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BIONOMICS AND BIOLOGY OF RED COTTON BUG, *DYSDERCUS KOENIGII* (FABRICIUS) ON *BT* COTTON

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ABSTRACT

A study on the bionomics of red cotton bug, *D. koenigii* was conducted under controlled laboratory conditions at a temperature of 27 ± 1.8/ °C and relative humidity of 70 ± 4.5%. The eggs were soft, whitish in colour and either oval or spherical in shape. The eggs were laid in clusters on soil surface and measured on average 1.27 ± 0.07 mm in length and 0.85 ± 0.03 mm in width. The average incubation period was 4.97 ± 0.82 days, with a hatchability rate of 80.00 ± 10.41%. The nymphs passed through five distinct instars. The average duration of first to fifth instars was recorded as 2.41 ± 0.50, 3.50 ± 0.51, 4.27 ± 0.87, 10.05 ± 0.84 and 14.50 ± 0.51 days, respectively, with a total nymphal duration of 37.92 ± 1.99 days. The average body length of the first to fifth instar nymphs was 1.43 ± 0.20, 3.62 ± 0.47, 5.69 ± 0.76, 7.56 ± 0.91 and 10.80 ± 0.83 mm, while the corresponding body breadths were 0.90 ± 0.06, 1.50 ± 0.19, 2.48 ± 0.50, 3.04 ± 0.54 and 4.23 ± 0.32 mm, respectively. Adults of both sexes were elongate, bright red in colour, with a black head and membranous wings. A distinct black oval spot was observed in the centre of the forewings. The average longevity of male and female adults was 21.48 ± 1.12 and 17.00 ± 0.82 days, respectively, indicating that males lived longer than females. Female adults were larger in size, measuring 15.19 ± 0.48 mm in length compared to 13.60 ± 0.45 mm in males. The average pre-oviposition, oviposition and post-oviposition periods were 7.32 ± 0.83, 9.12 ± 0.83 and 7.04 ± 0.71 days, respectively. The average fecundity was recorded as 95.72 ± 17.92 eggs per female. The total life span of male and female adults averaged 67.30 ± 6.33 and 70.05 ± 8.55 days, respectively.

***Key words*:** Cotton, red cotton bug, bionomics, biology, rearing

Introduction

Cotton (*Gossypium* spp.) is the world's most important natural fiber crop, playing a vital role in global agriculture, industry and sustainability. Grown across tropical to temperate regions (42°N-33°S), it supports livelihoods through its diverse uses in textiles, oil production, animal feed and biofuel. The global cotton industry employs approximately 350 million people across production, processing and trade sectors (Aslam *et al*., 2020). Beyond fiber, cottonseed contributes to oil extraction and organic fertilizer production, aligning with sustainability goals (Gogari *et al*., 2025). India, a leading cotton producer, cultivates four species *G. arboreum*, *G. hirsutum*, *G. barbadense* and *G. herbaceum* with *G. hirsutum* (upland cotton) dominating global production due to its high yield and superior lint quality. Cotton yields various products lint, seeds, oil, hulls and linters with lint being the most valuable for textile manufacturing (Khanpara & Vala, 2023). The seed oil industry, employing over 35% of the associated workforce, relies heavily on cotton as a primary raw material (Muhammad *et al*., 2023).

The red cotton bug, *D. koenigii* belonging to family Pyrrhocoridae (Hemiptera) is a common cotton stainer and sap-sucking pest (Pandey & Tiwari, 2011). It primarily feeds on flower buds and seeds, leading to premature bud shedding and reduced seed quality (Pruthi, 1923). Its high mobility and broad host range make field-level management challenging. The pest initiates feeding on young flower buds and progresses to flowers and developing bolls. As bolls mature and develop a buttery content, multiple bugs feed aggressively, causing

premature boll opening. They continue feeding on seeds and immature lint by sucking plant sap, which can lead to considerable damage (Rajendran *et al*., 2018). In addition to physical damage, lint is stained by bugs' yellow excreta and crushed nymphs during ginning (Arora *et al*., 2006). Moreover, both nymphs and adults can transmit bacterium *Nematospora gossypii* into bolls, further contributing to lint staining (Frazer, 1944). In Gujarat, *D. koenigii* has been observed on various hosts including cotton, okra, hollyhock, maize, clover, sorghum, pearl millet, musk mallow and gooseberry (Patel, 1969). Feeding on developing bolls and mature seeds can cause seed damage of up to 40% (Sammaiah, 2012). While precise data on lint quality loss due to *D. koenigii* is currently lacking, its potential impact warrants attention, particularly under conditions of high infestation (Vennila *et al*., 2007).

