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HOST RANGE, DAMAGE EXTENT AND LEAF CONSUMPTIONS BY THE BAGWORM, *THYRIDOPTERYX EPHEMERAEFORMIS* HAW. (LEPIDOPTERA: PSYCHIDAE) IN BANGLADESH

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Abstract

Bagworm, *Thyridopteryx ephemeraeformis* Haw. (Lepidoptera: Psychidae) is a polyphagous pest in Northern America and southern Australia, causing severe damage to several host plants. A study was conducted to record the host plants, damage extent, and morphometrics of bagworms in Patuakhali Science and Technology University (PSTU) from 2015 to 2018. Results revealed a limited number of host plants for bagworm namely guava (*Psidium guajava*), arborvitae/juniper (*Thuja standishii*), rangan or jungles, geranium (*Ixora grandiflora/Ixora coccinea*), mussaenda (*Mussaenda philippica*), cropperleaf (*Acalypha wilkesiana* 'Ceylon), henna (*Lawsonia inermis*), mango (*Mangifera indica*), pomegranate (*Punica granatum***)** and betel nut (*Areca catechu*). The length of tiny larvae, fully-grown larvae, pupa, adult winged male moths, and wingless adult maggot-like females was 1.02 mm, 24.8 mm, 14 mm, 15 mm, and 48 mm, respectively. The average length of the bag was 24.7 mm with a range of 21-28 mm, and the average breadth in the middle of the bag was 6.9 mm with a range of 6-8 mm. The highest number of larval cases per branch was found in guava (56), and the lowest was in copperleaf (8). The highest percent of leaf damage (86.23%) per plant was also observed in the guava plant, and the lowest percent of leaf damage (37.46%) was in copperleaf. The highest number of infested leaves and bags per leaf was observed in the lower stratum of the guava branch, while the lowest infestation was in the top stratum. The highest percentage of leaf area (30%) damage was recorded 72 hours after release (HAR), and the lowest percentage of leaf area (10%) damage was at 24 HAR in guava. The maximum amount of leaf was consumed by bagworm larva at 72 HAR and the minimum amount was consumed at 24 HAR in guava. The maximum leaf area (13.46 cm^2) consumption was recorded at 72 HAR, while the minimum amount (3.42 cm^2) was consumed at 24 HAR. No significant damage by *T. ephemeraeformis* was observed in the case of mango, pomegranate, and betel nut plants.

Key words: Bagworm, Damage extent, Host plant, Leaf Consumption, *Thyridopteryx ephemeraeformis*

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Introduction

The Bagworm, *Thyridopteryx ephemeraeformis* (Haworth) (Lepidoptera: Psychidae), is native to Pennsylvania, USA a serious pest of many trees and shrubs of a deciduous and evergreen group. The alternate names of this bagworm are eastern bagworm, evergreen bagworm, common basket worm, common bagworm, or North American bagworm due to feeding on plant species of different groups. Psychidae family has approximately 1,000 species (Rhainds *et al.*, 2009), in which all species' larvae are concealed in a bag, and most species have wingless adult females. The larval stage of *T. ephemeraeformis* is reported to feed on over 125 different plant species consisting of 50 families (Hoover, 2000; Moore and Hanks, 2004; Rhainds *et al.*, 2009). Its populations may build up very rapidly and become serious pests due to its potential to cause damage. It spreads slowly because the female has no wings; however, it can move to other host plants by crawling and spreading through infested nursery stock (Mazzey and Masiuk, 2013). Evergreen plants such as arborvitae (*Thuja* spp.), fir (*Abies* spp.), hemlock (*Tsuga* spp.), juniper (*Juniperus* spp.), southern red cedar (*Juniperus silicicola*), pine (*Pinus* spp.) and spruce (*Picea* spp.); Hosts such as honey locust (*Gleditsia triacanthos),* black locust (*Robinia pseudoacacia*), sweetgum (*Liquidambar styraciflua)* and sycamore (*Platanus occidentalis*) and like ornamental conifers, box elder, cedar, cypress, elm (*Ulmus* spp.) are stated as Deciduous plants, fruit and nut trees, live oak (*Quercus virginiana*), maple (*Acer* spp.), Indian hawthorn (*Raphiolepis indica*), ligustrum (*Ligustrum japonica*), viburnum (*Viburnum* spp.), persimmon, salt, sumac, wild cherry, willow (*Salix* spp.) serve as host plants for bagworm species (Mazzey and Masiuk, 2013). At the initial stage, feeding by larvae on evergreen trees causes brown and unhealthy branch tip damage (Baxendale and Kalisch, 2009). Severe infestation can destroy the aesthetics and health of host plants (Ellis *et al.*, 2005; Ellis *et al.*, 2005; Rhainds and Sadof, 2008).

