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Scirtothrips dorsalis, Hood (Thysanoptera: Thripidae): A major pest of tea plantations in North East India

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Abstract

Scirtothrips dorsalis Hood, is a polyphagous insect found colonizing on several crops including cotton, chilli, mango, pepper, citrus, grapes, strawberry, and peanuts including tea. Tea thrips feed the host plant tissues using the piercing and sucking mouth parts and consume the plant sap resulting curling and silvering of the tea leaves, which causes considerable yield loss in India, during the last few decades, the infestation of thrips has been increasing and it get recognized as a foremost sucking pests in the tea cultivated regions in India. Besides deforestation, climate change, continuous application of synthetic pesticides the biological characteristics like high reproductive rate, short generation time, has led to resistance to synthetic insecticides along with their manipulation in periodical outbreaks. In this review, all accessible information on *S. dorsalis* damaging the tea plants have been summarized in framework of its management strategies.

Keywords: Tea, thrips, *Scirtothrips dorsalis*, life cycle, nature of damage, management strategies

Introduction

Tea, *Camellia sinensis* (L) O. Kuntze, a perennial crop cultivated on both small as well as in large-scale plantations. According to FAO, 2005, tea is cultivated on more than 2.7 million ha in around 34 countries across Africa, Asia, Oceania and Latin America to produce more than 3.2 million metric tons of made tea per annum. It is infested by a number of insect and mite pests which are responsible for an average yield loss of 12–15 percent. Different thrips species *viz.*, i.e. *Scirtothrips bispinosus*, *Scirtothrips dorsalis*, *Physothrips setiventris* and *Heliothrips haemorrhoidalis* from different crops are reported and documented as pest [1]. Among them, *Scirtothrips dorsalis* causes severe damage to tea and chilli plants (fig. 1A). *S. dorsalis* is polyphagous in nature and considered as a common tropical insect pest [2]. Profound feeding scratch turns buds, tender leaves as well as colour of fruits become bronze to black. The infested leaves bend upward and come into sight distorted. Damaged plants become diminutive or dwarfed, and the leaves with petioles disengage from the stem which cause defoliation in case of some plants [1, 3]. Thrips feed the host plant tissues by the piercing and sucking mouth parts and consume the plant sap which cause in silvering of the leaves and finally cause necrosis of plant tissue [4, 5]. Oviposition by thrips also causes injury to fruit [6]. The tea plantations with the adjacent forest areas contribute a lot for the nourishment for insect pests of terrestrial ecosystem by providing widespread land cover with several species. Such monoculture plantations of the tea crop become so conducive for the continuation and establishment of arthropods in common and insect pests in particular.

A B C

Fig 1 A: *Scirtothrips dorsalis* (adult), B: *Scirtothrips bispinosus* (adult) and C: (larva)

Diversity of tea thrips: Thrips are generally gregarious in habit, occurring in large numbers and are confined to a particular part of the plant like foliage (phyllophilous), flowers (anthophilous) and galls (cecidogenous), besides the fallen leaf litter (mycophagous) [7]. Thrips that infest *C. sinensis* are considered as important pests of national significance owing to their severe damage and consequent crop loss. In India, nearly 18 species of thrips have been recorded from the tea plants, of which, *Scirtothrips bispinosus* (Bagnall) (fig. 1B and C) in southern India, *Scirtothrips dorsalis* and *Mycterothrips setiventris* in NE India are very important.

Bionomics: The population of thrips is always maintained round the year, but their density appears to be more during April to October with the peak during warm humid climatic period which coincides with the tea cropping season in India [8]. Even though rainfall diminishes their density to some extent, it becomes a challenging task for tea growers to control the pest in view of their fast movement, quick growth and development and appreciably high breeding ability.
In the beginning of 19th century thrips was recorded first time causing damage in the tea plants in different tea gardens of Jorhat area of Assam State in India. After few years it has been reported from the different tea growing areas of eastern India including the Assam Valley, Cachar, Dooars and Terai causing considerable damage to the tea crop [9]. In 1916, thrips was reported infesting castor in Coimbatore of Southern India which was later found infesting young leaves, buds, and tender stems of other plants including groundnuts, chilli, mango, cotton, beans, brinjal (egg plant) and *Casia fistula* [10, 11].