Materials and Methods

Cotton was sown in July using recommended spacing and crop was managed following standard agronomic practices. To initiate laboratory culture, specimens of red cotton bug, *D. koenigii* were collected from cotton fields at Anand Agricultural University, Anand during *kharif*, 2024-25. Nymphs and adults collected from the field were introduced into rearing cages (30 cm length × 30 cm width × 30 cm height) containing mature cotton bolls with intact pedicles as a food source. The pedicles were wrapped with cotton swabs moistened with water to preserve boll freshness (Fig. 1a). A layer of blotting paper was placed at the base of the cage to absorb moisture. Cotton bolls were replaced every 2-3 days. Adults emerging from the final nymphal instar were used for further studies on their biology.

For laboratory rearing, one male and one female adult, freshly emerged, were placed in plastic containers (18 cm in diameter) filled with moist soil. Three to four partially open green cotton bolls were provided for feeding and oviposition. The container opening was covered with muslin cloth, fastened with a rubber band to ensure airflow and prevent escape.

Egg

Twenty-five freshly deposited eggs were gently collected using a fine camel hairbrush to minimize damage and transferred to Petri dishes (90 mm) lined with moist blotting paper to maintain humidity. Eggs were examined daily under a stereomicroscope to record their colour, shape and dimensions. Measurements of length and width were taken precisely. Hatching was monitored and incubation period was noted from the time of oviposition until the emergence of nymphs. Hatching success was calculated based on the number of eggs that produced nymphs.

Nymph

Newly hatched nymphs were individually placed in transparent plastic jars (6 cm diameter × 12 cm height), each lined with blotting paper to reduce moisture buildup (Fig. 1b). The jar openings were covered with black muslin cloth and secured using rubber bands. Fresh cotton bolls were provided at intervals of 2 to 5 days as food. The developmental duration of each nymphal stage was recorded, along with the total period from first instar to adult emergence. Colour, shape and key morphological traits were documented for each instar. Morphometric data including body length, width, interocular distance, lengths of forelegs and hind legs, antennae and proboscis were obtained using a stereomicroscope.

Adult

Newly emerged adult males and females were collected and euthanized in a killing jar. They were then pinned with wings spread, air-dried and preserved for morphological examination. Detailed observations were made under a microscope to identify sex-based differences and record features such as body colour, shape, size and overall appearance. Wingspan was measured using a stereomicroscope.

1a. Rearing cage of *D. koenigii*

1b. Bionomics of *D. koenigii*

Fig. 1: Technique used to study the bionomics of red cotton bug, *D. koenigii*.

Pre-oviposition, Oviposition, Post-oviposition Periods and Fecundity

Fresh adult pairs were transferred to plastic containers (18 cm diameter) with moist soil and fresh cotton bolls were supplied daily. Eggs laid by each female on soil and within cotton bolls were counted daily using a damp camel hairbrush. The pre-oviposition period was recorded as time from female emergence to start of egg laying. The oviposition period encompassed days from first to last egg laying, while post-oviposition period extended from the end of oviposition to death of female. Fecundity was calculated as total number of eggs laid per female during her lifespan.

Adult Longevity

The lifespan of both male and female adults was tracked separately from day of emergence until natural death under laboratory conditions.

Results and Discussion

Bionomics of red cotton bug, *D. koenigii*

The bionomics of red cotton bug, *D. koenigii* was carried out on cotton under the laboratory conditions at temperature of 27 ± 1.8°C and 70 ± 4.5 per cent relative humidity. Results obtained are presented in the following subheadings.

Egg

The freshly laid eggs of the red cotton bug were soft, whitish in colour and either oval or spherical in shape, making them easily visible to the naked eye. Initially, the eggs appeared pure white (Fig. 3), but as they neared hatching, their colour gradually changed to buff yellow. Females laid eggs in clusters on the soil surface, which reflects their typical oviposition behaviour. The dimensions of freshly laid eggs were recorded under a microscope using an ocular micrometre, standardized with a stage micrometre. The measurements presented in Table 1 showed and Fig. 2 that the length of eggs varied between 1.12 and 1.45 mm, with a mean value of 1.27 + 0.07 mm, while the breadth ranged from 0.80 to 0.95 mm, with an average of 0.85 + 0.03 mm.

Hatching percentage

As shown in Table 2, the hatching percentage of red cotton bug eggs varied between 64 to 96%, with an average of 80.00 ± 10.41%, recorded at a mean temperature of 25.89 ± 3.35 °C and relative humidity of 58.85 ± 3.05%.

