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SEASONAL ABUNDANCE AND FEEDING BEHAVIOUR OF *OXYOPES BIRMANICUS* THORELL ON TEA MOSQUITO BUG *HELOPELTIS THEIVORA* WATERHOUSE

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ABSTRACT

The Burmese lynx spider, *Oxyopes birmanicus* Thorell (Araneae: Oxyopidae) is one of the endemic and entomophagous predatory arthropod species in India. This present study describes the seasonal abundance, vertical distribution, and feeding behaviour of *O. birmanicus* on nymph (4th/5th instar) and the adults of the tea mosquito bug, *Helopeltis theivora* Waterhouse (Hemiptera: Miridae) under laboratory conditions. The seasonal abundance of the *O. birmanicus* spider was considerably high from June to November and low from January to April. The abundance of *O. birmanicus* significantly correlated with the TMB infestation percentage. In a vertical distribution study, the *O. birmanicus* spider largely preferred the top level of the tea bush, the observed population was shared by the top and middle levels with 76% and 24% respectively. The feeding potential of the female *O. birmanicus* spider was significantly higher than the male and egg-guarding female. Both, male and egg-guarding female *O. birmanicus* showed on-par feeding efficacy. The study found that *O. birmanicus* was an efficient predator against TMB and the results may be useful in developing an integrated pest management strategy for TMB.

Key words: *Camelia sinensis*, tea, *Helopeltis theivora*, biocontrol, predator, spider, seasonal abundance, distribution feeding behaviour IPM, South India, *Oxyopes birmanicus*

Tea Mosquito Bug (TMB) *Helopeltis theivora* Waterhouse (Hemiptera: Miridae) is a major dreadful pest in southern Indian tea plantations. In India, the foremost existence of TMB was reported more than a century ago in tea and its outbreak started in the Vandiperiyar district (Kerala) around 1920 (Shaw, 1928; Rao, 1970). Around 80% of tea plantations are affected by TMB which causes crop losses of between 5 and 50% in India and sometimes, severe infestations can able to cause 100% crop loss (Radhakrishnan and Srikumar, 2015). In south India, the majority of growers adhere to conventional practices (application of synthetic chemicals) for the management of TMB (Bharathi et al., 2022a). Apart from conventional practices, natural enemies also play a vital role in the regulation of tea pests. So far, around 200 species of predators and 133 species of parasitoids were identified in the Indian tea ecosystem (Roy et al., 2014). Among them, the predators such as *Epidaus bicolor*, *Sycanus collaris*, *Sycanus croceovittatus*, *Oxyopes shweta, Chrysoperla* sp., *Oxyopes* sp., *Mallada* sp., and *Hierodula* sp., were recorded against TMB (Srikumar et al., 2017; Manikandan et al., 2018; Roy et al., 2015). Ambika et al (1979) reported that the ant, *Crematogaster wrougtoni* Forel (Hymenoptera: Formicidae) is also an effective predator on eggs and early instars of TMB. Other than tea, the reduviids *Panthous bimaculatus*, *Sycanus collaris* and *Rihirbus trochantericus luteous* were recorded as effective predators of nymphs and adults of the TMB on the cashew ecosystem (Bhat et al., 2013a). In addition to other arthropod predators, spiders are the most common entomophagous arthropods in the terrestrial ecosystem (Symondson et al., 2002; Singh, 2021). These predatory spiders are comes under the conservation biological control method which emphasizes enhancing beneficial organism populations that already exist in the system and effectively reducing the pest population by vigorous predation behaviour in several agroecosystems (Oraze and Grigarick, 1989; Carter and Rypstra, 1995; Marc et al., 1999; Riechert, 1999). A diverse and abundant population of predatory spiders can successfully reduce the pest population and they are also capable of surviving when the low density of the respective pest (Roince et al., 2013). Whitcomb (1974) described the four major roles of spiders in cropland as predators of destructive insects, food for other predators, predators of beneficial insects, and competitors for prey with other predators. To date, the order Araneae was noted as the dominant predatory arthropod which was compressive of 70 species of spiders (Roy et al., 2014). Siliwal and Molur (2007) reported that 1053 endemic spider species are reported in India. Among them, the Burmese lynx spider, *Oxyopes birmanicus* Thorell (Araneae: Oxyopidae) is one of the endemic spider species in India also reported it was rare species in the cashew ecosystem (Bhat et al., 2013b). The present study aimed to spell the seasonal abundance, vertical distribution and predatory potential of *O. birmanicus* on TMB under laboratory conditions, and the study results will be more valuable in the optimization of biocontrol strategies for the effective control of TMB through integrated pest management (IPM) strategies.