During summer, larvae of *T. ephemeraeformis* can cause severe defoliation that leads to the death of evergreen plant species. Larval development of *T. ephemeraeformis* occurs in localized infestation as they move only a few distances from their original host plant and results in maximum population density in some plants, while adjacent plants may have very few bagworms. This type of dispersal also led bagworms in spreading out in the host plant and showed a high population of the bagworm year after year (Rhainds and Sadof, 2008). After selecting a suitable host, the larva starts feeding and incorporating materials foe preparing bag such as pieces of twigs, leaves, and silk into its bag (Peterson, 1969). The spindle-shaped silk bag camouflaged with bits of foliage, bark, and other debris materials is formed by this pest (Shetlar, 2010). In whole larval instars, the larva increases its bag size because of growing and can live long periods without taking food

during the later stages of its development (Rhainds *et al.*, 2009). Completed bags range from 37.5 to 62.5 mm long (Shetlar, 2011). The mature caterpillar is about 25 mm long and takes up to 4 months to develop, depending on temperature (Rhainds *et al*., 2009). Larva attaches its bag firmly with a thick silken strand to its host plant or disperse to another structure. Before moulting and pupation, the bagworm seals the frontal part of the bag (Leonhardt *et al.*, 1983). The common bagworm caterpillar develops through seven instars before transforming into a pupa (Rhainds and Sadof, 2008). Immature caterpillars feed on the upper epidermis leaving small brown spots upon foliage. Mature caterpillars consume whole leaves of susceptible deciduous plant species, leaving only the larger veins (Baxendale and Kalisch, 2009). Recently the bagworm, *T. ephemeraeformis* has become a serious problem at PSTU campus because of damaging guava, thuja, mussenda, ixora plants, nuts, and palms. The Sharupkathi variety guava plants are seriously infested, and no fruiting occurrs in attacked plants. Many thuja plants have already died due to the attack of bagworms. So far, this insect, its host range, and its damage extent has not been reported yet in Bangladesh. Hence, the aims of the study were to know the host range, damage extent, and morphometrics of bagworms.

Materials and Methods

Location and duration of the study: Studies were conducted at the PSTU campus from January 2015 to October 2018.

Data collection procedure: The bagworms and damaged parts of the infested host plants were observed and collected at weekly interval. Before collecting samples, the infested plant was divided into three strata, lower, middle, and top. Ten infested leaves per branch of each stratum were collected, and the number of bags per branch was recorded. The number of holes per leaf from 10 infested leaves of guava, rangan, mussenda, copperleaf, and henna was also recorded. Bagworms were identified by cone-shaped bags, which were made of silk and bits of leaves and twigs (Plate 1). The exterior part of early larval stages is shiny black, and the undersides of their body are dull amber. The mature bagworms are a dull, dirty, and grey, with darker markings towards the head (Plate 2). The adult male transforms into a moth that can fly, but females do not transform into moths but remain inside the bag, which looks maggot having no functional eyes, legs, mouthparts, or antennae. Immature stages of bagworms, known as caterpillars, having chewing mouthparts (Plate 3).

