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Bioecology of the tea thrips, *Scirtothrips bispinosus* Bagnall (Thysanoptera: Thripidae) infesting tea in south India

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ABSTRCT: Investigations were carried out on the life history and seasonal abundance of the thrips, *Scirtothrips bispinosus* infesting tea at Coonoor, The Nilgiris, Tamilnadu. The total developmental duration of females from egg to adult stage was 18.15±0.23, 12.55±0.15 and 10.30±0.23 days at 20, 25 and 30°C respectively. The net reproductive rate (Ro), mean generation time (Tc), intrinsic rate of natural increase (rm), finite rate of increase (λ) and weekly multiplication (Wm) rates were high at 25°C followed by 30°C and 20°C. Multiple regression analysis revealed that population density of *S. bispinosus* showed a negative relationship with rainfall (-0.266), maximum temperature (-38.839) and maximum relative humidity (-3.356) and positive relationship with minimum temperature (63.205), minimum relative humidity (1.686) and sunshine period (2.887). Incidence of thrips was high in the fields recovering from pruning followed by second, third and fourth year in a pruning cycle. The number of thrips per shoot was significantly higher on the plucking table when compared to the shoots present below the plucking table and side branches. In the tea plantations of South India, four species of predatory mites (*Amblyseius cucumeris, A. fallacies, A. degenerans and Balaustium* sp.), two species of predatory thrips *(Franklinothrips vespiformis* and *Leptothrips mali),* an anthocorid predator (*Orius sp.*) and one parasitoid (*Trichogramma* sp.) were found feeding and parasitizing on tea thrips, *S. bispinosus.*

KEY WORDS: Tea plantation, *Scirtothrips bispinosus*, life table, seasonal abundance, natural enemies

INTRODUCTION

Tea (*Camellia sinensis* (L.)) is grown in three states of southern India *viz*., Tamilnadu, Kerala and Karnataka, covering an area of around 106850 ha. It is estimated that more than one thousand species of arthropods and 80 species of nematodes infest tea (Muraleedharan, 1992). Members of Acarina, Hemiptera, Thysanoptera, Lepidoptera, Coleoptera and Isoptera are the most important orders among the arthropod pests of tea. The tea thrips, *Scirtothrips bispinosus* (Bagnall) is endemic to south India. Unlike the polyphagus *Scirtothrips dorsalis*, *S. bispinosus* feeds only on the leaves of tea and coffee plants (Mound and Palmer, 1981). The infested tea leaves become uneven, curly and matty, exhibiting parallel lines of feeding marks on either side of the mid rib. Heavily infested fields sometimes acquire a bronze colour. Damaged terminal shoot may be discoloured, stunted, and deformed. Selvasundaram *et al.* (2004) studied the seasonal abundance in Idukki district, Kerala and reported 11 to 17% crop loss in tea due to infestation of *S. bispinosus*. Ananthakrishnan (1963) reported

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a brief account on developmental duration of *S. bispinosus*. Other than this, no reports are available describing the complete bio-ecology of this species. Most of the research on tea thrips had focused mainly on pest-management aspects and very little is known about its reproductive biology, mating behaviour, population dynamics and the influence of biotic and abiotic factors. Understanding the population dynamics and data on thrips biology are important to evolve control strategies against a pest in the long term. Pure scientific research, for instance in insect reproduction, helps to find unexpected solutions for crop protection problems in current agriculture. The paper enumerates complete aspects of biology, population dynamics, vertical distribution and the influence of biotic and abiotic factors on *S. bispinosus* population.

MATERIALS AND METHODS

Stock Culture: Stock culture was maintained by rearing *S. bispinosus* on the potted tea plants of the clone UPASI-9. The populations of *S. bispinosus* were collected from one of the organic tea estate in Nilgiris.

Rearing of nymphal instars: In the laboratory, *Scirtothrips bispinosus* was reared on leaf discs (ca. 5 cm^2) prepared from the tea clone UPASI-9. The leaf discs were placed on agar (0.5%, 10 mm thick) poured on plastic cups of size 65mm ϕ top X 60 mm ϕ bottom X 30 mm height. Five gravid adult females were introduced per cup and covered with transparent fine nylon mesh. These leaf cups were maintained in an incubator at 25^{o}C under 12L:12D photoperiod and 75±2% RH. Females laid eggs singly in an incision made in the leaf tissue with their ovipositor. The newly emerged larvae were reared on the same leaf disc until they reached the late second instar stage. The second instar larvae failed to pupate on the leaf surface hence the late second instar larvae (two days old) were transferred to a special pupal rearing container for pupation. The special pupal rearing container was standardized after conducting several experiments.

Rearing of pupae: Plastic container of 20 cm ϕ top x 15 cm ϕ bottom x 25 cm height with a closable lid was chosen for the present study. A circle of 5 cm dia was cut on the centre of the container lid and closed with fine transparent nylon mesh to allow ventilation. Rich soil collected from tea field was sieved using No.8 mesh (2057 μ) and mixed with 15 per cent each of vermicompost and dried tea leaf litter. One third of the plastic container was filled by this mixture and dried tea leaves were crushed and again spread over the soil. This acted as a pupal emergence media. For the initial survival of the late second instars fresh green tea leaves were added to ensure adequate supply of food. It is important to ensure that the food is supplied *ad libitum* before it reaches the non-feeding pupal stage. Pupation took place in the soil and leaf litter and the adult emerged within two days after pupation. The emerged adults were transferred to leaf cups to culture subsequent generations.

