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Effect of host plants on life history traits of *Dysdercus koenigii* (Hemiptera: Pyrrhocoridae)

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Abstract

Red Cotton Bug, *Dysdercus koenigii* F., (Hemiptera: Pyrrhocoridae) also called cotton stainer is a destructive pest of cotton and many other economical crops in Asia. D. *koenigii* feeds on a variety of hosts including cotton. It damages the crop by sucking sap and staining lint by its faeces. Being important pest of many important crops, the present work was planned to study the comparative biology and biometrics most appropriate word of D. *koenigii* on cotton, okra and simal under laboratory condition. Significantly lesser nymphal duration was observed in cotton 23.42±1.38 days as compared to okra and simal 28.20±2.08 and 28.39±1.96 days respectively. The longer adult life was observed on cotton (female 20.85±6.17 days and male 16.18±6.11 days) and simal (female 20.11±3.19 days and male 15.41±2.37 days) than the okra (female 17.60±2.58 days and male 10.92±2.49 days). In case of cotton D. *koenigii* mates three times in its life, while in case of okra it mates 1-2 times and it mates only once in its life period in case of Simal. Numbers of eggs laid were significantly higher in case of cotton 109.06±32.60 as compared to okra (52.93±8.72 eggs) and simal (43.63±13.29 eggs). Better vigor was observed in case of case of cottonseeds. Biology and life cycle studies on different hosts will help researchers and farmers to develop IPM strategies accordingly.

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Introduction

Behavioral management is an important insect pest management tool as it reduces reliance on broad-spectrum insecticides (Foster and Harris, 1997). Push-pull tactics combining the repellent and attractant crops are typical examples of behavioral manipulation for the management of insect-pests (Agelopoulos *et al.,* 1999) but utilization of these tactics involves comprehensive knowledge of alteration in life history traits of insect-pests due to alteration in host plants (Umbanhowar and Hastings, 2002, Awmack and Leather, 2002). Different host plants could play a significant role in outbreaks of polyphagous insect pests (Lu and Xu, 1998, Singh and Parihar, 1988). In majority of cases host–plant quality not only affects the body size of insect–pests and but other life–history parameters such as fecundity, longevity, and survival are also affected (Stern and Smith, 1960, Sequiera and Dixon, 1996, Awmack and Leather, 2002).

Dysdercus spp. (Heteroptera: Pyrrhocoridae) also known as cotton stainers include many species inhabiting tropical and subtropical areas of the world (Freeman, 1947, Van Doesburg, 1968).Members of this genus *Dysdercus* are also known as cotton stainers, and are primarily seed feeders (Ahmad and Schaefer, 1987, Maxwell–Lefroy, 1908). *D. koenigii* is not a new pest in cotton growing regions of Asia i.e. India, Pakistan, Srilanka, Burma etc (Ahmad and Mohammad, 1983, Freeman, 1947; Kamble, 1971, Kapur and Vazirani, 1956, Wadnerkar, 1979). Due to large scale adoption of Bt cotton in Sub-continent (Dhillon *et al.,* 2011), sucking pest pressure especially of *D. koenigii* has much increased during years 2011 and 2012 (Ashfaq *et al.,* 2011). *D. koenigii* is a polyphagous pest of important plant families Malvaceae and Bombaceae (Kamble, 1971, Kohno and Ngan, 2004).

Red cotton bug (*Dysdercus koenigii* Fb.) is an important insect pest as it multiplies rapidly in the field i.e. it has quicker egg development (Venugopal et al., 1994) thus only insecticides can't give sufficient control. In insecticide resistance management, host plant preference has been accepted as a rational approach (Saeed *et al.,* 2010). A few works were done on bionomics of *D. koenigii* on Okra, in India and Nepal (Kamble, 1971, Thapa, 1985, Varma and Patel, 2012) but due to work in different environmental conditions and some incomplete parameters its bionomics and biology on different hosts; we studied bionomics and life cycle of this pest on three different hosts i.e. Cotton, the most important fiber crop of Pakistan (Abro, 2004); Okra, an important vegetable grown on a large scale in Pakistan (Anwar, 2011) and Simal, a well-known ornamental as well as medicinal plant under controlled conditions (Kohno and Ngan, 2004, Rastogi and Mahrotra, 1980–1984).

