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Biology of pyrrhocorid predator, *Antilochus conqueberti* Fabr. (Hemiptera: Pyrrhocoridae) and its predatory potential on *Dysdercus cingulatus* Fabr. (Hemiptera: Pyrrhocoridae)

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ABSTRACT

The prey stage preference and the functional response of a pyrrhocorid predator, *Antilochus conqueberti* on *Dysdercus cingulatus* were studied in the laboratory along with the predator's biology under controlled conditions. The functional response shown by the predator were of type II, since the number of prey consumed per predator initially rises quickly as the density of prey increases but then levels off with further increase in prey density. The stage preference experiments suggests that the third instars of *Dystercus cingulatus* were preferred by II and III instars of the predator, *Antilochus conquebberti.* The V instars of *A. conqueberti* fed minimum on all the stages of the pest *D. cingulatus.* The biology of the predator were studied in the laboratory conditions and it was found that the eggs of *Antilochus coqueberti* were of light brown colour and laid in clusters which hatched into pale, fuscrus and testaceous nymphs. The first generation and second generation reared in the laboratory were found to have an incubation period of 8.00±0.00 days and 7.55±0.08 days respectively and the organism has to cross five instars to become an adult. The stadial period of first instar in the first and second generation ranged from 1.46±0.008 and 2.56±0.08 respectively, the second instar, 6.86±0.47 and 10.14±0.23, the third instar, 5.94±0.55 and 7.83±0.20, the fourth instar, 7.80±0.243 and 4.79±0.18, the fifth instar, 9.13±0.64 and 7.00±0.30, the adult, 31.88±0.30 and 39.00±0.30. The sex ratio of the first generation and second generation was found to be 1:0.50.

Keywords: pyrrhocorid, *Antilochus conqueberti*, *Dysdercus cingulatus*, functional response, stadial period, sex ratio.

1. Introduction

Biological control as a management tool dates back over 1,000 years when ancient Chinese citrus growers used ants to control caterpillar larvae infesting their trees. It is one of the safest methods of control since it is not toxic, pathogenic or injurious to humans. Today biocontrol is part of the larger pest management strategy known as the integrated pest management or IPM. Often biocontrol is the least expensive and most sustainable of the pest control options which makes it worthwhile to learn how and when to use it in a pest management program [1]. A nation like India which is highly dependent on agriculture, the crops attacked by various pests is also on its high. Ever since our country started the green revolution by depending on chemical pesticides to control insect pests, the damage caused by insect pests was brought down to a lower rate initially, but as the time proceeded, insect pests became resistant to the chemicals and thereby chemicals became an agent to make pests successfully proliferate rather combating them. So it is high time that we bring biological control into the foray and thereby counter the menace caused by insect pests to crops and save our environment from the serious drawbacks of administering chemical pesticides.

Cotton, being the most economically important natural fiber material in the world has a great history in India dating back to the period of Indus valley civilization. One of the major obstacles hindering cotton cultivation is insect pest infestations. In recent years, yield of cotton has become static rather it is declining due to the infestation of insect pests and diseases. Nearly 162 species of insect pests cause low yield of cotton production. The sucking pests of cotton include cotton stainer, jassids, aphids, white flies and thrips [2].

The red cotton bug or cotton stainer, Dysdercus cingulatus (Fab) (Hemiptera: Pyrrhocoridae) is considered as a serious pest of cotton [3;4] as it infests the cotton from young stage still harvest. In particular, the cotton strainers. Dysdercus spp. (Heteroptera: Pyrrhocoridae) cause serious damage by feeding on developing cotton balls and ripe cotton seeds and transmitting fungi that develop on the immature lint and seeds [5,6,7,8,9,10,11,12] Yasuda, K, 1992. *Dysdercus cingulatus* is difficult to control by insecticidal application because they are highly mobile and have many alternative wild hosts belonging to Malvaceae [9,14]. Thus an alternative biocontrol approach was used in this study to control *Dysdercus cingulatus* by another Pyrrhocorid, *Antilochus conqueberti*, which has been observed to prey upon the pest in the fields.