Life table studies: Life table of *S. bispinosus* was studied under laboratory conditions at three different temperatures *viz.,*20±2°C, 25±2°C and 30±2°C under 12L:12D photoperiod and 75±2% RH. A gravid adult female was introduced on leaf discs of approximately 5 cm^2 placed on agar (0.5%, 10mm thick) in a plastic cup (65 mm ϕ top X 60 mm ϕ bottom X 30 mm height) and allowed to lay eggs. The number of eggs laid by thrips was counted at every 12 h by observing under binocular stereo microscope. Leaf discs containing eggs were removed, labeled and kept separately for further observations on hatching and development. Fecundity of females was recorded till their death. Larvae emerged from the eggs were immediately transferred to leaf discs in plastic containers and reared individually to record the developmental duration. When the larvae entered the late second instar stage, they were transferred individually to pupal rearing containers of size 80 mm ϕ top & bottom x 70 mm height which was prepared as explained above to record the duration of prepupa and pupa. Once the adult emergence was noticed, they were checked under binocular stereo microscope to determine the sex. Accordingly the data were recorded and the developmental duration of both male and female were analysed. Number of female progenies (mx), was calculated using the number of eggs laid per female and female:male ratio. Observations were made daily from hatching of eggs to emergence and death of adults, which provided the values for life table (lx). Life tables were constructed as per the method of Birch (1948) and Atwal and Bains (1974).

Studies on Morphometrics: For morphometric study, semi-permanent slides were prepared and measurements were taken using calibrated ocular and stage micrometers in a research microscope (ZEISS-Jeneval GF-PA).

Seasonal abundance and vertical distribution: Field studies were carried out between January 2007 and December 2009 to determine the population trends and vertical distribution of *S.bispinosus* on tea bushes. For this purpose, four experimental blocks, designated A, B, C and D each consisting 100 bushes were laid out in UPASI Glysdale Experimental Farm, Coonoor, The Nilgiris, Tamil Nadu, located at an altitude of 1760 m above mean sea level (MSL) and 11.35^o N (latitude) 76.82^o E (longitude). The bushes in the experimental area were planted in 1982 with the clone UPASI-9 and spaced at 4.0 x 2.5 x 2.5 feet. They were pruned in August 2006 at a height of 60 cm above ground level and the field was not subjected to any pesticide application since pruning.

For assessing thrips populations, fresh tea shoots consisting of three leaves and a bud were collected at fortnightly intervals. From each block, 10 bushes were selected at random and from each bush six shoots were taken, two each from the top, bottom and middle levels. In the present study, shoots from the upper 10 to 15 cm of the bushes (plucking table), were considered "top level shoots" and those present on the bush up to a height of 4 to 40 cm above ground level were treated as "bottom level shoots". The foliage present in between the top and bottom levels was considered as "middle level shoots". The samples from each level of the bush were collected and the number of adults and nymphal instars in the abaxial and adaxial leaf surfaces and predators were counted using a hand lens and data recorded. The shoot samples were then collected in separate polythene bags, labelled and their mouths were tied to prevent the escape of thrips and their predators.

Influence of abiotic factors: Data on abiotic factors such as rainfall, maximum & minimum temperature, relative humidity and sunshine hours were collected from the crop weather observatory at UPASI Glysdale farm, Coonoor.

Influence of age of the field since pruning: To understand the vulnerability of field's age since pruning to thrips infestation, seven experimental plots were laid out in each I, II, III & IV year fields (4 treatments with 7 replications) after pruning and sampling of thrips was done by collecting 25 shoots at random from each block. Leaves were sampled at fortnight intervals on the 14th and 28th of every month. The total number of thrips on each shoot was counted in the field and recorded. Simple correlations were made to study the influence of age of the field since pruning on the incidence of thrips.

Survey on natural enemies: The areas surveyed for natural enemies of tea thrips include Anamallais (Coimbatore Dist., Tamil Nadu), Ooty, Coonoor, Kotagiri and Gudalur (Nilgiris Dist., Tamil Nadu), Vandiperiyar, Peermade and Munnar (Idukki Dist., Kerala), Nelliampathy (Palghat Dist., Kerala) and Wynadd (Wynaad Dist., Kerala). Estates which follow a regular plant protection schedule and also those which neglect this aspect of crop husbandry were included in the survey. One hundred tea shoots (three leaves and a bud) were collected from the fields which were severely infested by tea thrips. The shoots were examined in the field using hand lens for predators and parasitoids and collected in polythene bags for further observation in the lab after proper labeling. Few numbers were preserved in 70% ethyl alcohol for identification and the rest were cultured in the laboratory for further studies.