Focus of our work was to explore the knowledge about comparative biology of *D. koenigii* on three different hosts and to study comparative change in bionomics i.e. length, width, antennal size, proboscis, foreleg, hind leg and wing size of *D. koenigii* on three different hosts.

Materials and methods

Study area

The adults of *D. koenigii* were collected from cotton field in the Faculty of Agricultural Sciences and technology, Bahauddin Zakariya University, Multan. As adults of *D. koenigii* are not active fliers so after hand picking they were placed temporarily in plastic jars of about 15×25cm in size. For rearing on different hosts, Cottonseeds (*Gossypium hirsutum*; cultivar MNH–886) were obtained from Cotton research station of Multan, while okra seeds (*Abelomoschus esculentus*; cultivar Sabz Pari) were obtained from Pakistan Agriculture Research Council Laboratory in Bahauddin Zakariya University Multan and Simal seeds (*Salmalia malabarica*) were obtained from a local nursery.

Rearing technique

After adopting some necessary changes according to our environment in rearing earlier methods (Kamble, 1971, Kohno and Ngan, 2004) was used. Rearing was done under laboratory conditions (24±2ºC, 70±5% RH, 11L: 13D photoperiod) on soaked seeds of *G. hirsutum*, *A. esculentus* and *S. malabarica*; in plastic pots of 10×10 cm in size. Twenty seed provided in each pot every day considering them adequate feed for one pair. The pots were half filled with sterilized soil to offer this pest natural medium to lay eggs.

Life cycle and biology study

For each host, ten pairs (10 males and 10 females) were selected from the collection for studying the biology of their progeny; one pair was placed in a pot for copulation and egg–laying till mortality of both sexes. All the pots were cleaned, filter paper and food (20 soaked seeds) were replaced every day. To study the life cycle of *D. koenigii* after hatching on three different hosts, 180 newly hatched nymphs were randomly selected from the progeny of thirty parents; sixty pots were made for each host each pot containing a nymph. Biology and biometrics were studied on each host.

Biometrics of D. koenigii

For study of bionomics in each instar i.e. body length, body width, antennal length, proboscis length, length of foreleg and hind leg, forewing and hind wing length. Five individuals were randomly selected during every instar on each host. Measurements were done using stage micrometer (0.01 mm–1 mm), graded ocular (0.2 mm–2.5 mm) and graded scales (1 mm–150 mm) for ease in measurements.

Statistical analysis

The data were tabulated and statistically analyzed according to Completely Randomized Design on SAS program (SAS Institute, 2002).

Results

First instar

Duration of the 1st instar was found significantly longer in *S. malabarica* i.e. 3.37±0.40 days as compared to that of *G. hirsutum* 2.77±0.37 days and *A. esculentus* 2.89±0.44 days (P<0.0001, F=37.0, df =177, n=60) (Fig. 1). There was no significant difference in length, width of body, antennal length, and length of proboscis, length of foreleg and length of hindleg of 1st instar among the three hosts (Table 1).

Second instar

Duration of the 2nd instar was statistically longer in *A. esculentus* and *S. malabarica* i.e. 4.46±0.42 days and 4.48±0.42 days, respectively (P<0.0001, F=37.0, df =177, n=60) than *G. hirsutum* (Fig. 1). There was no significant difference in body length and length of foreleg of 2nd instar among the three hosts. However width of 2nd instar was significantly higher on *A. esculentus* i.e. 1.43±0.27 mm than other two hosts (P= 0.08, F= 3.08, df = 12, n=5). Antennal length, length of proboscis and length of hindleg 2.33±0.12 mm, 2.56±0.10 mm and 3.83±0.06 mm respectively was found to be significantly highest in case of *G. hirsutum* as compared to other two hosts (Table 1).

