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Biological Studies on *Zygogramma bicolorata* Pallister (Coleoptera : Chrysomelidae), a Potential Biocontrol Agent of *Parthenium hysterophorus* L. (Asteraceae)

K.P. JAYANTH and GEETHA BALI*
Division of Entomology and Nematology
Indian Institute of Horticultural Research
Hessaraghatta Lake Post, Bangalore 560 089

ABSTRACT

Biological studies were carried out in Bangalore on the leaf feeding chrysomelid beetle, *Zygogramma bicolorata* Pallister, introduced for biological control trials against the neotropical weed *Parthenium hysterophorus* L. (Asteraceae). The insect completed its development in 27-29 days at 25.5 ± 1°C. Sex ratio was in favour of females, with the males constituting only about 30% of the population. However, males lived longer (122-271 days) than females (109-198 days). Although females were capable of laying up to 3368 (mean 2590.8) eggs each, only 30-52% hatched.

Key words: *Zygogramma bicolorata*, biology, *Parthenium hysterophorus*

The neotropical weed *Parthenium hysterophorus* L. (Asteraceae) was accidentally introduced into many countries in Africa and Asia as also Australia in the last one hundred years. It is a serious weed of pastures, agricultural fields and waste lands in most parts of India. The allelochemicals produced by the plant suppress the growth of local vegetation, due to which the weed grows in thick, pure stands, threatening natural diversity. It also poses serious threat to human health, agriculture and livestock production (Towers *et al.*, 1977).

Biological control efforts against this weed were initiated in India with the introduction and release of the Mexican beetle *Zygogramma bicolorata* Pallister (Coleoptera : Chrysomelidae) in 1984. Although the insect established readily, its population did not increase to damaging levels until 1988 (Jayanth, 1987). Extensive studies carried out subsequently showed that *Z. bicolorata* is a potentially effective biocontrol agent for *P. hysterophorus* in Bangalore and surrounding areas (Jayanth, 1991).

There have been some reports on the biology of *Z. bicolorata* (McClay, 1980, 1985; McFadyen, 1992; McFadyen and McClay, 1981). However, detailed information on development, fecundity, longevity, sex-ratio, etc. is lacking. The present studies were undertaken to fulfil this lacuna.

MATERIALS AND METHODS

Z. bicolorata was reared in 11 x 14 cm clear plastic jars, with wire-mesh windows on their lids for aeration. Studies on development were carried out under laboratory conditions between June and October 1990 at 25.5 ± 1°C and 66-87% R.H. The experiment was inititated with 50 freshly-laid eggs. The larvae were reared in groups, as individual rearing was found to prolong development during preliminary studies. For calculation of larval duration, the moulted larvae were transferred with a fine camel hair brush to a separate rearing cage, until all the larvae had further moulted. This process was repeated for all the instars. An oculometer calibrated with a stage micrometer was used for measuring the

* Department of Zoology, Bangalore University, Bangalore 560 056.

head capsule width and body length of different instar larvae.

For studies on sexual dimorphism, 50 pupae were collected from the soil on the 5th day after the larvae had burrowed in. These were weighed using a monopan electrical balance and placed individually in numbered vials after recording their body length and width. When adults emerged, the sex of the individual was recorded by observing the last abdominal sternite, as described by McClay (1980). The sex ratio of the beetle was continuously monitored, using at least 100 adults collected from the field every month, between May and December 1989.

vations were also made on the hatchability of eggs.

RESULTS AND DISCUSSION

Z. bicolorata remained active under field conditions in Bangalore between May and October every year, which coincided with the rainy season. They underwent diapause within the soil as adults during the remaining months and emerged with the onset of rains.

Eggs were generally laid on the ventral surface of both young and old leaves. Oviposition was also observed on upper leaf surface, occasionally on the stems and even flowers under field conditions. The adults oviposited

Table 1. Measurements of larval instars of *Z. bicolorata**

Instar	Head capsule width (mm)	Maximum body length (mm)
1	0.52 ± 0.03	1.78 ± 0.08
2	0.80 ± 0.03	2.93 ± 0.14
3	1.08 ± 0.02	4.60 ± 0.11
4	1.51 ± 0.05	6.92 ± 0.34

* n = 50

Table 2. Development of *Z. bicolorata**

Stage	Duration (Days)	
	Mean	Range
Egg	5.00 ± 0.00	--
Larva 1	3.58 ± 0.70	2 - 4
Larva 2	2.27 ± 0.49	2 - 3
Larva 3	2.31 ± 0.47	2 - 3
Larva 4	3.73 ± 0.72	3 - 5
Total larval	11.88 ± 0.59	11 - 13
Pupal	10.77 ± 0.61	10 - 12
Total development	27.73 ± 0.77	27 - 29

* n = 50

Ten pairs of freshly emerged adults were used for studies on age-specific fecundity and longevity. The pairs were maintained in separate cages and eggs counted on alternate days until the death of the female. The mortality of the males was also recorded. Obser-

singly or in clusters of about 6 eggs. The eggs were oblong, the surface finely reticulated and yellow, yellowish orange or occasionally orange. Although egg colour was reported to change from light to deep yellow (McClay, 1980), no such colour change was noticed

during the present studies. Orange- coloured eggs were seen mainly during the cold season when the insect was reared in the laboratory. The eggs measured 1.21 mm long and 0.56 mm wide (Table 1).

