ZIBELINE INTERNATIONAL™ PUBLISHING

SSN: 2521-0858 (Print)
ISSN: 2521-0866 (Online)
CODEN: SHJCAS

Science Heritage Journal (GWS)

DOI: http://doi.org/10.26480/gws.02.2021.29.33

RESEARCH ARTICLE

BIOLOGICAL TRAITS OF BEAN FLOWER THRIPS, *Megalurothrips usitatus* (THYSANOPTERA: THRIPIDAE) REARED ON MUNG BEAN

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ARTICLE DETAILS

Article History:

Received 06 September 2021
Accepted 09 October 2021
Available online 14 October 2021

ABSTRACT

The bean flower thrips, *Megalurothrips usitatus* is a major pest of mung bean that causes flower dropping and significant yield loss of the crop. *M. usitatus* demonstrated to have variable lifespan when reared on different leguminous hosts but on mung bean, an important pulse crop in Bangladesh, is unknown. The experiment was conducted to determine the biological attributes of *M. usitatus* on mung bean in a climate control chamber at 26 ± 1°C, 75 ± 3% RH, and 16:8 hours L:D in the laboratory. The results revealed that the incubation period, first instar larva, second instar larva, prepupa, and pupal period of *M. usitatus* were 3.13 ± 0.06, 1.48 ± 0.05, 2.30 ± 0.08, 1.30 ± 0.07, and 2.26 ± 0.13 days, respectively. The combined developmental period from egg to adult was 10.54 ± 0.15 (mean ± SE) days. The larvae of *M. usitatus* were similar in appearance to the adults, but they lacked wings and were smaller and different in color. The first instar was pale yellow, while the second instar was darker and larger, ranging from deep yellow to orange-red. The wing pads of the prepupae were shorter than that of the pupae. The antennae of the prepupa were straight, but they were bent in the pupa. In the case of pre-adult mortality of *M. usitatus*, the mortality of the first instar larva was 14.41%, second instar larva 22.77%, prepupa 14.10%, and pupa 65.67%. The pre-adult mortality was 80.51% overall. Adult males had lower longevity (6.42 ± 0.44 days) than females (12.07± 1.56 days). The developmental period of *M. usitatus* on mung bean indicated the suitability of the leguminous crop as a potential host, as well as the need for information on the pest's various growth stages in order to design effective management strategies.

KEYWORDS

Megalurothrips usitatus, developmental period, pre-adult mortality, longevity, mung bean.

1. INTRODUCTION

Thrips (Thysanoptera: Thripidae) is one of the major insect pests of mung bean (*Vigna radiata*) that causes severe losses of the crop (Hossain et al*.,* 2004; Rahman et al., 2000). *Megalurothrips usitatus* (Bagnall) is the most prevalent thrips in the blossoms of cultivated legume plants over most of tropical Asia (Palmar, 1987). *M. usitatus* causes significant damage by feeding directly on the contents of individual plant cells, resulting in a decrease in photosynthetic ability (Shipp et al., 2000). Silvering is the most prevalent symptom caused by thrips removing the cell contents that can be seen on leaf tissue. The crop's blossoming period is especially vulnerable to this pest, and losses resulting from scarring and deformation of petals and fruits are more economically significant (Zhang et al., 2007). Thrips can be found throughout the growing season and cause yield losses by causing blooms to drop prematurely. Thrips can injure bean pods in a variety of ways, from mild scarring to severely twisted and scared pods.

Within the flower, thrips feed on the pollen and nectar generated by the flower, as well as the developing pods, which are soft green and easily injured (Duff, 2012). *M. usitatus* is not known to spread viruses. The larvae of thrips cause more harm than adults due to their vast numbers, low mobility, gregariousness, and commitment to feeding (Childers, 1997). All the scars made by thrips on the leaves, petals, pods, and young stem cause dehydration in plants, resulting in flower drops. Flower shedding of 40-89% has been documented in mung bean (Sinha, 1977). The infestation of *M. usitatus* on mung bean during the vegetative stage through the pod filling stage is adversely correlated with grain yield, resulting in a yield loss. This harm happens inside the flowers when the pods are being fertilized and where the thrips are protected (Sepswasdi et al., 1991). Mung bean yield losses range from 13% to 64% when infested with *M. usitatus* (Farajallah, 2013).