Common names: *Scirtothrips dorsalis* Hood 1919 are also known as tea thrips, strawberry thrips, chilli thrips, Thrips jaune du théier (French), Tya-na-kiiro-azamiuma (Japanese) and Nordindischer Teeblasenfuss (German)

Identification
The tiny size (< 2 mm) and speedy movement of *S. dorsalis* cause it complicated to distinguish them in fresh vegetation. Eggs are very minute and stay up to one week inside the soft plant tissues. Dimension of a normal first and second instar larvae range between 0.36-0.38 mm and 0.68-0.71 mm respectively, whereas the size of the pupae can range between 0.78-0.80 mm [12]. Using some features the morphological detection of thrips can be made [13] *viz*: the D1 and D2 setae which are present on the abdominal IXth terga and head in a larvae are funnel shaped. The D1 setae present on the Xth terga also funnel shaped. Pronotum is reticulated which is consists of 6-7 pairs of pronotal setae. There are 8-12 setae in the each abdominal segment of the larvae. Distal two thirds of the fore femora of the larvae consists of four funnel shaped setae and the body posses granular plaques. In case of adults, the body is light yellow in colour and abides gloomy brown antecostal ridges on tergites and sternites. Body sizes of a normal adult are less than 1.5 mm which bears dark fringed wings. Two numbers of antennae (eight segmented) with a forked sensorium on each of the III and IV segments are present in the head which is wider than the long. In the abdomen dark spots which forms incomplete stripes can be notice dorsally [12]. On the head, there are three pairs of ocellar setae. Between the two hind ocelli the third pair is present which also known as intercellular setae. Pronotum setae (anteroangular, anteromarginal and discal setae) are consists of closely spaced horizontal lineations which are more or less equal in length and very short. Broader posteromarginal seta-II is longer than the posteromarginal seta I and III. Medially positioned metanotal setae present in the rear of the anterior margin and the posterior half of the metanotum bears longitudinal striations. Three nos of discal setae are to be found on the lateral microtrichial fields of the abdominal tergites. On the distal half, shaded forewings are present with posteromarginal straight cilia which are distally lighter in color. In sternites the discal setae are absent where these are enclosed with several microtrichia [2, 14]. Following the conventional taxonomic keys, an adult thrips can be recognized to the genus level, but to identify them up to species level requires substantial expertise due to the intra-specific morphological dissimilarities in several species [15]. Now a days it is become easier for species specific identification of thrips using the molecular marker (rDNA ITS2) [16].

Geographical distribution
S. dorsalis is indigenous to India, Myanmar, Bangladesh, Sri Lanka, Pakistan, Thailand and Taiwan, but has become more widespread in the past 20 years, expanding its host range because of amplified globalization and open agricultural trade [17]. Now days, it turn out to be an important pest in eastern and southern Asia, Oceania and Africa [18]. In Asia, the pest is present in India, China, Bangladesh, Brunei, Cambodia, Indonesia, Japan, Israel, the Republic of Korea, Myanmar, Pakistan, Malaysia, Sri Lanka, the Philippines, Taiwan, Thailand and Vietnam. In Oceania, *S. dorsalis* is found in northern Australia, New Guinea, Papua and the Solomon Islands. Plant quarantine seize imply that it is also scattered across East Africa (Kenya) and West Africa. It is widely distributed in the Caribbean and Central America, Jamaica, Barbados, St Lucia, St Vincent, Tobago, Puerto Rico and Trinidad [19]. This pest is causing severe damage to grapevine in Suriname and western Venezuela [17, 19, 20]. On the African continent, this pest from South Africa and the Ivory Coast, indicating a extensive distribution throughout East Africa (Kenya) and West Africa [19] whereas *S. dorsalis* in Israel in addition to in the Caribbean islands [21].

