https://doi.org/10.33307/entomon.v44i1.425
Entomon 44(1): 49-56 (2019)
Article No. ent. 44105

Franklinothrips vespiformis Crawford (Thysanoptera: Aeolothripidae), a potential predator of the tea thrips, *Scirtothrips bispinosus* Bagnall in south Indian tea plantations

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ABSTRACT: During the surveys carried out for natural enemies of *Scirtothrips bispinosus* Bagnall in tea plantations, the predatory thrips *Franklinothrips vespiformis* Crawford was found preying on tea thrips in High ranges, Nilgiris and Central Travancore regions of south India. The life history and predatory potential of *F. vespiformis* were studied in the laboratory by providing different life stages of *S. bispinosus* as feed. Studies on life history revealed that *F. vespiformis* had six life stages with a greater potential for population increase at 25 °C. Adult stages of *F. vespiformis*, consumed more number of thrips than the larval instars. However, per day consumption was more in second instar larva than adult and first instar. All the active life stages of *F. vespiformis* except the non-feeding pupa preferred mostly first instar larvae for feeding followed by the second instar. Field observations revealed that increase in predator population coincided with the population increase of prey species. The results of the present study indicate *F. vespiformis* as an efficient predator against *S. bispinosus* and therefore it could be explored as a potential biocontrol agent in the management of tea thrips.

KEY WORDS: *Franklinothrips vespiformis, Scirtothrips bispinosus,* tea thrips, life table.

INTRODUCTION

Scirtothrips bispinosus Bagnall (Thysanoptera: Thripidae) is endemic to south India and unlike the polyphagous *S. dorsalis,* it has been reported only on tea and coffee plants (Mound and Palmer, 1981). Its infestation leads not only to crop loss but also to the deterioration of quality of processed tea. Although the chemical control of this pest is possible, continuous use of chemicals may result in the development of resistance against pesticides and also leads to residue problems. In natural tea ecosystem, predatory arthropods play a prominent role in determining the numbers of plant-feeding insects under natural conditions. In view of this, a detailed survey was carried out in the tea plantations of south India to explore the natural enemies of tea thrips *S. bispinosus*. The survey revealed the presence of seven species of natural enemies among which the predatory thrips, *Franklinothrips vespiformis* was found prominent as a predator on tea thrips in high ranges, Nilgiris and Central Travancore regions of south India. The present paper discusses in detail about the life history, population dynamics and predatory potential of *F. vespiformis* on tea thrips.

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MATERIALS AND METHODS

Survey on natural enemies

Surveys were carried out between 2007 and 2009 in all the major tea growing areas of southern India viz., the Anamallais (Coimbatore Dist., Tamil Nadu), Ooty, Coonoor, Kotagiri and Gudalur (The Nilgiris, Tamil Nadu), Vandiperiyar, Peermade and Munnar (Idukki Dist., Kerala), Nelliampathy (Palghat Dist., Kerala) and Meppadi (Wayanad Dist., Kerala). Both organic and conventional tea areas were explored for the presence of natural enemies.

Studies on the life history of *F. vespiformis*

Adults and larvae of *F. vespiformis* collected from tea fields were reared in large glass containers (15 cm dia. x 20 cm depth) by providing different life stages of *S. bispinosus* as feed. The females of *F. vespiformis* collected from this stock colony were introduced individually into Plexiglas boxes (8 cm dia. x 7 cm depth) containing thrips infested tea leaves placed on moist cotton. The number of eggs laid per female during the first five days of oviposition period was counted and observed at eight hours intervals to record the eclosion percentage. Newly emerged larvae were individually transferred onto thrips infested tea leaf (5 cm x 5 cm) placed on wet cotton and each box was covered with a transparent muslin cloth. These boxes were kept at environmental growth chamber at 25±2ºC, 75±5% of relative humidity (RH) and with a photoperiod of 16 h of light and 8 hours dark to study the developmental duration. When adults emerged the females were transferred to freshly infested tea leaf at every 24 h until the female died to record the data on fecundity, duration of incubation, periods of pre-oviposition, oviposition and post-oviposition and longevity of adults using binocular stereo microscope. Life tables were constructed as per the method of Birch (1948) and Atwal and Bains (1974).

Studies on prey population Vs predator density

For exploring the prey and predator populations, a study was carried out in the UPASI experimental farm, Coonoor, The Nilgiris between 2007 and 2009. A second year tea field planted with tea clone UPASI-9 (B/6/61) was selected for the present study. The experimental area consisted of four plots each of 100 bushes. This field has not received any pesticide application during the study period. Population density of both nymphs and adults of *S.bispinosus* and *F. vespiformis* were assessed at fortnightly intervals by randomly collecting 100 shoots (3 leaves and a bud) from the plucking table, below the plucking table, and side branches. The number of prey and predators were counted and recorded in the field using hand lens.