Incubation period

The data presented in Table 3 indicate that the incubation period of red cotton bug ranged between 4

Table 1: Morphometric parameters of red cotton bug, *D. koenigii* (n = 25).

Stages	Particular	Min (mm)	Max (mm)	Mean ± SD
Egg	Length	1.12	1.45	1.27 ± 0.07
	Breadth	0.80	0.95	0.85 ± 0.03
Nymph				
I Instar	Length	1.02	1.73	1.43 ± 0.20
	Breadth	0.80	0.99	0.90 ± 0.06
	Proboscis	0.71	0.96	0.80 ± 0.06
	Antenna	0.68	1.06	0.88 ± 0.08
	Foreleg	0.71	0.90	0.78 ± 0.05
	Hind leg	0.75	1.45	0.96 ± 0.12
II Instar	Length	2.92	4.50	3.62 ± 0.47
	Breadth	1.21	1.94	1.50 ± 0.19
	Proboscis	2.11	3.25	2.43 ± 0.32
	Antenna	1.99	3.25	2.54 ± 0.42
	Foreleg	1.22	2.51	1.72 ± 0.29
	Hind leg	1.97	3.71	2.32 ± 0.37
III Instar	Length	4.11	7.50	5.69 ± 0.76
	Breadth	1.87	3.81	2.48 ± 0.50
	Proboscis	2.79	5.06	3.55 ± 0.63
	Antenna	4.11	7.33	5.62 ± 0.58
	Foreleg	3.10	3.99	3.46 ± 0.25
	Hind leg	4.15	7.41	5.79 ± 0.63
IV Instar	Length	5.62	9.83	7.56 ± 0.91
	Breadth	2.12	4.16	3.04 ± 0.54
	Proboscis	5.04	6.38	5.38 ± 0.29
	Antenna	5.39	6.97	6.31 ± 0.42
	Foreleg	4.12	4.96	4.48 ± 0.30
	Hind leg	6.42	8.07	7.21 ± 0.46
V Instar	Length	9.20	12.92	10.80 ± 0.83
	Breadth	3.50	4.85	4.23 ± 0.32
	Proboscis	5.10	6.08	5.76 ± 0.30
	Antenna	5.75	7.90	7.06 ± 0.58
	Foreleg	4.80	7.56	5.66 ± 0.71
	Hind leg	6.47	10.14	8.84 ± 0.87
Adult (Male)	Length	13.12	15.23	13.60 ± 0.45
	Breadth	4.02	4.98	4.50 ± 0.28
	Proboscis	6.02	7.45	6.60 ± 0.46
	Antenna	7.27	8.56	8.31 ± 0.28
	Foreleg	8.12	9.99	9.05 ± 0.46
	Hind leg	10.63	14.72	12.02 ± 0.91
	Fore wing	10.14	11.53	10.63 ± 0.40
	Hind wing	7.41	9.42	8.52 ± 0.40
Adult (Female)	Length	14.56	16.42	15.19 ± 0.48
	Breadth	5.23	6.54	5.80 ± 0.35
	Proboscis	7.33	8.26	7.98 ± 0.26
	Antenna	8.35	9.96	9.01 ± 0.43
	Foreleg	8.11	10.65	9.39 ± 0.62
	Hind leg	13.11	14.99	13.76 ± 0.48
	Fore wing	11.15	12.63	12.04 ± 0.40
	Hind wing	8.74	9.85	9.35 ± 0.31

Table 2: Hatching percentage of eggs of red cotton bug, *D. koenigii*.

Average temperature (°C)	Average relative humidity (%)	Period of study	Number of eggs observed	Number of eggs hatched	Hatching (%)
25.89 ± 3.35	58.85 ± 2.05	11/09/2024 – 20/09/2024	25	18	72
			25	22	88
			25	18	72
		21/09/2024 – 30/09/2024	25	21	84
			25	24	96
			25	17	68
		01/10/2024 – 20/10/2024	25	21	84
			25	16	64
			25	23	92
		21/10/2024 – 30/10/2024	25	22	88
			25	20	80
			25	17	68
Minimum					**64**
Maximum					**96**
Average ± SD					**80.00 ± 10.41**

and 7 days, with a mean duration of 4.97 ± 0.82 days, observed under an average temperature of 25.50 ± 3.76°C and relative humidity of 55.19 ± 21.36%.

Nymph

In the present investigation, it was confirmed that the nymphal stage of red cotton bug progresses through five distinct instars before reaching adulthood.

