A Technique to Measure the Loss in Tea Crop by the Defoliating Pest (*Hyposidra talaca* Walker) on the Basis of Dry Mass and Leaf Area Parameters

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Abstract

Tea (*Camellia sinensis*) is known as the queen of all beverages. India is the second largest producer of tea in the world, but the crop is largely damaged by the defoliating pest, *Hyposidra talaca* Walker (Geometridae: Lepidoptera) in the Darjeeling foothills and plains. A study conducted under laboratory conditions on its biology and food consumption shows that 4th and 5th instars of this looper caterpillar are the most destructive as they feed both on young (pluckable) and maintenance tea leaves. On an average, 25.1±1.9 (%) of 4th instar and 19.7±2.6 (%) of 5th instar caterpillars will survive from the eggs laid by a single moth. A 4th instar looper caterpillar can eat 3.55±0.31 (cm^2) of the leaf area and 0.021±0.002 (g) of weight of tea leaves in terms of dry mass in 24 hrs. Whereas, a 5th instar caterpillar can eat 16.19±1.21 (cm^2) the leaf area and 0.084±0.007 (g) of weight of tea leaves in terms of dry mass in 24 hrs. A female moth of looper (*H. talaca*), collected from the tea plantations, lays on an average of 500 eggs. Therefore, it may be interpreted that the surviving individuals of 4th and 5th instars will cause an overall loss of 12,690.33 cm^2 of the leaf area (both pluck-able and maintenance leaves) therefore losing a part of photosynthate content of both pluckable leaf and maintenance leaf and a loss of 66.67 g dry mass of the leaves. Besides direct loss from feeding, excess defoliation may cause a loss of the photosynthesizing leaf-area; hence reduce the bush growth and its productivity in long term.

1. Introduction

Tea is the most common beverage of India. India is the 2nd largest producer of tea. Most of the common people of the north-east India depend upon this agro-industry. But tea crop is facing large amount of loss due to pest infestation. Tea plantations with perennial foliage are infested by about 167 insect species in the North-eastern tea growing regions of India (Das, 1965; Mukhopadhyay and Roy, 2009) including the Darjeeling slopes and plains. Of these, six species have attained major pest status causing 11-55% crop loss in general (Gurusubramanian, et al., 2008). *Hyposidra talaca* (Walker) (Lepidoptera: Geometridae) is reported as one of the most destructive defoliator of tea plantations (Basumajumdar, 2004 and Das et al., 2010). Tea plants have a rhythmic growth pattern, dormancy and flush, coinciding with either management practice or unfavorable environmental conditions or a combination of both (Manivel, 1980). The permanent leaves below the plucking surface are known as maintenance foliage. These maintenance foliage produce photosynthates which are supplied to other parts of a plant, which respire and grow actively with the help of these photosynthates (Kabir, 2001). *Hyposidra* spp. were found prominently even during the winter months due to lack of obligatory winter diapauses with at least eight broods $year^{-1}$ (Das et al., 2010). The invading pest species (*Hyposidra* sp.), otherwise known to occur on wild forest and fruit plants, has lately emerged as major defoliator of tea, consuming both young and mature leaves. As in peak season the occurrence of these loopers was about 200 individuals or more $bush^{-1}$, the quantum of crop loss appeared to be substantial (Das et al., 2010). The caterpillars of this species prefer to feed upon the pluckable leaves. But if the pluckable leaves are not available, they even feed on the mature leaves or maintenance leaves, hence resulting into crop loss in terms of pluckable leaves and the loss of photosynthetic surface in terms of maintenance leaves. This study is an attempt to estimate the crop loss and the loss of photosynthetic surface based on the available information on the eco-physiology of tea, as well as from present findings of laboratory based experiments on tea leaf-consumption and stage-specific survivorship of the loopers of *H. talaca*.

2. Materials and Methods

2.1. Life-cycle study

Moths of *H. talaca* collected from the tea plantations were allowed to lay eggs in the laboratory conditions. Both mass (n=100), and individual rearing (with 20 replicates) was done simultaneously for studying food consumption in the post-embryonic developmental stages.