Thrips have a short life cycle from egg to adult, which varies depending on the host and abiotic variables. Egg, larval I, larval II, prepupa, pupa, and adult are the six developmental stages of *M. usitatus.* Adults emerge in about 5 days after the mature larvae crawl downward and pupate 1-6 cm below the soil surface (Chang, 1987). Depending on temperature and humidity, most thrips complete their life cycle from eggs to adults in 2-3 weeks (Kirk, 1997). Thrips reproduce more quickly at a temperature of 25°C and relative humidity of 70%. Soil-dwelling stages have a better chance of surviving if the moisture content of the soil is between 10% and 13% (Lewis, 1997). Adult thrips are weak to good flyers, but their small size makes them susceptible to wind and weather, limiting their dispersal. The length of the life cycle of an insect depends on the temperature and quality of the food sources, and can be as short as 10-12 days at 30ºC or as long as 19 days at 20ºC (Persley et al., 2007).

Thrips lay their eggs in plant tissue, leaves, or flowers, and depending on the climate, they can hatch in as little as 3 days or as long as 10 days. After hatching, both larvae and adults are found inside the bean blossom, which is only open for a few days. Both larvae and adults are located inside the bean blossom after hatching, which is only open for a few days. The eggs

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Cite The Article: Sabera Yasmin, Mohammed Ali, Md. Mizanur Rahman, Mst. Salma Akter, Md. Abdul Latif (2021). Biological Traits of Bean Flower Thrips, *Megalurothrips Usitatus* (Thysanoptera: Thripidae) Reared on Mung Bean. *Science Heritage Journal, 5(2): 29-33.*

must have been laid during the flower's green bud stage, hatching as the blossom changes color and opens, allowing the small thrips to enter (Duff, 2012). *M. usitatus* larvae are yellow when they first emerge, but they soon turn deep yellow or orange-red. Adults are greyish-brown in hue, with the deepest colors on the head and striped abdominal segments. Females develop from fertilized eggs, while males develop from unfertilized eggs in the majority of Thysanoptera (Moritz, 1997).

It's crucial to first understand the biological properties of a new insect problem before predicting its future spread (Morse and Hoddle, 2006). The thrips population is affected by temperature, rainfall, and relative humidity (Chyzik and Ucko, 2002). Thrips management requires a thorough understanding of the insect's biology to implement successful control measures at the appropriate stage of the insect infesting the crops. However, while the extensive study has been done on the biology of thrips on various leguminous crops worldwide, data on the biology of *M. usitatus* infesting mung bean in Bangladesh are extremely scarce. Hence, the present study was planned to investigate the biology of *M. usitatus* and to determine the pre-adult mortality percentage and adult longevity on mung bean.

2. Meterials and Methods

2.1 Experiment Location and Duration

The study was conducted in the laboratory of the Department of Entomology of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh, from May to July 2016 to observe the duration of different instars (life cycle), pre-adult mortality percentage, and adult longevity (male, female) of *M. usitatus*.

2.2 Thrips rearing and preparation

The population of the *M. usitatus* was collected from a mung bean field at Sher-e-Bangla Agricultural University, Dhaka. The bean pod method was then used to rear this population (Mollema et al., 1993). In a climate control chamber, the colony was kept at 26 ± 1°C, 75 ± 3% RH, and 16:8 hours L:D.

2.3 Development time of different instars of *M. usitatus*

Firstly, 7 fresh mung bean pods were placed in a single glass jar used for rearing, which contained approximately 100 adult *M. usitatus* of various ages. For 12 hours, adult females were allowed to oviposit on mung bean pods. After 12 hours, the adults were removed and each egg-bearing pod was placed in separate Petri dishes (9 cm diameter). To keep the eggs and pods from drying out, the bottom of each Petri dish was covered with water-soaked filter paper. Parafilm was used to fasten the Petri dish lids to prevent the escapes of newly emerged larvae. The Petri dishes were then kept in a climate control chamber under the same conditions mentioned above in section 2.2 until the larvae hatched from the eggs. The egg development period was calculated by keeping track of how long it took for larvae to appear.

