian lotus	Roseum Plenum
April	14.05b	1.07b	57.27a	2.58b
May	12.09c	3.33c	73.62a	28.95b
June	34.49a	1.36c	11.53bc	14.60b
July	143.67a	20.07c	54.00b	11.78c
August	185.15a	10.24c	141.95b	35.07c
September	20.37a	0.00c	7.33b	0.27c

[1]Within rows, means followed by the same letters are not significantly different (P = 0.05, DMRT)

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

Correlation among thrips population abundance and temperature, relative humidity and rainfall

The climatic conditions from April to September, 2016 in the study area ranged from 27.20–32.57 °C, RH 72–83% and rainfall 0–19 mm (*Table 8*). *S. dorsalis* density on lotus flower was highest in April and deceased gradually to 10.85, 11.68 and 7.85 in May, June and July, respectively. In August and September, there were 1.17 and 1.45 thrips/flower, respectively (*Fig. 2*). *F. schultzei* density was highest in August and lowest in June. The correlation between the amount of thrips on lotus flower over the five months of sampling and the abiotic factors temperature, relative humidity and rainfall was statistically analyzed. The results showed that temperature and relative humidity were significantly correlated with the change in *S. dorsalis* (r = 0.7918 and -0.7588, respectively). *F. schultzei* density on lotus flowers was not significantly correlated to temperature, relative humidity and rainfall (*Table 9*).

Table 8. *Abiotic condition of temperature, relative humidity and rainfall during the sampling periods*

Months (2016)	Temp (°C)	RH (%)	Rainfall (mm)
April	32.57	72	0.00
May	28.20	80	8.95
June	30.36	75	19.00
July	28.60	79	1.50
August	29.50	75	0.68
September	27.20	83	0.00

Discussion

Both abiotic and biotic factors affect insect population abundance (Lewis et al., 2017). *S. dorsalis* is a polyphagous insect pest with a global distribution (Dickey et al., 2015). It feeds on meristem and young plant parts. *S. dorsalis* prefers the outer corolla of lotus flower and its pedicel. In addition, it feeds on lotus leaves (Mungnimitr and Bumroongsook, 2007). *F. schultzei* primarily attacked lotus flowers and caused discoloration. The female deposits egg on flower tissue and it takes about 13 days to complete life cycle (Kakkar et al., 2012a). *F. schultzei* was observed on full bloom lotus flowers. Aggregation density of insects on host plant corollas induce mating success (Kang et al., 2009). High density of *F. schultzei* on lotus flowers was similar to the finding of Kakkar et al. (2012b), who reported that adult are the most numerous in tomato flower.

As noted above, Hindu lotus and East Indian lotus are categorized as a single flower and Album Plenum and Roseum Plenum are a double flower (Mandal and Bar, 2013). The structure of single lotus flowers could allow *F. schultzei* to build up populations more easily than double lotus flowers. Further studies should be investigated if various colors of lotus flowers attract thrips to different degrees.

The lower the relative humidity value and the higher the temperature, the higher the number of *S. dorsalis* observed. Previous research reported similar results on relationship among temperature, relative humidity and thrips population (Hamdy and Salem, 1994). *S. dorsalis* was found on leaves and the outer parts of lotus flowers, therefore it is more exposed to the environmental condition than *F. schultzei*. On the contrary, *F. schultzei* density on lotus flowers might not depend on the abiotic factors

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

like temperature, relative humidity and rainfall due to its cryptic habitat. The microhabitat within flowers could play important roles on observed population of thrips (Salguero_Navas et al., 1991).