Morphometric study: The length and breadth of tiny larvae, fully-grown larvae, pupa, adult winged male moths and wingless adult maggots like female bagworms (Plate 4) and bags were measured by using a scale (Plate 5).

Leaf area consumption: The collected specimens were kept in a polybag and then processed, mounted, and labeled for studying leaf area consumption. The damaged area of the guava leaf by the larva was assessed under laboratory condition. Thirty leaves consisting of 10 per replication were used in leaf consumption. Leaf consumption by bagworm larvae was measured by leaf area meter at 24, 48, and 72 hours after the release of the larva. Leaf consumption based on weight was measured at 24, 48, and 72 hours after the release of larva. During foliage feeding, the larvae emerged from the top of the bag and hung onto the host plant with a silken thread and their legs. The lower end of the bag remains open to pass out fecal materials or frass from the body.

Plate 1. Rearing of bagworm on the henna plant in glass jar and petri dish. A. Leaf case moth. B. stick case and leaf case moths, C. Leaf case moths.

Statistical analysis: WASP 1.0 (Web-based Agricultural Statistical Package) software and Excel program were used to analyze data.

Plate 2. Different stages of bagworms with their case. A. Male. B. Male. C. Female. D. Mature Larva. E. Pupa. F. Larva inside the soft bag. G. Pupa inside rough bag

Plate 3. Adult male (left) and adult female (right). (Source: Shetlar, 2010).

Plate 4. Bagworm eggs. (Source: Shetlar, 2010).

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Plate 5. Measurement of bag made by bagworm

Results and Discussion

Host range: Host plants infested by bagworm, *T. ephemeraeformis* were identified as guava (*Psidium guajava*), arborvitae/juniper (*Thuja standishii*), rangan or jungle geranium (*Ixora grandiflora/I. coccinea*), mussaenda (*Mussaenda philippica*), cropperleaf (*Acalypha wilkesiana* 'Ceylon), henna (*Lawsonia inermis*), mango (*Mangifera indica*), pomegranate (*Punica granatum***)** and betel nut (*Areca catechu*) (Table 1) in PSTU campus. Numerous plants such as evergreen trees, broadleaf, and shrubs like arborvitae and other ornamental conifers, cedar, cypress, box elder, elm fruit, nut trees, maple, locust, juniper, live oak, persimmon, salt cedar, sumac, sycamore, wild

cherry, willow, and many other ornaments served as bagworm host plants (Baxendale and Kalisch, 2009; Mazzey and Masiuk, 2013).

Table 1. List of host plants infested by bagworm, *T. ephemeraeformis*.

Sl. No.	Common name	Scientific name	Family
1	Guava	*Psidium guajava*	Myrtaceae
2	Arborvitae/Juniper/Thuja	*Thuja standishii*	Cupressaceae
3	Rangan or jungle geranium	*Ixora grandiflora/I. coccinea*	Rubiaceae
4	Mussaenda	*Mussaenda philippica*	Rubiaceae
5	Copperleaf	*Acalypha wilkesiana*	Euphorbiaceae
6	Henna	*Lawsonia inermis*	Lythraceae
7	Mango	*Mangifera indica*	Anacardiaceae
8	Pomegranate	*Punica granatum*	Lythraceae
9	Betel nut	*Areca catechu*	Arecaceae

Morphological characteristics and morphometrics of *T. ephemeraeformis*

The tiny larva was 1.02 mm long. The length and breadth of full-grown larvae were 24.8 mm and 4.8 mm, respectively, which appeared medium to dark brown. The length and breadth of the pupa were 14 mm and 5 mm, respectively, which appeared dark brown to black. The adult male moth was a hairy and charcoal-black body with feathery antennae. The length and breadth of the male moth were 15 mm and 5 mm, respectively. The wings of the male moth were membranous or clear having a length of 12.5 mm and a breadth of 6.5 mm while the length and breadth of female moth were 48 mm and 8 mm, respectively (Table 2). The results are supported by Peterson (1969); Rhainds and Sadof (2008).