However, because thrips eggs are implanted in the mung bean pod tissue, egg mortality could not be determined (Park et al., 2010; Zhang et al., 2007; van Rijn et al., 1995). A soft fine hairbrush was used to move the newly emerged larvae into each 5 ml vial containing 2 cm length of the pod. To prevent the thrips from escaping, each vial was then sealed with a cotton plug. Each of these vials was considered as a replicate. During the larval stages, new mung bean pods (2 cm) were replaced every three days, but pods were not changed during the quiescent pupal stage so that they could be disturbed. Immature stages were tracked every 12 hours until they died or developed. Dead individuals of any developmental stage of *M. usitatus* were omitted from the calculation of the average developmental duration at a certain stage.

2.4 Identification of developmental stages

The approach devised was used to identify the various immature instars (Zhang et al., 2007). Because there are no visible physical variations between the two stages of thrips development, the transition from the first to second instar stage was determined by the presence of a molted skin on the vial (van Rijn et al., 1995). Prepupae were recognized by their short wing sheaths and straight antennae, whereas pupae were recognized by their lengthy wing sheaths that almost reached the end of the abdomen and bent antennae that curved backward along with the head. The fringed wings of adults were used to identify them. A dissecting microscope was used to monitor the growth of immature stages until they emerged as adults.

2.5 Mortality of immature stages

The length of mortality of immature stages was recorded daily. The percent mortality of each immature stage was computed as follows:

$$\text{Percent mortality} = \frac{\text{Number of dead insects in each immature stage}}{\text{Initial number of insects in each immature stage}} \times 100$$

2.6 Duration of adult longevity

A newly emerged adult was collected and put with a soft brush into a glass tube (2.5 cm diameter, 15 cm length) containing a fresh pod and as such thirteen glass tubes were prepared with one adult in each which regarded as replications. All glass tubes were incubated at the above-mentioned conditions (section 2.2). The pods were replaced every day, and the lids were sealed with cotton plugs. The number of live adults of each sex was counted until all adults had died. The adult longevity of both males and females was recorded.

2.7 Data analysis

The mean and standard error of the egg hatching period, the development time of immature instars, and adult longevity on mung bean were calculated using MS office excel 2007. The percent mortality of each immature stage was also calculated using a formula mentioned in section 2.5 in MS office excel 2007.

3. Results and Discussion

3.1 Development time

Developmental time of different instars of *M. usitatus* have been furnished below-

3.1.1 Incubation period

Adult female *M. usitatus* oviposited eggs in mung bean pods and needed 3.13 ± 0.06 days to hatch. The range of the incubation period was 1.5- 4 days (Table 1). Almost similar findings were reported where the egg hatching period of *M. usitatus* was 2.89 ± 0.04, 3.02 ± 0.04, 3.29 ± 0.03, and 3.35 ± 0.04 days on the snap bean, cowpea, pea and, lima bean, respectively (Tang et al., 2015). According to study females of *M. usitatus* lay eggs within the leaf tissues, hence the eggs may not be apparent to the naked eyes and required two to three days for incubation (Srinivashan, 2014). Thus, the similarity of the results of previous studies with the present study indicate that *M. usitatus* have a consistent incubation time irrespective of species of host plants under the family Leguminosae.

Table 1: The length of developmental periods (days; mean±SE) of *M. usitatus* on mung bean pod

Developmental time in days			
Life stages	**Mean ± SE**	**Range**	**No of observation**
Egg	3.13 ± 0.06	1.5 - 4	118
First instar larva	1.48 ± 0.05	1 - 3	101
Second instar larva	2.30 ± 0.08	1.5 - 4.5	78
Prepupa	1.30 ± 0.07	0.5 – 2.5	67
Pupa	2.26 ± 0.13	1.5 – 3.5	23
Egg to adult	10.54 ± 0.15	9.5-12	23

3.1.2 Larval period

The larvae of *M. usitatus* were similar in appearance to the adults, but they lacked wings (apterous) and were smaller and lighter in color. During the larval stages, there were two instars. The first instar was pale yellow and took 1.48 ± 0.05 days to develop, with a range of 1-3 days (Table 1, and Figure 1). The first instar molted into the second (Figure 2a). The second instar was discovered to be larger and deeper yellow to orange-red in hue (Figure 2b, 3, and 4). The developmental time of the second instar was 2.30 ± 0.08 days (Table 1). These findings agreed with the statement of who described that the larvae of *M. usitatus* are pale yellow at first and then become yellowish to orange-red, with a larval period ranging from 1 to 2 weeks depending on temperature (Srinivashan, 2014). Results recorded from the present study were also aligned with the findings of Tang et al.