Third instar

Duration of 3rd instar was significantly highest in *A. esculentus* i.e. 6.05±0.45 days followed by *S. malabarica* (5.82±0.57 days) and *G. hirsutum* (4.98±0.51 days) (P<0.0001, F= 71.3, df=177, n=60) (Fig. 1). Measured body length (5.58±1.31 mm), width of body (2.50±0.71 mm), antennal length (3.78±0.78 mm), length of proboscis (3.66±0.38 mm), length of foreleg (4.31±0.70 mm) and length of hindleg (5.56±1.00 mm) were found to be significantly highest on *G. hirsutum* than other two hosts i.e. *A. esculentus* and *S. malabarica* (Table 1).

Fourth instar

Significantly highest duration of 6.36±0.38 days during fourth instar was found in *A. esculentus*, followed by *S. malabarica* (6.18±0.44 days) and *G. hirsutum* (5.71±0.47 days) (P<0.0001, F= 36.2, df=177, n=60) (Fig. 1). Body length (9.64±0.40 mm), width of body (3.60±0.16 mm), antennal length (8.33±0.12 mm), length of proboscis (4.95±0.11 mm), length of foreleg (6.45±0.08 mm) and length of hindleg (8.12±0.19 mm) were found to be significantly highest on *G. hirsutum* than other two hosts i.e. *A. esculentus* and *S. malabarica* (Table 1).

Table 1. Bionomics of different body parts of *Dysdercus koenigii* on three different hosts.

Stages	Host (Seeds)	Width(mm)	Length (mm) ± S.E**						
		Body	Body	Antennae	Proboscis	Fore leg	Hind leg	Forewing	Hindwing
1st	***G. hirsutum***	1.11±0.09a*	1.63±0.17a	1.06±0.15a	0.83±0.06a	1.36±0.08a	1.55±0.08a		
Instar	***A. esculentus***	1.13±0.09a	1.60±0.13a	1.01±0.15a	0.83±0.06a	1.36±0.08a	1.55±0.08a		
	S. malabarica	1.06±0.10a	1.57±0.10a	1.03±0.12a	0.76±0.07a	1.32±0.10a	1.50±0.08a		
2nd	***G. hirsutum***	1.21±0.10ab	3.07±0.12a	2.33±0.12a	2.56±0.10a	1.90±0.08a	3.83±0.06a		
Instar	***A. esculentus***	1.43±0.27a	3.09±0.09a	2.08±0.10ab	2.04±0.24c	1.75±0.20a	2.20±0.21b		
	S. malabarica	1.18±0.08b	3.01±0.07a	2.22±0.13b	2.29±0.15b	1.43±0.12a	2.36±0.11b		
3rd	***G. hirsutum***	2.50a±0.71a	5.58±1.31a	3.78±0.78a	3.66±0.38a	4.31±0.70a	5.56±1.00a		
Instar	***A. esculentus***	1.96±0.10b	4.03±0.12ab	2.85±0.11b	2.96±0.10b	2.52±0.10b	3.87±0.14b		
	S. malabarica	1.27±0.08c	4.60±0.40b	3.07±0.12b	3.14±0.11b	1.65±0.29c	4.04±0.11b		
4th	***G. hirsutum***	3.60±0.16a	9.64±0.40a	8.33±0.12a	4.95±0.11a	6.45±0.08a	8.12±0.19a		
Instar	***A. esculentus***	2.64±0.30b	7.08±0.19b	5.03±0.13b	4.06±0.11b	3.88±0.40c	5.44±0.18c		
	S. malabarica	1.57±0.16c	7.00±0.20b	4.93±0.12b	4.04±0.11b	2.30±0.16c	6.15±0.11b		
5th	***G. hirsutum***	5.11±0.14a	12.14±0.21a	8.42±0.19a	6.12±0.15a	8.10±0.16a	11.16±0.12a		
Instar	***A. esculentus***	2.94±0.27b	9.54±1.57b	6.90±0.42b	5.04±0.11b	6.04±0.34b	7.86±0.21b		
	S. malabarica	2.95±0.22b	9.00±0.79b	6.08±0.10c	5.49±0.14c	6.12±0.15b	7.86±0.28b		
Male	***G. hirsutum***	7.35±0.08a	14.07±0.12a	9.46±0.10a	7.02±0.10a	10.65±0.08a	14.45±0.08a	10.51±0.22a	10.10±0.23a
Adult	***A. esculentus***	3.65±0.11b	11.86±0.23b	8.01±0.19c	6.67±0.27b	7.34±0.38c	11.12±0.92b	10.14±0.22b	9.75±0.21b
	S. malabarica	3.00±0.22b	11.69±0.20b	8.45±0.08b	5.95±0.11c	10.08±0.19a	11.10±0.16b	10.10±0.11b	9.10±0.16c
Female	***G. hirsutum***	8.45±0.08a	15.26±0.10a	10.08±0.10a	7.23±0.10a	12.14±0.10a	15.35±0.11a	11.5±0.47a	11.10±0.23a
Adult	***A. esculentus***	3.82±0.13b	14.02±0.29b	8.94±0.19b	6.84±0.09b	10.90±0.26b	13.98b±0.18	11.11±0.47b	10.10±0.21b
	S. malabarica	3.34±0.29c	13.32±0.38b	8.90±0.16b	6.46±0.38c	10.35±0.28b	13.13±0.18b	11.25±0.47b	10.74±0.11b

