Potential of *Blaptostethus pallescens* Poppius (Hemiptera: Anthocoridae) on *Tetranychus truncatus* Ehara (Prostigmata: Tetranychidae)

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ABSTRACT: Efficiency, functional and numerical responses of anthocorid bug *Blaptostethus pallescens* Poppius on the spider mite, *Tetranychus truncatus* Ehara were examined under laboratory conditions. Nymphs of *B. pallescens* exhibited a Hollings type II functional response when females of spider mite were offered at densities of 10, 20, 30, 40, 50, 60 and 70 mites/bug. Individual fifth instar bugs consumed up to 45.3 adult females of *T. truncatus* in 24 h at prey mite densities of 60 mites/ bug. Studies on numerical response revealed that the nymphs of the anthocorid bug failed to complete development when the food was restricted to mite alone. Numerical response studies on adult bugs, when offered *T. truncatus* at densities of 10, 20, 30, 40 and 50 females showed no significant differences in the average fecundity of the female bug. Results indicate that the anthocorid predator, *B. pallescens* has a very high predatory potential though with a weak numerical response.
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KEYWORDS: Anthocorid bug, spider mite, functional and numerical responses

INTRODUCTION

Spider mites are highly polyphagous and have been reported to be serious pests of nearly 150 economically important species of plants. Farmers routinely resort to application of synthetic acaricides for mite in polyhouses, which results in pest resurgence as well as residue problems. Biological control of phytophagous mites using predators can be a much safer alternative to chemical control especially in protected cultivation (Yang *et al.*, 2014). Several arthropod natural enemies have been evaluated for their efficacy against spider mites under protected conditions. Predatory mites like *Neoseiulus longispinosus*, coccinellids such as *Stethorus* spp., thrips, lacewings and bugs have been evaluated for the biological control of phytophagous mites with varied results. Predatory anthocorids, remains the most sought-after natural enemies for mite pest management across countries like France, the United Kingdom, the Netherlands, Germany *etc.* (Ballal and Yamada, 2016). *Blaptostethus*

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pallescens Poppius (Hemiptera: Anthocoridae), has long been a promising natural enemy of spider mites, especially in protected cultivation.

Studies on functional and numerical responses of a predator help to assess its potential as a biocontrol agent since density responsiveness is considered as a desirable attribute for an effective natural enemy. Functional response is defined as number of hosts attacked by an individual natural enemy in relation to host density over a given time interval, while; numerical response is the increase in predator density as prey density increases and can result from increased rate of predator reproduction (reproductive response) and also from attraction of predators to prey aggregations (aggregation response) (Solomon, 1949). Very few studies have been reported on the functional and numerical responses of anthocorids in general and *B. pallescens* in particular. Hence, an attempt was made to assess its potential against the spider mite, *Tetranychus truncatus* Ehara (Prostigmata: Tetranychidae).

MATERIALS AND METHODS

Stock cultures

Nucleus culture of anthocorid bug *B. pallescens* was obtained from ICAR- National Bureau of Agricultural Insect Resources, Bengaluru. The bugs were reared in transparent plastic jars (1 l capacity, 9 cm diameter x 12.5 cm height) lined with tissue paper. A thin layer of absorbent cotton was provided at the base. UV sterilized eggs of rice meal moth were sprinkled over cotton on alternate days as food for the bug. Bean pods (*Phaseolus vulgaris* L.) cut into pieces were provided for oviposition. These jars were covered using muslin cloth, held in position by using rubber bands. The bean pod pieces in the jars were replaced daily with fresh pieces. Bean pods with eggs laid were placed in plastic jars with cotton at base for the eggs to hatch. The freshly emerged nymphs were provided UV sterilized rice meal moth eggs. Newly hatched adults (0-24 h old) were transferred into new plastic jars and rearing was carried out as described by Ballal *et al*. (2003).