Statistical Analysis: The data were statistically analysed using IBM SPSS Statistics software version 20 (IBM Corp., USA). Arithmetic mean and standard error (SE) were calculated wherever necessary. Data on developmental duration, vertical distribution were subjected to one way ANOVA with post hoc Tukey's Honestly Significant difference (HSD) test. Data on effect of age of the field since pruning on thrips incidence was analysed using one way ANOVA with Duncan's post hoc multiple range test. The influence of weather parameters on seasonal abundance was ascertained using multiple regression analysis.

RESULTS AND DISCUSSION

Observations on Life stages

Scirtothrips bispinosus had five life stages *viz.*, egg, larva I, larva II, prepupa, pupa and adult (Plate 1). Data on morphometrics of different life stages of *S. bispinosus* are given in Table.1. Tea thrips deposited eggs within the soft tissues of tea leaf using its hook like ovipositor. Eggs were bean shaped and about 0.3 mm long and 0.15 mm wide; at first, they were small, hyaline in nature which could be partially seen as white patches on leaf surface when observed under a stereo microscope. The freshly hatched larva (Larva I) was pale white and turned yellow during development. It measured about 0.50±0.15 mm long and 0.12±0.00 mm wide. Larva II was yellowish and about 0.77±0.01 mm in length and 0.14±0.00 mm in breadth. The prepupa was whitish and was 0.76±0.01 mm long and 0.14±0.00 mm wide. Wing buds did not exceed the third abdominal segment and measured 0.14±0.00 mm. Pupa was white or pale yellow with the eye spots developed. Pupa measured 0.80±0.01 mm long and 0.15±0.0 mm wide. Wing buds exceeded the fourth abdominal segment and measured 0.46±0.01 mm. The newly emerged adults were brown with dark terminal segments. Females were bigger than the males and measured 0.89±0.01 mm long and 0.16±0.00 mm wide. Ovipositor was present on 9th abdominal segment and was about 0.08±0.00 mm long (Plate 2). Male was small, slender and about 0.78±0.00 mm long and 0.15±0.00 mm wide (Plate 3). Recently, Ng *et al.* (2014) re-described *S. dorsalis* from Malaysia based on both morphological and molecular approach. They reported that mean body lengths of first and second instar larvae measured about 370µm and 700µm respectively. The body lengths

Table 1. Morphometrics of different life stages of *S.bispinosus* (*Mean±SE of 10 replications*)

Life stages	Length (mm)	Breadth (mm)
I Instar	0.50±0.01	0.12±0.00
II Instar	0.77±0.01	0.14±0.00
Prepupa	0.76±0.01	0.14±0.00
Prepupa-wing buds	0.14±0.00	0.00±0.00
Pupa	0.80±0.01	0.15±0.00
Pupa-wing buds	0.46±0.01	0.00±0.00
Female	0.89±0.01	0.16±0.00
Antenna	0.18±0.00	0.00±0.00
Wings	0.60±0.00	0.06±0.00
Head	0.06±0.00	0.05±0.00
Pronotum	0.07±0.00	0.06±0.00
Thorax	0.12±0.00	0.12±0.00
Abdomen	0.60±0.00	0.10±0.00
Ovipositor	0.08±0.00	0.03±0.00
Male	0.78±0.00	0.15±0.00
Antenna	0.16±0.00	0.00±0.00
Wings	0.55±0.01	0.05±0.00
Head	0.05±0.00	0.05±0.00
Pronotum	0.10±0.00	0.06±0.00
Thorax	0.17±0.00	0.12±0.00
Abdomen	0.42±0.00	0.09±0.00

of adults ranged from 950 to 1100 µm. Males were similar to females but smaller (<1000 µm).

Influence of Temperature on Life History

Temperature had a direct influence on the life history. Duration of development for different life stages of *S. bispinosus* decreased with increasing temperatures. First and second instar larvae foraged on tea leaf as actively as adults at different temperatures. But, when the second instar larva about to moult into prepupa it stopped feeding and reached the prepupal stage. Both prepupa and pupa remained quiescent and did not feed until it emerged as adult. The developmental time of *S. bispinosus* from egg to adult was found to be relatively similar as reported by Ananthakrishnan (1963) at 25°C. In the present study, *S. bispinosus* reached adulthood faster at higher temperature *i.e.,* 30°C followed by 25°C and 20°C. Total developmental period of male was a little shorter than that of the females (Table 2).