(2015), who found that the first instar larvae of *M. usitatus* developed in 1.69 ± 0.03, 1.68 ± 0.03, 1.73 ± 0.03, and 2.02 ± 0.04 days, on the snap bean, cowpea, pea, and lima bean, respectively at 26 ± 1°C. They also found that the second instar larvae developed in 2.89 ± 0.03, 2.90 ± 0.05, 2.97 ± 0.05, and 3.05 ± 0.05 days, on those four leguminous crops, respectively. Moreover, the larval duration of the first and second instar *M. usitatus* matches the pattern exhibited by another species of flower thrips *Frankliniella occidentalis* (Pergande). Reitz (2008) reported that the duration of second instar larvae of *F. occidentalis* was two times longer than the first instar.

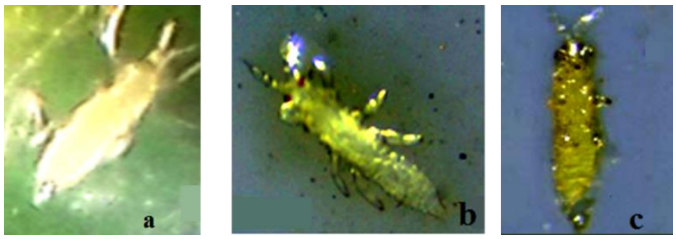

Figure 1: Pale yellow first instar larva (a) at 10 X, (b) and (c) at 90X.

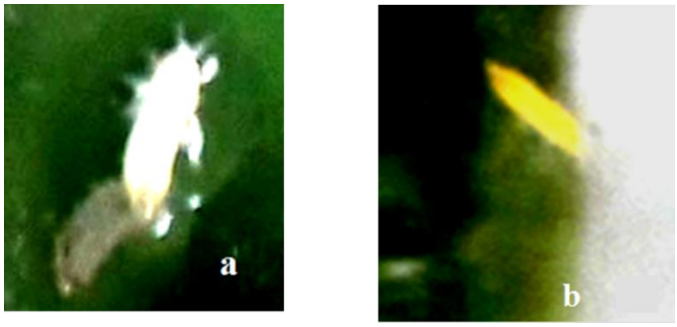

Figure 2: (a) First instar larva moulted to second instar (with exuviae), (b) newly emerged deep yellow second instar larva (at 10 X).

Figure 3: (a) and (b) Second instar larva turns to orange (at 10 X).

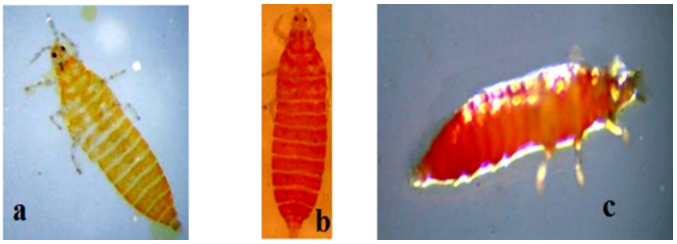

Figure 4: (a), (b), (c) Second instar larva (Deep yellow to orange) at 80X.

3.1.3 Pupal period

Figure 5: Second instar larva moulted to be prepupa (at 60 X).

The second instar larvae were molted to prepupa (Figure 5). During the pupal period, there were two instars: a prepupal instar that was almost inactive, and a pupal instar that was both inactive and nonfeeding. Unless they were disturbed, neither stage sucks or moves. The wing pads of the prepupae were shorter (Figure 6) than that of the pupae (Figure 7). The antennae of the prepupa were straight (Figure 6) but found curved in the pupa (Figure 7). The laboratory study showed that the prepupal period was 1.30 ± 0.07 days which ranges from 0.5-2.5 days. The pupal stage on the mung bean pod was 2.26 ± 0.13 days which ranges from 1.5-3.5 (Table 1). Almost similar findings were reported by Tang et al. (2015), who found that the prepupal period was 0.95 ± 0.03, 1.05 ± 0.02, 1.06 ± 0.04, and 1.06 ± 0.04 days on the snap bean, cowpea, pea, and lima bean, respectively. They also found that the pupal period was 1.69 ± 0.04, 2.13 ± 0.06, 2.19 ± 0.09, and 2.27 ± 0.09 days on those four leguminous crops, respectively. The findings highlighted the significant role of temperature in the development of another bean thrips, *Thrips palmi* by reporting the combined prepupal and pupal development time that was around 4 and 3 days at 26º, and 32ºC, respectively (Capinera, 2015). However, in this present study influence of temperature was not included.