Host range
The major wild host plants of *S. dorsalis* belong to the family Fabaceae, which includes Brownea, Acacia, Saraca and Mimosa. In the Indian subcontinent, this pest is considered as one of the major serious threats of tea and chilli crops [22]. It is a major pest of tea and *Arachis* in India [23], sacred lotus in Thailand and citrus and tea in Japan [3]. It is polyphagous in nature having surplus 100 recorded host plants from around 40 families which includes the following host plants too: *Camellia sinensis* (tea); *Acacia arabica*, *Amaranthus blitum* (purple amaranth); *Acacia* spp. (acacia); *Acer* sp. (maple); *Ampelopsis brevipedunculata* (porcelain berry); *Arachis hypogaea* (peanut); *Anacardium occidentale* (cashew); *Asparagus officinalis* (asparagus); *Camellia japonica* (Japanese camellia); *Calotropis gigantea* (bowstring hemp); *Camellia sasanqua* (sasanqua camellia); *Capsicum frutescens* (Tabasco pepper); *Castanea crenata* (Japanese chestnut); *Chrysanthemum morifolium* (chrysanthemum); *Cayratia japonica* (bushkiller); *Citrus aurantifolia*, *Dahlia* sp. (dahlia); *C. maxima*, *C. unshiu*, *Citrus* spp. (citrus); *Distylium racemosum* (isu tree); *Diospyros kaki* (Japanese persimmon);

Syzygium malaccense (Malay apple); *Eurya japonica* (eurya); *Euonymus japonicus* (euonymus); *Ficus carica* (edible fig); *Cuphea hyssopifolia* (Mexican heather); *Fragaria ananassa* (strawberry); *Glycine max* (soybean); *Ginkgo biloba* (ginkgo); *Gossypium herbaceum* (Levant cotton); *Hevea* sp. (rubber); *Ilex integra* (Mochi tree); *Lamium barbatum* (dead nettle); *Jasminum multiflorum* (star jasmine); *Laurus nobilis* (bayleaf); *Photinia glabra* (Japanese photinia); *Mangifera indica* (mango); *Ilex crenata* (Japanese holly); *Lycopersicon esculentum* (tomato); *Melanoxylum* sp. (brauna); *Musa* sp. (banana); *Fagopyrum esculentum* (buckwheat); *Nelumbo* sp. (lotus); *Mimosa pudica* (sensitive plant); *Osmanthus heterophyllus* (holly olive); *Phaseolus vulgaris* (bean); *Pieris japonica* (Japanese pieris); *Podocarpus macrophyllus* (podocarpus); *Pittosporum tobira* (pittosporum); *Prunus salicina* (Japanese plum); *Prunus mume* (Japanese apricot); *Prunus* sp. (cherry); *Pyracantha angustifolia* (firethorn); *Pyrus* sp. (pear); *Quercus glauca* (Japanese blue oak); *Rhododendron* sp. (rhododendron); *Rosa* sp. (rose); *Sauropus androgynus* (sweetleaf bush); *Ricinus communis* (castor bean); *Saraca indica* (ashoka); *Solanum melongena* (eggplant); *Tamarindus indica* (tamarind); *Sonchus asper* (sowthistle); *Theobroma cacao* (cocoa); *Vigna radiata* (mung bean); *Viburnum odoratissimum* var. awabuki (awabuki viburnum); *Zanthoxylum piperitum* (Japanese pepper); *Vitis vinifera* (grape) [3]. So various factors could be attributed to the differences host plants of thrips from diverse geographical regions and these a variety of factors could comprise accessibility of hosts, accessibility of predators in the area of invasion, environmental surroundings, deviation in competition with other insect pests etc. [24].

Nature of damage

This tiny insect feeds on the meristematic tissues, terminal along with the tender parts of tea plant resulting adverse feeding scars, deformation of tea leaves and discoloration of buds [25] (fig. 2A). It prefers to feed the young plant tissues (fig 2B). As it bears piercing and sucking mouthparts, it extracts the contents from the epidermal cells, which leads to the necrosis of tissue. After feeding the colour of the tissue changes from silvery to black or brown, the leaves curl upward which indicates the presence of *S. dorsalis* (fig. 2D). Feeding by thrips causes lacerations of tissue and makes it appear as streaks (fig. 2E). Both the larvae and the adults suck the cell sap of the leaves [26]. Damaged shoots become fragile and plunge down. The feeding marks are made one after one, which forms thin light appearance on the underneath of leaves analogous to the main vein (fig. 2C). In case of severe infestation, the tender shoots and the leaves become brittle, as a result complete defoliation of the host plant is noticed and cause a huge yield loss. Thrips spread so quickly in a short period of time due to its easy local dispersal [24]. Adults fly for short distances immediately after the population density reaches the peak density [27]. Passive dispersal on wind currents enables long-distance spread [24].