There is no previous record in a way to understand the biocontrol potential of pyrrhocorid, *A. conqueberti*, a phytophagous, gregarious and hibernate as adults. on D. cingulatus. Thus a study was made.

2. Materials and Methods.

2.1. Insect collection and maintenance

The predator and the pests were collected from Loyola college campus, Chennai, Tamil Nadu, India and maintained under the laboratory conditions {31±10 ^{0}C, 75±5% RH and 11-13 hours (L:D) in plastic containers of 20 cm diameter}. The hatched nymphs were separated and reared in plastic containers. The pyrrhocorid predator was initially fed ad libitum on Corcyra cephalonica. Laboratory emerged second generation nymphs and adults of *Antilochus conqueberti* were used for this experiment. Observations on nymphal mortality, adult longevity were recorded. The nymphs and adults of *Dysdercus cingulatus* were reared in the laboratory on seeds of the cotton plant, Gossypium arboretum L.as a rearing host.

2.2. Biology of *Antilochus conqueberti*

The biology of *Antilochus conqueberti* was studied in the laboratory by calculating the incubation period of eggs and stadial period of instars and adults with a special mention of the sex ratio.

2.3. Bioefficacy

2.3.1. Stage preference

Even among the preferred prey species the predator exhibits a specific selection to a particular stage of the prey. Selection of one stage over another could also affect the dynamics of prey- predator interaction. So it is important to assess the stage preference of any predator. Laboratory data on the stage preference of the predators helps in assessing its impact on various stages of the insect pests. The pyrrhocorid, *Antilochus conqueberti*, is best known as a predator of other pyrrhocorids, especially *Dysdercus* [12,15]. The host specificity of predators is governed principally by the size of their prey rather than their taxonomic affinity [16,17]. Such information is essential for better utilization of any biological control agent. Hence stage preference study of the third, fourth, fifth nymphal instars and adult of *Antilochus conqueberti* on *Dysdercus cingulatus* were evaluated by choice experiment. The prey used in the experiment i.e., *D. cingulatus* were of laboratory reared III, IV, V & VI nymphal instars and adults. The prey was introduced into the Petri dish and was left undisturbed for ten minutes. Each nymphal instar and adult of the predators was introduced into the Petri dishes separately and successful killing of the prey by the predators and percentage of consumption were recorded.

2.3.2. Functional response

To evaluate the functional response, 10 newly emerged (24 h starved) third, fourth, fifth instar nymphs and adults of *Antilochus conqueberti* were used in each one of the densities (1, 5, 10, 20, 40 and 60) of preferred life stages of *Dysdercus cingulatus*. After 15 minutes, the predators were individually released into the petri dish (9 cm diameter). To mimic the natural condition, a cotton leaf was place inside the experimental set up. Predatory behaviour such as approaching time and handling time were recorded for 3 hours continuously by visual observation. The numbers of ingested or killed and remaining preys were recorded after 24 h (T). The predator search efficacy was calculated form the number of dead and offered prey. X- Prey density; y- total number of prey killed in given period of time (Tt); y/x- the attack ratio; Tt- total time in days when prey was exposed to the predator, b- time spent for handling each prey by the predator (7t/k); a- rate of discovery per unit of searching time [(y/x)/Ts]. Discovery was instantaneous, with little searching time being required. Although the parameter rate of discovery was theoretically infinite, the predator did spend some time in searching for the prey at lower prey density but no time at higher prey density. The extent of searching was clearly related to be degree to satiation.

