Looper Caterpillar Invasion in North East Indian Tea Agro-Ecosystem: Change of Weather and Habitat Loss May be Possible Causes?

Binu Antony, Palatty Allesh Sinu, Azizul Rehman

1 Department of Entomology, Tea Research Association, Tocklai Experimental station, Jorhat 785 008, Assam state, India.
2 Plant Protection Department, Nagrakata Regional R&D Station, Tea Research Association, Nagrakata, Jalpaiguri, Pin 735 225, West Bengal, India.

Corresponding author email: binuantony@yahoo.co.in; Authors


Abstract Tea industry in India hit a record loss of tea production in 2009-11 due to widespread attack of tea defoliators, looper caterpillar pests of geometrid moths (Lepidoptera) in major tea growing eco-belt of Assam and West Bengal states. This geometrid pest complex has at least four sister species, two each of Biston and Hyposidra; and a mixed brood of Ectropis sp. The former one was reported as a pest of tea in India since 1911, and later one reported from China and introduced to India; but Hyposidra is a novel tea pest globally, reported recently and that too first from northeast India. Through this article, we attempt to portray the severity of looper outbreak and raised two key questions; viz., present looper outbreak as an indication of climate change in north-east India? and habitat loss may be the fundamental reason for the primary invasion of looper?

Keywords Tea; looper caterpillar; Biston; Hyposidra; Ectropis; climate-change

1 Tea Ecosystem and Climate Change

Tea (Camellia sinensis L.) is a global beverage and India is the largest producer and consumer of tea. Tea is grown in thirteen states of India, and north-eastern parts, particularly Assam (26°00'N 93°00'E) and West Bengal (23°00'N 87°00'E) states contribute over 65% of the total national production. Way back from 1891, tea growing areas were rapidly increasing and now it spread from Upper Assam (Dibrugarh district), South Bank (Sibasagar, Jorhat and Golaghat districts), North Bank (Sonitpur, Darrang and Nalbari districts), Cachar, Dooars (Jaipaiguri district) to Darjeeling districts of North Bengal (Figure 1); and contribute around 70 million kg of tea per month and earning 25 million US $ (data based on June 2010 report of Tea Board, India (http://www.teaboard.gov.in).

Being a plantation crop that too formed at the cost of tropical and subtropical forests of north-east India, tea ecosystem is under constant pressure from insect pests since time immemorial. With global warming resulting in climate change, tea growing environments are undergoing rapid changes and new challenges and pest outbreaks are arising every now and then. Analysis of 100 years weather data as recorded at different eco-regions of tea growing belt by Tocklai Experimental Station (http://www.tocklai.net), Jorhat (26°7'N 94°13'E) showed a deficit rainfall (6%~8% from the normal) resulted greater frequency of drought, elevated CO2 level (1.5 ppm per year) and rise in temperature for north-east India. The minimum temperature on an average has risen at many places from 1°C to 1.2°C over past 90 years, but at the same time a decrease in maximum temperature in the peak production phase has also been observed, and more than 200 mm of annual average rainfall has been lost. Winter temperature during past one decade has increased by 0.7°C from the past 30 year average (Refer: http://www.tocklai.net/Concept%20note%20on%20climate%20change[1].2.pdf). The last one decade has particularly experienced extreme fluctuation in weather conditions in Dooars (26°32'N 88°46'E West Bengal). The year 2006 recorded 400 mm and 660 mm deficit rainfall compared to previous and successive years; 2008 and 2009 also experienced deficit rainfall in the same tune. 2010, however, recorded second highest rainfall in past 30 years, 5 129 mm. Meantime, a rise of 1.1°C in minimum winter temperatures (November–January) has been recorded during 2005-2006 than previous year. According to the meteorological data released by TRA during 2009 showed drastic decline of rain-fall, erratic
a season-long rain-fall, rise in temperature, high precipitation level and dry seasons resulted greater frequency of drought in almost all districts of Assam and West Bengal.