A B C D E

Fig 2(A-D): Damage symptoms after feeding by thrips in tea, E: Microscopic (10x) observation of thrips infested tea leaf

Life cycle

A gravid female lays the eggs inside of a plant tissue and they hatch within 5-8 days based on the environmental circumstances [9, 21]. The eggs are microscopic and bean-shaped, a little narrower in one end and newly laid eggs are colourless. Freshly hatched larvae looks white but once it started sucking the plant sap, their colour progressively turns to light yellow and the second instar larvae looks orange yellow. Within 8-10 days it become pupa which can be identify by the presence of free antennae directed forward and reflected over the head to reach the middle of the pro-thorax. Based on the environmental conditions the within 2-4 days the adult emerged from the pupa and the adult is light yellow in colour. The size of a female is about 1.05 mm length and 0.19 mm width whereas a male is about 0.71 mm in long and 0.14 mm in width. The adults can survive around 13-15 days (fig. 3). The duration of the life cycle of *S. dorsalis* is significantly inclined by the variety of host plant they are feed.

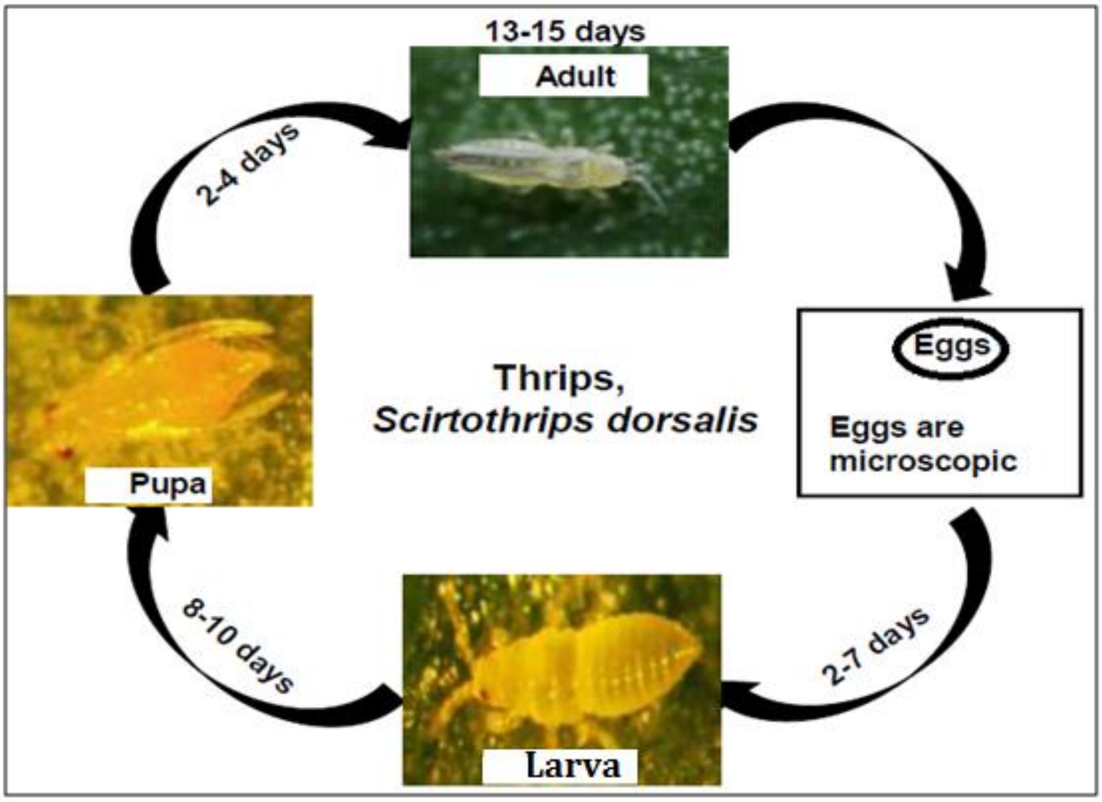

Fig 3: life cycle of *S. dorsalis*

Pest biology

S. dorsalis complete its life cycle in 5 different stages viz. egg, two active feeding larval stages, prepupa and pupa both of which are relatively inactive, and a winged, feeding adult stage [17]. Thrips mainly feed on the actively growing plant tissue therefore the feeding stages generally found on the immature parts of a plant [18]. *S. dorsalis* followed the procedure of arrhenotoky for reproduction, i.e. the unfertilized eggs produces males and the fertilized eggs produces females. Normally they laid a higher proportion of fertilized eggs in to the soft parts of the plants above the soil. A female thrips lays eggs 2-4 numbers in a day, with a total number of around 60-200 eggs in her life time on chilli plant [28]. Eggs of thrips hatch after 5-8 days, larval period continues up to 8-10 days before transforming in to pupae and within 2.6 – 3.3 days the pupae become adult [17]. The entire development period depend on the environmental conditions, particularly temperature along with the host species on which they are feeding. The temperature range for the normal growth ranges between 9.7 °C and 33.0 °C, with 265 degree-days (DD) from egg to adult and 281 DD from egg to egg. In Japan, adult females' diapauses in temperate regions and more than five generations occur per year [29, 30, 31]. *S. dorsalis* starts to lay eggs in late March or early April [32]. High population densities were observed during prolonged dry conditions [17]. But in India *S. dorsalis* is multi-voltine and no diapauses are reported [30].

Intra-specific diversity

