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NOTES ON THE BIOLOGY OF *BAGRADA CRUCIFERARUM* KIRK.

By R. RAKSHPAL, PH.D.

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Bagrada cruciferarum Kirk. is very common in India. A brief account of the species has been given by Hutson (1935), but in view of its importance, the writer carried out a detailed study of the biology of the insect during the last three years and the observations are reported in this paper.

FOOD PLANTS AND GEOGRAPHICAL DISTRIBUTION

B. cruciferarum is one of the most serious pests of mustard, cabbage, cauliflower, turnips, radish, knol-kohl and many other cruciferous plants. It has also been recorded by Anderson (1917) as attacking coffee and by Pillai (1921) as a serious pest of paddy in Travancore.‡ In some cases the damage is very serious, causing the young plants to wilt and die, spoiling heaps of cabbages and cauliflowers and greatly reducing the yield of seed of the mustard crop. Thus the annual losses brought about by the pest in this country are heavy. The pest is not confined to India, having been recorded from Ceylon, Burma, Kenya, Bagdad and East Africa. So far, the writer has not seen any record of the pest from any of the European, American or Australian countries.

LIFE-HISTORY OF *Bagrada cruciferarum*

Copulation.—The freshly emerged males and females begin to copulate within two to six days. Pairs may remain in coitus for several hours at a time. Oviposition does not begin immediately after the first copulation, but follows about a week later. During this period they may mate again. Pairing does not stop with the first oviposition but may take place repeatedly almost till death. The maximum number of times mating was noted during the life time of a pair which lived for 40 days was 34. The inter-copulation period varies from one to five days. Repetition of mating does not, however, appear to be a biological necessity, as female bugs kept separate after the first insemination continued to lay fertilised eggs that developed into normal adults.

Oviposition.—About a week after the first copulation the female begins oviposition. Unfertilised females do not lay eggs. Eggs are laid singly, but sometimes they have been found in groups of two to thirteen. They are generally laid on the leaves of the host plant, but sometimes on the stem and inflorescence also. The female continues egg-laying almost till death. The inter-oviposition period varies from one to five days. The maximum number of eggs laid by a female during her life-time was 114, and during a day, 19.

* The observations were carried out in Gwalior (1947).

‡ The record of *Bagrada picta* attacking paddy in 1921 appears rather doubtful, as it has not been confirmed by subsequent reports either at the Central Agrl. Res. Institute, New Delhi or at the Entomological section of the Travancore Agrl. Department. Perhaps *Menida histrio* had been mistaken to be *Bagrada*.—EDITOR.

Incubation-period.—Incubation-period varies from two to five days, eggs laid about the same time on the same leaf do not necessarily hatch simultaneously even when they are of the same sex.

Eggs.—The eggs are firmly glued to the plant surface by a sticky secretion. Each egg is oval, dirty white at the time of laying, and twice as long as broad. The average length is about 1 mm. and width about 0.55 mm. Under the microscope a rather coarse reticulation is seen on the surface of the egg. The colour of the egg changes as the development proceeds, from dirty white to yellow, orange-yellow and ultimately a beautiful orange, when it is quite conspicuous. The process of development of the embryo can be seen through the egg shell. The duration of the egg stage is about four days. A few hours before hatching, the eyes and the parts of the head can be marked easily. At the time of hatching, the egg-shell opens out at one end allowing a cap-like portion of the shell to separate out, but to continue to remain attached to it at one side. The egg shells remain attached to the leaf for days even after the nymphs have crawled out. First of all, the head of the nymph emerges and then the whole body comes out of the shell. The whole process of the emergence of the nymph takes about 20 minutes. After emergence, the nymph takes rest for some time, then begins to move about and suck the cell-sap from the leaf.

Number of moults.—The insect passes through five moults, the last one occurring when the imago emerges. It need not necessarily follow that nymphs hatching together on the same day should grow at the same rate and moult at the same time, even though they may be given the same food and be of the same sex. The duration of the nymphal period varies from 16 to 27 days.

First instar nymph.—The body colour of the newly hatched nymph is bright orange with scarlet red eyes. There are no marks of any kind anywhere on the body. As the nymph develops, the body colour changes to reddish brown. The head, antennae, legs and the margin of the thoracic segments become smoke coloured. At the same time smoky patches, one on each segment, also appear on the third to ninth abdominal segments. Just before moulting, the body colour

Length of Rostrum in various instars (in mm.)

Instars	1st segment	2nd segment	3rd segment	4th segment	Total
First	0.12	0.16	0.10	0.12	0.50
Second	0.26	0.30	0.16	0.20	0.92
Third	0.28	0.42	0.18	0.24	1.12
Fourth	0.50	0.70	0.24	0.36	1.80
Fifth	0.78	0.86	0.32	0.44	2.40
Adult female	0.86	1.00	0.40	0.54	2.80
Adult male	0.84	0.88	0.38	0.46	2.56

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Length of Antenna in various instars (in mm.)

Instars	Scape	Pedicel	Post-pedicel	4th segment	Last segment	Total
First	0.08	0.12	0.18	..	0.22	0.60
Second	0.12	0.22	0.20	..	0.40	0.94
Third	0.16	0.38	0.50	1.36
Fourth	0.20	0.58	0.44	..	0.54	1.76
Fifth	0.28	0.86	0.66	..	0.86	2.66
Adult female	0.34	0.82	0.60	0.86	0.84	3.46
Adult male	0.34	0.66	0.50	0.82	0.84	3.16

Length of Tarsus in various instars (in mm.)