2.2. Survivorship

An account of stage specific mortality (Edillo et al., 2004) was recorded daily. Stage specific survivorship, $S_i=N_i \div (N_i-1)$

Where, S_i represents stage specific survivorship, N_i is the total number of immature entering the life stages i (i.e. instar) and (N_i-1) is the number alive in the previous instar.% survival $(\%S)=S_i \times 100$

2.3. Food consumption

Life cycle and nutritional indices of *H. talaca* were studied during summer months, when maximum temperature ranged between 29-33ºC, minimum temperature ranged between 22-26ºC and the relative humidity was 75±5%. Young tea leaves were provided for larval rearing in transparent plastic containers (27.5×27 cm) under aseptic condition till the emergence of adult. Change of instars was recorded every 24 hrs. Measurement of length and weight was taken for each newly molted instar. A record of food consumption and change in the weight of just molted late instar larvae (4th and 5th) was kept for the dry mass budget analysis. Food consumed by the caterpillar was determined simply by deducting the area of remaining leaf from the initial area of leaf (Pratissoli et al., 2002). The unconsumed leaf was then dried completely and the weight was taken.

3. Results and Discussion

3.1. Survivorship curve of H. talaca

Mass rearing of *H. talaca* was done to get an idea about the survivability of 4th and 5th instar. The survivorship study showed that 25% of 4th instar and 20% of 5th instar survived in laboratory condition from a single brood containing 500 eggs (Figure 1).

3.2. Estimation of crop loss based on food consumption

Effect of the injury on plant physiology caused by defoliation can be evaluated by measuring leaf mass consumed unit^{-1} of land area, timing of leaf consumption and location of the defoliation (Pedigo, 1999). Before calculating the Economic Injury level, one major step is to estimate the loss insect^{-1} by food consumption experiment. Reduction in yield is often attempted to be related intensely with infestation. Yield for this purpose is usually taken as the economic product harvested which in case of tea are leaves. Leaf area damaged can be measured by photography, air flow, scanning, measurement on graph or leaf area meter, weighing. The 3rd instar caterpillars fed on a negligible amount of leaf in terms of dry mass covering a small area less than even 1 cm^2 in 24 hrs, which is much less in comparison to 4th and 5th instar caterpillar. Whereas a just molted 4th instar caterpillar consumed an area of 3.55±0.31 cm^2 and a dry mass of 0.02±0.002 g in 24 hrs. A 5th instar can consume 4 times more than a 4th instar of *H. talaca* caterpillar, 16.19±1.21 cm^2 of leaf area and 0.08±0.01 g of dry mass. Pratissoli et al. (2002) observed that leaf-area consumed by the 5th instar of a Cassava defoliator, is 6.4 times higher than that of 4th instar. As the developmental period for a 4th instar is about 3 days, it does not result in substantial crop loss, but if it advances to 5th instar stage, which has a developmental period of around 7 days, a huge crop loss is envisaged both in terms of yield as well as in terms loss of photosynthetic area. A 5th instar caterpillar feeds on young pluckable leaves as well as on maintenance leaf. Defoliation in the initial stages may not be reflected in the yield but experiments conducted by Justseen and Tammes (1960) showed that the relationship between damage and initial population density of pest is exponential. Often farmers or Planters as a routine measure apply pesticides, hence the necessity of cost:benefit ratio arises.