The parameter 'b', 'k' and 'a' were directly measured in the present study. The handling time 'b' was estimated at the time spent for pursuing, subduing, feeding and digesting each prey. The maximum predation was represented by 'k' value and it was restricted to the higher prey density. Another parameter 'a' the rate of discovery was defined as the proportion of the prey attacked successfully by the predator per unit of searching time. Assuming the predator efficiency is proportional to the prey density and to the time spent by the predator in searching prey (7s) the expression of relationship in

$$Y=a\ Ts\ x \ldots\ldots\ldots\ldots\ (1)$$

But time available for searching is not constant. It is reduced from the total time (Tt) by the time spent for handling the prey. If we presume that each prey requires, a constant amount of time 'b' for the consumption, then

$$Ts= Tt-by \ldots\ldots\ldots\ldots\ldots\ (2)$$

Substituting (2) in (1), Holling's 'disc' equation is

$$Y=a(Tt-by)x \ldots\ldots\ldots\ldots....(3)$$

The linear regression graphs were plotted for the feeding efficacy of the predator.

3. RESULTS:

3.1. Biology of *Antilochus conqueberti*

The eggs of *Antilochus coqueberti* were of maroon colour and individually laid without any cementing material. The different batches of maroon coloured eggs were gently transferred from the plastic container to that of a wet cotton swab (changed periodically to prevent fungal attack) which is placed in a petri dish for maintaining optimum humidity. The eggs hatched into pale, fuscrus and testaceous nymphs. The first generation and second generation reared in the laboratory were found to have an incubation period of 8.00±0.00 days and 7.55±0.08 days respectively and the organism has to cross five instars to become an adult. The stadial period of first instar in the first and second generation ranged from 1.46±0.008 and 2.56±0.08 respectively, the second instar, 6.86±0.47 and 10.14±0.23, the third instar, 5.94±0.55 and 7.83±0.20, the fourth instar, 7.80±0.243 and 4.79±0.18, the fifth instar, 9.13±0.64 and 7.00±0.30, the adult, 31.88±0.30 and 39.00±0.30. The sex ratio of the first generation and second generation was found to be 1:0.50.

Table 1: Biology of *Antilochus conqueberti*

Generation		Incubation period	Stadial period						Sex ratio
			I	II	III	IV	V	I to Adult	
Antilochus conqueberti	I	8.00±0.00	1.46±0.08	6.86±0.47	5.94±0.55	7.80±0.243	9.13±0.64	31.88±0.30	1:0.50
	II	7.55±0.08	2.56±0.08	10.14±0.23	7.83±0.20	4.79±0.18	7.00±0.30	39.00±0.30	1: 0.50