Instars	Proximal segment	Middle segment	Distal segment	Total
First	0.08	..	0.20	0.28
Second	0.12	..	0.24	0.36
Third	0.20	..	0.32	0.52
Fourth	0.28	..	0.48	0.76
Fifth	0.40	..	0.50	0.90
Adult female	0.48	0.24	0.38	1.10
Adult male	0.56	0.24	0.34	1.14

becomes dirty red, the smoky markings become blackish and the eyes deep red. The nymph is about 1.2 mm. long and about 0.85 mm. broad. The greatest width is across the first abdominal segment. Body oval; head more or less elliptical. The compound eyes project from the sides of the head. Antennae four-segmented; rostrum also four-segmented, reaching beyond the metasternum, its distal segment provided with a few bristles at the tip. All the three thoracic segments are distinct, the prothorax being the broadest. Nota simple; wing rudiments absent. The thoracic spiracles located ventro-laterally on the meso- and metathorax. Legs stout and six-jointed; tarsi two-segmented. Ten abdominal segments are visible; the last two are very small and remain telescoped inside, but become visible when the abdomen is pressed a little. Seven pairs of abdominal spiracles are noticeable situated on the 2nd to 8th abdominal segments. The first moult occurs about 2.5 days after the emergence from the eggs.

Second instar nymph.—The newly emerged nymph is bright orange with head and thorax greenish and eyes scarlet red. It is about 1.5 mm. long and about

1.0 mm. broad. The posterior margins of the nota become convex. The nymphs moult after about four days.

Third instar nymph.—The nymph is reddish, the markings become blacker; about 1.8 mm. long and 1.45 mm. broad. The head is more or less rectangular and the two compound eyes project prominently from the antero-lateral corners of the head. The posterior margins of the meso- and meta-nota show postero-lateral out-growths. The wing-rudiments are still undeveloped. Only nine abdominal segments are visible. The anus opens on the last segment. The genital appendages are not yet developed. The nymphs moult after about four days.

Fourth instar nymph.—The fourth instar nymph is reddish, the markings become very distinct. It is about 2.9 mm. long and about 2.0 mm. broad. The head is more or less triangular and the two well-developed compound eyes project from the basal angles. The pronotum becomes triangular and a little reduced. The meso- and meta-nota begin to grow postero-laterally and thus giving origin to wing-pads. The nymphs moult after about 4.5 days.

Fifth instar nymph.—The fifth instar nymph assumes the coloration of the adult, all the markings become well developed. It is about 4.6 mm. long and about 3.2 mm. broad. The prothorax is very much reduced and forms only a collar-like structure between the head and the meso-thorax. The meso- and meta-thorax are further developed. The meso- and meta-nota become triangular, the apices pointing posteriorly. From the basal angles of each notum elongated projections grow backward forming well developed wing pads. The genital appendages begin to make their appearance. The nymphs moult after about six days.

Imago.—The male can be distinguished from the female by its smaller size and by the very complicated genitalia at its posterior end. The female is about 7.5 mm. long and about 4.0 mm. broad, while the male is about 6.6 mm. long and about 3.0 mm. broad. The female completes its life history in about 24.5 days and the male in about 22 days. The males live longer than the females, the average life duration being 18 and 16 days respectively. The antennae are five-segmented and the tarsi three-segmented.

Application of Dyar's Law.—Measurements of the width of head of the different instars of *B. cruciferarum* indicate that the increase in the width follows a geometrical progression envisaged under Dyar's Law as shown below:—

Instars	Observed width of the head (millimetres)	Calculated width of head (millimetres)
First instar	0.544	..
Second instar	0.712	$0.544 \times 1.31 = 0.712$
Third instar	0.922	$0.712 \times 1.31 = 0.932$
Fourth instar	1.248	$0.922 \times 1.31 = 1.207$
Fifth instar	1.632	$1.248 \times 1.31 = 1.634$

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Parasites of *B. cruciferarum*.—A species of *Alophora* (Tachinidae) has been found to parasitise *B. cruciferarum*. A single full-developed maggot emerges out of an adult host, and pupates outside the body of the host which dies shortly after the emergence of the parasite. Samuel (1942) has recorded two egg-parasites of *B. cruciferarum*.

Table showing Life History of *Bagrada cruciferarum*

	Maximum in days	Minimum in days	Average in days	No. of observations
First instar	6	1	2.35	118
Second instar	6	3	4.00	125
Third instar	7	2	4.00	129
Fourth instar	7	3	4.30	119
Fifth instar	8	4	6.03	104
Life-history of male	31	20	22.02	48
Life-history of female	31	20	24.53	53
Longevity of male	40	0	18.00	17
Longevity of female	31	0	16.00	18
Pre-copulation period	6	1	2.70	14
Pre-oviposition period	14	4	9.40	14
Incubation period	3	2	3.80	126

SUMMARY

Bagrada cruciferarum is one of the most serious pests of cruciferous plants; it attacks the plants at all stages. The eggs are usually laid on the leaves but sometimes on the stems and the inflorescence also. The pre-copulation period varies from two to six days. Copulation takes place frequently. The pre-oviposition period is about 9 days, oviposition may continue till death. The maximum number of eggs laid by a female during its lifetime is 114, and in a single day 19. The incubation period is two to three days during March-April. There are five moults. The life history is completed by males and females in about 22 and 25 days respectively. Post-embryonal growth conforms to Dyar's Law. The antennae are four-segmented and the tarsi two-segmented in the nymphal stages, while in the adults they become five- and three-segmented respectively. *B. cruciferarum* is parasitised by *Alophora* sp. (Tachinidae).

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