First instar

The freshly emerged first instar nymph of red cotton bug, *D. koenigii* was oval in shape and exhibited an orange-buff coloration, which gradually turned red within 30 hr. The head was narrower compared to thorax and abdomen and compound eyes were red, positioned dorso laterally on either side of head. The antennae were five-segmented, with the terminal segment being club-shaped and bearing numerous fine setae. While abdomen appeared oval in newly hatched nymph, it became posteriorly pointed after 24 hours of feeding (Fig. 3). The first instar nymphs displayed gregarious behaviour, were highly active and moved around for some time following emergence from eggs. Subsequently, they settled to feed on the tender cotton bolls provided as food.

The length and breadth of first instar nymph of red cotton bug ranged from 1.02 to 1.73 mm (mean 1.43 ± 0.20 mm) and 0.80 to 0.99 mm (mean 0.90 ± 0.06 mm), respectively. The antennae were shorter than the body and measured 0.68 to 1.06 mm (mean 0.88 ± 0.08 mm). The length of forelegs varied between 0.71 and 0.90 mm (mean 0.78 ± 0.05 mm), while hind legs measured 0.75

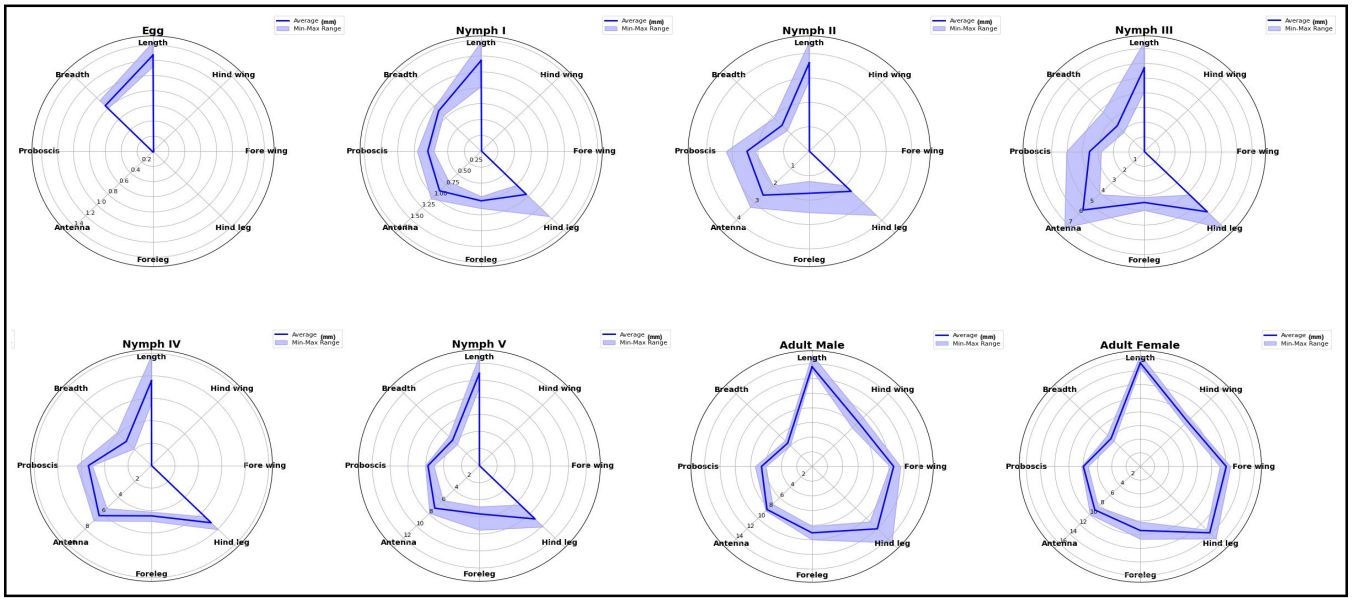

Fig. 2: Developmental morphometrics of red cotton bug, *D. koenigii* visualized by radar chart.

to 1.45 mm (mean 0.96 ± 0.12 mm). The proboscis length ranged from 0.71 to 0.96 mm (mean 0.80 ± 0.06 mm) (Table 1 and Fig. 2). Notably, wing pads were absent in first instar nymph. The duration of first instar nymphal stage of red cotton bug as presented in Table 3, ranged from 2 to 3 days, with an average of 2.41 ± 0.50 days.

Second instar

The newly moulted second instar nymph of red cotton bug was larger than first instar, oval in shape and reddish in colour with black eyes dotted with red pigment (Fig. 3). The mesonotum was distinct but smaller than the pronotum.