Pre-oviposition, oviposition and post oviposition periods of *S. bispinosus* was comparatively short at 30°C followed by 25°C and 20°C (Table 3). Although oviposition period was longer at lower temperature (20°C), *S. bispinosus* laid less number of eggs when compared to 25°C and 30°C. The other parameters such as oviposition rate, percentage hatchability and survival rates of immature stages were high at 25°C than 20 and 30°C. This is in agreement with the results given for *Heliothrips haemorrhoidalis* with different temperature regimes (Rivnay, 1935; Chhagan and Stevens, 2007). Adult females of *S. bisbinosus* survived longer (20.13±0.19 days) at lower temperature (20°C) but laid less numbers of eggs (16.07±0.43). However, the longevity of *S. bispinosus* decreased with increase in temperature (17.20±0.24 days at 25°C and 14.67±0.23 days at 30°C) and laid 35.80±0.72 and 27.13±0.83 eggs at 25°C and 30°C respectively (Table 3; Fig. 1). Similarly, Teulon and Penman (1991) reported a

Table 2. Developmental duration of the thrips, *S. bispinosus*

	Developmental duration in days (Mean±SE)*					
Temp. (°C)	Egg incubation	I instar	II instar	Prepupa	Pupa	Total
Female						
20	5.30±0.15c	2.40±0.11c	4.25±0.10b	2.35±0.11b	3.85±0.13c	18.15±0.23c
25	3.90±0.12b	1.95±0.05b	2.55±0.11a	1.15±0.08a	3.00±0.07b	12.55±0.15b
30	3.10±0.10a	1.60±0.11a	2.30±0.11a	1.10±0.07a	2.20±0.09a	10.30±0.23a
Male						
20	5.25±0.14c	2.25±0.10c	3.95±0.09b	2.15±0.08b	3.75±0.10c	17.35±0.21c
25	3.85±0.08b	1.90±0.07b	2.40±0.11a	1.10±0.07a	2.90±0.07b	12.15±0.11b
30	2.80±0.09a	1.45±0.11a	2.10±0.07a	1.10±0.07a	2.10±0.07a	9.55±0.15a

*Values followed by same alphabets are not significantly different at 0.05 level (Tukey's HSD)

Table 3. Fecundity, oviposition period and adult longevity of females of *S. bispinosus* at different temperatures

Temp (°C)	N[a]	Total no. of eggs/female[b]	Pre-oviposition period[b]	Oviposition period[b]	Post oviposition period[b]	Total adult longevity[b]
20	15	16.07±0.43c	3.93±0.12b	12.53±0.17c	3.67±0.13b	20.13±0.19c
25	15	35.80±0.72b	2.87±0.17a	11.47±0.22b	2.87±0.17a	17.20±0.24b
30	15	27.13±0.83a	2.40±0.13a	9.07±0.18a	3.20±0.17ab	14.67±0.23a

[a]Number of females tested; [b] values shown are mean±SE and the values followed by same alphabets are not significantly different at 0.05 level (Tukey HSD)

decrease in longevity of *Thrips obscuratus* (Crawford) as temperature increases. Ekesi *et al.* (1999) also found a reduction in adult longevity at high temperatures in addition to reduction in egg production at high photophase in *Megalurothrips sjostedti*. Dev (1964) reported a female biased sex ratio in *S. dorsalis.* However, in the present study, although sex ratio was in favour of females, the ratio of males increased with increasing temperatures. The female: male ratio was observed as 1:0.18, 1:0.24 and 1:0.37 at 20, 25 and 30°C respectively.

Studies on life table parameters revealed that net reproductive rate (Ro), intrinsic rate of natural increase (rm), finite rate of increase (λ) and weekly multiplication (Wm) rates were high at 25°C followed by 30 and 20°C. Similarly, the doubling time was short at 25°C (5.245 days) followed by 30 (6.083 days) and 20°C (10.017) (Table 4). It clearly shows that *S. bispinosus* could multiply faster between 25 and 30°C. *Scirtothrips aurantii* and *S. dorsalis* are reported to cause economic damage to crops over summer when temperatures are high (Bedford, 1943; Shibao, 1996). However, the present study indicates that temperatures below 20°C and above 30°C will slow down the population buildup of *S. bispinosus.*

Seasonal Abundance

The population of tea thrips started increasing from April and reached the peak between May and July and declined after August in Nilgiris (Fig.2). Selvasundaram *et al.* (2004) studied the seasonal abundance of *S. bispinosus* in Vandiperiyar (Idukki district, Kerala) and reported that the population of thrips was more between March and May and decreased during wet months. However, in the present study the population of *S. bispinosus* was high up to the month of July. This is mainly due to the difference in the rainfall and its distribution pattern between Nilgiris and Idukki districts. Moreover, the first phase pruning cycle is normally carried out during the month of April/May in Nilgiris. These pruned fields recover during July and ensures the presence of young succulent foliage which in turn favours the buildup of thrips population. The nymphs mostly occupied the lower surfaces of tea leaves and therefore they escaped from small drizzles and thus available even during wet season. However, heavy rainfall reduced the thrips population considerably as reported by Selvasundaram *et al.* (2004). Multiple regression analysis revealed that population density of *S. bispinosus* showed a negative relationship with rainfall (-0.266), maximum temperature (-38.839) and maximum relative humidity (-3.356) and positive relationship with minimum temperature (63.205), minimum relative humidity (1.686) and sunshine period (2.887) (Table 5). Rattan (1992) reported that in Kenyan tea fields, populations of thrips gradually declined with the onset of monsoon, however prolonged droughts were associated with outbreaks of black tea thrips, *Heliothrips haemorrhoidalis*. Similarly, Sing *et al.* (1999) and Sathyan *et al.* (2017) reported that populations of cardamom thrips, *Sciothrips cardamomi* were high during dry periods and showed positive relationship with sunshine hours and negative relationship with rainfall.

