

Ecology of *Dysdercus cingulatus* morphs

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Abstract

We recorded whether male and female *Dysdercus cingulatus* (Fab.) (Heteroptera: Pyrrhocoridae) had a black scutellar spot in addition to the two forewing spots, and then mated all the combinations. Offspring of these crosses were assessed under laboratory conditions for a number of variables: nymphal developmental period, sex ratio, fecundity, hatchability and offspring size. Offspring of the cross 3M2F took the largest time to attain the adult stage, but fecundity was higher in 2M2F offspring. The incubation period was highest when parents had the same, rather than different, numbers of spots.

Introduction

Studies on dispersal polymorphism in insects have played a pivotal role in advancing our understanding of population dynamics, life history evolution, and the physiological basis of adaptation (Zera & Denno 1997). Polymorphism of Heteroptera in general (Socha *et al.* 2005), and Pyrrhocoridae in particular (Socha & Zemek 2003) has been studied by many scientists.

Dysdercus cingulatus (Fab.) (Heteroptera: Pyrrhocoridae) is commonly known as the red stainer or red cotton bug. This is a multivoltine insect having five to six gonadotrophic cycles in its lifespan, and constitutes one of the key pests of cotton and other malvaceous plants. *D. cingulatus* develops faster when fed cultivated rather than wild species, and host plant properties such as the weight of feeds and growth habit (arboreal or herbaceous) could not explain the observed differences in survival and developmental rate (Kohno & Thi, 2004).

Here we investigated the preferred food plant, and also the effect of the presence or absence of a scutellar black spot on features of the life history (development, survival, sex ratio, fecundity and hatchability).

Materials & Methods

D. cingulatus adults and nymphs were collected from cotton fields in Thalapathi Samuthiram, Sivanthipatti, Killikulam and Alangulam of Tirunelveli District, Tamil Nadu, India and were maintained under laboratory conditions (27 ± 2 °C, 70-75% RH, 11L:13D photoperiod) in plastic containers (20 x 10 x 15 cm) on soaked cottonseeds. Newly emerged adults (>3 hr) were categorized into two-spotted males/females and three-spotted males/females.

All combinations were mated together: two-spotted males with two-spotted females (2M2F), three-spotted males with three-spotted females (3M3F), two-spotted males with three-spotted females (2M3F) and three-spotted males with two-spotted females (3M2F). Ten pairs of male and female bugs were randomly selected from the stock and each pair was kept in a separate container for copulation and oviposition and was maintained in the laboratory till death. Copulation time, the number of eggs laid, the number of nymphs hatching, and adult longevity of both male and female were recorded. Sixty first-instar nymphs were then maintained from each category separately, five per plastic container (500 ml capacity), with 12 replications in each category. Nymphs were provided with water and soaked cottonseeds, replaced every 24 hours. Nymphal developmental time, mortality, number of males and female emerged from each category and female sex ratio (Sahayaraj *et al.*, 2004) were recorded. Loose sterilized soil was placed inside the plastic boxes up to 2 cm for oviposition purposes.

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Females dig an egg chamber in the soil for laying her eggs: we recorded the diameter and height of the egg chamber for each morph separately.

The preferred host of this pest was tested using 30 to 45-day-old *Gossypium hirsutum* (cotton), *Abelmoschus esculentus* (lady's fingers) and *Phaseolus mungo* (black gram), each plants maintained in a separate pot 15×24×25 cm. A 24-hr-starved adult (irrespective of morph and sex) was released onto each caged plant, and we recorded the time to approach, the feeding site selected, and the sucking times (in mins). The pots were covered with transparent polyster to prevent excess loss of water and to prevent the escape of the insects. Seven replications were made for each plant.

Data from the developmental and fecundity studies were subjected to analyses of variance, with differences between particular treatments determined by Duncan's Multiple Range Test. Differences between means were considered significant at the 5% level (SYSSTAT 9.0). Chi-square analyses were performed to find out the significance if any, in sex ratio.

Results

The red cotton bug preferred to feed on cotton, followed by black gram and lady's fingers. In both cotton and black gram, *D. cingulatus* selected for feeding the lower part of the young and mature leaves, particularly the vein. Bugs had lower search times for cotton (3.0 ± 0.4 mins, n = 7) than black gram (5.1 ± 0.04 mins, n = 7) and lady's fingers (16.0 ± 0.7 mins, n = 7), and these differences were significant ($F_{2,18} = 24.0$, p<0.01). They also spent more time feeding from cotton leaves (41.7 ± 0.2 mins) than from black gram (14.3 ± 0.4) and lady's fingers (18.7 ± 0.1 mins), also significant ($F_{2,18} = 19.4$, p<0.01).