Studies on predatory potential

Predatory efficiency (No choice feeding)

Predatory efficiency of individual life stage of *F. vespiformis* was studied in the laboratory by releasing 100 numbers of individual life stages of *S. bispinosus* into the leaf cup. Here, no choice had been given to the predator to choose its prey stage.

Prey stage preference (Free choice feeding)

Prey stage preference of individual life stage of *F. vespiformis* was studied by releasing all life stages (50 numbers each) of *S. bispinosus* in a single leaf cup. Here the predator had the option to choose its prey stage for consumption.

In both the experiments the leaf cup was prepared by placing leaf discs of approximately 5 cm^2 on agar substrate (0.5%, 15 mm thick) in a plastic container. The experimental boxes were placed in an incubator at 25 ± 1^oC, 75 ± 5% RH and photoperiod of 16L: 8D.

Daily consumption of each life stage was observed under a binocular stereo microscope by counting the number of *S. bispinosus* individuals left from the number of individuals supplied on the leaf disc, after 24 h. The predators were transferred to new leaf cups in the following day and the procedure was repeated until the larva reached adulthood. Each experiment was replicated eight times.

RESULTS AND DISCUSSION

Distribution

During the surveys, the predatory thrips *F. vespiformis* (Plate 1) was found preying on tea thrips *S. bispinosus* (Plate 2) in high ranges, the Nilgiris and Central Travancore regions of south India. This species was first reported in tea plantations of south India by Mahendran (2011). Later, Kaomud and Vikas (2013) and Varatharajan (2018) reported this species in Chhattisgarh, India and Cachar district, Assam respectively. In the present study, the adults and larvae of *F. vespiformis* were noticed on tea leaves on the upper canopy of tea bushes. The females were fast moving and very active over the tea bushes seeking and attacking the prey.

Prey population Vs predator density

More numbers of *F. vespiformis* was noticed in high ranges (Munnar), followed by Nilgiris (Coonoor) and Central Travancore regions (Vandiperiyar). Increase in predator population (*F. vespiformis*) coincided with the population increase of prey species (*S. bispinosus*) (Fig.1).

Life history

Life history of *F. vespiformis* studied providing *S. bispinosus* as prey revealed, egg, larva I, larva II, pupa I, pupa II and adult stages during the course of development. It laid eggs singly within the soft tissues of tea leaves and stems by using its ovipositor. The egg was kidney shaped and translucent in colour. *F. vespiformis* laid 43.27±1.29 eggs during the first five days of oviposition period; out of which 74.79±2.16 per cent hatched. However, the survival rate in immature was only 45.07±1.43 per cent (Table 1). The developmental duration of each life stage of *F. vespiformis* are shown in Table.2. Incubation of eggs took more than eight days to hatch, both larval instars (I and II) and pupa I lasted for two days each and pupa II took four days to become adult. The total developmental period from egg to adult stage was 18.45±0.27 days (Table 2). Both larva I and larva II preyed on tea thrips as actively as adults. Both larval stages were very similar to each other and possessed red hypodermal pigments. Second instar larva could be distinguished with red transverse bands on the head, prothorax and on the abdominal segments; but I instar larva was pigmented only on

Plate 1. *Franklinothrips vespiformis*

Plate 2. *Scirtothrips bispinosus*

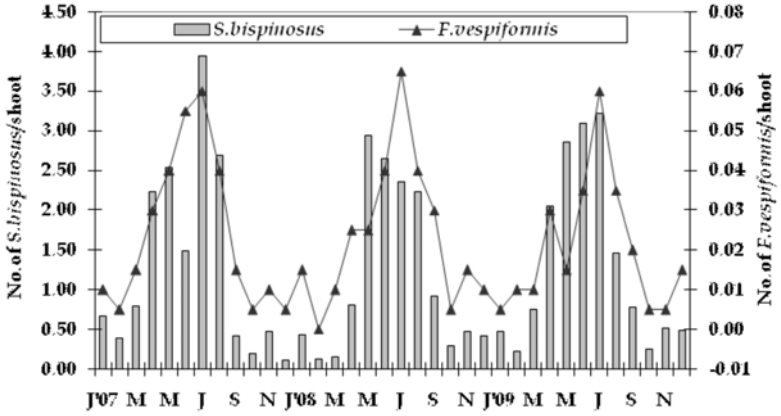

Fig. 1. Influence of prey density (*S. bispinosus*) on predator population (*F. vespiformis)* in tea ecosystem