Vertical and Spatial Distribution

Mean number of thrips occupied per shoot was significantly more on the plucking table than on the leaves situated below the plucking table and side branches (Table 6). However there was no

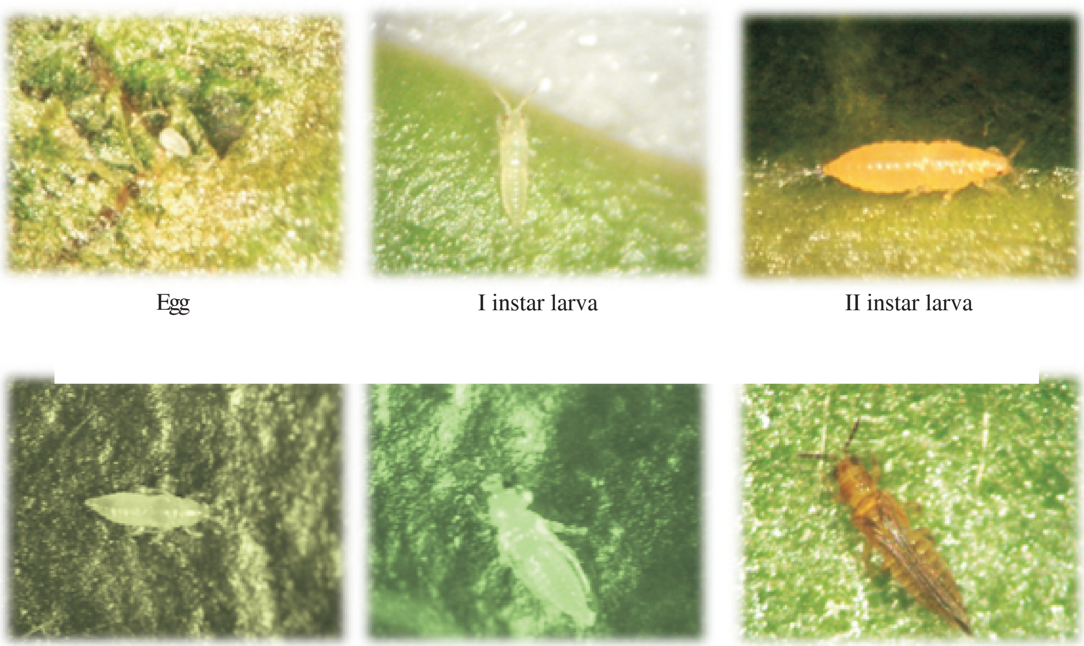
Table 4. Life table parameters of *S.bispinosus* at different temperatures

Temp (°C)	Net reproductive rate (Ro)	Mean generation time (Tc)	Intrinsic rate of natural increase (rm)	Finite rate of increase (λ)	Weekly multiplication (Wm)	Doubling time (DT)
20	6.178	26.316	0.069	1.072	1.623	10.017
25	15.613	20.794	0.132	1.141	2.522	5.245
30	6.331	16.196	0.114	1.121	2.22	6.083

Table 5. Multiple regression analysis among weather factors and *S. bispinosus*

Variable	Partial regression Coefficient	SE	T	P	R^2	F
X_1 Temperature minimum (°C)	63.205	52.457	1.205	0.238	0.512	5.074
X_2 Temperature maximum (°C)	-38.839	56.075	-0.693	0.494		
X_3 Relative humidity minimum (%)	1.686	2.901	0.581	0.566		
X_4 Relative humidity maximum (%)	-3.356	5.527	-0.607	0.548		
X_5 Rainfall (mm)	-0.266	0.100	-2.647	0.013		
X_6 Sunshine (h)	2.887	29.229	0.099	0.922		

$Y = 307.968 + 63.205, * X_1 - 38.839, * X_2 + 1.686, * X_3 - 3.356, * X_4 - 0.266, * X_5 + 2.887, * X_6$, *Significant at $P < 0.001$