3.2. Bioefficacy of the pyrrhocorid predator, *Antilochus conqueberti*

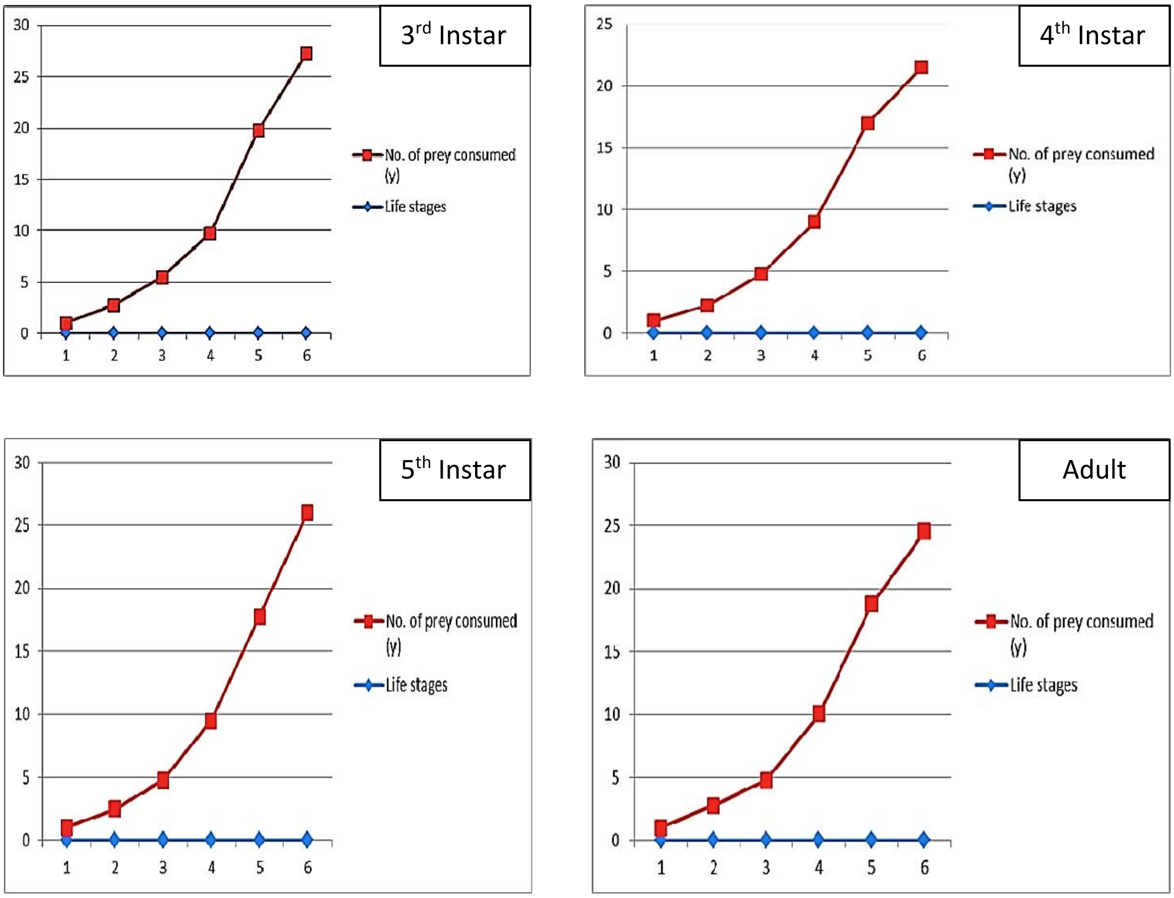
3.2.1 Functional response

Functional response is a density dependent function of the tested predator's response to the increasing prey density by killing more number of prey than it killed at lower prey densities i.e., its predatory rate was increased with increase in prey density. The functional response of third, fourth, fifth and adult of *Antilochus conqueberti* on *Dysdercus cingulatus* were recorded, and the results revealed that the attack ratio decreased with increase in prey density the predator's response. Handling time seemed to decrease with increasing prey density in both fifth nymphal instars and adults, but this relation was not defined in the third and fourth nymphal instars of *A. conqueberti* while provided with *D. cingulatus*. The predator exhibited a typical functional response and thus established the applicability of the second model of Hollong's 'disc' equation. The third, fourth and fifth nymphal instars and adult of *A. conqueberti* on *D. cingulatus* showed maximum values (27.25, 21.5, 26, and 24.5) at 60 prey densities respectively.

Table 2: Bio-efficacy of *Antilochus conqueberti* on III, IV, V instars and adults of *Dysdercus cingulatus*