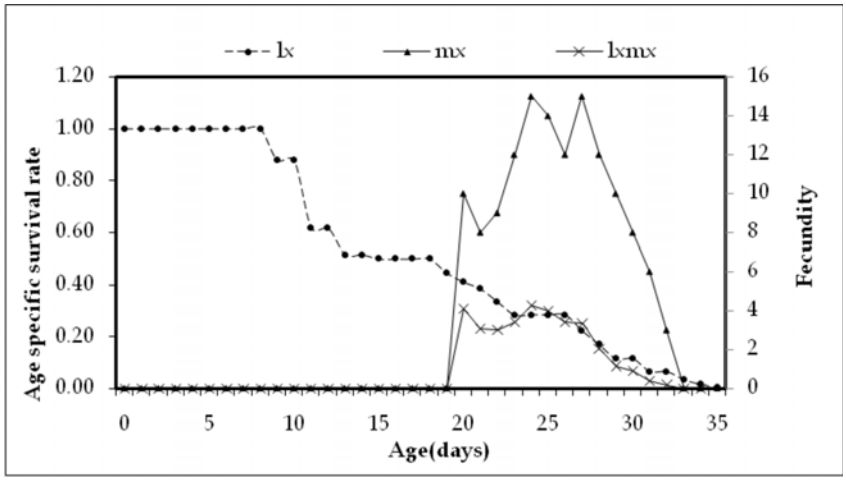

Fig. 2. Age specific survival rate (lx) age-specific fecundity rate (mx) and lxmx curves in *F.vespiformis.* lx=(eclosion of eggs) x (proportion of females alive at age x), mx= (proportion of females) x (age specific oviposition)

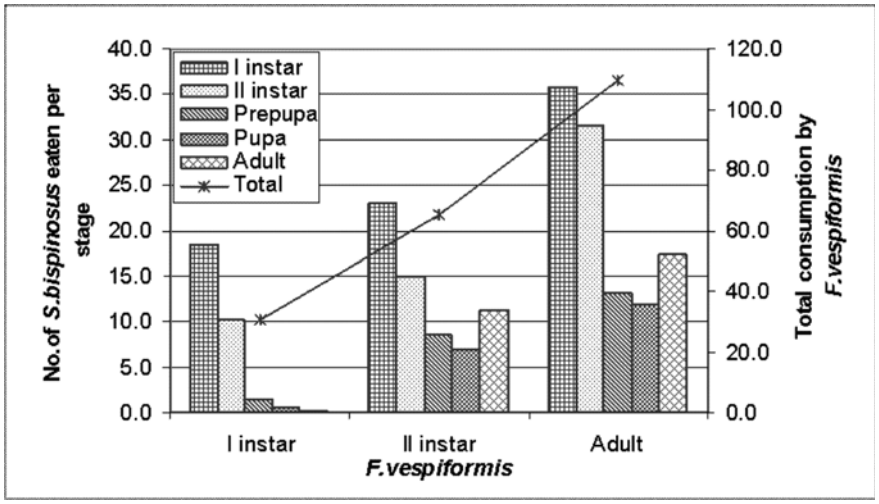

Fig. 3. Prey stage preference by *F. vespiformis* on different life stages of *S. bispinosus*

certain abdominal segments. Pupation took place on the leaf surface, the mature second instar larva during later stage spun cocoon and concealed inside. Initially the cocoon was transparent and the body of the pupa I was seen with its red hypodermal pigments. It again moulted inside the cocoon and reached the second pupal stage. This stage was little invisible since it was fully covered with silken material. In contrary to the above observations, Reijine (1920) and Stannard (1952) reported that members of this genus had just one pupal stage. However, Arakaki and Okajima (1998) and Sureshkumar and Ananthakrishnan (1987) reported two pupal stages for *Franklinothrips* sp. as reported in the present study. Cocoon spinning is a plesiotypic habit amongst terebrantian Thysanoptera, because it also occurs amongst species of Heterothripidae (Pinent *et al*., 2002).

Results of the present study also indicated a greater potential for population increase by this predator at 25°C when provided with *S. bispinosus* as feed. It laid 134.10±3.38 eggs/female in an oviposition period of 12.80±0.29 days. It had a total adult longevity of 16.80±0.25 days (Table 3). Parameters of population increase such as net reproductive rate (Ro), mean generation time (Tc), intrinsic rate of increase (rm), finite rate of increase (ë), weekly multiplication (Wm) and Doubling time (DT) at 25±2ºC, 75±5% RH are presented in Table 4. The sex ratio was completely female biased as the laboratory reared populations produced all females by thelytoky. Age specific survival rate (lx), age specific fecundity rate (mx) and lxmx curves in *F. vespiformis* are given in Fig. 2. These results are in accordance with Hoddle *et al.* (2000). They studied the life history of this species at different temperatures and reported that at 25°C, the demographic growth parameters were significantly greater than the same parameters calculated for *Franklinothrips* sp. at 20 and 30°C.