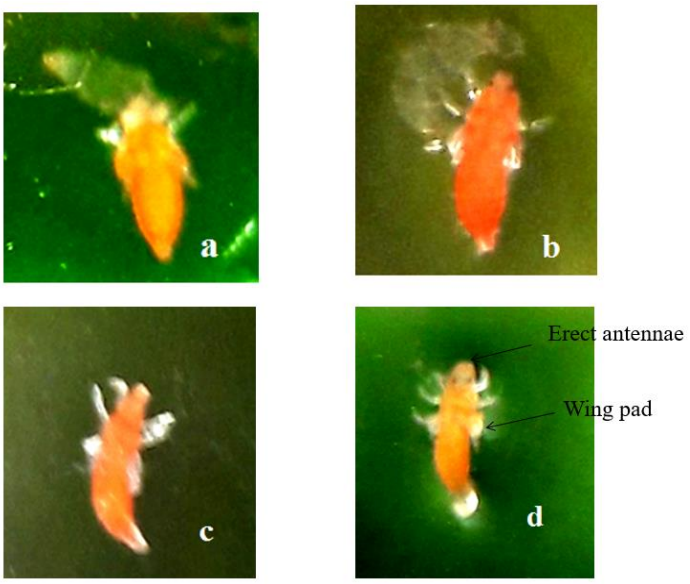

Figure 6: (a), (b) Orange-red prepupa with exuviae; (c), (d) Prepupa (at 10 X).

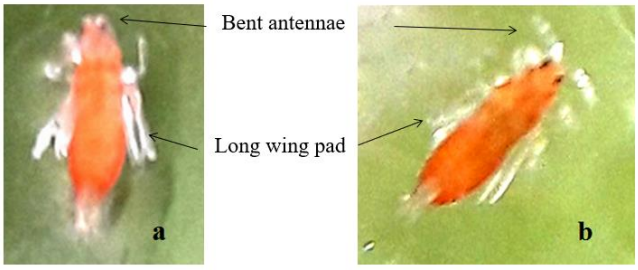

Figure 7: (a), (b) Orange-red pupa (at 10 X).

3.1.4 Total development period (egg to adult)

The pupa eventually molted into a dark brown adult. The male was paler (Figure 8) than the female (Figure 9). On mung bean pods, the total developmental time from egg to adult was 10.54 ± 0.15 days (Table 1). The length of an insect's life cycle is influenced by the quality of its host plants as well as the ambient temperature, albeit the influence of temperature was not included in this study (Brodbeck et al., 2002). Insects that develop rapidly on a host plant indicate that it is well suited as a host plant (van Lenteren and Noldus, 1990). A group of researchers found that the development time (egg to adult) of *M. usitatus* varied depending on the legume species in question, ranging from 9.4 to 11.6 days on four leguminous host plant species, namely snap bean, cowpea, pea, and lima bean (Tang et al., 2015). *M. usitatus* on an acceptable diet had a shorter development period due to the rapid development of the larval stages, but the non-feeding prepupal and pupal stages also had a shorter development time. Similar results were reported for *Frankliniella occidentalis* (Zhang et al., 2007; Hulshof et al., 2003). A study reported that the egg, larva I, larva II, prepupa, pupa, and total duration of *M. peculiaris* on *Dolichos lablab* leaves were 4.0 ± 0.4, 3.4 ± 0.3, 4.4 ± 0.3, 1.8 ± 0.2, 3.0 ± 0.2, 18.4 ± 1.9 days, respectively (Maisnam et al., 2012).