MATERIALS AND METHODS

The study area was UPASI Experimental farm (10°16'11.2"N 76°57'57.2" E) located at Valparai, Tamil Nadu, India and the period of study was between January 2020 and December 2021. The study plot was constructed with approximately 1000 numbers of mixed tea seedlings with an average height of 100 cm and covering around 0.25 ha. The experiment plot was maintained with no pesticide application throughout the study period. To study the seasonal abundance, sampling was done every fortnight interval and the collection was done during the morning time (8.30 AM to 10.30 AM). At each time of sampling, *O. birmanicus* spider population was noted with numbers by observing with the naked eye while walking around the plot and meanwhile, the TMB infestation percentage was also recorded as per the guidelines of Radhakrishnan (2014). The vertical distribution study was done with three different levels *viz.,* the top, the middle and the bottom levels of tea bushes. The plucking table is normally considered as a 'top level' of the bush, it measures 0-20 cm from the upper part of the bushes. The 'middle level' measures 21 to 60 cm from the top level and the 'bottom level' measures 61-100 cm from the top level. Ten bushes were randomly selected from the study plot and a complete naked-eye observation was done to study the distribution of *O. birmanicus* in all three levels. The observation was done once a month.

Field-collected adult *O. birmanicus* spider was reared with a diet of adult *Corcyra cephalonica* under laboratory conditions. The *O. birmanicus* adults were divided into three populations viz*.,* male, female and egg-guarding female and each population were evaluated individually against the nymphs and adults of TMB at 25±1°C, 75% RH with the photoperiod of 12L:12D. Twenty numbers of adults and 4^{th}/ 5^{th} instar nymphs of TMB were obtained from the stock culture then introduced separately into a plastic container and fed as per the method described by Sudhakaran (2000). A single male *O. birmanicus* spider was introduced into the plastic container and their feeding efficiency was recorded after 24 hours. The prey population (TMB) was then maintained at 20 individuals, and this process was repeated continuously for five days. Similarly, the predatory efficacy of female and egg-guarding female was also evaluated against the nymphs and adults of TMB. Each treatment was replicated ten times. The abundance of *O. birmanicus* was correlated with biotic (TMB infestation percentage) and abiotic factors (weather factors). The feeding potential was subjected to one-way ANOVA and the means was separated by Duncan Multiple Range Test (DMRT). All statistical analysis was done using SPSS v16 software.

RESULTS AND DISCUSSION

The seasonal abundance of the *O. birmanicus* spider was considerably high during the months from June to November. Especially, high numbers (10 nos.) were noted during June 2020 and August 2021. Similarly, the lowest numbers (2 nos.) were recorded during the dry months such as January, February 2020 & April 2021 (Fig. 1). The TMB infestation percentage was 1-23 during the study period. High TMB incidence was noted during monsoon months from June to November (Fig. 1). The biotic and abiotic factors significantly predicted the abundance of *O. birmanicus* ($F_{(7, 16)}$=7.648, p<0.001). The multiple regression equation was: Y= -7.407 + 0.378 × (TMB infestation %) + 0.050 × (T_{max}) - 0.240 × (T_{min}) + 0.116 × (RH_{mor}) + 0.15 × (RH_{eve}) + 0.001 × (Rain fall) - 0.152 × (Sunshine). The *O. birmanicus* abundance was positively correlated with TMB infestation %, relative humidity % (morning), relative humidity % (evening), rainfall (mm) and temperature (maximum), and negatively correlated with temperature (minimum) and sunshine (hours) (Table 1).

In a vertical distribution study, a total of 8 numbers of *O. birmanicus* spiders were observed during the entire study period. Spider distribution was relatively very high on the top level, low on the middle level, and relatively nil on the bottom level of the tea

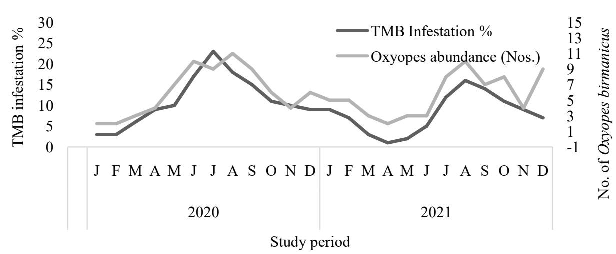

Fig. 1. Seasonal abundance of *Oxyopes birmanicus* and TMB infestation %

bushes (Fig. 2). The entire observed population was shared by the top and middle levels with 76 and 24% respectively. Mostly *O. birmanicus* spiders preferred the abaxial surface of the tea leaves. The abundance of *O. birmanicus* was might be due to the stable and complex ecosystem of tea plantations which provides a suitable habitat for many predatory spider species that play a vital role in controlling the insect pest population in tea (Das et al., 2010; Yan et al., 1998). In addition to *O. birmanicus, Oxyopes shweta* Tikader and other two *Oxyopes* sp. were reported in the south Indian tea ecosystem. *O. shweta* was found highly active during the summer (Mar-May) and winter seasons (Nov-Feb). The other two *Oxyopes* sp. were noted high during the monsoon (Jun-Oct) and winter (Nov-Feb) (Radhakrishnan, 2016). However, the cultivation practices might decrease the diversity and abundance of predators in tea (Thomas and Marshall, 1999). Many previous studies reported that the abundance and density of the spider population were significantly affected due to the continuous disturbance of the ecosystem by the application of pesticides (Mansour, 1987; Fountain et al., 2007; Solanki and Kumar, 2011). In south India, conventional cultivation practices have been followed for the control of tea pests (Bharathi et al., 2022b) and it might harm the seasonal abundance and density of the predatory spiders in respective fields.