2 Tea Looper Caterpillar

Though a perennial crop, tea ecosystem of north-east India is unique for its dormancy in winter months (December to March) and the monsoonal climate characterized by the alternate wet and dry seasons (May-August). Tea ecosystem provides resources and niche for over 1000 species of insects that includes both beneficial and harmful ones (Hazarika et al., 2009). Tea, like any other agro-ecosystems, characterized by the strength of tri-trophic (plant, herbivores and their natural enemies) interactions that were resulted from a long adaptive process specific to a particular environment and relatively stable climatic conditions. Climate change can weaken this interactions particularly the one between herbivores and their natural enemies (Stireman et al., 2005). This can result in pest resurgence and resurrection of minor pest to major one. The year 2006 witnessed first early notable invasion of a mixed species of geometrid moths, popularly known as looper caterpillar because of larval looping movement. The problem worsened in the year 2009 and 2010 and even a winter brood of mixed looper infestation has been reported from Doors (West Bengal) and Dibrugarh (27°29'N 94°54'E Assam) districts. At least five looper pests, viz., Biston (Buzura) bengaliaria Guen., B. suppressaria Guen, Hyposidra talaca Walk., H. infixaria Walk. and Ectropis sp. (Lepidoptera: Geometridae) are ecologically-adapted to survive in tea gardens at present (Figure 2). A compendium of research reports (1910-2010) from Indian Tea Research Association suggests that B. suppressaria as an occasional minor pest during 1900-1920 (Antram, 1911; Anonymous, 1915), and a minor attack of looper (B. suppressaria) had been reported in the districts of Sibsagar (26°59’N 94°38’E) and Golaghat (26°31’N 93°58’E) and also in certain tea estates in the eastern Doors in mid of last century (Anonymous, 1958); but became the most severe caterpillar pest in late last century (1990-2000) (Hazarika et al., 2009). Except B. suppressaria and occasional incidence of Ectropis sp., no mention on any other looper species had been available during last century. However, for the past three years B. suppressaria was outnumbered by two hitherto unrecorded
Figure 2 Major looper complexes of north-east Indian tea agro-ecosystems
Note: Female moth: A: Biston bengaliaria; B: B. suppressaria; C: Hyposidra infixaria; D: H. talaca; E: Ectropis sp.

Figure 3 Severely defoliated tea bushes due to looper attack in Dooars, North Bengal, India

Figure 4 Different instars of looper feeding tea leaves and chrysalids

3 Climate Change and Habitat Loss May Be the Fundamental Reason of Looper Invasion?
It is hypothesised and established at least in laboratory conditions that as temperature increases duration required for life cycle completion shorten (Stireman et al., 2005). This has crucial repercussions in north-east Indian tea ecosystems. As tea plants go dormant at least for three months in winter (Barua, 1969), pest species too would be quiescent in different life stages or prolong their life cycle duration. What we learnt from our experience and literature that the looper infestation is comparatively less in winter months (November–March); but for past two years the species laboratory studies showed that single larvae can consume 4–5 young leaves within 3 hours (unpublished data). As the larvae mature they prefer eating mature maintenance foliages of tea, which later pupated in the soil and crevices of tea bushes. The female moths emerged from the pupae fly towards the shade tree and secrete sex pheromone to attract the male moth of the same species, and mating occurs during night. The eggs are laid in heaps, on the trunk of shade trees, each containing 200–400 eggs covered with a buff coloured hairs. The young caterpillar feeds shade tree leaves and later moves down to the tea leaves, and if early instars are unnoticed the entire tea bush would be stripped off (Figure 3).
exhibit its devastation in several tea gardens with at least one normal brood size. This aberration in the population build up of pest is unlikely to get adapted by the naturally occurring enemies of the pest species unless the changing climate persists for next several years. Winter temperature during past one decade has increased by 0.7°C from the past 30 year average. In 2009, aseasonal rainfall in late October in North Bengal (Dooars: Jaipaiguri district) brought additional cheer to planters as much warranted last flush was far more than the normal. Though it contributed some more kilograms of tea in the kitty of many gardens the crop was not desirable when the “additional flush” was weighed. This happened as looper caterpillars too were cheered with additional resources, and paraded tea gardens with clearly defined brood. Though pest species can get along easily with the changing climate, insect and microbial natural enemies cannot. This missing important component of the tri-trophic interaction can escalate the population of pest that go for dormancy in tea.