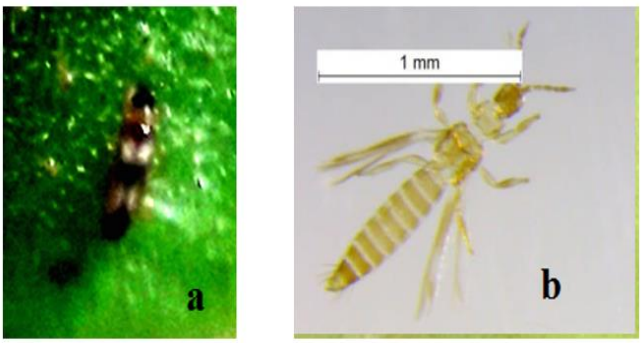

Figure 8: (a) Adult male M. usitatus at 10X, (b) adult male at 60X

Figure 9: (a) Adult female M. usitatus at 10X, (b) adult female at 60X

3.2 Pre-adult mortality percentage of *M. usitatus*

Data illustrated in Table 2 showed the pre-adult mortality percentage of *M. usitatus* on mung bean pods. The mortality rates for the first instar larva, second instar larva, prepupa, and pupa were 14.41%, 22.77%, 14.10%, and 65.67%, respectively. Overall, the pre-adult mortality was 80.51%. Some researchers reported that the mortality of another thrips species, *Thrips tabaci* reared on Mazandaran tobacco was 58.33%, which was rather lower than the present findings, and mortality occurred primarily during the larval stage (Fekrat et al., 2009). However, in this study, the maximum mortality was recorded on the pupal stage of *M. usitatus.*

This could be related to lower the moisture content in pods, as pods were not replaced during the pupal period to avoid disturbing the quiescent pupal stage of *M. usitatus*. Chang found that pupa mortality of *M. usitatus* was high (77 percent) in soils with low humidity (2 percent or less) and porosity (Chang, 1989).

Table 2: The pre-adult mortality percentage (%) of different instars and adult longevity of *M. usitatus* on mung bean pod

Different instars	Mortality percentage (%)	No of live insects at that developmental stage
First instar larva	14.41	101
Second instar larva	22.77	78
Prepupa	14.10	67
Pupa	65.67	23
Total	80.51	118

3.3 Adult longevity of *M. usitatus*

In the present study, the longevity of adult males and females of *M. usitatus* reared on mung bean pods was 6.42 ± 0.44 days and 12.07 ± 1.56 days, respectively (Table 3). The longevity of adult males was shorter than adult females. The minimum and maximum longevity of adult males were 5 and 8 days, whereas, the minimum and maximum longevity of adult females were 8 and 18.5 days, respectively (Table 3). The longevity of adult male and female *M. usitatus*, depends on the species of legume on which they develop. Some groups found that the quality of food had a significant impact on the adult longevity of *M. usitatus* (Tang et al., 2015). On the lima bean, the shortest female longevities while reproducing sexually or parthenogenetically were 13.83 and 15.63 days, respectively, but on the snap bean, the longest female longevities were 15.63 and 20.61 days, respectively. Male longevities were found to be 6.42 days on the lima bean and 14.67 days on the snap bean, although females lived longer than males. Capinera (2015) reported that temperature influenced development time and the adult longevity of *Thrips palmi* was 10 to 30 days for females and 7 to 20 days for males. On bean plants (pods), comparable longevity statistics for *F. occidentalis* were 27.88 days, 24.45 days, and 10.8 days (Zhi et al., 2005; Gerin et al., 1994; Brodsgaard, 1994).

Table 3: The adult longevity (in days; mean ± SE) of *M. usitatus* on mung bean pod

Sex type	Mean± SE	Range	No of observation
Male	1.42 ±0.44	5-8	6
Female	12.07±1.56	8-18.5	7

4. Conclusion

M. usitatus is a threat to the production of leguminous crops but aspects of its biology have been seldom studied. The biological traits of the pest on mung bean cultivated in Bangladesh were unknown. Therefore, the present study investigated several biological traits of *M. usitatus* on mung bean. The life cycle of *M. usitatus* was similar to that of other thrips and includes the egg, larva I, larva II, prepupa, pupa, and adult stages and takes 10-11 days to complete its development on mung bean. A higher pre-adult mortality rate of *M. usitatus* was observed in pupal stage than that of prepupal and larval stages. The longevity of adult males was shorter than adult females. The overall results of the study highlighted the different growth stages of *M. usitatus*, its duration, identifying traits, stage-specific mortality during its development which is necessary to adopt control measures at an appropriate stage of the pest infesting the crop. Thus, the results would contribute to the future management plan to suppress this pest.

Acknowledgements

The authors thank the Ministry of Science and Technology (Bangladesh) authority for financial support to conduct the study.