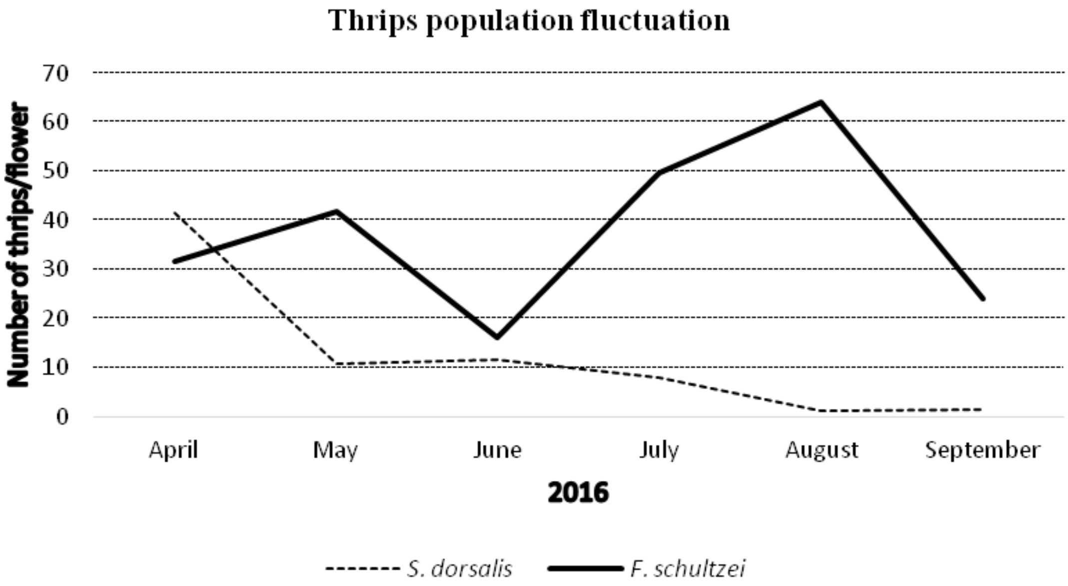

Figure 2. *Population density of thrips on lotus flowers*

Table 9. *Correlation of population density of S. dorsalis and F. schultzei and temperature, relative humidity and rainfall*

Thrips species	Correlation coefficient		
	Temperature	**Relative humidity**	**Rainfall**
S. dorsalis	0.7918*	-0.7588*	-0.0260
	(0.8899)	(0.8711)	(0.1613)
F. schultzei	0.4365	0.2113	0.4164
	(0.6607)	(0.4597)	(0.6453)

(R) = values in parentheses are R adjusted
*Statistically difference at $p = 0.05$

Conclusions

S. dorsalis attacked flower pedicels and the outer part of lotus petals and population peak during high temperature and dry weather. Abiotic factors such as the temperature and relative humidity played a remarkable role on *S. dorsalis* abundance. Regarding *F. schultzei*, this is the first report that they attack four varieties of lotus flowers. The *F. schultzei* mainly inhabit and feed on the petals and the pollen areas of lotus flower. Biotic factors (age of host plant and food selection) shaped the distribution and abundance of *F. schulzei*. In addition, lotus flower structures as protective shelter and microclimate within the flowers are factors that influenced the population abundance of *F. schulzei*. Size and cryptic behavior of these thrips make them difficult to control. Therefore, phytosanitary treatment of these thrips for lotus cut flowers export is probably the most challenging task.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

Acknowledgements. Thanks go to Assoc. Prof. Saen Tigwattananont for thrips identification. My thanks also extend to Ms Sayomporn Pleansri, King Saengkoso and undergraduate students who participated in all aspects of data collection.

REFERENCES

[1] Amin, P. W., Palmer, J. M. (1985): Identification of groundnut Thysanoptera. – Tropical Pest Management 31(4): 286-291.

[2] Campos, W. G., Schoereder, J. H., Picancol, M. C. (2003): Performance of an oligophagous insect in relation to the age of the host plant. – Neotropical Entomology 32(4): 671-676.

[3] Cho, J. J., Mau, R. F. L., Hamasaki, R. T., Gonsalves, D. (1988): Detection of tomato spotted wilt virus in individual thrips by enzyme-linked immunosorbent assay. – Phytophathology 78: 1348-1852.

[4] Dickey, A. M., Kumar, V., Hoddle, M. S., Funderburk, J. E., Morgan, J. K., Jara-Cavieres A., Shatters, R. G. Jr, Osborne, L. S., McKenzie, C. L. (2015): The *Scirtothrips dorsalis* species complex: endemism and invasion in a Global Pest. – PLoS One 10(4): e0123747.

[5] Hamdy, M. K., Salem, M.(1994): The effect of plantation dates of onion, temperature and relative humidity on the population density of the onion thrips, *Thrips tabaci* Lind. in Egypt. – Annals of Agricultural Science 39(1): 417-424.

[6] Kakkar, G., Seal, D. R., Kumar, V. (2012a): Assessing abundance and distribution of an invasive thrips *Frankliniella schultzei* (Thysanoptera: Thripidae) in South Florida. – Bulletin of Entomological Research 102: 249-259.

[7] Kakkar, G., Seal, D. R., Stansly, P. A., Liburd, O. E., Kumar, E. (2012b): Abundance of *Frankliniella schultzei* (Thysanoptera: Thripidae) in flowers on major vegetable crops of South Florida. – Florida Entomologist 95(2): 468-475.

[8] Kang, L., Chen, B., Wei, J. N., Liu, T. X. (2009): Roles of thermal adaptation and chemical ecology in Liriomyza distribution and control. – Annal. Review of Entomology 54: 127-145.

