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Studied on the biology and bionomics of red cotton bug, *Dysdercus koenigii* (Fabricius) on Okra, *Abelmoschus esculentus* in Gwalior, Madhya Pradesh (India)

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Abstract
Red Cotton bug, *Dysdercus koenigii* (Fab.) is one of the major pest of okra in India. It damages the crop plant by sucking the leaves and the developing fruits. Both adult and nymphal stages reduce the fruit quality and crop yield. Red cotton bug is a small, blood red or dusky brown colored insect. The female lays eggs in the soil and decaying vegetable matter. Its biology, life cycle and bionomics were studied during kharif- 2018. It undergoes hemimetabolous type of development. Female was little larger than the male ones and measured 15.19±0.17 mm length and 8.42±0.32 mm width as compared to male with 13.16±0.94 mm in length and 7.25±0.67 mm in width. There were five nymphal stages that completed their development in 33-41 days with an average of 37.30±2.87 days. Life cycle duration varied between 39-48 days with an average of 43.***7****0*±3.16 days. The total adult life cycle period of male and female 53-65 days with an average of 59.20±4.32 days and 48-60 days with an average of 54.00±3.82 days, respectively. Fecundity ranged between *5*4-***6****5* with an average of 60.50**±**4.30.

Keywords: biology, life history, bionomics, hemiptera-nymph, *Dysdercus koenigii* and okra seeds

1. Introduction
Okra (*Ablmoschus esculentus* L. Moench) popularly known as "Bhindi" or "Ladies finger" is an important vegetable crop grown in India (Ndunguru and Rajabu, 2004) [5]. Besides India, okra is also grown in many tropical and subtropical parts of the world. India is second larger producer of vegetable production after China in the world. Okra is widely cultivated in plans of the India with average area of 5.06 lakh ha. and production 60.73 lakh MT and productivity 12.00 tons ha^{-1}. In Madhya Pradesh, okra is grown in 0.4012 lakh ha. area with production of 5.3673 lakh MT and 13.02 tons ha^{-1} productivity (Anon., 2017-18) [2]. The importance of vegetable in human diet is well known since time immemorial as they supply all main component of human diet. Among vegetables okra is tender fruits and used as vegetables or in culinary preparations as sliced and dried pieces. It is also used for thickening gravies and soups, because of its high mucilage content. Matured fruits and stems containing crude fiber are used in paper industry. It has good nutritional value, particularly the high content of vitamin C (30mg/100g), and Ca (90mg/100g), Fe (1.5mg/100g) and other minerals like mg and K, vitamin A and B, fats and carbohydrates (Singh *et al.,* 2013) [8]. On other hand, the sucking pest complex of okra consisting of aphid, leaf hopper, white flies, thrips, red cotton bug and mites causes 17.46% yield loss and if failure to control them in initial stages, damage was reported to cause 54.04% yield loss (Anitha and Nandihalli, 2008) [1]. Red cotton bug, *Dysdercus koenigii* Fab. (Order Hemiptera, suborder heteroptera and family Pyrrhoiridae) is the economically important cotton pest. It is reported to flourish on other malvaceous plants as okra, *Abelmoschus esculentus*, holly-hock and non malvaceous plants like tobacco and *Ipomea batata* (Verma and Patel, 2012) [10]. Red cotton bug is an important insect pest, which reproduces rapidly in the field, so it has fast and affiant egg development (Venugopal *et al.*, 1994) [9] thus they are default to control only with insecticides. In order to develop an effective pest management system for *D. koenigii*, the studies on life cycle, reproductive biology and bionomic of the pest are necessary. Despite of the fact that some work on the bionomics and life cycle of red cotton bug in India has been reported (Kamble, 1971 and Verma, 2012) [4/10]. In gird region of Madhya Pradesh the life cycle of red cotton bug was not studied previously. Looking to the importance of the insect and changing in climatic condition. In the present investigation, biology, life cycle and bionomics of *D. koenigii* was studied under laboratory conditions on okra at Gwalior (Madhya Pradesh region).