The body length, body breadth, antennae length, foreleg length, hind leg length and proboscis length of second instar nymph of red cotton bug ranged from 2.92 to 4.50 mm (mean 3.62 ± 0.47 mm), 1.21 to 1.94 mm (mean 1.50 ± 0.19 mm), 1.99 to 3.25 mm (mean 2.54 ± 0.42 mm), 1.22 to 2.51 mm (mean 1.72 ± 0.29 mm), 1.97 to 3.71 mm (mean 2.32 ± 0.37 mm) and 2.11 to 3.25 mm (mean 2.43 ± 0.32 mm), respectively (Table 4 and Fig. 2). The duration of second instar ranged from 3 to 4 days, with an average of 3.50 ± 0.51 days (Table 3).

Third instar

The freshly moulted third instar nymph of red cotton bug, *D. koenigii* was initially bright red in colour, which turned reddish within a day and was flat in shape with a triangular head. The most notable morphological change in this instar was the development of wing pads arising from mesothoracic and metathoracic regions (Fig. 3). Additionally, three pairs of unclear dorsal spots were developed on the abdomen.

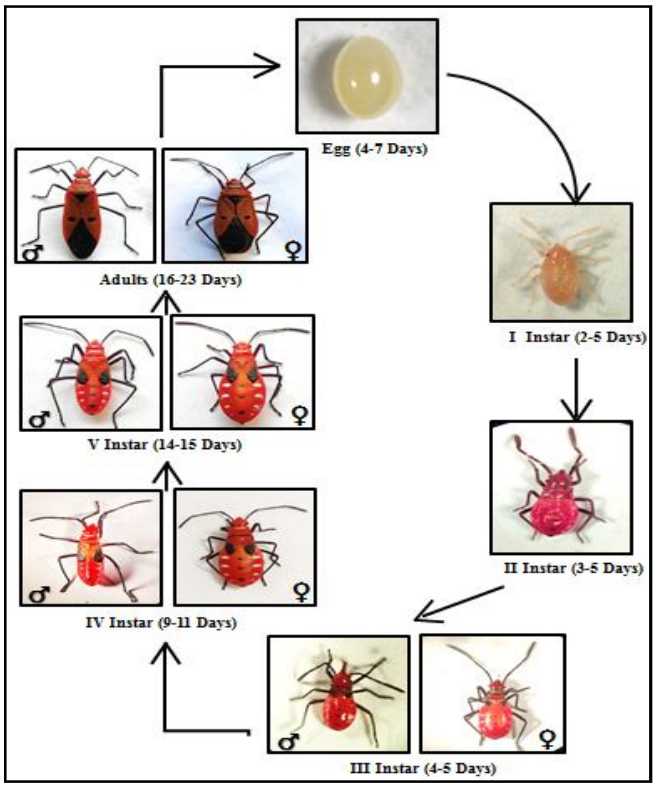

Fig. 3: Different life stages of red cotton bug, *D. koenigii*.

The length and breadth of third instar nymph of red cotton bug ranged from 4.11 to 7.50 mm (mean 5.69 ± 0.76 mm) and 1.87 to 3.81 mm (mean 2.48 ± 0.50 mm), respectively. The antennae length varied between 4.08 and 5.88 mm (mean 5.45 ± 0.28 mm), foreleg length ranged from 3.12 to 3.99 mm (mean 3.46 ± 0.25 mm), hind leg length from 4.15 to 7.41 mm (mean 5.79 ± 0.63 mm) and proboscis length from 2.79 to 5.06 mm (mean 3.55 ± 0.63 mm) (Table 1 and Fig. 2). The third instar nymphal stage of red cotton bug as shown in Table 3, ranged from 4 to 5 days, with an average duration of 4.27 ± 0.50 days.

Fourth instar

The fourth instar nymph of red cotton bug, *D. koenigii* exhibited a cylindrical body shape with a distinct scarlet-red colouration. At this stage, the mesothorax wing pads showed significant development, extending up to posterior margin of the metathorax. The distal margin of the wing pads appeared deep black, contrasting with the lighter proximal region. The metathorax was visible only along its mid-dorsal line. Additionally, white transverse bands were observed extending laterally across third to seventh abdominal sterna (Fig. 3).