Life stages	Prey density (x)	No. of prey consumed (y)	Consumed ratio (y/x)	Handling (by)	Days searching (Ts=1-by)	Prey^1 Y^1=a (1-by)	Predicted attack (Y^1/x)	Max (Y)	B= by/y	Raye of discover a=yx/Ts
III	1	1	1	0.003	0.997	0.99	0.99		0.003	1.003
	5	2.75	0.55	0.003	0.997	0.54	0.10		0.001	0.551
	10	5.5	0.55	0.003	0.998	0.54	0.05		0.00003	0.551
	20	9.75	0.48	0.003	0.997	0.47	0.02		0.00003	0.481
	40	19.75	0.48	0.003	0.997	0.47	0.01		0.00001	0.481
	60	27.25	0.45	0.003	0.997	0.44	0.007	27.25	0.00001	0.451
IV	1	1	1	0.003	0.997	0.47	0.47		0.003	0.481
	5	2.25	0.45	0.002	0.998	0.54	0.10		0.00008	0.551
	10	4.75	0.47	0.003	0.997	0.47	0.04		0.00006	0.481
	20	9.0	0.45	0.002	0.998	0.54	0.02		0.00002	0.551
	40	17	0.42	0.003	0.997	0.47	0.01		0.00001	0.481
	60	21.5	0.35	0.003	0.997	0.47	0.007	21.5	0.0001	0.48
V	1	1	1	0.004	0,996	0.99	0.99		0.004	1.004
	5	2.5	0.5	0.003	0.997	0.49	0.09		0.0012	0.501
	10	4.75	0.47	0.003	0.997	0.46	0.04		0.003	0.471
	20	9.5	0.47	0.004	0.996	0.46	0.46		0.00006	0.471
	40	17.75	0.44	0.004	0.996	0.43	0.43		0.00002	0.441
	60	26	0.43	0.003	0.997	0.42	0.42	26	0.00001	0.431
Adult	1	1	1	0.007	0.993	0.99	0.99		0.007	1.007
	5	2.75	0.55	0.002	0.998	0.54	0.10		0.0007	0.551
	10	4.75	0.47	0.003	0.997	0.46	0.04		0.00006	0.471
	20	10	0.5	0.003	0.997	0.49	0.02		0.0003	0.501
	40	18.75	0.46	0.003	0.997	0.45	0.01		0.00016	0.461
	60	24.5	0.04	0.003	0.997	0.03	0.005	24.5	0.00001	0.040

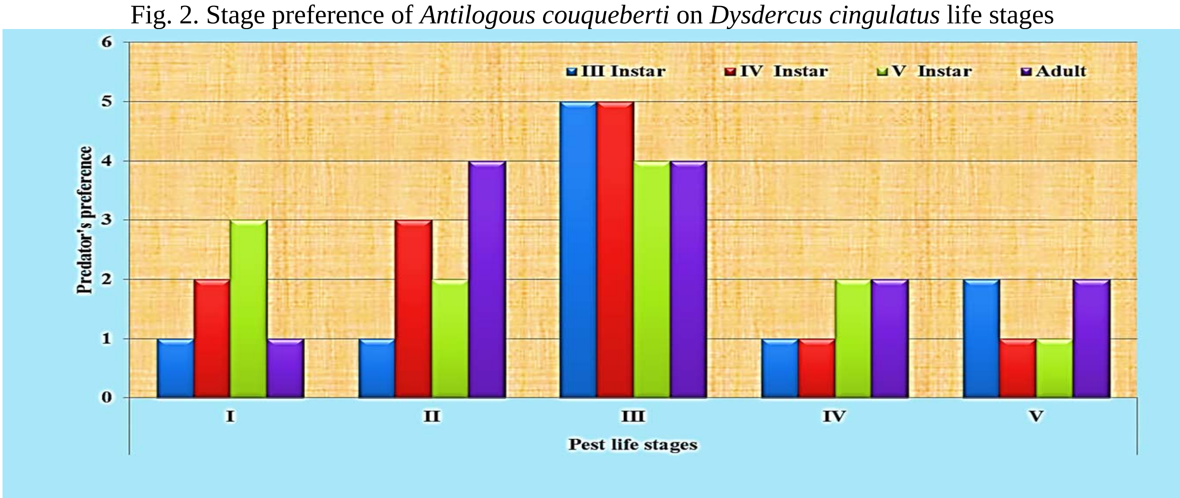
Figure 1: Functional response of *Antilochus couquiperti* on *D. cingulatus*



3.2.2. Stage preference

The third instars of *Dystercus cingulatus* were preferred by II and III instars of the predator, *Antilochus conquebberti*. The V instars of A. conqueberti fed minimum on all the stages of the pest *D. cingulatus.* The results show that life stages of *A. conqueberti* although preyed on different stages of the tested pest but the maximum preference has been shown to the third instars of the pest, *Dystercus cingulatus*. The results also suggest that second instar and third instar of the predator were more successful in controlling *D. cingulatus.*