2. Materials and Methods
2.1 Collection and rearing of Red cotton bug, *D. koenigii*:
The studies on the biology of red cotton bug was carried out on okra cultivar Arka Anamika under laboratory condition in the Department of Entomology, RVSKVV, College of Agriculture, Gwalior Madhya Pradesh from last September to November- 2018. The adult pair of *D. koenigii* was collected from okra field. Rearing was done under lab conditions (***2***8±2 ºC temperature and 70-75% RH) in jars with filter paper on the bottom and mouth of the jar was closed with muslin cloth. The fresh seeds of okra were provided at every second days interval. Adults pair were confined in jars separately with filter paper at the bottom to obtain eggs, moist cotton was provided under filter paper to maintain the humidity. Jars were checked daily to observe eggs laying. After egg laying, 20 eggs were collected from jar and then kept in 10 peridishes (two eggs/ petridish and incubation period was recorded. After hatching newly born nymphs were transferred to other petri-dish which were wrinkled by moist filter paper and fresh okra fruit seeds were provided from feeding. Filter paper and food were changed at two days intervals. Nymphal stages were observed daily and data recorded with regards to moulting duration and length, and

width of the nymph, length of forewing of each nymphal instar. All life instars were recorded morph metrically. The adult longevity of male and female were recorded separately. The number of eggs laid by each female was also observed to find out the fecundity. Measurements were done using graded scales (1-150 mm).

3. Results and Discussion

Life history of Red cotton bug, *D. koenigii* (Fab.)

3.1 Incubation Period

The freshly eggs were creamy white, soft, round or egg-shaped in shape and yellowish orange and later on turned in to red in colour. The incubation period was 5-7 days with an average *of* 6.40±*0.70* days. However, Verma and Patel (2013) [11] reported that the incubation period of 4-7 days with an average of 4.97±0.82 days and Jaleel *et al.* (2013) [3] reported that the incubation period 4.7±0.42 days. During present investigation, the length and width of egg varied between 1.12-1.23 mm with an average of 1.12±0.10 mm and 0.69-0.86 mm with an average of 0.80±0.06 mm, respectively. Similar to the present findings of Shrikhandia *et al*. (2017) [7] reported that the length and breadth of an egg were 1.05 to 1.21 mm with an average of 1.13±0.07 mm and 0.75 to 0.86 mm with an average of 0.80±0.04 mm, respectively at J & K.

3.2 Nymphs

In the life history of red cotton bug, *D. koenigii* (Fab.), five nymphal instars were observed. Biology, duration and bionomics of each nymphal period were described as under:

3.2.1 First instar

The newly hatched nymphs were light orange in colour which turns to blood red within one day. Similar to the present findings with Verma and Patel (2012) [10]; Jaleel *et al*., (2013) [3] and Shrikhandia *et al*., (2017) [7] who reported that the first emerged nymph was orange in colour which turns to red colour with in one day. However, Ranjan and Kumar (2018) [6] observed that freshly hatched nymphs were pale orange, later on turned into red colour. Duration of first nymphal instar lasted for 2-3 days with an average of 2.60±0.52 days. Their length and width were 1.39**-**1.75 mm with an average of 1.56±0.18 mm and 0.74-0.85 mm with an average of 0.79±0.04 mm, respectively (Table-1). Similar to the present findings of Jaleel *et al*., (2013) [3] and Shrikhandia *et al*., (2017) [7] reported that the length and breadth were 1.38-1.72 mm with an average of 1.56±0.14 mm and 0.76-0.80 mm with an average of 0.78±0.02 mm. Wing pads were not present in first nymphal instar.

Table 1: Life cycle duration, Longevity, Fecundity and Bionomics of Red cotton Bug, *Dysdercus keonigii* in Laboratory condition

Developmental Stages	Duration(Days) Range, Mean ± SD ± SEM		Body length(mm) Range, Mean ± SD ± SEM		Body width(mm) Range Mean ± SD± SEM		Forewing length(mm) Range Mean ±SD± SEM
Incubationperiod	5 - 7	6.40 ± 0.70 ± 0.22	1.02-1.23	1.12 ± 0.10 ± 0.03	0.69-0.86	0.80 ± 0.06 ± 0.02	
Nymphal period							
1st instar	2 - 3	2.60 ± 0.52 ± 0.16	1.39-1.75	1.56 ± 0.18 ± 0.06	0.74-0.85	0.79 ± 0.04 ± 0.01	Absent
2nd instar	3 - 4	3.60 ± 0.52 ± 0.16	1.98-2.82	2.42 ± 0.41 ± 0.13	1.26-1.61	1.44 ± 0.16 ± 0.05	Absent
3rd instar	6 - 7	6.10 ± 0.57 ± 0.18	4.08-4.61	4.34 ± 0.27 ± 0.09	1.58-1.88	1.72 ± 0.14 ± 0.04	Absent
4th instar	10-12	10.60 ± 0.70 ± 0.22	4.95-6.12	5.52 ± 0.53 ± 0.17	2.75-3.79	3.27 ± 0.47 ± 0.15	Absent
5th instar	13-15	14.40 ± 1.35 ± 0.43	8.98-1.23	10.80 ± 1.14 ± 0.36	3.98-4.02	3.89 ± 0.13 ± 0.04	Absent
Total nymphal period	33-41	37.30 ± 2.87 ± 0.91					
Total life cycle duration	39-48	43.70 ± 3.16 ± 1.00					
Adult Longevity							
Male	20-24	21.80 ± 1.40 ± 0.44	12.25-14.12	13.16 ± 0.94 ± 0.30	5.98-7.85	7.25 ± 0.67 ± 0.21	9.98-10.12 10.06 ± 0.05 ± 0.02
Female	15-19	16.60 ± 1.58 ± 0.50	14.98-15.37	15.19 ± 0.17 ± 0.05	8.10-8.75	8.42 ± 0.32 ± 0.10	10.85-11.85 11.12 ± 0.29 ± 0.09
Total life period							
Male	53-65	59.20 ± 4.32 ± 1.36					
Female	48-60	54.00 ± 3.82 ± 1.21					
Fecundity	54-65	60.50 ± 4.30 ± 1.36					