Fifth instar

Significantly highest duration was observed on *A. esculentus* i.e. 8.42±0.40 days followed by *S. malabarica* (8.56±0.41days) and *G. hirsutum* (6.12±0.78 days) (P<0.0001, F= 361, df=177, n=60) (Fig. 1). Body length (12.14±0.21 mm), width of body (5.11±0.14 mm), antennal length (8.42±0.19 mm), length of proboscis (6.12±0.15 mm), length of foreleg (8.10±0.16 mm) and length of hindleg (11.16±0.12 mm) were found to be significantly highest on *G. hirsutum* than other two hosts (Table 1).

Adult Male

Statistically longer adult male life of 16.18±6.11 days and 15.41±2.37 days was found in *G. hirsutum* and *S. malabarica* as compared to *A. esculentus* 10.92±2.49 days (P<0.0001, F= 29.6, df=177, n=60) (Fig. 1). Body length (14.07±0.12 mm), width of body (7.35±0.08 mm), antennal length (9.46±0.10 mm), length of proboscis (7.02±0.10 mm), length of foreleg (10.65±0.08 mm) and length of hindleg (14.45±0.08 mm) were found to be significantly highest on cotton than other two hosts. Wing length 10.14±0.09 mm and 11.15±0.11 mm of forewing and hind wing was significantly higher in case of *G. hirsutum* than *A. esculentus* and *S. malabarica* (Table 1).

Adult Female

Statistically longer adult female life of 20.85±6.17 days and 20.11±3.19 days was found in *G. hirsutum* and *S. malabarica* as compared to *A. esculentus* 17.6±2.58 days (P<0.0001, F= 9.52, df=177, n=60) (Fig. 1). Body length (15.26±0.10 mm), width of body (8.45±0.08 mm), antennal length (10.08±0.10 mm), length of proboscis (7.23±0.10 mm), length of foreleg (12.14±0.10 mm) and length of hindleg (15.35±0.11 mm) were found to be significantly highest on *G. hirsutum* than other two hosts. In females wing length 11.50±0.47 mm and 11.10±0.23 mm of forewing and hind wing was significantly higher in case of *G. hirsutum* than *A. esculentus* (11.11±0.47 mm and 10.10±0.21 mm) and *S. malabarica* (11.25±0.47 mm and 10.74±0.11 mm) (Table 1).