Authors Contributions

SY and MAL designed the study. SY collected and analyzed the data. SY, MAL, MA, MMR and MSA contributed in writing and fine-tuning the paper.

Conflict of Interest

The authors have no conflict of interest to report.

References

Brodbeck, B.V., Funderburk, J., Stavisky, J., Andersen, P.C., Hulshof, J., 2002. Recent advances in the nutritional ecology of Thysanoptera, or the lack thereof, in: Thrips and Tospoviruses: Proceedings of the 7th International Symposiumon Thysanoptera. Australian National Insect Collection (ANIC), Canberra, Pp. 145-153.

Brødsgaard, H.F., 1994. Effect of photoperiod on the bionomics of *Frankliniella occidentalis* and *Thrips tabaci* (Thysanoptera: Thripidae). J. Appl. Entomol., 117, Pp. 498-507.

Capinera, J.L., 2015. Melon Thrips, *Thrips palmi* karny (insecta: thysanoptera: thripidae). UF/IFAS Extension University of Florida. EENY-135. https://edis.ifas.ufl.edu/publication/IN292 (accessed 10 March 2021).

Chang, N.T., 1987. Seasonal abundance and developmental biology of thrips *Megalurothrips usitatus* on soybean at southern area of Taiwan. Plant Protect. Bull., 29, Pp. 165-173.

Chang, N.T., 1989. Impact of soil physical factors on the pupation of bean flower thrips *Megalurothrips usitatus* (Bagnall) (Thysanoptera: Thripidae). Plant Prot. Bull., 31, Pp. 377–386.

Childers, C.C., 1997. Feeding and oviposition injures to plant, in: Lewis, T. (Ed.), Thrips as crop pests. CABI, Oxford United Kingdom, Pp. 505-538.

Chyzik, R., Ucko, O., 2002. Seasonal Abundance of the Western Flower Thrips *Frankliniella occidentalis* in the Arava Valley of Israel. Phytoparasitica, 30 (4), Pp. 335-346.

Duff, J., 2012. Thrips management in the green beans industry. Department of Employment, Economic Development and Innovation. Project Number: VG07017. Horticulture Australia Ltd. ISBN 0 7341 2805 3.

Farajallah, A., 2013. Effect of chemical and botanical insecticides on thrips and yield of mungbean. Indonesian J. Agril., 6 (2), Pp. 87-92.

Fekrat, L., Shishehbor, P., Manzari, S., Nejadian, E.S., 2009. Comparative development, reproduction and life table parameters of three populations of *Thrips tabaci* (Thysanoptera: Thripidae) on onion and tobacco. J. Entomol. Soc. Iran., 29 (1), Pp. 11-23.

Gerin, C., Hance, T., Impe, G.V., 1994. Demographical parameters of *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae). J. Appl. Entomol., 118, Pp. 370-377.

Hossain, M.A., Ferdous, J., Sarkar, M.A., Rahman, M.A., 2004. Insecticidal management of thrips and pod borer in mungbean. Bangladesh J. Agril. Res., 29 (3), Pp. 347- 356.

Hulshof, J., Ketoja, E., Vanninen, L., 2003. Life history characteristics of *Frankliniella occidentalis* on cucumber leaves with and without supplemental food. Entomol. Exp. Appl., 108, Pp. 19-32.

Kirk, W.D.J., 1997. Distribution, abundance and population dynamics, in: Lewis, T. (Ed), Thrips as crop pests. CAB Intnl, Wallingford, UK, Pp. 217-258.

Lewis, T., 1997. Pest thrips in perspective, in: Lewis, T. (Ed.), Thrips as crop pests. CABI Intl, Oxon, Pp. 1–14.

Maisnam, S., Singh, O.D., Varatharajan, R., 2012. Diversity and diagnostics of Thysanoptera inhabiting leguminous plants with a note on life cycle of *Megalurothrips peculiaris* Bagnall. Indian J. Entomol., 74 (3), Pp. 274-280.

Mollema, C., Steenhuis, M.M., Inggamer, H., Soria, C., 1993. Evaluating the resistance to western flower thrips (*Frankliniella occidentalis*) in cucumber. IOBC/ WPRS Bull., 13, Pp. 113-117.

Moritz, G., 1997. Structure, growth and development. in: Lewis, T. (Ed.). Thrips as Crop Pests. CABI Intl., New York, Pp. 15-63.