The length and breadth of fourth instar nymph of red cotton bug ranged from 5.62 to 9.83 mm (mean 7.56 ± 0.91 mm) and 2.12 to 4.16 mm (mean 3.04 ± 0.54 mm), respectively. The antennal length varied between 5.39 and 6.97 mm (mean 6.31 ± 0.42 mm), foreleg length ranged from 4.12 to 4.96 mm (mean 4.48 ± 0.30 mm), hind leg length from 6.42 to 8.07 mm (mean 7.21 ± 0.46 mm) and proboscis length from 5.05 to 6.39 mm (mean 5.38 ± 0.29 mm) (Table 1 and Fig. 2). As presented in Table 3, the fourth instar nymphal stage of red cotton bug, *D. koenigii* lasted between 9 and 11 days, with an average duration of 10.05 ± 0.84 days.

Fifth instar

The fifth instar nymph of red cotton bug, *D. koenigii* exhibited a cylindrical body shape with a characteristic scarlet-red colouration. The proboscis retained its crimson-red colour, while the legs and antennae were distinctly black. The antennae were composed of five segments and the mesothoracic wing pads became highly prominent at this stage. Additionally, a white band was noticeable along the anterior margin of prothorax (Fig. 3). No significant morphological changes were observed in the abdomen. It was also noted that nymphs destined

Table 3: Duration of different life stages of red cotton bug, *D. koenigii* (n = 25).

Stages	Particulars		Duration (Days)		
			Min	Max	Mean ± SD
Egg			4	7	4.97 ± 0.82
Nymph	I Instar		2	5	2.41 ± 0.50
	II Instar		3	4	3.50 ± 0.51
	III Instar		4	5	4.27 ± 0.87
	IV Instar		9	11	10.05 ± 0.84
	V Instar		14	15	14.50 ± 0.51
	Total nymphal period		35	40	37.92 ± 1.99
Adult	Pre oviposition		6	9	7.32 ± 0.83
	Oviposition		7	10	8.12 ± 0.83
	Post oviposition		6	8	7.04 ± 0.71
	Longevity	Male	20	23	21.48 ± 1.12
		Female	16	18	17.00 ± 0.82
	Fecundity		58	130	95.72 ± 17.92
	Total life span	Male	56	77	67.30 + 6.33
		Female	57	82	70.05 + 8.55

to become female adults were generally larger than those developing into males.

From Table 1 and Fig. 2, it can be observed that the body length, body breadth, antennae length, foreleg length, hind leg length and proboscis length of fifth instar nymph of red cotton bug ranged from 9.20 to 12.92 mm (mean 10.80 ± 0.83 mm), 3.50 to 4.85 mm (mean 4.23 ± 0.32 mm), 5.75 to 7.90 mm (mean 7.06 ± 0.58 mm), 4.80 to 7.56 mm (mean 5.66 ± 0.71 mm), 6.47 to 10.13 mm (mean 8.84 ± 0.87 mm) and 5.10 to 6.08 mm (mean 5.76 ± 0.30 mm), respectively. As per the data presented in Table 3, the fifth instar nymphal stage of red cotton bug lasted between 14 and 15 days, recording an average of 14.50 ± 0.51 days.

Total nymphal period

The total nymphal period, as shown in Table 3, ranged from 35 to 40 days, with an average duration of 37.92 ± 1.99 days

Adult

Colour and appearance

The adults of red cotton bug, *D. koenigii* found to be strongly built, medium-sized and scarlet reddish in colour. The head was distinctly triangular in shape and the antennae were five-segmented. The thorax was well developed and connected to the head by a cervix, which was not visible from the dorsal side due to the overhanging pronotum. The pronotum was large, convex and shield-like, being narrow anteriorly and broad posteriorly. Among three thoracic segments, mesothorax was the most developed and was attached to the first pair of wings. The mesonotum was broader than both pronotum and metanotum. The forewings were longer and narrower than the hind wings. The proximal region of forewings contained fewer and thinner veins, whereas the distal region had well-defined veins. A distinct black oval spot was present in the centre of each forewing. The hind wings were transparent, membranous and broader than the forewings and when at rest, remained concealed underneath them. The posterior margin of each abdominal sternum possessed a white transverse band, which was broader at the middle. No distinct morphological characters were observed to differentiate between male and female adults; however, males were generally smaller in size and lighter in weight compared to females (Fig. 3). During copulation, the male was observed to mount on the abdomen of the female, bending his abdomen downward to establish genital contact. After coupling, the male descended and turned in the opposite direction, so that both individuals faced away from each other. The copulating pair continued feeding and moving in direction determined by female, as she was stronger and larger in size. Mating lasted up to three days. A subsequent mating was observed within two to three days following the laying of the first egg mass. In some cases, the females died during copulation and males were seen dragging the dead female around.