Fecundity

Fecundity was significantly highest in *D. koenigii* when fed on *G. hirsutum* i.e. 109.06±32.60 eggs as compared to *A. esculentus* 52.93± 8.72 and *S. malabarica* 43.63±13.29 eggs respectively ($P<0.05$, $F=85.58$, $df=87$, $n=30$) (Fig. 2).

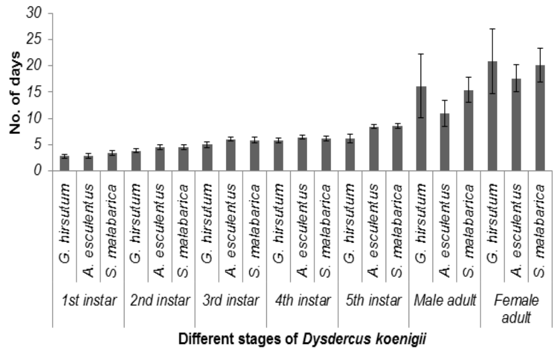

Fig. 1. Duration of different instars of *Dysdercus koenigii* on Cottonseeds, Okra and Simal Seeds.

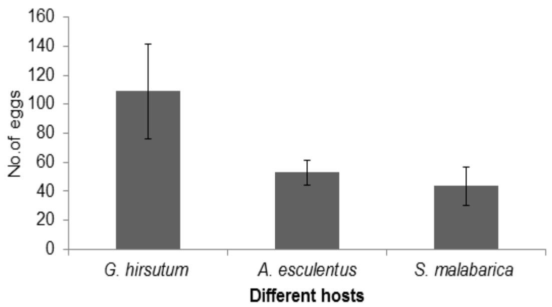

Fig. 2. Number of eggs laid by *Dysdercus koenigii* when reared on Cottonseeds, Okra and Simal Seeds.

Discussion

D.koenigii was reared on seeds of *G. hirsutum*, *A. esculentus* and *S. malabarica* to keep up uniformity (Kohno and Ngan, 2004). This pest feeds on oil contents in seeds (Kamble, 1971). Though oil contents were highest in case of *S. malabarica* and *G. hirsutum* but due to toxic compounds in Simal seeds (Heikal, 2012) and more amount of Palmitic acid in Simal seeds (Anonymous, 2013) nymphal duration was smallest in cottonseeds. Fecundity was highest in case of *G. hirsutum* (Saxena, 1969). Biometrics i.e. body length, width, antennal size, proboscis, foreleg, hind leg, forewing and hind wing were highest in case of *G. hirsutum*, while lesser vigor observed in *A. esculentus* was due to lesser oil contents in its seeds (Anwar *et al.,* 2011) and in *S. malabarica* due to toxic effect (Heikal, 2012) however difference in *A. esculentus* and *S. malabarica* was non–significant. Results in first two instars were non–significant (Thangavelu, 1978).

There is a strong relationship between the food preferences of *D. koenigii* and the nutritional contents of the host plant seeds. The carbohydrate contents are least in seeds of *G. hirsutum* and *S. malabarica* as compared to *A. esculentus* (Rastogi and Mahrotra, 1980–1984, Saxena, 1969), presumably contributing to a faster development rate of *D. koenigii* on *G. hirsutum* (Hibbs *et al.,* 1964, Maltais and Auclair, 1957).

The more nitrogen contents in seeds of *G. hirsutum* make it most preferred host (Rastogi and Mahrotra, 1980–1984, Saxena, 1969) as increased nitrogen contents increased the fecundity, longevity and survival of aphids (Emden, 1973).

A lower sugar nitrogen ratio is associated with a greater susceptibility of the host plant (Jayaraj and Seshadri, 1967). Lesser C/N ratio for seeds of *G. hirsutum* (Saxena, 1969) makes it a preferred host (Van Emden, 1973).

When reared on a more preferred and nutritious host i.e. *G. hirsutum*, higher fecundity, more vigor and faster rate of developments were noticed in *D. koenigii*, presumably due to the high protein and nitrogen content, low sugars and a narrow C/N ratio of cottonseeds and vice versa.