Nucleus culture of spider mite *T. truncatus* was obtained from All India Network Project on Agricultural Acarology, College of Horticulture, Kerala Agricultural University and were multiplied on mulberry leaves as described by Bachhar *et al*. (2019). Mulberry leaves washed in water and wiped dry using a tissue paper were kept upside down on moistened synthetic absorbent sponge in plastic trays. Gravid females of *T. truncatus* were transferred onto the above mulberry leaves using a camel hair brush. Leaves were replaced with fresh ones every four days.

Functional response of *B. pallescens*

Mulberry leaf discs (4x4cm²) were placed upside down in Petri plates of 9 cm diameter and 1.5 cm height and lined with moistened absorbent cotton. Newly emerged adult females of *T. truncatus* were transferred on to leaf bits using camel hair brush to obtain densities of 10, 20, 30, 40, 50, 60 and 70 mites/ leaf disc. A single, 0-24 h old fifth instar nymph of *B. pallescens,* pre- starved for two hours, was released into each Petri plate. Petri plates were closed and sealed using cling film. Petri plates with mites but devoid of predator were maintained for each prey density to assess natural mortality if any. Each treatment was replicated four times. Number of mites killed by the anthocorid bug in 24 h was counted.

Numerical response of *B. pallescens*

Studies on numerical response of *B. pallescens* on *T. truncatus* involved two experiments. The first experiment attempted studying the numerical response of *B. pallescens* reared on the prey mite right from first instar onwards. The second experiment involved exposure of adult female bugs reared on *C. cephalonica* to prey mite, *T. truncatus* at varying densities.

a. Reared on *Tetranychus truncatus*

Mulberry leaf discs (4x4 cm²) were placed upside down in plastic boxes (10.5 cm diameter x 4.5 cm height) lined with moistened absorbent cotton. Females of *T. truncatus,* transferred on to the leaf bits using camel hair brush at five different densities

of 10, 20, 30, 40 and 50 per box constituted the treatments. Subsequently, a single 0-24h old first instar nymph of *B. pallescens* was released into each box. Each treatment was replicated thirty times. Number of prey in each box was maintained by replacing dead mites with live ones daily. The boxes were observed daily under stereo microscope to record the duration of different instars.

b. Reared on *Corcyra cephalonica*

Studies on numerical response were also carried out by using adult female bugs reared on *C. cephalonica* eggs. *B. pallescens* were reared on *C. cephalonica* eggs as described in stock culture. Fifth instar nymphs were separated out and reared to adults under constant observation. Newly emerged (0-24h old) male and female bugs were paired and transferred to individual boxes containing 20, 40, 60, 80 and 100 adult females of *T. truncatus* to yield predator prey ratio of 1:10, 1:20, 1:30, 1:40 and 1:50 respectively. Mulberry leaf discs containing prey mites were replaced daily with fresh pieces to maintain prey- predator ratio a constant. After the average pre oviposition period of four days, the females alone were retained in the container furnished with a piece of bean pod as oviposition substrate. The bean pods were replaced daily with fresh pieces. The bean pods provided on the previous day were examined under stereo microscope (30X) to count the number of eggs laid. Female longevity was also recorded.

Statistical Analysis

Functional response curve was determined by logistic regression of proportion of mites consumed as a function of initial density (Trexler *et al.*, 1988). Polynomial function from Juliano (1993) as given below was used to fit the data on proportion of *T. truncatus* killed.

$$\frac{N_e}{N_0} = \frac{\exp (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}{1 + \exp (P_0 + P_1 N_0 + P_2 N_0^2 + P_3 N_0^3)}$$

Where N_0 - was the initial prey density, Ne - the number of mites killed and Ne/N_0 represented the probability of mites being killed. The maximum

likelihood estimates of the parameters P_0, P_1, P_2, and P_3 were obtained using logistic regression (CATMOD in SAS). The positive and negative signs of the significant linear (P_1), quadratic (P_2), and cubic (P_3) terms were used to determine the functional response type (Juliano 1993). Linear terms that did not differ significantly from zero indicated a type I functional response, a significant negative linear term suggested a type II response, and significant positive linear term indicated a type III functional response.