North East Indian forests are Sal (*Shorea robusta* Roth.: Dipterocarpaceae) dominated (Shankar et al., 1998). Recent forest fragmentation due to slash and burning for agriculture (primarily for tea) and other developmental activities allows certain generalist species to dominate the forests (Shankar et al., 1998). *S. robusta*, due to its coppicing ability, becomes a co-dominant species in forest plantations that are primarily raised for *Tectona grandis* (Verbenaceae) timber production. Similarly, Cinchona that is originally raised in high range slopes of adjoining Darjeeling hill during 1860s (Kennedy, 1996); but less returns from these plantations has made the administration to abandon many of these plantations these days. *S. robusta* and Cinchona are important food plants of geometrid moths (Intachat et al., 2001; Sen-Sharma and Thakur, 2008). With the available information, it is imperative that Dipterocarpacean dominated forests and Cinchona plantations must have concentrated the natural foraging resources indispensable for *Hyposidra* colonization in the region (Sinu et al., 2011). In tea garden, shade trees are recommended as regulators of light penetration to maintain the leaf temperature and humidity optimum for photosynthesis. The shade trees (comprised primarily of leguminaceous members) however, are bane for entomologists as most of the looper pests took advantages of them for invasion and establishment in tea gardens. Shade trees like *Albizia* spp. (*A. odoratissima, A. chinensis, A. procera, A. lucida, A. lebek and A. moluccana*) and *Indigofera teysmanii*, widely planted in tea gardens of Assam, are the preferred oviposition sites and provide resources for first two instar stages of the larvae (Figure 5). Hence, habitat loss due to the deforestation might be the fundamental reason for the primary invasion of looper caterpillars to tea ecosystem; but the increased plantation of shade trees might have accelerated the invasion further as the shade trees might have given a suitable micro-climate condition that was optimum for the moth survival in natural conditions.

The tea looper caterpillar, *Ectropis obliqua*, is one of the major pests of tea bushes in China and pest incidence has been reported from Zhejiang, Jiangsu, Hunan and Anhui provinces of China (Quiag Xiao, TRI-CAAS, China). Recent decades, several Chinese varieties of tea bushes were planted in Darjeeling hills of West Bengal and several parts of Nepal. Hence an assumption has been drawn from *Ectropis* outbreak is that the pest might have introduced in this region from China along with the planting material. To support this notion, recently we reported nucleopolyhedroviruses showing high nucleotide similarity with *B. suppressaria* Chinese Isolates, and found infecting looper caterpillar in India (Antony et al., 2011).

4 Conclusion

In the year 2009-11 there was a widespread, severe looper outbreak in almost all tea cultivating areas of Assam and West Bengal states of India linked with drastic weather change in North East India. There are
reports that herbivores respond rapidly to the climate change and increased CO₂ level in the atmosphere causes increased herbivory (Agrell et al., 2005). Apart from this, temperature change, high precipitation level, fluctuation in rain-fall pattern, and continuous dry seasons may be conducive for herbivore population to build up, particularly that of geometrids (Intachat et al., 2001). We therefore hypothesised that there is unambiguous relationship between looper outbreak and drastic weather parameter changes in tea agro-ecosystem in North East India. In addition, habitat loss due to the deforestation and indiscriminate planting of shade trees in tea garden might be the fundamental reason for the attraction of loopers from forest to the tea garden. To conclude, the looper caterpillar outbreak in tea garden in north east India might be as a result of deforestation and habitat loss leads to agro-climatic change in this region.

Insect pests in any ecosystem develop many new adaptations in their short life-span in order to survive and thrive in the changing environmental conditions. Considering ever increasing cost of agriculture inputs, reduction in production cost and increasing productivity would be the major challenge in any agriculture, however, pest problems always upsets these efforts. Research on what are the major causes of looper outbreak in North East India needs to be figure out. Whether it’s because of habitat loss or climate change, what physiological, molecular changes and behavioural adaptation ultimately evolved in these geometrids for the rapid expansion in tea growing belt is without delay to find out.

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