Results of this research explain the pattern of infestation of polyphagous insects like *D. koenigii* which develop and multiply on a favored host in an efficient manner. Results proved that *G. hirsutum* was the best host as compared to *A. esculentus* and *S. malabarica*. Results also explain why infestation of *D. koenigii* is becoming a major pest in *G. hirsutum*. This detailed study will help farmers and researchers in planning better management strategies for this pest due to the fact that detailed knowledge on alteration in life parameters like duration and biometrics due to variation in host-plants helps in behavioral manipulation of insect-pests.

References

Abro GH, Syed TS, Tunio GM, Khuhro MA. 2004. Performance of transgenic Bt cotton against insect pest infestation. Biotechnology **3,** 75- 81.

Agelopoulos N, Birkett MA, Hick AJ, Hooper AM, Pickett JA, Pow EM, Smart LE, Smiley, DWM, Wadhams LJ, Woodcock CM. 1999. Exploiting semiochemicals in insect control. Pesticide Science **55,** 225- 235.

Ahmad I, Mohammad FA. 1983. Biology and immature systematics of red cotton stainer *Dysdercus koenigii* (Fabr.) (Hemiptera: Pyrrohocoridae) with a note on their phylogenetic value. Bulletin of Zoology **1,** 1- 9.

Ahmad I, Schaefer CW. 1987. Food plant and feeding biology of the Pyrrhocoroidea (Hemiptera). Phytophophaga **1,** 75- 92.

Anonymous. 2013. Fatty acid Composition, http://www.jatropha.pro/oil_composition.htm.

Anwar F, Rashid U, Mahmood Z, Iqbal T, Sherazi TH. 2011. Inter–varietal variation in the composition of Okra (*Hibiscus esculentus*L.) seed oil. Pakistan Journal of Botany **43,** 271- 280.

Ashfaq S, Khan IA, Saeed M, Saljoki AR, Kamran S, Mamzor F, Shoail K, Habib K, Sadozai A. 2011. Population dynamics of insect pests of cotton and their natural enemies. Sarhad Journal of Agriculture **27,** 251- 253.

Awmack CS, Leather SR. 2002. Host plant quality and fecundity in herbivorous insects. Annual Review of Entomology **47,** 817- 844.

Beck SD. 1956. A biomodal response to dietary sugars by an insect. Biological Bulletin **10,** 219- 228.

Dhillon MK, Gujar GT, Kalia V. 2011. Impact of Bt cotton on insect biodiversity in cotton ecosystem in India. Pakistan Entomologist **33,** 161- 165.

Foster SP, Harris MO. 1997. Behavioural manipulation methods for insect pest management. Annual Review of Entomology **42,** 123- 146.

Freeman P. 1947. A revision of the genus *Dysdercus boisduval* (Hemiptera: Pyrrhocoridae), excluding the American species. Transactions of Royal Entomological Society London **98,** 373- 424.

Heikal MT, Mossa ATH, Nawwar GAM, El–Sherbiny M, Ghanem HZ. 2012. Protective Effect of a Synthetic Antioxidant “Acetyl Gallate Derivative” against dimethoate Induced DNA Damage and Oxidant/Antioxidant status in Male Rats. Journal of Environmental and Analytical Toxicology **2,** 155 (doi: 10.4172/2161–0525.1000155).

Hibbs ET, Dahiman DL, Rice RL. 1964. Potato foliage sugar concentration in relation to infestation by the potato leafhopper, *Empoasca fabae* (Harr) (Homoptera:Cicadellidae). Annals of the Entomological Society of America **57,** 517- 521.

Jayaraj S. 1967. Effect of leafhopper infestation on the metabolism of carbohydrate and nitrogen in castor varieties in relation to their resistance to

Empoasa flavescens F. (Homoptera: Jassidae). Indian Journal of Experimental Biology **5,** 156- 162.

Kamble ST. 1971. Bionomics of *Dysdercus koenigii* Fabr. Journal of the New York Entomol. Society. **79,** 154- 157.