There are molecular differences between morphologically indistinguishable populations of *S. dorsalis* which is a complex of species including at least three taxa [33]. Indian and South African specimens that were identified morphologically as *S. dorsalis* belonged to different species [15]. The genetic differences between these samples were considered to be too great to support the conclusion that separate host races were present. Different populations of thrips have host preferences without substantial modifications to life history traits such as development, survival and fecundity [21]. A novel pull of *S. dorsalis* caused damage to capsicum in addition to tea and mango which was reported in Japan [30].

Thrips- vectors of Tospoviruses:

Thrips an insect vector which transmits the tospovirus in a constant propagative approach [34, 35]. Around 15 numbers of thrips species can transmit as a minimum one tospovirus and among them *Frankliniella occidentalis* is the major one [36]. Due to the polyphagous nature thrips feed a broad range of host plants, consequently it spread worldwide which spread tospoviruses globally [37, 38, 39]. Transmission of tospovirus occurs when the thrips (during their larval stages) feed the tospovirus-infected plants. Once the virus goes inside the alimentary canal, it starts replicating in the salivary glands, midgut epithelium and in the muscle cells [34, 40] and can spread the virus till their existence [35, 41, 42]. Due to tospovirus infection, apparent pathogenic effect is seen in the infected plants but the thrips do not suffer not impacted in their life span, fecundity or in the offsprings [43]. As a result of infection, tospovirus induce the necrosis in tissues as a result spots and streaks occur on the leaves and bleached rings and spots occur on the fruits [44].

Management strategies

The considerable damage occurring in tea bushes after pruning. Appropriate control measures have to be adopted for reducing the economic loss due to thrips infestation when the thrips population is around three thrips per shoot [45]. To control the thrips different types of control measures are being followed:

Cultural practice

There is a rapid buildup of thrips during March - April and during May it attaining at peak. Population can be minimized to some point if plucking interval is shorter. As most of the common weeds are alternate host of the thrips, therefore the tea field should be kept free of weeds. Yellow sticky traps (@ 20 -25 traps/ hectare) can be used to control adult population of thrips by placing them just above the plucking table [46] (fig.4). Rotation of position of the traps at 2-3 days interval helps better trapping. Study related to trapping of thrips in yellow sticky trap shows that around 1200 numbers of thrips attracted and trapped in a single yellow sheet after 14 days of installation whereas average number of natural enemies and associated insects trapped in the same sheet were negligible in comparison to the thrips [46] (fig. 5).