Leaf consumption by insects is believed to directly affect absolute photosynthesis of the remaining plant canopy (Pedigo, 1999). The photosynthetic efficiency of young expanding leaves of tea develops gradually and they do not become fully efficient until they have grown to more than half of their final size (Barua 1953, 1964). The mature leaves which are left

Table 1: A comparison of feeding activity of two advanced looper stages of *H. talaca* and the consequent leaf damage

Starting viable eggs=500	4th instar (mean±SE)*	5th instar (mean±SE)*
Survival (%)	25.1± 1.97* (25%)	19.75± 2.64* (20%)
Number of surviving caterpillars (larva)	125	100
Stadium (days)	2.7	7.1
Food consumed by each individual (cm^2)	3.55± 0.31*	16.19± 1.21*
Food consumed by each individual (dry mass; gm)	0.02± 0.002*	0.08± 0.01*
Total area loss (cm^2) caused by surviving 4th & 5th instar	12690.33	
Total dry mass loss (gm) caused by surviving 4th & 5th instar	66.669	

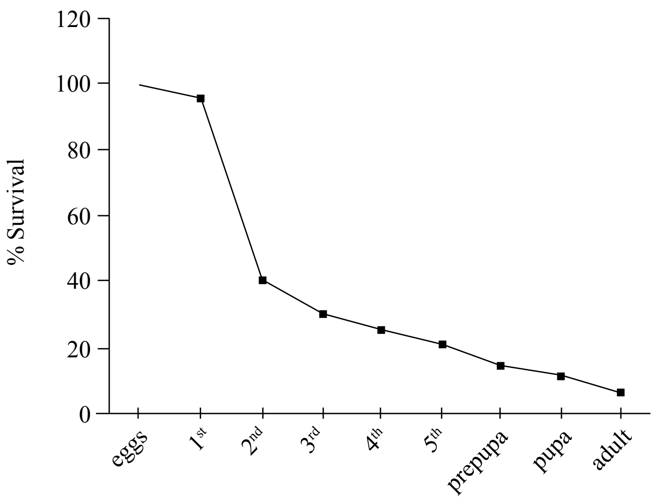

Figure 1: Survivorship curve of *Hyposidra talaca* on Tea

permanently on the tea bush for the production and supply of saccharides to various sinks are known as maintenance leaves (source leaves).Out of the total photosynthates produced by the maintenance leaves, only 11.08% is allocated to the commercially useful harvestable two and a bud shoots which is accepted as the harvest index of tea. The photosynthetically active maintenance leaves retained 19.05% of photosynthates (Barman and Saikia, 2005). Tea being an evergreen plant is more sensitive to the foliage loss than any deciduous plant (Feeny 1976; Mooney & Gulmon, 1982; Coley, 1988). But the characteristic features of defoliation by looper is not concentrated one, rather it is always dispersed and damage is partial until the plantation is not heavily infested. They rarely finish a whole leaf and move to other. Several studies have shown that damage dispersed over many leaves is less detrimental to the plant than damage concentrated on fewer leaves (Lowman, 1982; Marquis, 1992; Mauricio et al., 1993). In case of dispersed damage, the distribution of damage could potentially affect plant recovery from defoliation by compensatory photosynthesis. Concentrated damage does not stimulate photosynthesis in remaining leaves to the same degree as dispersed damage (Meyer, 1998). Therefore, the principal effect of leaf-mass consumption seems to be through reduction of photosynthesizing leaf-area, not reduction or enhancement of photosynthetic capacity of remaining tissue of injured leaves (Peterson and Higley, 1996).

Optimal control decisions cannot be made without reliable crop loss estimates (Madden, 1983), therefore, a technique must be formulated to estimate approximate crop loss by using the data given in the Table 1. For studying the relationship between the level of pest infestation and yield, the most common method of artificial infestation is used. Known number of pests is put on plants which may be inside the cages or within enclosed walls. Regulated level of artificial infestations is done by exposing the test plants. The effect of the pest damage in terms of yield loss (area or weight) can be measured as it is easy to compute the damaged leaves (Chatterjee, 1991).

4. Conclusion

This study can have the utility of estimating the biotic stress on the tea plantation due to folivory by advance stage loopers of *Hyposidra talaca*. The dimension of crop loss by 4th and 5th instar looper due to destruction of tea leaves may caution tea planters, prompting them to take appropriate control measures in time. As the present study is a lab-based, the same work may be taken at in the field (plantations) to acquire more applied knowledge.

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