Measurement

The female adults of red cotton bug, *D. koenigii* were observed to be larger than the males in all morphological parameters. The body length of females ranged from 14.56 to 16.42 mm, with a mean of 15.19 ± 0.48 mm and body breadth ranged from 5.23 to 6.54 mm (mean 5.80 ± 0.35 mm). In comparison, male adults measured 13.12 to 15.22 mm in length (mean 13.60 ± 0.45 mm) and 4.02 to 4.98 mm in width (mean 4.50 ± 0.28 mm). The antennae length of female adults ranged from 8.35 to 9.96 mm (mean 9.01 ± 0.43 mm), whereas in males it ranged from 7.27 to 8.56 mm (mean 8.31 ± 0.28 mm), indicating longer antennae in females. The foreleg length of female adults varied from 8.11 to 10.65 mm (mean 9.39 ± 0.62 mm), while in males it ranged from 8.12 to 9.99 mm (mean 9.05 ± 0.46 mm). Similarly, hind leg length of females was observed between 13.11 to 14.99 mm (mean 13.76 ± 0.48 mm), whereas in males it ranged from 10.63 to 14.72 mm (mean 12.02 ± 0.91 mm), confirming that females possess relatively longer hind legs. The length of proboscis also showed sexual dimorphism, measuring 7.33 to 8.26 mm (mean 7.98 ± 0.26 mm) in females and 6.02 to 7.45 mm (mean 6.60 ± 0.46 mm) in males. The forewing length of females ranged from 11.154 to 12.632 mm (mean 12.04 ± 0.40 mm), while in males it ranged from 10.14 to 11.53 mm (mean

10.63 ± 0.40 mm). The hind wings of females measured 8.745 to 9.854 mm (mean 9.35 ± 0.31 mm), compared to 7.41 to 9.42 mm (mean 8.52 ± 0.40 mm) in males (Table 1 and Fig. 2). Thus, the data clearly indicate that female red cotton bug are consistently larger and heavier in terms of body size and appendage length compared to males, which aligns with the sexual dimorphism commonly observed in Hemipteran insects.

Pre-oviposition, oviposition and post-oviposition periods

During the present investigation on the biology of red cotton bug, *D. koenigii* detailed observations were recorded on previposition, oviposition and post-oviposition periods under controlled laboratory conditions. During these observations, temperature and relative humidity ranged from 18.5 to 35°C and 34.4 to 80 %, with mean values of 26.33 ± 4.34°C and 55.19 ± 21.36%, respectively. The data presented in Table 3 revealed that the pre-oviposition period of red cotton bug ranged from 6.0 to 9.0 days, with an average of 7.32 ± 0.83 days. The oviposition period varied from 7.0 to 10.0 days, with an average of 8.12 ± 0.83 days, while post-oviposition period ranged from 6.0 to 8.0 days, averaging 7.04 ± 0.71 days.

Longevity

The longevity of male red cotton bug, *D. koenigii* ranged from 20 to 23 days, with an average duration of 21.48 ± 1.12 days. In comparison, female red cotton bug short a lifespan ranging from 16 to 18 days, with an average of 17 ± 0.82 days (Table 3). The data indicate that males tend to live longer than females.

Fecundity

The female red cotton bug, *D. koenigii* laid between 58 to 130 eggs, with an average fecundity of 95.72 ± 17.92 eggs during its entire lifespan (Table 3). Name *et al*., (2015) recorded a fecundity of 76 to 274 eggs per female on groundnut kernels.

Entire Life Span of Male

The entire lifespan of male red cotton bug from egg stage to adult ranged from 56 to 77 days, with an average duration of 67.30 ± 6.33 days (Table 3).

Entire Life Span of Female

For females, the total life span ranged from 57 to 82 days, with an average of 70.05 ± 8.55 days (Table 3).