3.2.2 Second instar

The second nymphal instar was reddish colour and egg-shaped, it was similar in appearance to that of first nymphs instar but was larger in size. Duration of second nymphal instar lasted for 3-4 days with an average of *3.60*±0.52 days. Similar to the present findings of Shrikhandia *et al*., (2017) [7] and Ranjan and Kumar (2018) [6] reported that the duration of second instar lasted for 3-4 with an average of 3.54±0.39 days. The second nymph instar length and width were *1.98***-**2.82 mm with an average of *2.42***±**0.41 mm and *1.26-1.61* mm with an average of *1.44***±**0.16 mm, respectively. Similar to the present findings with Shrikhandia *et al*., (2017) [7] reported that the length and breadth were 2.03-2.41 mm with an average of 2.25±0.16 mm and 1.31-1.62 mm with an average of 1.47±0.13 mm, respectively (Table-1). However, Ranjan and Kumar (2018) [6] reported that the second instar nymph was measured 3.02±0.2 mm in length and 1.25±0.04 mm in width. Wing pads were not present in second nymphal instar.

3.2.3 Third instar

The newly molted instar was orange red in colour which turned to reddish colour with one day. Initiated moulted nymphal instar was flat shaped with singular head. Three pair of unclear dorsal spots development on the abdominal region. Third nymphal instar different from the 1st and 2nd instar in the appearance of wing pad on the thorax. The duration of 3rd nymphal instar varied between 6-7 days with an average of 6.10±0.57 days. Similar to the present findings with Ranjan and Kumar (2018) [6] reported that the duration of third instar ranged from 6-7 days with an average of 6.5 days. However, Shrikhandia *et al*., (2017) [7] reported that the duration of third instar lasted for 4 to 5 days with an average of 4.44±0.41 days. The length and width were 4.08-4.61 mm with an average of 4.34±0.27 mm and 1.58-1.88 mm with an average of 1.72±0.14 mm, respectively (Table-1). Similar to the present findings of Shrikhandia *et al*., (2017) [7] reported that length and breadth were 4.98 to 6.00 mm with an average of 4.26±0.21 mm and 1.58 to 1.81 mm with an average of 1.73±0.09 mm. respectively. However, Jaleel *et al*., (2013) [3] reported that the length of third instar was measured 5.52±1.25, width 2.36±0.89 mm.

3.2.4 Fourth instar
The fourth nymphal instar was crimson red in colour and tubular in shape. The wing pad develops up to posterior margin of metathorax. The distal region of wing pad was darker in colour in than the proximal part. The metathorax segment was seen only in its mid-dorsal area. While transverse bands appeared on the 3rd to 7th abdominal segments (sterna). Duration of fourth nymphal instar varied between 10-12 days with an average of 10.60±0.70 days. Similar findings were reported by Shrikhandia *et al*., (2017) [7] and Ranjan and Kumar (2018) [6] who observed that the duration of fourth instar lasted for 10-12 days with an average of 11±0.079 days and 9-11 days with an average of 10.00 days. The 4th instar nymphal length and width were 4.95-6.12 mm with an average of 5.52±0.53 mm and 2.75-3.79 mm with an average of 3.27±0.47 mm, respectively (Table-1). Similar results also reported by Shrikhandia *et al*., (2017) [7] that length and breadth were 4.98-6.00 mm with an average of 5.50±0.40 mm and 2.53-3.02 mm with an average of 2.75±0.19 mm, respectively.