After determining the type of functional response curve, non- linear least square regression (proc NLIN in SAS) was done to estimate the parameters associated with Holling type models (Holling, 1966). As the prey mite numbers depleted during the experiment, the type II functional response random predator equation used was:

$$Ne = N_0 [1-\exp \{a (T_h Ne - T)\}]$$

where, T_h is the handling time, T is the total time for which the bugs were exposed to prey mite and a is the predator attack coefficient or instantaneous searching rate (Rogers, 1972).

RESULTS AND DISCUSSION

Functional response of *B. pallescens*

Fifth instar nymphs of *B. pallescens* readily preyed upon adult females of *T. truncatus*. Highest mean mortality of 45.33 mites was observed at the predator – prey ratio of 1:60 and lowest mean mortality observed was 7.5 mites at density of 10 mites/ nymph (Fig. 1). Results from logistic regression showed that linear parameters were negative and significant (P value < 0.05) (Table 1), indicating *B. pallescens* exhibited a type II functional response.

Parameters associated with Holling's type models were estimated by non-linear least squares regression (Table 2). The attack rate (a) and handling time (T_h) for *B. pallescens* estimated using the random predator equation was respectively 0.041h[-1] (SE = 0.0173) and 0 < T_h < 0.5060 h (SE =0.3366).

Table 1. Maximum likelihood estimates of the parameters by logistic regression of proportion of *T. truncatus* killed by *B. pallescens* as a function of initial density

Parameter	Estimate	Standard error	X^2	P- value
Intercept	-0.3412	0.4500	0.57	0.4484
Linear (P1)	-0.0724	0.0215	11.34	0.0008
Quadratic (P2)	0.00101	0.000233	18.92	<0.0001

Numerical response of *B. pallescens*

a. Reared on *T. truncatus*

Though the developmental duration of different instars decreased as the density of prey mite offered increased, there was no significant difference between the various densities (Table 2).

Table 2. Mean duration of different instars of *B. pallescens* at varying prey density

Prey density	Duration of instars (days)				
	I	II	III	IV	V
T1 (1:10)	3.10				
T2 (1:20)	3.00				
T3 (1:30)	2.82	4.28	4.75		
T4 (1:40)	2.95	3.58	3.28	5	
T5 (1:50)	3.00	3.10	3.25	3.75	8

Further, the nymphs failed to complete nymphal stage in treatments offering *T. truncatus* at 10, 20, 30 and 40 mites/ nymph. Only one nymph at the predator prey ratio of 1:50 moulted into adult but was deformed.

b. Reared on *Corcyra cephalonica*

The mean number of eggs laid varied from 0.8 per female bug at a prey density of 1:20 to 3.4 at prey density of 50 mites/ female bug. No significant difference was observed among the different treatments. The number of female bugs that laid eggs were also recorded, and varied from 5 (50%) at the lower ratios of 1:20 and 1:30 to 8 (80%) at the higher predator prey ratios of 1:40 and 1:50.

Table 3. Mean fecundity and longevity of *B. pallescens* females at varying prey densities

Predator-prey ratio	Fecundity	No. of females that laid eggs	Longevity (days)
1:10	1.2	5	15.6
1:20	0.8	5	14.9
1:30	2.4	7	14.4
1:40	3.3	8	13.2
1:50	3.4	8	15.0

Mean longevity of females of *B. pallescens* varied from 13.2 days to 15.6 days and no significant variation was observed at different prey densities (Table 3).

B. pallescens exhibited a type II functional response on its prey, *T. truncatus* as the proportion of prey killed decreased as the prey density increased before reaching an upper plateau (predator prey density at 1:50 and beyond) at which satiation occurred (Fig. 2). The nature of response was further confirmed through logistic regression analysis in which the linear parameters were negative and significant.