Morphometrics of bag formed by bagworm larvae

The length and breadth in the middle of the bag formed by the full-grown larva of the bagworm are presented in Table 3. The average length of the bag was 24.7 mm, with a range of 21-28 mm and standard error of 0.667. The average breadth in the middle of the bag was 6.9 mm, with a range of 6-8 mm and a standard error of 0.179.

Table 2. Morphological characteristics, length and breadth of *T. ephemeraeformis.*

Stages of bagworm	Morphological characteristics	Size of bagworm	
		Length (mm)	Breadth (mm)
Egg	Smooth, cylindrical in shape, covered by tuft-like waxy layer.	-	-
Tiny larva	Tiny long caterpillars attached themselves on silken threads to new leaf and make a very small conical shaped bag which they bear upright as they move	1.02	-
Full-grown larva within a bag	The posterior part of the caterpillar was medium to dark brown, with dorsal part of the first 3 segments are white to yellow with a dark brown pattern. Caterpillar developed through 7 instars before it transformed into a pupa	24.8	4.8
Pupa	Dark brown to black pupa remained inside the bag. The duration of pupal period was 7-10 days.	14	5
Adult winged male moth	Hairy and charcoal black body with feathery antennae	15	5
Male wing	Wings were transparent or membranous	12.5	6.5
Adult wingless maggot-like female	Females were not transformed into moths, but remained concealed into the bag, which appeared as maggot having no functional legs, eyes, antennae or mouthparts.	48	8

Table 3. Length and breadth of bag formed by the full-grown larva of bagworm

No. of observation	Bag size formed by the larva	
	Length (mm)	Breadth (mm) at middle
1	28	7
2	27	8
3	21	7
4	26	7
5	25	6
6	26	7
7	23	6
8	24	7
9	23	7
10	24	7
Mean	24.7	6.9
Range	21-28	6-8
SE	0.667	0.179

Plate 6 Contd.

Plate 6. Bagworms and their damage on leaves of guava (A&B), thuja (C&D), rangan (E&F), mussaenda (G&H), copperleaf (I&J), henna (K&L), and mango (M&N) at PSTU campus. A. Leaf case moth, B. Leaf case moth, C. Cone case moth, D. Leaf case moth, E. Leaf case moth, F. Leaf case moth, G. Stick case moth, H. Stick case moth, I. Cone case moth, J. Cone case moth, K. Leaf case moth, L. Leaf case moth, M. Leaf case moth, N. Leaf case moth

Damage symptoms and extent of the damage: The immature caterpillars fed on the upper epidermal tissues leaving small brown spots on the foliages. Mature caterpillars consumed whole leaves of host plants leaving only the larger veins. Sometimes major leaf veins were also removed by mature caterpillars. Host plants were completely defoliated when female bagworms were abundant in infested plants (Plate 6). Highly infested thuja plants were died at the PSTU campus (Plate 7). The mature caterpillars usually attached their bags to a branch by folding extra silk that didn't spoil rpidly. This silk made band may have girdled the branch of the host plant as it grows, resulted in dead branches several years Shetlar (2010) supported this results, who explained that female bagworms could not fly and local populations can build rapidly on an established preferred host. Numerous caterpillars may eat the buds of attacked conifers, causing branch dieback of the host plants. Moderate defoliation might be unsightly but excessive defoliation of conifers may cause whole plant death during the next season.

Plate 7. Dead thuja plant as a result of bagworm infestation at PSTU campus.

Number of larval cases per branch: The highest number of larval cases per branch was observed in guava (55.8), followed by thuja (38.4) and mussaenda (26.9) while the lowest number of larval cases per branch was in copperleaf (8.3) followed by henna (14.9) and rangan (18.2) (Fig. 1).