Fig. 2. Stage preference of *Antilogous couqueberti* on *Dysdercus cingulatus* life stages



4. Discussion

The bioefficacy of an organism includes stage preference and functional response towards a prescribed pest. Functional response characterizes the relationship between the number of prey consumed by individual predators and the density of available prey [18,19]. The effectiveness of the predator under controlled condition depends upon the type and number of prey consumed. Moreover, before utilizing a natural enemy for biological control, it is important to assess its ability to capture and consume relevant stages of the targeted insect pests. The results revealed that particular stages of the predator preferred certain specific stages of the pests. Moreover younger predators preferred younger prey and vice versa. TNAU Agritech Portal reported that *Dystercus cingulatus* fed by sucking the sap from the seeds, leaves, flowers, inflorescence of the cotton plant, but the major damage has been reported to cause to the bolls, which are very vital and stains the cotton with its faecal matter and thus the cotton turns reddish brown and therefore the organism is commonly called red cotton bug and it has been claimed to be the major pest of cotton plant. *Dysdercus cingulatus* was also reported to feed on several species belonging to the plant family Malvaceae as well as a few species of Bombacaceae. It is considered to be the most serious pest of cotton in South and Southeast Asia; its life history at various localities of the Oriental Region was treated in detail already in the early 20th century [20,5]. Host plants and life history were studied based on field observations in the Ryukyus by [21,22] development on various cultivated and wild host plants was investigated under laboratory circumstances by[14]. In the Ryukyus, it reproduces almost all year round because of shifting between its various host plants according to their phenology. A detailed review of the literature on the importance of the species was presented by [23]. Based on previous reports and our research experience, we tried to control the pest in eco- friendly conditions using the pyrrhocorid, A. conqueberti since the pest readily adapts to all kinds of pesticides. Functional responses may provide important information on the voracity of a biological control agent, and on the effects of abiotic (e.g., temperature) or biotic (e.g., host insect) factors on its foraging efficiency [24,25,26,27]. Although most predators attack the largest available individuals of their prey species, those species are generally smaller in body size than the predator. Predatory arthropods are known to be an exception to this limition of predator prey relative body size ratios, because maximum prey size can be increased through the use of venoms, traps, or group hunting[28].The results of the present study indicate that A. conqueberti is capable of low level but fairly consistent success has been noted in killing its larger hemipteran prey. The results of our analyses indicate that the percentage of hemipteran life stages of tested prey attacked by A. conqueberti decreased as prey availability increased, typifying a Type II density independent functional response[18,29,30]. A similar Type II functional response curves have been reported in a number of other predatory insects belonging to the family reduviids[31,32,33]. However, [29] stated that predators showing a type III response are theoretically more capable of suppressing prey populations. Although the shape of the functional response curve is an important factor, it is insufficient as a criterion to predict success or failure of a predator as a biocontrol agent, as other factors such as numerical response, intrinsic growth rates, host patchiness, competition, and environmental complexities (abiotic and biotic factors) also have a major influence on the efficiency of a predator in managing a pest population [34].Inversely proportional relationship was found between the attack and prey level. It is presumed that the predators required less time to search the prey and spent more time on non-searching activities at higher prey densities, which in turn might have caused perceptive decline in the attack rate until hunger was established. Moreover, higher prey density also results in reduction of unsuccessful attacks of a predator on a prey, as there are less chances of escape when compare to those in scarce prey density, where there are more chances for the prey to escape from the predator [35]. The feeding efficacy of the predators increased while the prey density increased. This exhibits a typical type II model Holling's disc equation. The feeding efficacy was correlated positively with prey density but the attack ratio was higher in low prey densities. This experiment clearly reveals that different stages of the predator can be utilized in pest management programs. However, before recommending these predators for biological control programs, it is essential to evaluate its potentiality at augmentation level.

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