Egg I instar larva II instar larva

Prepupa Pupa Adult

Plate 1. Life stages of *S. bispinosus*

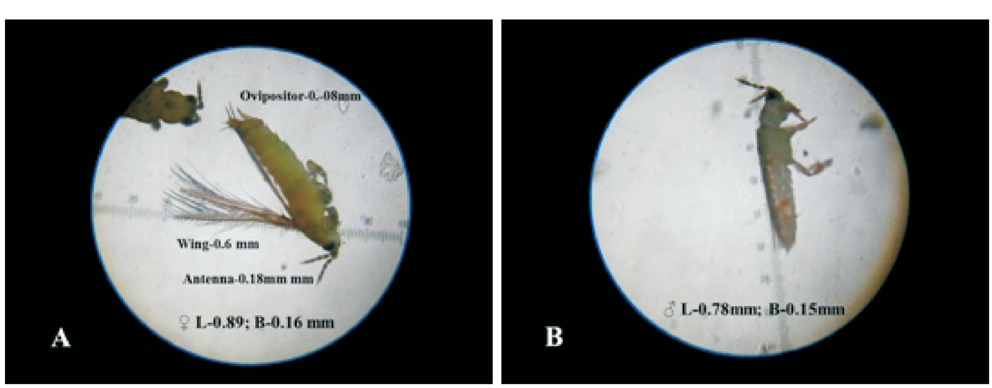


Plate 2. Morphometry of female (A) and male (B), *S. bispinosus*

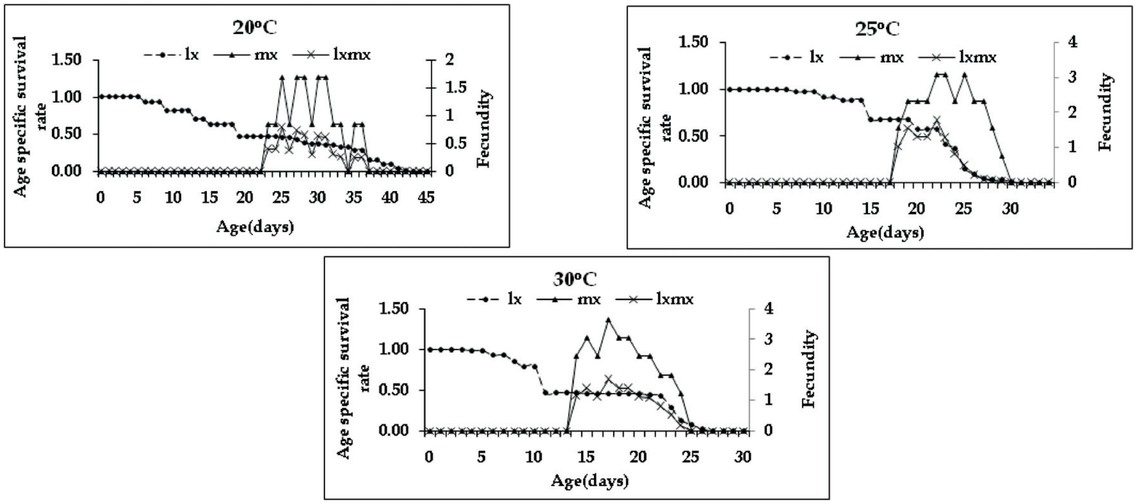


Fig. 1. Age specific survival rate (lx) age-specific fecundity rate (mx) and lxmx curves in *S.bispinosus*[lx=(eclosion of eggs) x (proportion of females alive at age x); mx= (proportion of females) x (age specific oviposition)]

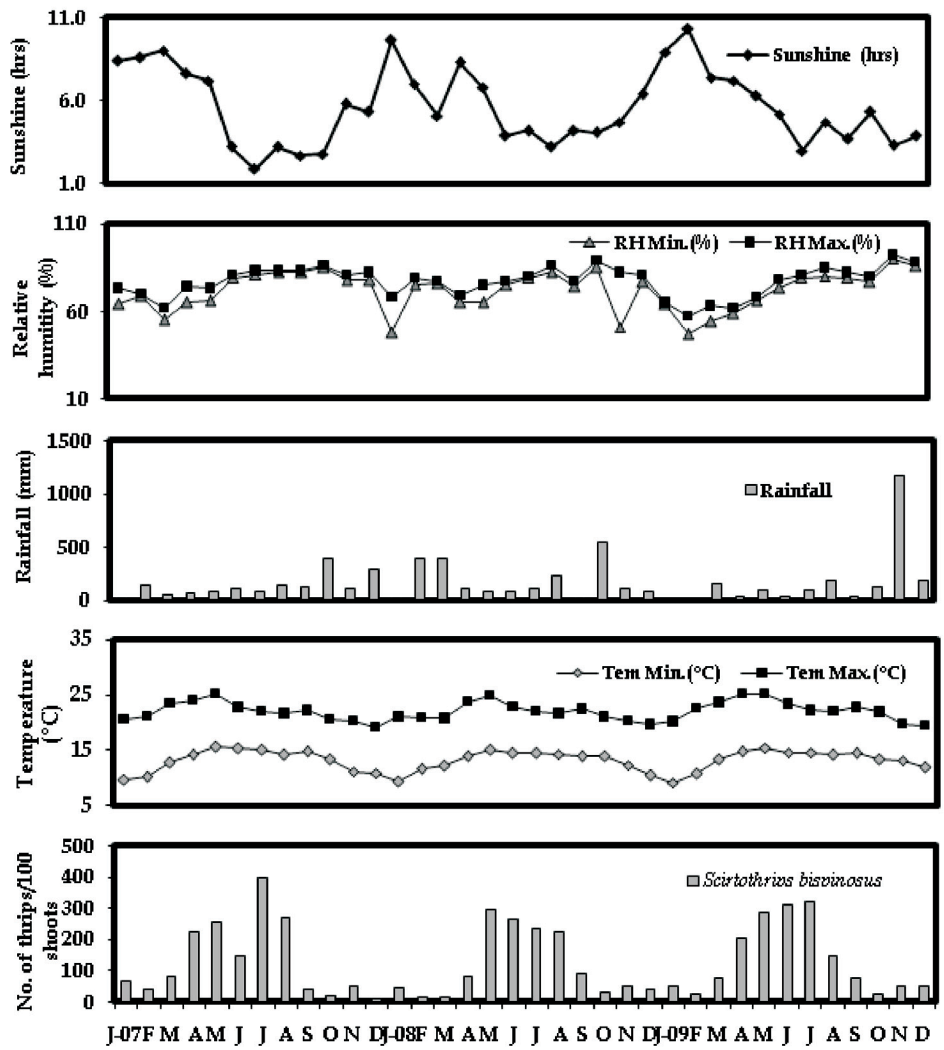


Fig. 2. Seasonal abundance of *S.bispinosus* and weather factors at Coonoor, The Nilgiris