[9] Kirk, W. (1997): Feeding. In: Lewis, T. (ed.) Thrips as Crop Pest, pp.119-174. – CAB International, Wallingford.

[10] Lewis, J. S., Farnsworth, M. L., Burdett, C. L., Theobald, D. M., Gray, M., Miller, R. S. (2017): Biotic and abiotic factors predicting the global distribution and population density of an invasive large mammal. – Scientific Report 7: 441-452.

[11] Mandal, R. N., Bar, R. (2013): The sacred lotus: An incredible wealth of wetlands. – Resonance 18(8): 732-737.

[12] Mannion, C. M., Derksen, A. I., Seal, D. R., Osborne, L. S., Martin, C. G. (2014): Population dynamics of *Scirtothrips dorsalis* (Thysanoptera: Thripidae) and other thrips species on two ornamental host plant species in Southern Florida. – Environmental Entomology 43(4): 849-858.

[13] Milne, J. R., Jhumlekhasing, M., Walter, G. H. (1996): Understanding Host Plant Relationships of Polyphagous Flower Thrips, a Case Study of *Frankliniella schultzei* (Trybom). In: Goodwin S, Gillespie, P. (eds) – Proceedings of the 1995 Australia and New Zealand Thrips Workshop: Methods, Biology, Ecology and Management, pp. 8-14. NSW Agriculture, Gosford.

[14] Milne, M., Walter, G. H., Milne, J. R. (2002): Mating aggregations and mating success in the flower thrips, *Frankliniella schultzei* (Thysanoptera: Thripidae), and a possible role for pheromones. – Journal of Insect Behavior 15: 351–368.

[15] Moritz G, Brandt S, Triapitsyn, S., Subramanian, S. (2013): Identification and Information Tools For Pest Thrips in East Africa. – Centre for Pest Information Technology and Transfer, The University of Queensland, Brisbane.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836

[16] Mound, L. A., Palmer, J. M. (1981): Identification, distribution and host plants of the pest species of *Scirtothrips*. (Thysanoptera: Thripidae). – Bulletin of Entomological Research 71: 467-479.
[17] Mungnimitr, S., Bumroongsook, S. (2007): Identification of *Frankliniella schultzei* (Trybom) and *Scirtothrips dorsalis* Hood on *Nelumbo nucifera* Gaertn by ITS-RFLP. – The Proceeding of IWGS Annual Symposium, SuanLuang Rama IX Public Park, Bangkok.
[18] Nagata, T., De Avila, A. C. (2000): Transmission of chrysanthemum stem necrosis virus, a recently discovered tospovirus, by thrips species. – Journal of Phytopathology 148: 123-125.
[19] Salguero_Navas, V. E., Funderburk, J. E., Beshear, R. J., Olson, S. M., Mack, T. P. (1991): Seasonal patterns of *Frankliniella* spp. (Thysanoptera: Thripidae) in tomato flowers. – Journal of Economic Entomology 84: 1818-1822.
[20] Seal, D. R., Klassen, W. (2008): Chilli Thrips, *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae). In: Capinera, J. L. (eds.) Encyclopedia of Entomology. – Springer, Dordrecht.
[21] Seymour, R. S., Schultze-Motel, P. (1996): Thermoregulating lotus flowers. – Nature 383: 305.
[22] Seymour, R. S., Schultze-Motel, P., Lamprecht, I. (1998): Heat production by sacred lotus flower depends on ambient temperature, not light cycle. – Journal of Experimental Botany 49: 1213-1217.
[23] Shuaib, M., Khan, S. H., Mulghani, N. A. (2008): Effect of temperature and relative humidity on population dynamics of sucking insect pests of cotton (*Gossypium hirsutum* L.). – ENDURE International Conference 2008: Diversifying Crop Protection, 12-15 October 2008, La Grande-Motte, France.
[24] Waiganjo, M. M., Gitonga, L. M., Mueke, J. M. (2008): Effects of weather on thrips population dynamics and the implication on the thrips management. – African Journal of Horticultural Science 1: 82-90.
[25] Xiao, Y. F., Chen, J., Cantliffe, D., McKenzie, C. L., Houben, K., Osborne, L. S. (2011): Establishment of papaya banker plant system for parasitoid, *Encarsia sophia* (Hymenoptera: Aphilidae) against *Bemisia tabaci* (Hemiptera: Aleyrodidae) in greenhouse tomato production. – Biological Control 58(3): 239-47.
[26] Yadav, R., Chang, N. T. (2014): Effects of temperature on the development and population growth of the melon thrips, *Thrips palmi*, on eggplant, *Solanum melongena*. –J of Insect Science 14: 78.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1603_28272836