These results are in agreement with the findings of Varshney *et al.,* (2020) who obtained a Hollings type II functional response curve of *B. pallescens* at different densities of blossom thrips, *Frankliniella schultzei* Trybom and that of Devi (2012) who obtained same type of functional response curve on eggs of *C. cephalonica* and handling time for the bug as 48 minutes. Type II functional response has also been reported in several
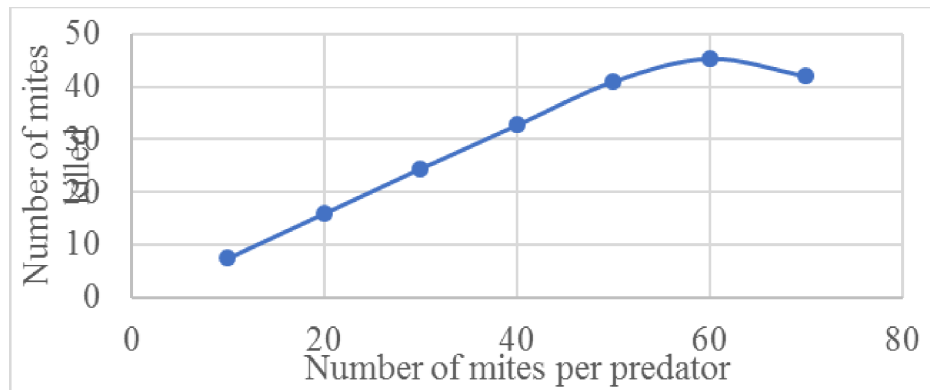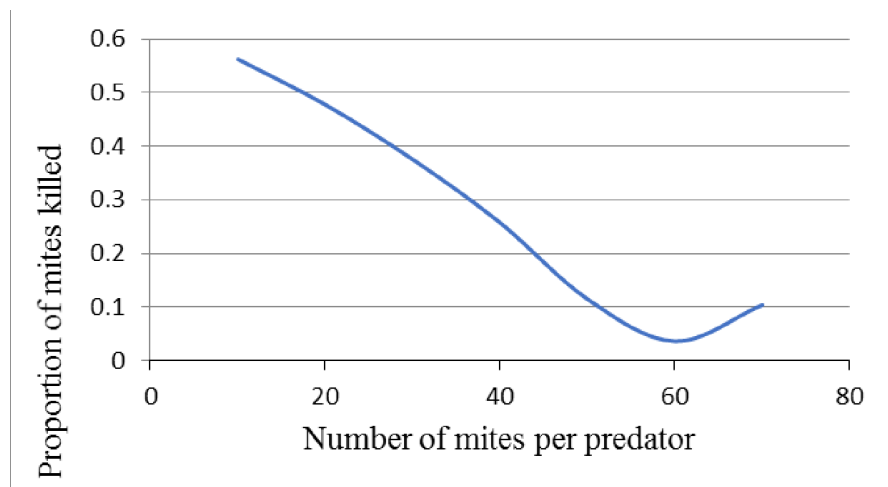
Fig 1. Number of mites killed at varying density

Fig 2. Proportion of mites killed at varying density

species of anthocorids like, *Orius. insidiosus* (Say) (Coll and Ridgway (1995) and *Anthocoris nemoralis* (F.) (Emami *et al*., 2014). Also, a number of studies have credited anthocorid bugs, including *B. pallescens,* with type III functional response. Queiroz *et al.* (2015) reported that *B. pallescens* and *Amphiareus constrictus* (Stal) showed a type III functional response when fed on eggs of tomato pin worm, *Tuta absoluta* (Meyrick) at different densities. The influence of environmental conditions on predator responses, as brought out in case of *B. pallescens* at two different temperatures also could account for the variability among different studies (NBAIR, 2019).