Table 6. Vertical distribution of *S. bispinosus* on tea bushes

Area of bush	Mean No. of thrips*
Plucking table	13.8±1.40b
Below the plucking table	5.92±0.59a
Side branches	3.84±0.58a

*the values shown are Mean ± SE and the values followed by the same alphabets are not significantly different at 0.05 level (Tukey HSD)

Table 7. Influence of age of the field (since pruning) on the incidence of *S. bispinosus**

Year from Pruning	Mean No. of thrips/shoot
I Year	5.40c
II Year	2.96b
III Year	0.70a
IV Year	0.44a

*values followed by the same alphabets are not significantly different at 0.05 level (Duncan Multiple Range test)

significant difference in the number of thrips on the leaves present below the plucking table and side branches. About 72% of the active population (nymphs and adults) was observed on the lower surface of tea leaves (Fig. 3).

Age of the bushes since pruning on thrips incidence

The age of the bush since pruning had a definite influence on the incidence of *S. bispinosus*. The mean number of thrips per shoot was significantly high in first year after pruning followed by second, third and fourth year fields (Table 7). The closeness of fit between thrips population and age of the bushes from pruning was measured and the correlation was positively significant (P =0.05) (Fig.4). The main reason for the higher incidence of tea thrips in the first year after pruning was due to the presence of succulent tea shoots in the bushes. Similarly, Rahman *et al.,* (2014) reported that *S. dorsalis* prefer buds and tender leaves and show less preference to the mother leaf *i.e.* 4^{th} leaf from the apical bud. Radhakrishanan and Mahendran (2010) reported an 'edge effect' which had direct influence on the population density of *S. bispinosus.* They reported that number of thrips per shoot was more on the edges *i.e.,* near the roads and foot paths than the bushes in the center of the field.