Morse, J.G., Hoddle, M.S., 2006. Invasion biology of thrips. Annual Rev. Entomol., 51, Pp. 67–89.

Park, C.G., Kim, H.Y., Lee, J.H., 2010. Parameter estimation for a temperature-dependent development model of *Thrips palmi* Karny (Thysanoptera: Thripidae). J. Asia-Pacific Entomol., 13, Pp. 145-149.

Palmer, J.M., 1987. *Megalurothrips* in the flowers of tropical legumes: a morphometric study, in: Holman, J., Pelikan, J., Dixon, A.F.G. and Weismann, L. (Eds.), Population structure, genetics and taxonomy of aphids and Thysanoptera. The Hague (SPB Academic Publishing), Pp. 480-495.

Persley, D., Sharman, M., Thomas, J., Kay, I., Heisswolf, S., McMichael, L., 2007. Thrips and Tospovirus: A Management Guide. CRC (Cooperative Resreach Centre) for Tropical Plant Protection, Brisbane, Department of Primary Industries and Fisheries, Queensland, Pp.18.

Rahman, M.M., Bakr, M.A., Mia, M.F., Idris, K.M., Gowda, C.L.L., Kumar, J., Dev, U.K., Malek, M.A., Sobhan, A., 2000. Legumes in Bangladesh. in: Johansen, C., Duxbury, J.M., Virmani, S.M., Gowda, C.L.L., Pande, S. and Joshi, P.K. (Eds.), Legumes in rice and wheat cropping systems of the Indo-Gangetic Plain–Constraints and opportunities. Andhra Pradesh, India: ICRISAT and Ithaca, New York, USA, Cornell University, Pp. 230.

Reitz, S.R., 2008. Comparative bionomics of *Frankliniella occidentalis* and *Frankliniella tritici*. Fla. Entomol., 91(3), Pp. 474-476.

Sepswasdi, P., Pitaksa, S., Chareonrak, T., Phapoom, V., Heuel-Rolf, B., 1991. Crop loss assessment for major mungbean pests in rice-based cropping systems. Proc. of the mungbean meeting 90 Bangkok, Thiland. Tropical Agriculture Reseach centre, Pp. 259-267.

Shipp, J.L., Wang, K., Binns, M.R., 2000. Economic injury levels of western flower thrips (Thysanoptera: Thripidae) on greenhouse cucumber. J. Econ. Entomol., 93, Pp. 1732-1740.

Sinha, S.K., 1977. Food legumes: Distribution adaptability and biology of yield. FAO (Food and Agriculture Organization), third ed. Rome, Italy, Pp. 130. ISBN: 9251001863

Srinivasan, R., 2014. Insect and mite pests on vegetable legumes. in: Mecozzi, M. (Ed.), A field guide for identification and management. AVRDC–The World Vegetable Center, AVRDC Publication: 14-778, Taiwan, Pp. 30-33. ISBN 92-9058-206-5.

Tang, L.D., Yan, K.L., Fu, B.L, Wu, J.H., Liu, K., Lu, Y.Y., 2015. The life table parameters of *Megalurothrips usitatus* (*Thysanoptera:Thripidae*) on four leguminous crops. Florida Entomol., 98 (2), Pp. 620-625.

Van Lenteren, J.C., Noldus, L.P.J.J., 1990. Whitefly-plant relationships: behavioral and ecological aspects, in: Whiteflies: their bionomics, pest status and management. Andover, UK, Pp. 47-89.

Van Rijn, P.C.J., Mollema, C., Steenhuis-Broers, G.M., 1995. Comparative life history studies of *Frankliniella occidentalis* and *Thrips tabaci* (Thysanoptera: Thripidae) on cucumber. Bull. Entomol. Res., 85, Pp. 285-297.

Zhang, Z.J., Wu, Q.J., Li, X.F., Zhang, Y.J., Xu, B.Y., Zhu, G.R., 2007. Life history of western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), on five different vegetable leaves. J. Appl. Entomol., 131, Pp. 347-354.

Zhi, J.R., Fitch, G.K., Margolies, D.C., Nechols, J.R., 2005. Apple pollen as a supplemental food for the western flower thrips, *Frankliniella occidentalis*: response of individuals and populations. Entomol. Exper. Appl., 117, Pp. 185-192.