Kapur AP, Vazirani TG. 1960. The identity and geographical distribution of the Indian species of the genus *Dysdercus boisduval* (Hemiptera: Pyrrhocoridae). *Rec. Indian. Mus.*, **54,** 107- 150.

Kohno K, Ngan BT. 2004. Effects of host plant species on the development of *Dysdercus cingulatus* (Heteroptera: Pyrrhocoridae). Applied Entomology and Zoology **39,** 183- 187.

Lu ZQ, Xu YH. 1998. The consideration of the incessant outbreak of the cotton bollworm, *Helicoverpa armigera*. Entomological Knowledge **35,** 132- 136.

Maltais JB, Auclair JL. 1957. Factors in resistance of peas to the aphid *Acyrthosiphon pisum* (Harr) (Homoptera: Aphididae) I. The sugar nitrogen ratio. Canadian Entomologist **89(3),** 65- 370.

Maxwell–Lefroy H. 1908. The red cotton bug (*Dysdercus cingulatus* Fabr.). Memoirs of the Department of Agriculture in India. Entomological Series **2,** 47- 58.

Rastogi RP, Mahrotra BM. 1980–84. *Compendium of India Medicinal Plant*. CSIR *Luck now Publication and information directorate* **1**, 2. New Dehli.

Saeed R, Sayyed AH, Shad SA, Zaka SM. 2010. Effect of different host plants on the fitness of diamond–back moth, *Plutella xylostella* (Lepidoptera: Plutellidae). Crop Protection 29, 178- 182.

SAS Institute. 2002. The SAS System for Windows, Release 9.0, SAS Institute, Cary, N.C.

Saxena KN. 1969**.** Patterns of insect–plant relationships determining susceptibility or resistance of different plants to an insect. Entomologia Experimentalis et Applicata **12,** 751- 766.

Sequiera R, Dixon AFG. 1996. Life history responses to host quality changes and competition in the Turkey–oak aphid. European Journal of Entomology **93,** 53- 58.

Singh OP, Parihar SBB. 1988. Effect of different hosts on the development of *Heliothis armigera* Hub. Bulletin of Entomological Research **29,** 2168- 2172.

Stern VM, Smith RF. 1960. Factors affecting egg production and oviposition in populations of Colias philodice eurytheme. Hilgardia **29,** 411- 454.

Thangavelu K. 1978. Some notes on the host specificity of dusky cotton bug, *O. laetus* (Heteroptera: Lygaeidae). Journal of Natural History London **82,** 481- 486.

Thapa RB, Neupane FP. 1985. Biology of the Red Cotton Bug, *Dysdercus koenigii* Fab. (Hemiptera: Pyrrhocoridae). Journal of the Institute of Agriculture and Animal Science **6,** 11- 20.

Van Emden, HF. 1973. Aphid host plant relationships: Some recent studies; in *Perspectives in Aphid Biology,* 54–64 ed. A.D. Lowe. Entomological Society of New Zealand Bulletin 2.

Umbanhowar J, Hastings A. 2002. The impact of resource limitation and the phenology of parasitoid attack on the duration of insect herbivore outbreaks. Theoretical Population Biology **62,** 259- 269.

Van-Doesburg, PH Jr. 1968. A revision of the new world species of *Dysdercus* Guérin Méneville

(Heteroptera, Pyrrhocoridae). Zoologische Verhandelin **97,** 1- 215.

Varma HS, Patel RK. 2012. Biology of red cotton bug (*D. Koenigii*). Agres an International e-journal., **1,** 148- 156.

Venugopal KJ, Kumar D, Singh AK. 1994. Development studies on proteins from haemolymph, fat body and ovary of a phytophagous pest *Dysdercus koenigii*. Journal of Biochemistry **10,** 297- 302.

Wadnerkar DW, Gailkawad BB, Thombrev T. 1979. New record of alternate host plant of red cotton bug *Dysdercus koenigii* (Fabr.). Indian Journal of Entomology **41,** 185.