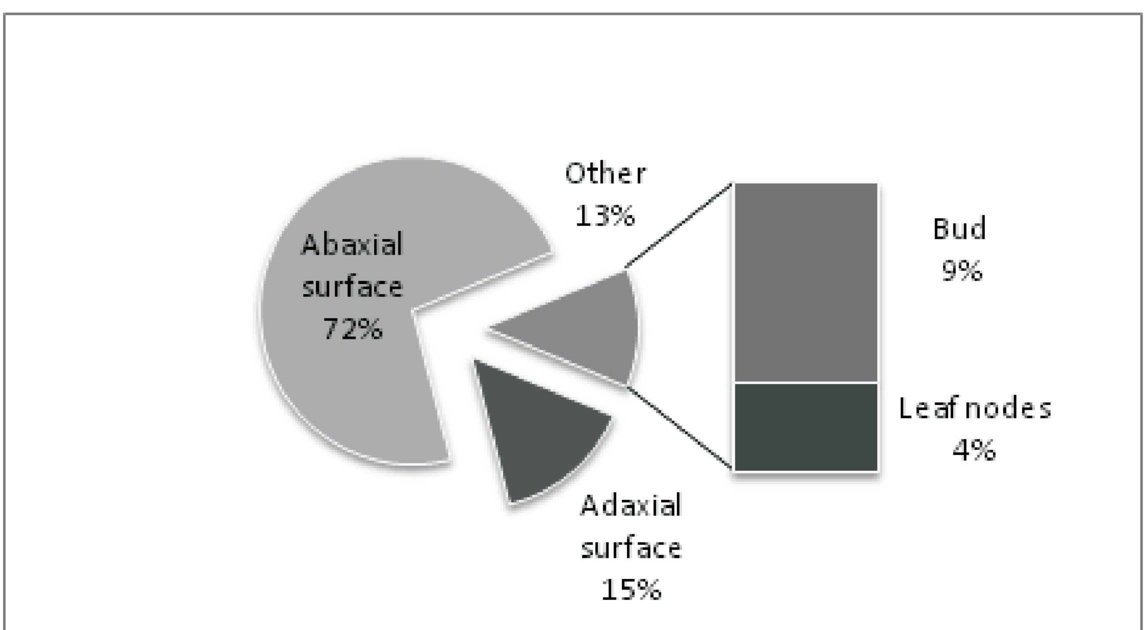


Fig. 3. Distribution of tea thrips (adults and nymphs) on tea shoots

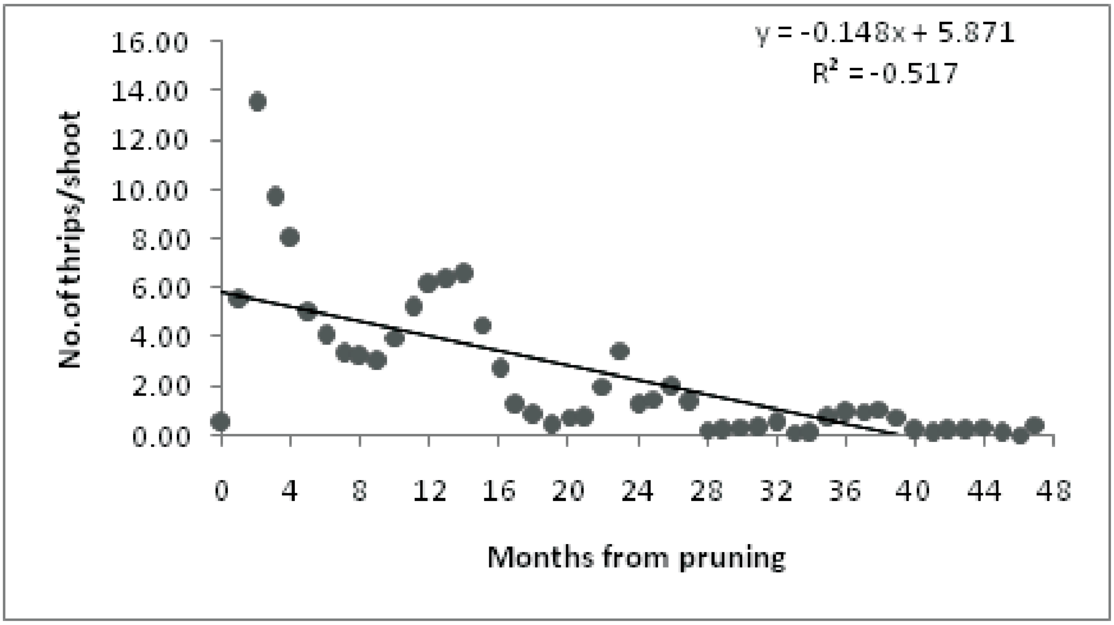


Fig. 4. Relationship between the age of the field since pruning and the population density of *S.bispinosus*

Table 8. Natural enemies of tea thrips, *S. bispinosus*

Sl. No	Species	Family	Order	Period of the peak activity	Distribution
		Predatory Mites			
1	*Amblyseius cucumeris*	Phytoseiidae	Acarina	April-Sep	Coonoor, Vandiperiyar, Munnar
2	*Amblyseius fallacies*	Phytoseiidae	Acarina	April-Sep	Coonoor, Vandiperiyar, Munnar
3	*Amblyseius degenerans*	Phytoseiidae	Acarina	April-Sep	Vandiperiyar, Munnar
4	*Balaustium* sp.	Erythraieidae	Acarina	April-Sep	Munnar
		Predatory Thrips			
5	*Franklinothrips vespiformis*	Aeolothripidae	Thysanoptera	April-Sep	Coonoor, Vandiperiyar, Munnar
6	*Leptothrips mali*	Aeolothripidae	Thysanoptera	April-Jul	Coonoor
		Anthocorid Bug			
7	*Orius* sp.	Anthocoridae	Coleoptera	Apr-Jul	Coonoor, Munnar
		Nymphal parasitoid			
8	*Trichogramma* sp.	Trichogrammatidae	Hymenoptera	Apr-Jul	Coonoor

Studies on natural enemies

Extensive survey's carried out in the tea plantations of south India revealed the presence of eight species of natural enemies which were found preying & parasitizing on *Scirtothrips bispinosus*. Among them, four were predatory mites (*Amblyseius cucumeris, A. fallacis, A. degenerans* and *Balaustium* sp.); one anthocorid predator (*Orius* sp.), two predatory thrips (*Franklinothrips vepiformis* and *Leptothrips mali*) and a nymphal parasitoid, *Trichogramma* sp. Peak activity of predatory mites and *F. vepiformis* were seen between April and September and *L. mali, Orius* sp. and *Trichogramma* sp. between April and July (Table 8). Among the natural enemies identified, predatory potential of *F. vespiformis* on *S. bispinosus* was already reported by the authors (Mahendran and Radhakrishnan, 2019).

It is established that the development of *S. bispinosus* could multiply faster between 25 and 30°C. It is also understood that high rainfall, maximum temperature and relative humidity affected the population of tea thrips in the field and minimum temperature, minimum relative humidity and long sunshine hours favoured the buildup of thrips population to certain extend. The studies conducted on vertical and spatial distribution of thrips on tea bushes revealed that major population of thrips occupied the top layer of the tea bush *i.e.,* the plucking table and more particularly on the abaxial (lower) surface of young tea leaves. The present study has also ascertained that fields recovering from pruning harboured more numbers of thrips followed by second, third and fourth year fields in a pruning cycle. There are eight species of natural enemies reported in the present study which helps the scientists to explore its potential in controlling *S. bispinosus.*

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