3.2.5 Fifth instar
The fifth nymphal instar was also crimson red in colour and tubular or cylindrical in shape. Wing pads develop into prominent. The proboscis was deep red in colour and while five segmented. The nymphal that developed into adult male was smaller than that of female. The duration of fifth nymphal instar varied between 13-15 days with an average of 14.40±1.35 days. These findings are close agreement with Shrikhandia *et al*., (2017) [7] and Ranjan and Kumar (2018) [6] reported that the duration fifth instar lasted for 12-16 days with an average of 14±1.58 days. The nymphal length and width were 8.98-12.23 mm with an average of 10.80±1.14 mm and 3.98-4.02 mm with average of 3.89±0.13 mm respectively. However, Shrikhandia *et al*., (2017) [7] reported that length and breadth were 8.00-10.12 mm with an average of 9.07±0.88 and 3.20-3.50 mm with an average of 3.32±0.12 mm.

3.2.6 Adult
The adult of red cotton bug, *D. koenigii* Fab. Was crimson/red in colour and medium in size. The head was triangular shaped with 5 segmented antennae. The hind wings were membranous and broader than forewings and hind wings remained concealed under for wings at rest. Forewings have black spot in midpoint. The thorax was well developed and jointed with head by a cervix which was in distinguishable from the dorsal side due to overhanging of pronotum. The pronotum made an appearance of convex shielded and larger in size. The posterior margin of each abdomen sternum bears a white transverse band which was broader at the center and narrow at the end. There were no distinction between male and female adults but generally female is larger than the male in length and width. similar to the present findings of Ranjan and Kumar (2018) [6] reported the female nymphal is little longer than the male ones. The duration of male adult lasted for 20-24 days with an average of 21.80±1.40 days while that female adult lasted for 15-19 days with an average of 16.60±1.58 days. Similar to the present findings of Shrikhandia *et al.,* (2017) [7] reported the adult male lived longer with an average of 21.08±2.38 days than the female adults with an average of 16.5±1.11 days. The female larger than the male length and width varied between 14.98-15.37 mm with an average of 15.19±0.17 mm and 8.10-8.75 mm with an average of 8.42±0.32 mm as compared to male with length and width lasted 12.25-14.12 mm with an average of 13.16±0.94 mm and 5.98-7.85 mm with an average of 7.25±0.67 mm, respectively (fig.-1). However, Shrikhandia *et al.,* (2017) [7] reported that completed five instars their development in 35.48±3.59 days and completed life cycle from egg laying to adult emergence in 36-47 days with an average of 41.48±4.38 days. Fore wing in male was measured 9.98-10.12 with an average of 10.06±0.05 mm, while in female they measured lasted for 10.85-11.85 with an average of 11.12±0.29 mm, respectively (Table-1). These findings are close agreement with Jaleel *et at.,* (2013) reported that the forewings in female was measured 11.22±0.22 mm, while in male they measured 10.04±0.69 mm.

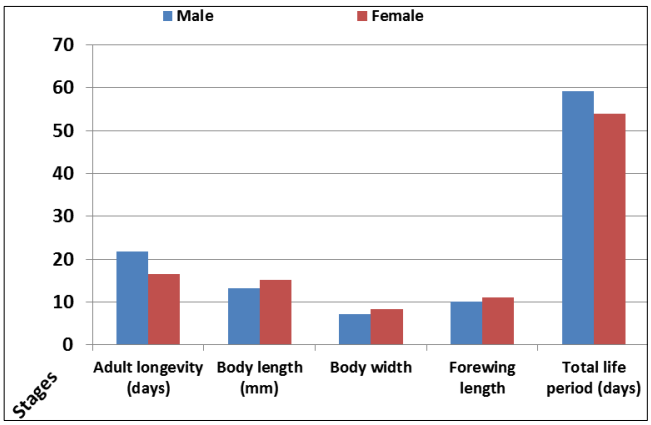

Fig 1: Comparison of male and female each stage of red cotton bug

3.2.7 Total life cycle period
Data of life history showed the male and female they lived varied between 53-65 days with average of 59.20±4.32 days and 48-60 days with an average of 54.00±3.82 days respectively. These findings are close agreement with Shrikhandia *et al.,* (2017) [7] and Ranjan and Kumar (2018) [6] reported that total life period of male and female varied between 50-65 days with an average of 57.28±5.97 days and 46-58 days with an average of 51.98±4.69 days.

3.2.8 Fecundity
Female laid 54-65 eggs with an average of 60.50±4.30 eggs and mated three times in her life. However, Ranjan and Kumar (2018) [6] observed that the fecundity ranged between 54-64, respectively**.**

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