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# Biology of *Chilocorus bijugus* Mulsant (Coleoptera : Coccinellidae), Predator of San Jose scale, *Quadraspidiotus perniciosus* (Comstock)

U.S.RAWAT, S.K.SANGAL[1] and A.D.PAWAR[2]
Central Biological Control Station, Solan - 173 212, India

The coccinellid, *Chilocorus bijugus* Mulsant is a potential predator of San Jose scale, *Quadraspidiotus perniciosus* (Comstock), a serious pest of apple crop in certain hilly tracts of India (Pruthi and Rao, 1951; Tuhan *et al.*, 1979; Rawat *et al.*, 1988 a,b). Available literature reveals that insufficient studies have been undertaken on the biology of such an effective predator all over the world. Kapur (1954) and Chanyuvadze (1976) have only given some brief information on the biology of this predator. Since, information on the biology of *C. bijugus* is very scanty, an attempt was made to study in detail and the results are presented in this communication.

The predator was reared on San Jose scale-infested pumpkin fruits in the rearing cage (45x45x50cm) in the laboratory at 25 to 28°C and 65-75% RH. The eggs obtained were kept in sterilised Petri dishes (4cm dia.) for hatching. Observations were recorded on shape, size, colour and incubation period of eggs. Measurements were taken from 15 eggs with the help of oculometer fitted in the stereobinocular.

Soon after hatching, the larvae were transferred to small plastic tubes (6x4cm) provided with San Jose scale crawlers daily for rearing them to pupal stage. Daily observations on the number of instars and their duration, shape, size and colour were recorded on 15 larvae of each instar in separate plastic tubes. The last instar grubs (4th instar) ready for pupation were provided with additional crawlers of the scales for pupation. The pupae were not disturbed till the adults emerged from them. Observations on the shape, size, weight, colour and pupal duration were recorded from 15 pupae.

As soon as the adults emerged, the colour change from the newly emerged pupae to its normal colour was recorded on 8 individuals. The size, shape and weight of male and female were recorded separately in addition to adult and total longevity of predator observed at 27 ± 1°C and 65 ±5% RH. Observations were also recorded on sex ratio, mating behaviour, fecundity, pre-mating, pre- oviposition, oviposition and post-oviposition periods at 25 to 28°C (Average 26.5°C) and 65 to 75% RH.

The eggs were oblong to oval, cigar-shaped and light yellow in colour when freshly laid, but turned to dull yellow at the time of hatching. Data presented in Table 1 show that the length of eggs ranged between 0.87 to 1.02 (mean = 0.93)mm while the breadth ranged between 0.41 to 0.50 (mean = 0.46) mm. These observations are in close conformity with those reported by Ahmad and Ghani (1966) in *C. infernalis* and Ahmad (1970) in *C. nigritus*.

The incubation period ranged from 3 to 6 days (mean = 4.8) (Table 1). Kapur (1954) reported it as 3.44 days without mentioning the temperature at which the study was made, whereas Jalali and Singh (1989) reported it as 6.0 to 6.8 days on different host insects at 27 ±1.8°C and 55±2.3% RH. However, these findings are not in agreement with those

1. Professor & Head Department of Zoology, D.A.V. (P.G.) College, Dehradun
2. Directorate of Plant Protection, Quarantine & Storage, N.H. IV, Faridabad

**Table 1. Size and duration of eggs, larval instars, pupae and adults of *Chilocorus bijugus* reared on *Q. perniciosus* under laboratory conditions**

| Stage | *Mean size (mm±SE) | | | *Duration (days) | | |
|---|---|---|---|---|---|---|
| | Length | Breadth | Weight (mg±SE) | Min. | Max. | Average (±SE) |
| Egg | 0.93±0.01 (0.87-1.02) | 0.46±0.01 (0.41-0.50) | | 3 | 6 | 4.8±0.255 |
| Larva | | | | | | |
| instar I | 1.15±0.04 (0.83-1.49) | 0.51±0.02 (0.40-0.73) | | 3 | 6 | 4.46±0.252 |
| instar II | 2.34±0.19 (1.70-3.20) | 0.92±0.09 (0.70-1.20) | | 7 | 10 | 7.85±0.251 |
| instar III | 4.10±0.17 (3.50-5.00) | 2.16±0.16 (1.70-2.80) | | 6 | 13 | 9.69±0.368 |
| instar IV | 6.44±0.20 (5.70-7.50) | 2.94±0.17 (2.20-3.70) | | 9 | 11 | 9.90±0.246 |
| Pupa | 5.75±0.16 (5.10-6.50) | 3.70±0.12 (3.50-4.20) | 14.57±0.25 (12.50-16.40) | 11 | 16 | 12.62±0.297 |
| Adult | | | | 20 | 27 | 23.86±0.361 |
| Male | 4.79±0.16 (4.00-5.20) | 4.06±0.18 (3.20-4.60) | 18.59±0.34 (15.10-21.10) | | | |
| Female | 5.90±0.14 (5.40-6.50) | 4.90±0.10 (4.50-5.20) | 23.68±0.38 (22.50-27.60) | | | |
| Total life cycle | | | | 59 | 89 | 73.18 |

* Mean of 15 observations

Figures in parentheses indicate the range

reported by Chanyuvadze (1976) (8 to 9 days) and Murushevskaya (1969) (8-9 days) for *C. renipustulatus*. These differences in the incubation periods may be attributed to variations in ambient temperature and relative humidity.