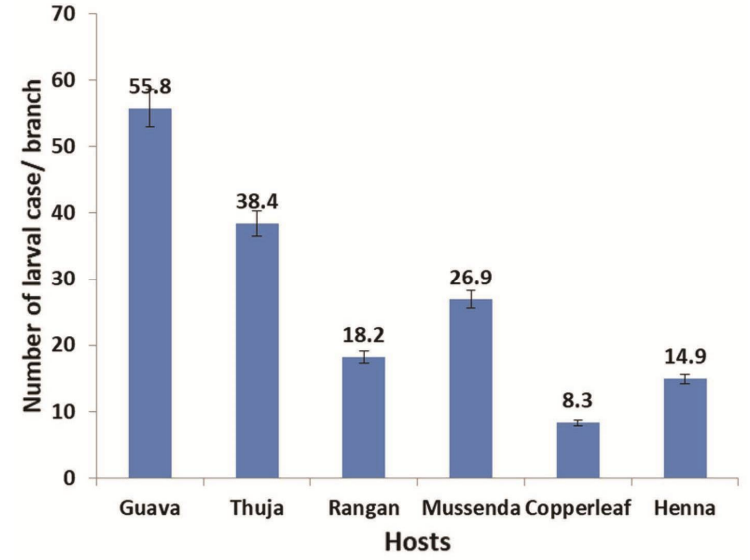

Fig. 1. Number of larval cases per branch of selected host plants.

Percentage of leaf damage: The highest percent of leaf damage was observed in guava (86.23%), followed by thuja (75.24%) and mussaenda (72.15%), and the lowest percentage of foliage damage was in copperleaf (37.46%) followed by henna (42.45%) and rangan (46.32%) (Fig. 2).

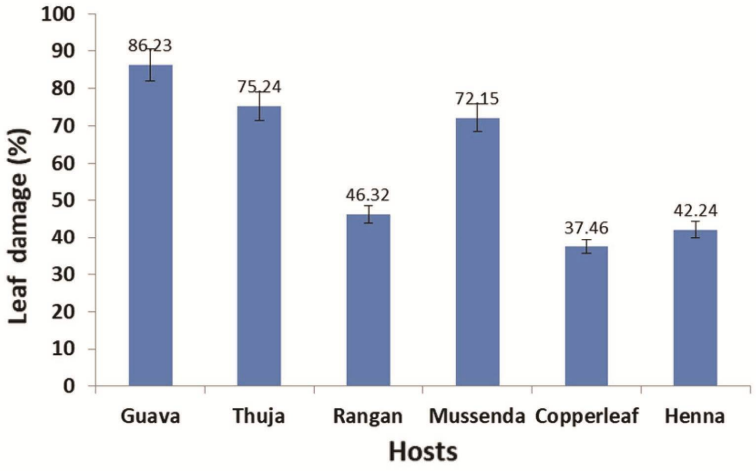

Fig. 2. Percentage of leaf damage caused by bagworm larva in selected host plants.

Number of holes per leaf: The highest number of holes per leaf was recorded in the guava plant (7.75), followed by mussaenda (7.5), while the lowest number of holes per leaf was in the copperleaf (4.5) plant, followed by rangan (Fig. 3).

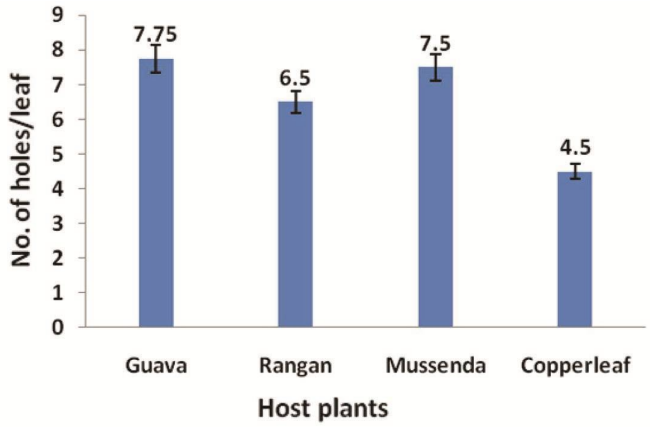

Fig. 3. Number of holes per leaf caused by bagworm larva in four selected host plants.