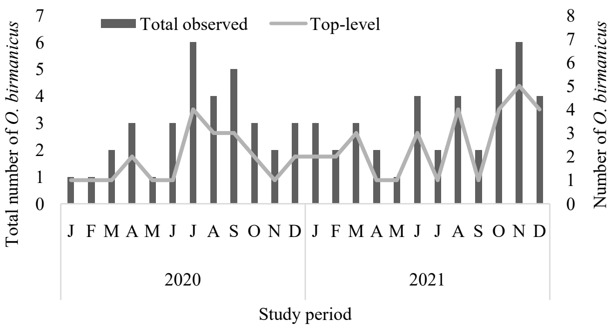

Fig. 2. Vertical distribution of *O. birmanicus*

Fig. 3. An egg-guarding female *O. birmanicus* feeding on adult tea mosquito bug, *Helopeltis theivora*

A male, female and egg-guarding female of *O. birmanicus* fed a total of 37, 56 and 38 adults, and 48, 57 and 41 nymphs respectively during the five days of observations. Significant feeding differences were found between the male, female and egg-guarding female (df=5, f=6.721, $P<0.001$). The feeding potential of the female *O. birmanicus* was significantly higher than the male and egg-guarding female *O. birmanicus*. A single female *O. birmanicus* fed an average of 11.4± 0.51 and 11.2± 0.86 numbers of nymphs and adults respectively per day. Egg-guarding female *O. birmanicus* resulted in

Table 1. Dynamics of TMB infestation and *O. birmanicus*

Variables	TMB infestation %						
	Correlation coefficient	Regression coefficient	SE	*t*-value	*P*	R^2	F
X_1 - TMB infestation %	0.857**	0.378	0.1	3.77	0.001	0.77	7.648
X_2 - Temperature maximum (°C)	-0.701**	0.05	0.587	0.085	0.934		
X_3 -Temperature minimum (°C)	0.477*	-0.24	0.255	-0.94	0.361		
X_4 - Relative humidity morning (%)	0.632**	0.116	0.4	0.29	0.773		
X_5 - Relative humidity evening (%)	0.472*	0.015	0.026	0.584	0.568		
X_6 - Rain fall (mm)	0.664**	0.001	0.002	0.684	0.504		
X_7 - Sunshine (h)	-0.648**	-0.153	0.632	-0.241	0.813		

$Y= - 7.407 + 0.378 * X_1 + 0.050 * X_2 - 0.240 * X_3 + 0.116 * X_4 + 0.15 * X_5 + 0.001 * X_6 - 0.152 * X_7.$
**Significant at p<0.001; *Significant at p<0.05.

non-significant feeding behaviour with the male. They feed an average of 7.6 and 8.2 individuals of adults and nymphs, respectively per day. Males can able to feed an average of relatively few nymphs (9.6 individuals/ day) than adults (7.4 individuals/ day). In general, spiders feed on any prey that is 50-80% of their body size (Marc et al., 1999; Huseynov, 2006), and the size of TMB is a very small and affordable range, hence the handling and feeding efficacy of *O. birmanicus* was in remarkable range. The current findings are comparable to those made by Lingren et al., (1968) and Furuta, (1977) under laboratory conditions, they observed that male Oxyopids feed less frequently than females, and Jackson (1977) and Givens (1978) reported similar observation in the family Salticidae (jumping spiders). In addition, the egg-guarding behaviour of Oxyopid females facilitates the protection of eggs as well as increases the survival of the offspring, nevertheless egg-guarding female spiders limit their hunting activity (Fink 1986) and a similar statement was reported in the wolf spiders by Huseynov (2006). Basnet and Mukhopadhyay (2014) studied the feeding efficacy of male and female *Oxyopes javanus* on adult TMB and they found that *O. javanus* fed an average of 3.67 and 11.67 adult *H. theivora*, respectively. The feeding efficacy of Male *O. javanus* was very less and female *O. javanus* showed on-par results with the present study. Furthermore, the spiders such as *Telamonia dimidiate* and *Epocilla aurantiaca* have also been recorded as predators of TMB in south India (Radhakrishnan, 2016). Other than tea, *Oxyopes shweta* and *Oxyopes sunandae* were reported as a predator against TMB in cashew plantations (Vanitha et al., 2021).

In conclusion, the tea ecosystem provides excellent habitat for the many predatory arthropods for a prolonged period. The cultural practices might have a serious concern about the diversity and abundance of various predators in tea. From the study, the abundance of *O. birmanicus* was observed throughout the year and their feeding potential was also in a remarkable range against the tea mosquito bug, *Helopeltis theivora*. *In situ* conservation of the *O. birmanicus* would help in the reduction of the TMB population in an effective manner. The study will help us in the development of an integrated pest management programme on TMB in near future.

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AUTHORS CONTRIBUTION STATEMENT

NSB and TPR designed the experiment; NSB conducted the experiments and wrote the manuscript. The authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

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