The type II nature of functional response of *B. pallescens* reveals that the bug does not show

any delay in initiating predation. Hence, the bug would be an efficient predator at low prey densities. Many predators that have shown type II functional response under laboratory conditions have proved to be successful biocontrol agents in field (Xiao and Fadamiro, 2010). Further, the shorter handling time for *B. pallescens* in the study also indicates its higher predation rate as predators with longer handling time shows a tendency to saturate faster (Kisdi and Liu, 2006).

Numerical response studies showed that *B. pallescens* nymphs were unable to complete development (Table 2) on *T. truncatus.* Similar results were reported by Devi (2012), who observed that nymphs of *B. pallescens* failed to complete fourth instar stage when reared on

T. urticae, suggesting that spider mites could be poor hosts for anthocorid bugs. On the other hand, Srikumar *et al.* (2017) and Ballal *et al.* (2009) reported that *B. pallescens* was able to complete development when reared on spider mites. Inability of *B. pallescens* to effect complete control of *T. urticae* was also observed by Ballal *et al.* (2009) and the effect of host plants of two spotted spider mite on the reproductive biology of *B. pallescens* was reported by El- Basha (2016).

In numerical response studies using adult female bugs, the average number of eggs laid per female bug on the whole increased as the prey mite density increased with no significant difference among various treatments (Table 3). The highest mean fecundity of 3.4 eggs, was recorded at the peak density of 50 mites/female. It is noteworthy that the number of female bugs that laid eggs also had increased progressively as the prey mite density increased. While there are few studies of a similar nature for comparison of the above results, Viswanathan and Ananthakrishnan (1974) observed an increase in field population of anthocorid predator following a rise in population of *Megalurothrips distalis, Frankliniella schultzei* and *Haplothrips ganglbaueri*, though the contribution of resident females to the population increase is not clear. Coll and Ridgway (1995), likewise observed an increase in egg laying by the anthocorid bug *Orius insidiosus* at increased densities of *Frankliniella occidentalis* on bean and corn. A positive density response was also reported by Scutareanu *et al.* (1999) who observed that number of anthocorid bugs showed a positive correlation with that of pear psyllids.

Apparently, longevity of adult females of *B. pallescens* was not affected by the quantity of prey mite offered. Tangkawanit *et al.* (2018) similarly observed that the longevity of mirid predator, *Cyrtorhinus lividipennis* was not affected by the density of its prey, *Nilaparvata lugens*.

On closer observation, duration of different nymphal instars of *B. pallescens* found to have been extended on *T. truncatus,* when compared with that on *C. cephalonica* eggs. Further, average fecundity and adult longevity of the bug was far less when compared with those on other hosts. Average duration of different nymphal instars was 2.64, 1.93, 2.01, 2.5 and 5.1 days respectively from first to fifth instars when reared on *C. cephalonica*. An average of 134 eggs was laid and females lived for 52 days on rice meal moth eggs (Jose and Subramanian, 2020). This is consistent with earlier studies with extended nymphal period when *B. pallescens* was reared on mites. (Ballal *et al.*, 2009; Devi, 2012). Sudies have pointed out the significant reduction in fecundity of *B. pallescens* reared on mites. Tawfik and El- Husseini (1971), for instance, recorded mean fecundity of *B. pallescens* as 78 when the bugs were fed with lepidopteran larvae as against 5.7 eggs when reared on mites. Devi (2012) documented that no egg laying was observed when newly emerged adults of the bug were given *T. urticae* as food. Remarkably lower adult longevity was also documented by Ballal *et al.* (2009), who observed that the longevity of adult female of *B. pallescens* bugs was only 21 days when fed on *T. urticae*, while it lived up to two months on *C. cephalonica*. El- Basha (2016) also reported that female longevity was only 17.7 days when fed on spider mites on cucumber. Even though *B. pallescens* exhibited a very weak numerical response with *T. truncatus*, predatory capacity of the bug is very high and hence, can bring down the population of spider mites to a safer level with augmentative releases at initial stages of spider mite infestation.

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