Fig 4: Yellow sticky traps in tea field

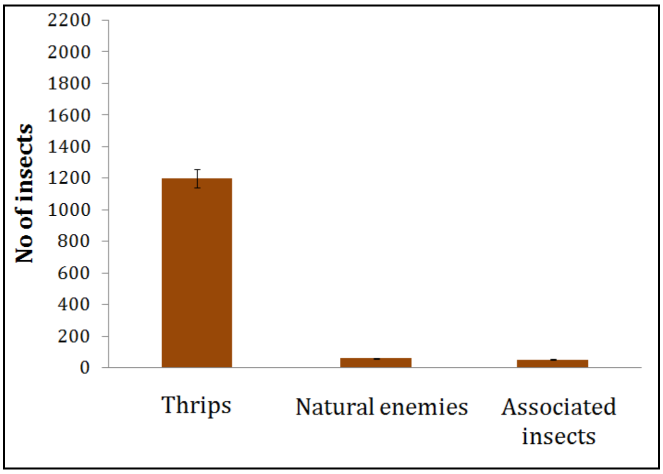

Fig 5: Average number of thrips attracted in yellow sticky traps (after 14 days of installation)

Biological control: There are more than 170 species of entomopathogens, parasites and predators, hyperparasites and antagonists are available in the natural environments which are highly effective in controlling several insect tea pests, weeds and pathogens [47].

Natural enemies of thrips

Predators: predatory thrips (*Mymarothrips garuda, Aeolothrips intermedius*), *Anthocoris* and Orius spp., *Chrysoperla carnea,* praying mantis, *Mallada* sp, ladybird beetles, spiders, syrphid flies etc are present in nature [48].

Pathogens: *Verticillium lecanii, Steinernema* sp., *Beauveria bassiana, Paecilomyces fumerosus, Metarhizium anisopliae* can be use for effective control of thrips. *Lecanicellium lecanii* @ 2 kg/400L (400L of water is required for 1-hectare area in tea plantation) along with jaggary @ 1 kg/400Lcan be used as an alternative strategies for the control of thrips [49, 50, 51, 52].

Chemical control: The ETL for thrips in tea plantations is three thrips / shoot. Once it crosses the ETL immediate post plucking spraying of PPC recommended insecticide should be carried out [53]. For this each and every small scattered pocket infested by thrips should be identified and the pest populations also need to be monitored at a regular interval of time [54]. For the control of this pest, Quinalphos @ 1L/400L, Parafinic oil @ 1500 ml/400L and Thiamethoxam @ 100 g/400L are being used for the control of this pest in south India [25]. Timely application of the pesticide and the interval between the rounds of applications are important in dealing with these pests. Treat the affected patches with a round of contact insecticide and followed by a round of any systemic insecticides. Chemical pesticides like Quinalphos 25 EC @ 1L/400L, Thiamethoxam 25 WG @ 100 gm/400L, Bifentrin 8 SC @ 250ml/400L, Deltamethrin 2.8 EC @ 200 ml/400L, Thiacloprid 21.7%SC @ 400ml/400L, Clothianidin 50WDG @ 90gm/400L etc. are recommended against the thrips [55]. Based on the severity of infestation the number of spraying rounds may vary. Spraying should be thorough covering both the surface of the leaves, buds, and succulent shoots. It is desirable to rotate the chemicals instead of using the same chemical over prolonged period to avoid developing resistance to the chemicals.

In view of pesticide residue awareness around the globe, it is very important to use synthetic pesticides as little as possible by integrating different alternate control strategies by adopting Integrated Pest Management (IPM) programs. There are several natural enemies that regulate the population of thrips. However, none of them alone can reduce the thrips populations to a low, non-economical density. Furthermore, the intensive use of pesticides will adversely affect the natural enemies in tea ecosystem. In view of these problems, sustainable crop production by adopting eco-friendly pest management techniques is gaining momentum. Entomopathogenic fungi are considered as the most versatile biological control agents, due to their wide host range that often results in natural epizootics.

Conclusion

The tiny thrips has become the foremost pest in Indian tea plantations and to control this pest chemical insecticides are repeatedly used which backfires persistently and leading to development of resurgence, resistance and replacement. To combat these circumstances, it is essential to employ all the resources obtainable in the agro-ecosystem by following the integrated pest management strategies in an effective manner to minimize the thrips population in tea ecosystem and make pesticide free tea.

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