The eggs hatched in 5 days (Table 2). The newly hatched larvae were yellowish, turning creamy white as they grew. The body was slightly curved with a protrusible proleg-like structure at the posterior end, which was used in locomotion. The larvae moulted thrice, and the 4 larval stages could be differentiated by the width of their head capsules (Table 1).

The first two larval stages looked alike, except for size. Likewise the 3rd and 4th instar larvae had similar appearance. The 3rd and 4th instars could be differentiated from the earlier stages by their spiracles, which were seen as clear dark spots after the 2nd moult.

The newly hatched larvae fed initially on the area adjoining the oviposition site and later moved to the terminal and axillary buds, where they congregated and fed. The third and fourth instars fed mainly on the peripheral leaves. The four larval instars lasted for 3.58, 2.22, 2.31 and 3.75 days respectively, with a total larval life of 11-13 days (Table 2). The full grown larvae rested without feeding for a few hours to one day on the undersurface of leaves before they burrowed into the soil for pupation.

Pupation took place in a chamber formed by the larva 1-3 cm below the soil surface. They remained as pre-pupae for about a day before entering the pupal stage. The insect remained within the soil for 10-12 days before emerging as fully formed adult. Total development was completed in 27-29 days (Table 2).

The adults of *Z. bicolorata* were attractively coloured. The elytra were marked with undulating dark brown lines that ran longitudinally over an off white background. The rest of the body and appendages were dark brown, except that the pronotum had off white patches at the anterior edges.

The female pupae of *Z. bicolorata* were larger in size and weighed more than males. Similarly adult females were generally larger than males (Table 3). However, the sexes could not be separated based on size as there was considerable overlapping. But they were easily differentiated by the shape of the last abdominal sternite as described by McClay (1980). The posterior margin in the case of the female was entire, while it was slightly serrated at the tip in the male. In addition, the males also had a faint depression at the centre of the last abdominal sternite.

Table 3. Sexual dimorphism of *Z. bicolorata* pupae*

Particulars	Female		Male	
	Mean	Range	Mean	Range
Length (mm)	6.21 ± 0.29	5.56 - 6.50	5.74 ± 0.23	5.2 - 6.11
Width (mm)	3.85 ± 0.22	3.61 - 4.17	3.50 ± 0.11	3.33 - 3.67
Weight (mg)	41.00 ± 0.40	33 - 50	31.00 ± 0.30	24 - 35

* n = 20

The sex ratio was found to be in favour of females. Samples collected from the field at monthly intervals showed that the mean sex-ratio was 1 female: 0.40 males. The ratio of males was found to be highest during June (1:0.60) and lowest in September (1:0. 36) (Table 4).

The males of *Z. bicolorata* lived for 122-271 (mean 210.80) davs while the females had

Table 4. Sex-ratio of *Z. bicolorata* adults collected from the field during 1989

Month	No. observed	Sex-ratio (Female : Male)
May	112	1 : 0.60
June	105	1 : 0.62
July	111	1 : 0.54
August	137	1 : 0.54
September	151	1 : 0.36
October	515	1 : 0.40
November	275	1 : 0.38
December	120	1 : 0.46
Total	1526	1 : 0.40

Table 5. Longevity (days) and fecundity of *Z. bicolorata

Particulars	Mean	Range
Pre-oviposition period	20.10 ± 18.32	10 - 70
Oviposition period	103.40 ± 16.54	89 - 138
Post-oviposition period	7.60 ± 6.35	1 - 21
Longevity (Female)	129.30 ± 30.81	109 - 198
Longevity (Male)	210.80 ± 59.88	122 - 271
Fecundity	2520.90 ± 548.41	1695 - 3360

* n = 10

a shorter life span of 109-198 (mean 129.30) days (Table 5). Similar results were obtained when field- collected adults were reared in the laboratory. As the sex-ratio favoured females, with the males constituting only about 30% of the population, longer survival of males would be advantageous in ensuring fertilization of all females, since the adults were capable of mating repeatedly throughout their life span.

Freshly emerged adults were observed to mate only from the 5th day. Mating was found to last as long as 3 hours. Pre-oviposition period lasted for 10-70 days. Oviposition occurred at all times of the day and continued for 89-138 days. Post-oviposition period was short and the adults died within 1-21 days after the termination of egg laying (Table 5).

The total number of eggs laid by a female ranged between 1695-3368 (mean 2520.90). The females were capable of laying up to 45 eggs per day and 299.60 eggs per week. The maximum number of eggs were laid between the 7th and 15th weeks, with a peak during the 9th week (Fig. 1). Although oviposition extended for 29 weeks from the date of emergence, 50% of the eggs were found to be laid by the 10th week, 75% by the 14th week and 90% by the 18th week.