The present investigation on the bionomics and biology of *Dysdercus koenigii* (red cotton bug) under controlled laboratory conditions revealed findings that are largely in conformity with those of earlier workers while offering detailed morphometric and developmental insights. Eggs were observed to be laid in masses on the moist soil surface, initially yellowish-white and later turning buff-yellow before hatching. These characteristics were also described by Patel (1969), Kamble (1971) and Varma (2009). Morphometric data recorded in the present study showed that egg length and breadth averaged 1.27 ± 0.07 mm and 0.85 ± 0.03 mm, respectively, which aligns closely with the findings of Patel (1969) who reported 1.17 ± 0.004 mm × 0.79 ± 0.003 mm and Varma (2009) who recorded 1.08 ± 0.02 mm × 0.76 ± 0.08 mm. The hatching percentage in this study averaged 80.00 ± 10.41%, falling within the range reported by Patel (1969) at 85.03% and Varma (2009), who documented 80–92% (mean 87.33 ± 3.61%) at 22.89 ± 1.35°C and 52.85 ± 2.05% RH. The incubation period ranged from 4 to 7 days with a mean of 4.97 ± 0.82 days, which is consistent with the findings of Varma (2009), Patel (1969) and Kamble (1971), who reported similar durations between 4 and 6.18 days. Nymphal development was observed through five instars, each exhibiting distinct morphological and color changes. First instar nymphs were orange-red and elongated, measuring 1.43 ± 0.20 mm in length and lasting 2.41 ± 0.50 days. These observations align well with earlier reports by Patel (1969), Jaleel *et al*., (2013) and Varma (2009), with reported lengths ranging from 1.58 ± 0.11 mm to 1.80 mm. The second instar was reddish and oval, measuring 3.62 ± 0.47 mm in length and lasting 3.50 ± 0.51 days, which is consistent with the reports of Patel (1969) and Jaleel *et al*., (2013), who recorded 2.91 mm and 3.02 ± 0.20 mm in length, respectively. The third instar nymph was flat and triangular-headed, with average dimensions of 5.69 ± 0.76 mm and a duration of 4.27 ± 0.50 days, aligning closely with Patel (1969) and Jaleel *et al*., (2013), who observed lengths of 4.31 mm and 5.52 ± 1.25 mm. The fourth instar displayed pronounced wing pad development and scarlet-red coloration, measuring 7.56 ± 0.91 mm and lasting 10.05 ± 0.84 days, which matches previous descriptions by Patel (1969), Varma (2009) and Jaleel *et al*., (2013), who reported measurements of 6.45 mm to 9.06 ± 1.34 mm. The fifth instar, the longest in duration (14.50 ± 0.51 days), was cylindrical and reddish in colour, averaging 10.80 ± 0.83 mm in length. These findings conform with those of Varma (2009), Jaleel *et al*., (2013) and Lal and Bhadauria (2019), who reported similar morphological features and durations ranging from 6.12 ± 0.77 days to 15 days. The total nymphal period was found to range from 35 to 40 days, averaging 37.92 ± 1.99 days, closely matching the 35–41 days reported by Varma (2009) and the 37 days reported by Ranjan and Kumar (2018). Adult bugs were scarlet-red, elongated and sexually dimorphic, with females being larger and heavier than males a pattern well-supported by Patel (1969), Varma (2009) and Jaleel *et al*., (2013).

Female adults measured 15.19 ± 0.48 mm in body length, while males measured 13.60 ± 0.45 mm. Female antennae, forelegs, hind legs and proboscis were all longer than those of males, confirming sexual dimorphism in structural traits. The pre-oviposition, oviposition and post-oviposition periods recorded were 7.32 ± 0.83, 8.12 ± 0.83 and 7.04 ± 0.71 days, respectively, which align with earlier studies. Fecundity ranged from 58 to 130 eggs per female, with a mean of 95.72 ± 17.92 eggs, consistent with Varma (2009) who reported 95.2 ± 19.13 eggs per female and earlier reports by Patel (1996) and Lal and Bhadauria (2019). Longevity was higher in males (mean 21.48 ± 1.12 days) than in females (mean 17.00 ± 0.82 days), matching Varma (2009) and Ranjan and Kumar (2018), though Jaleel *et al*., (2013) recorded a broader longevity range of 27.5–56 days for males and 32.5–61.5 days for females. The total life span, from egg to adult death, was slightly longer than previous reports, possibly due to favourable laboratory conditions. Male life span ranged from 56 to 77 days (mean 67.30 ± 6.33 days), which compares to 55–66 days (mean 60.0 ± 3.52 days) reported by Varma (2009) and 43–75 days by Patel (1969). Similarly, female life span in the present study ranged from 57 to 82 days (mean 70.05 ± 8.55 days), which was longer than the 51–59 days (mean 55.68 ± 2.42 days) reported by Varma (2009) and the 43–75 days reported by Patel (1969). In conclusion, the present findings confirm and expand upon prior knowledge on the life cycle, developmental durations, morphological traits and reproductive parameters of *D. koenigii* and provide a reliable reference for future ecological and pest management strategies targeting this key cotton pest.

Conclusion

Based on the experimental observations, it can be concluded that red cotton bug, D. koenigii undergoes five distinct nymphal instars before reaching adulthood on cotton. The total lifespan of red cotton bug was found to range from 45 to 60 days in males, while females lived slightly longer, ranging from 50 to 65 days.

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