Number of infested leaves on guava: The highest number of infested leaves was observed in the lower stratum (17.3), followed by the middle strata (6.3). The lowest infestation was observed in the leaves of the top (2.5) stratum (Fig. 4).

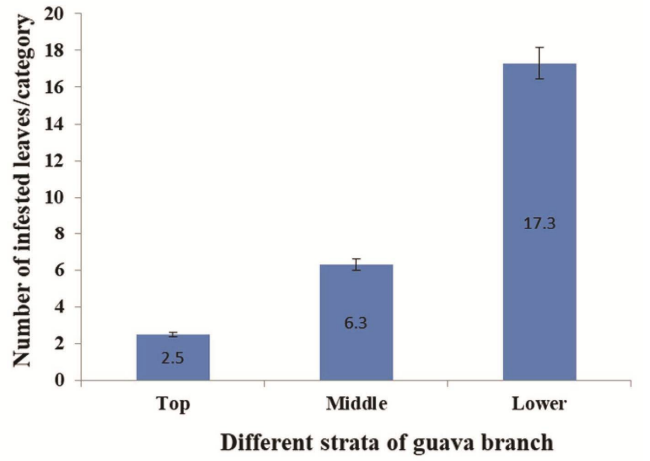

Fig. 4. Number of infested leaves at different strata of guava branch.

Number of bags per leaf on guava: The highest number of bags per leaf (2) was observed in the middle, and lower strata leave compared to the top (0.7) stratum (Fig. 5).

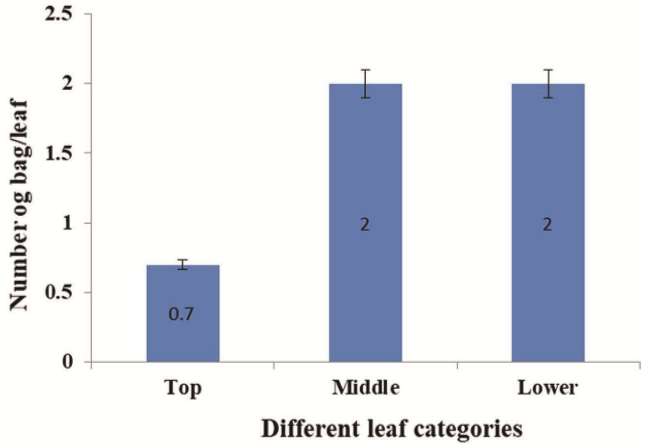

Fig. 5. Number of bags per leaf formed by bagworm larvae on guava.

Percentage of leaf area damage in guava under laboratory conditions: The highest percentage of leaf area (30%) damage was recorded 72 hours after release, followed by 48 hours (20%), and the lowest leaf area (10%) damage was at 24 hours after release (HAR) (Fig. 6).

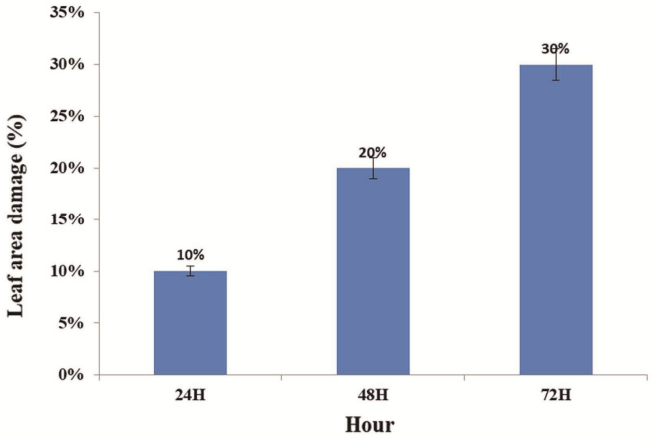

Fig. 6. Percentage of leaf area damaged by bagworm larva in guava under laboratory conditions.