Predatory potential

The present study revealed that the adult stages of *F. vespiformis*, consumed more number of thrips than the larval instars (Table 5). However, per day consumption was more for second instar larva than the adult and first instar (Table 6). All the active

Table 1. No. of eggs laid during the first five days of the oviposition period, percentage hatchability in *F. vespiformis*

Parameter	N=15
No. of eggs laid/female[b]	43.27±1.29
No. of eggs hatched[b]	32.27±1.14
% hatchability[b]	74.79±2.16
% survival rate in immatures[b]	45.07±1.43

N - Number of females tested; *values shown are Mean±SE

Table 2. Developmental duration of different life stages of *F. vespiformis*

Life stages	Developmental duration in days (Mean±SE); N=20
Egg incubation	8.05±0.25
I instar	2.15±0.08
II instar	2.30±0.11
Pupa I	1.95±0.09
Pupa II	4.00±0.10
Total	18.45±0.27

N- Number of females tested

Table 3. Oviposition rates and various durations (in days) of female adults of *F. vespiformis* at three different temperatures under a 16L:8D photoperiod

Parameter	N=10
Total no. of eggs/female[b]	134.10±3.38
Pre-oviposition period[b]	1.10±0.10
Oviposition period[b]	12.80±0.29
Post oviposion period[b]	2.90±0.18
Total adult longevity[b]	16.80±0.25

N-Number of females tested; [b]Mean±SE

Table 4. Life Table - parameters of population increase (*F. vespiformis*) at 25 ± 2ºC, 75±5% RH

Net reproductive rate (Ro)=Ólxmx	74.769
Mean generation time (Tc)=ÓXlxmx/Ro	24.288
Intrinsic rate of natural increase (rm)	0.178
Finite rate of increase (ë)	1.194
Weekly multiplication (Wm)	3.468
Doubling time (DT)	3.902

Table 5. Feeding efficiency of predatory thrips, *F. vespiformis* on different life stages of *S. bispinosus*

Life stages of predator	Life stages of *S. bispinosus*				
	I instar	II instar	Prepupa	Pupa	Adult
I instar	41.8±2.13	24.3±1.66	13.9±1.41	10.5±0.87	4.3±0.25
II instar	87.4±2.94	65.1±2.23	59.3±1.47	55.4±1.19	50.8±1.68
Adult	174.1±5.51	132.5±4.20	102.5±2.64	94.5±2.48	88.6±3.06

values shown are mean±SE of 8 replicates

Table 6. Per day consumption by *F. vespiformis* on different life stages of *S. bispinosus*

Life stages of predator	Life stages of *S. bispinosus*				
	I instar	II instar	Prepupa	Pupa	Adult
I instar	10.4±0.53	6.1±0.41	3.5±0.35	2.6±0.22	1.1±0.06
II instar	21.8±0.73	16.3±0.56	14.8±0.37	13.8±0.30	12.7±0.42
Adult	19.1±0.69	14.6±0.63	11.6±0.38	11.1±0.33	9.9±0.40

Values shown are mean±SE of 8 replicates

life stages of *F. vespiformis* (larva I, larva II & adult) except the non-feeding pupa preferred mostly first instar larvae of *S.bispinosus* for feeding followed by the second instar (Fig. 3). Hoddle (2003) reported that *F. orizabensis* encountered and attacked more second instar larvae of *S. perseae* although attack rates on first and second instars were not significantly different. Though the first and second instars of *F. vespiformis* preferred first and second instars of *S. bispinosus* for feeding, they fed adults as well since they were efficient against adults. First instar larvae of *F. vespiformis*, did not prefer chasing the adults of *S. bispinosus* since they were little aggressive against this life stage. However, when there was no choice, first instar chased adults as well. Various members of the genus *Franklinothrips,* are considered to be useful biological control agents against pest thrips (Loomans and Heijboer, 1999; Loomans and Vierbergen, 1999).

As the present study showed the possibilities for the laboratory establishment of *F. vespiformis* as well as its predatory potential over *S. bispinosus*, this species can be effectively utilized as a prospective biocontrol agent in IPM program for the effective management of tea thrips.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. R. Varatharajan, Professor, Manipur University, India for identifying both the prey and predatory thrips specimens. The authors are also grateful to Dr. N. Muraleedharan, Former Director, UPASI Tea Research Institute for his continuous encouragement and support during the study period.

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(Received January 17, 2019; revised ms accepted February 28, 2019; published March 30, 2019)