Table 1. Nymphal developmental period (in days) of *Dysdercus cingulatus* produced by parents of different morphs mated together

Parents	Life stages					Adult
	I	II	III	IV	V	
3M-3F	3.0 ± 0.00	2.9 ± 0.1	4.8 ± 0.3	3.6 ± 0.2	6.8 ± 0.1	21.1 ± 0.7
2M-2F	3.0 ± 0.00	2.8 ± 0.0	4.0 ± 0.2	5.6 ± 0.4	6.5 ± 0.1	$21.9 \pm 0.7^{\text{NS}}$
3M-2F	3.0 ± 0.00	4.1 ± 0.1	4.2 ± 0.4	5.2 ± 2.4	7.3 ± 0.7	$23.3 \pm 0.6^*$
2M-3F	3.0 ± 0.00	2.4 ± 0.2	4.0 ± 0.2	3.5 ± 0.2	5.3 ± 0.3	$18.2 \pm 0.5^*$

2M = two-spotted male; 2F = two-spotted female, 3M = three-spotted male; 3F = three-spotted female; NS = not significant; * shows significance at the 5% level by Tukey's Multiple Range Test.

The influence of the spot polymorphism on the nymphal developmental period (Table 1) was clear. The offspring differed in their development times ($F_{3,22} = 8.70$, p<0.05): those of similar parents (2M2F & 3M3F) had moderate development times and did not differ from one another; 2M3F offspring developed more quickly, and 3M2F took longer. Further investigations are necessary to confirm this finding.

Females were heavier than the males, and in both sexes, *D. cingulatus* with two scutellar spots were lighter (males 289.3 ± 1.5 ; females 532.2 ± 3.0 mg) than those with three spots (males 359.2 ± 2.8 ; females 580.5 ± 1.7 mg). In a 2-way ANOVA, sex ($F_{1,18} = 19.4$, p<0.05) and morph ($F_{1,18} = 39.4$, p<0.025) were significant, as was the interaction ($F_{1,24} = 19.4$, p<0.05).

There were significant differences in sex ratio (χ^2 , p<0.01) among pairings, male-biased in the 3M2F and 2M3F pairings, and approximately equal in 2M2F and 3M3F (Table 2). During oviposition as adult females, 3M3F offspring made deeper egg chambers (1.8 ± 0.1 cm), followed by 2M2F (1.2 ± 0.1 cm), 3M3F (1.2 ± 0.1 cm) and 2M3F (1.2 ± 0.1 cm). Chamber widths were always 6 to 8 mm.

D. cingulatus usually finished oviposition activity within 20-30 mins. Females from 2M2F crosses laid the maximum number of eggs, followed by 3M3F, 2M3F, and 3M2F and these were significantly different ($p<0.05$). A similar order was also observed for nymphal hatching ($p<0.05$). Incubation period was very shorter for 3M2F followed by 2M3F, 2M2F and 3M3F. Statistical analyses among the four groups were significant ($P < 0.010$) (Table 3).

Table 2. Morph distribution and sex ratio of the offspring of various parental morph matings in *Dysdercus cingulatus*

Parental morphs	Number of offspring	Offspring with two spots		Sex ratio	Offspring with three spots		Sex ratio	Overall sex ratio
		male	female		male	female		
3M-3F	136	32	42	0.62	36	26	0.38	0.50
2M-2F	120	29	39	0.65	26	26	0.43	0.54
3M-2F	36	32	2	0.11	0	2	0.11	0.11
2M-3F	108	78	30	0.56	0	0	0.00	0.28

Sex ratios are expressed as the proportion female

Table 3. Combination of various morphs on number of eggs laid, incubation period (in days) and per cent of egg hatching of *D. cingulatus*

Parental morphs	Mean number of eggs laid	Incubation period	Hatching %
3M-3F	79.8	5.8	75.88
2M-2F	91.8	5.3	77.44
3M-2F	59.0	4.5	62.03
2M-3F	72.0	4.8	58.53
F-value	10.13	34.12	9.45

Discussion

Cotton is the most economically important natural fiber material in the world. One of the most important problems hindering cotton cultivation is insect pest infestation. The cotton stainer bug causes serious damage by feeding on developing cotton balls and ripe cotton seeds, and transmitting fungi that develop on the immature lint and seeds (Ahmad & Schaefer 1987; Yasuda 1992). Observations on the various biological parameters of the different morphs reveal intraspecific variation, and breeding experiments suggest that they are not strictly genetic.

Kohno & Thi (2004, 2005) reported that cotton was the preferred food, as we found here. They also report that reproductive ability depends on host and insect density: we provided water-soaked cotton seeds to nymphs and adults and constant density was maintained throughout the life stages. Thus differences were purely dependent on morph variation.

No information was available about polymorphism in *D. cingulatus*. Ford (1937) explained polymorphism as “the occurrence together in the same habitat at the same time of two or more distinct forms of the same species in such as proportion that the rarest of them cannot be maintained by recurrent mutation”. In the present study we recorded two distinct forms in both sexes, with two and three spots on the dorsum: two spots are present in the forewing, with the third on the scutellum.

Carroll & Loye (1990) reported male-biased sex ratios as common in *Dysdercus bimaculatus*, but our mating combinations produced female-bias in *D. cingulatus*. Results of both laboratory and field observations showed that the 3M3F matings were more frequent than either 3M2F or 3F2M: the larger size and heavier weight of the three-spotted morph might be the reason for this preponderance. 2M2F matings laid more eggs than 3M3F; the latter spent more time and hence energy to make the egg chamber during oviposition, a possible reason for the difference. In reduviids, heavier and larger insects lay more eggs (Sahayaraj *et al.* 2004).

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