Leaf consumption in guava plant: Based on weight, the maximum quantity (0.43 g) of the leaf was consumed by bagworm larva at 72 HAR followed by 48 HAR (0.27 g), and the minimum quantity (0.13) was consumed at 24 HAR (Fig. 7). Similar trend was also observed in case of area of leaf consumption. The maximum quantity (13.46 cm^2) of leaf area consumption was recorded at 72 HAR followed by 48 HAR (7.73 cm^2), while the minimum quantity (3.42 cm^2) was consumed at 24 HAR (Fig. 8) (Plate 8).

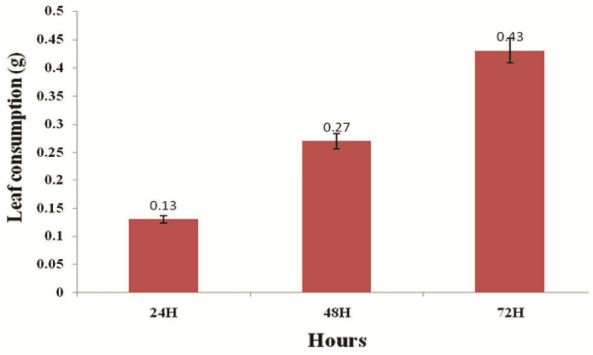

Fig. 7. Guava leaf consumption in weight by bagworm larva under laboratory conditions.

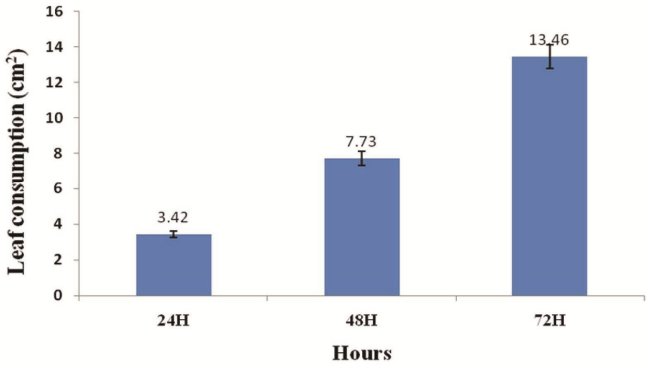

Fig. 8. Area of guava leaf consumption by bagworm larva under laboratory conditions.

The present study's findings are in conformity with Rhainds *et al.* (2009) who stated that bagworms can eat on numerous various kinds of plants, and *Thyridopteryx ephemeraeformis* can feed on over 50 families of deciduous and evergreen trees and shrubs (Rhainds *et al.*, 2009). As the caterpillars increase in size and shape, their feeding

Plate 8. Area of guava leaf consumed by different aged larvae of bagworms.

symptoms appeared as more visible and prominent due to their requirement for a higher quantity of food sources (Baxendale and Kalisch, 2009). Due to enough food, they may resident on the similar host plant as their mother causing significant damage (Rhainds and Sadof, 2008). Woody plant can tolerate less than 10% damage on it by consumers (Lemke *et al*., 2005), and as few as 4 bagworm larvae can cause a four-foot thuja to be unmarketable for sale during the summer months (Sadof and Raupp 1987). The presence of bagworms often remains unnoticed until they become mature and extensive damage is appeared (Hoover, 2000).

Conclusion

Nine plants were recorded as hosts of *T. ephemeraeformis* for the first time in Bangladesh. The fully-grown larva was longer than the pupa, while the wingless maggot-like female was larger than the male moth. The leaves of guava, thuja, rangan, mussaenda, henna, and copperleaf were found severely infested by bagworm larvae at the PSTU campus. The highest infestation in respect of infested leaves, number of bags per leaf, percentage of leaf area damage, and leaf consumption was observed in guava, followed by thuja, which was the lowest in copperleaf.

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