It was reported earlier that *Z. bicolorata* produced an average of 836 eggs per female, with a maximum of 1786 (McFadyen and McClay, 1981). During the present studies the beetles were found to be capable of laying nearly thrice the number of eggs reported earlier. These variations in the longevity and fecundity may be due to differences in environmental factors including temperature, availability of food, etc. For example, in *Lixophaga diatraea* (Towns.) (Diptera : Tachinidae), the size of the adult was shown

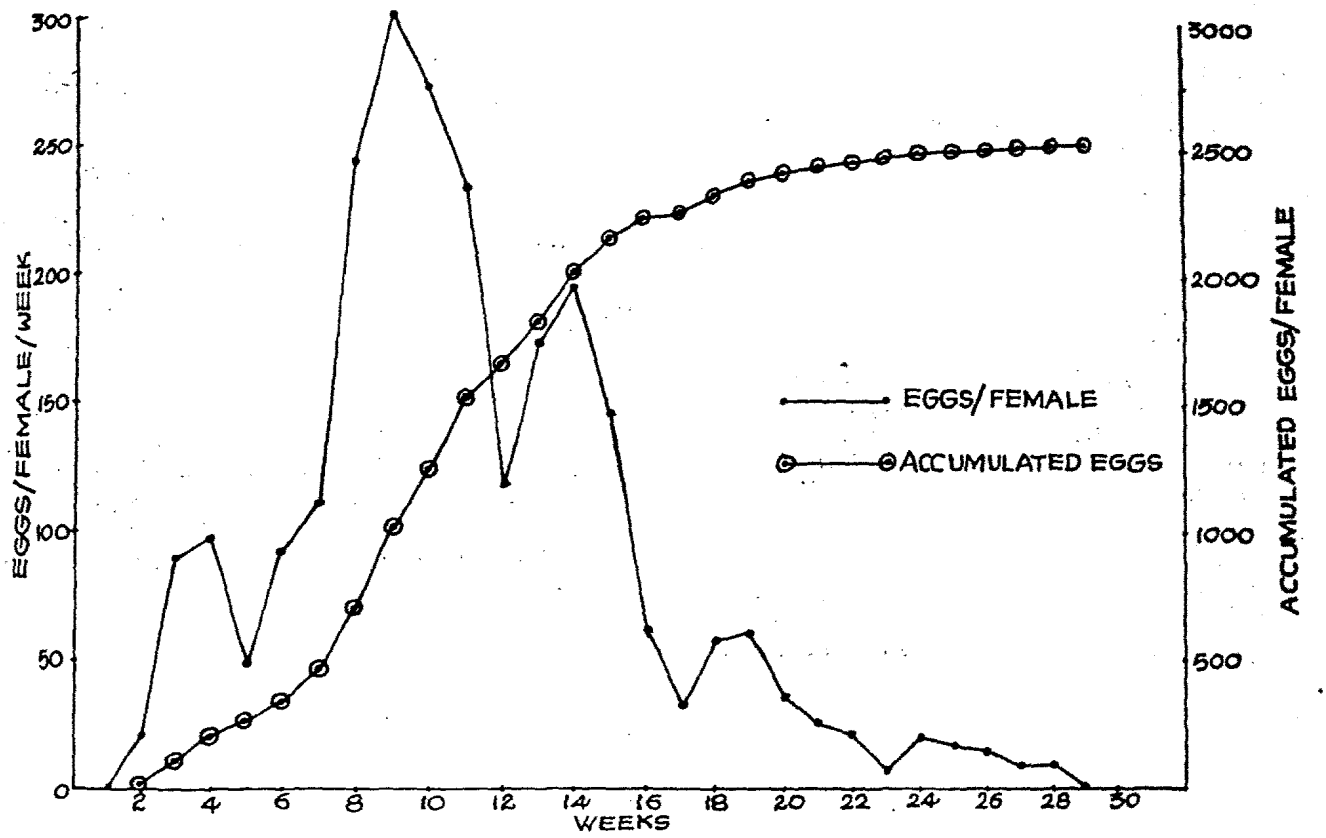

Fig.1 Age-specific fecundity of *Z. bicolorata*

to be affected by the amount of food available to the larvae (King *et al.*, 1976), which in turn affected their reproductive potential (Etienne, 1972). Similarly, temperature was found to affect the longevity and fecundity in another tachinid fly, *Eucelatoria bryani* (Sabroski) (Bryan *et al.*, 1972).

Although the fecundity of *Z. bicolorata* was high, only about 30-53% of the eggs hatched under laboratory conditions. Similar results were obtained when eggs collected from the field between May and November were kept under observation in the laboratory. Observations on field-collected eggs also indicated that the percentage of hatching was higher earlier in the breeding season (May to July) as compared to later months (August to October).

The present studies clearly indicate that *Z. bicolorata*, in spite of low egg hatchability, has all the qualities of a potential biological control agent. This is borne out by the rapid defoliation of parthenium caused by the beetle in Bangalore and surrounding areas (Jayanth, 1991). However, it remains to be seen whether the beetle can be effective in all climatic regions in the country, infested by the weed.

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