The grubs passed through four instars to become pupae. First instar grub was light black in colour, sluggish and the whole body was covered with scolus. The grubs preferred to feed on the crawlers and did not consume the old scales. The length varied between 0.83 to 1.49 (average 1.15)mm while the breadth ranged between 0.40 to 0.73 (average 0.51)mm. The first instar took 3 to 6 days with an average of 4.46 days for development. The second instar grub measured 1.70 to 3.20 mm with an average of 2.34mm in length and 0.70 to 1.20mm with an average of 0.92mm in breadth. The development period ranged between 7-10 days with an average of 7.85 days when reared on San Jose scale crawlers. In comparison to first instar, the colour was slightly black and dorsum of first abdominal segment and mid dorsal line brownish to near white. The whole body was covered with blackish scolus. Third instar grub was blackish in colour, somewhat fusiform with greatest width in the region of mesothorax to first abdominal segment. It measured from 3.50 to 5.00 mm with an average 4.10mm in length and 1.70 to 2.80mm with an average of 2.16mm in breadth. The development period of third instar was 6 to 13 days (average 9.69 days). The length of full grown fourth instar grub varied between 5.70 to 7.50 (average 6.44)mm while the breadth ranged between 2.20 to 3.70 (average 2.94)mm. Fourth instar

grub took 9 to 11 days with an average of 9.9 days. The other morphological characters were almost the same as reported by Ahmad and Ghani (1969).

The total development period of grub varied from 25 to 40 days with an average of 31.9 days. Our findings are in fair agreement to the findings of Jalali and Singh (1989) but differ from those reported by Kapur (1954), Chanyuvadze (1976) and Ahmad and Ghani (1966).

The newly developed pupa was brownish and gradually changed to deep brown and black. It was somewhat triangular and V shaped in appearance. Eight abdominal segments were visible dorsally and last segment has forked feet or organ for attachment. The pupa developed within the shed larval skin, which split lengthwise at the mid dorsal line from anterior margin of cervical shield to the anterior portion of six abdominal tergite. The mean length of pupa was 5.75 (range 5.10 to 6.50)mm, and the average breadth 3.70 (range 3.50 to 4.20) mm. The weight varied from 12.50 to 16.40 (average 14.57) mg. The pupal duration varied from 11 to 16 days with an average of 12.62 days. Our observations corroborate with those of Chanyuvadze (1976) who reported 11 days in case of *C. bijugus* but differ from the findings of Kapur (1954), Ahmad and Ghani (1966) and Jalali and Singh (1989) who reported the pupal duration as 7.2 to 8.0 for *C. infernalis* and 6.1 to 8.0 days in case of *C. bijugus* respectively. The observed differences may be attributed to variation in the ambient temperature and relative humidity which was not specified in most of the studies. The variation may also be due to inherent species difference and the prey insect on which larvae were reared.

Although the morhological characters of *C. bijugus* were described by Kapur (1954) and Nagaraja and Hussainy (1968), none explained the dimension and sex determination in male and female *C. bijugus*. Data presented in Table 1 reveal that the male has an average length of 4.79 (range 4.0 to 5.2)mm and average breadth of 4.06 (range 3.2 to 4.6)mm with an average 18.59 (range 15.1 to 21.1)mg in weight. The average length of female was 5.90 (range 5.40 to 6.50)mm, the average breadth at the widest part 4.90 (range 4.50 to 5.20)mm and the average weight was 23.68 (range 22.50 to 27.60)mg. It is clear from the Table that the average size and weight of female is generally more than those of the male adult. In young female, the last visible abdominal sternite is somewhat semicircular while in male it is quadrangular with a notch in its apical margin.

The sex ratio (female : male) varied from 0.9:1 to 1.3:1 and on an average it was 1:1. These observations support the findings of Chanyuvadze (1976) who reported the same sex ratio in *C. bijugus* in U.S.S.R. The adult survived for 20 to 27 (average 23.86) days and the total longevity (egg, grub, pupal and adult period) of the beetle varied from 59 to 89 days with an average of 73.18 days (Table 1).

The premating period varied from 5 to 8 days (mean $6.3 \pm 0.33$ days). Ahmad and Ghani (1966) reported it as 3 to 8 days (average 5.5 days) in case of *C. infernalis*. Copulation lasted for 0.40 to 4.00 (average $2.23 \pm 0.31$)h. Copulatory behaviour was very much similar to that described by Ahmad and Ghani (1966) but differred from that of Ahmad (1970) who noted that copulation lasted for 15 to 56 (average 28) minutes perhaps owing to differences in rearing conditions of *C. nigritus*. Pre-oviposition period varied from 12 to 18 (average $15.1 \pm 0.44$) days which confirmed the findings of Ahmad and Ghani (1966) and Jalali and Singh (1989) who reported it 14 to 20 and 13 to 17 days respectively. These results however do not agree with the findings of Ahmed (1970) who reported 8 to 13 (average 10) days for *C. nigritus*.

The oviposition period varied from 8 to 16 (average $11.6 \pm 0.48$) days under laboratory conditions. The female on an average produced $100.7 \pm 1.44$ (range 60 to 135) eggs.

These results are close to the findings of Jalali and Singh (1989) who reported that *C. bijugus* had a high fecundity of 92 on *Q. perniciosus* but differ from those of Ahmad and Ghani (1966), Ahmad (1970) and Greathead and Pope (1977). These workers have reported very high fecundity (228 to 858 eggs) in case of *C. nigritus*. The female had the maximum post oviposition period of 11 days, whereas the minimum recorded was 5 days. These observations are in close agreement with the findings for Ahmad (1970) who reported it as 15 days for *C. nigritus* but differ from that of Ahmad and Ghani (1966) who reported 8 to 53 days for *C. infernalis*, perhaps owing to difference in adult longevity under laboratory conditions.

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KEY WORDS : *Chilocorus bijugus*, biology, San Jose scale, *Quadra spidiotus perniciosus*

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