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Biology of *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) and Their Feeding Potential on Parthenium and Sunflower

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Studies on biology of *Zygogramma bicolorata* Pallister on *Parthenium hysterophorus* (Linnaeus) showed that the mexican beetle laid small, oblong, elongated, light yellow eggs on leaf surface and lid of the container under the laboratory condition. The average incubation period and hatching percentage were, 4.40 ± 0.49 days and 66.82 ± 2.17 per cent, respectively. The larvae passed through four instars. The average larval period was 11.78 ± 1.02 days while pre-pupal and pupal period were, 1.32 ± 0.47 and 6.56 ± 0.50 days, respectively. The average pre-oviposition, oviposition and post-oviposition periods were, 8.68 ± 0.653, 53.30 ± 1.53 and 18.58 ± 0.81 days, respectively. The average fecundity of the female was 1019.08 ± 18.37 eggs during entire life span. The average longevity of male and female were, 85.48 ± 2.16 and 80.56 ± 1.47 days, respectively. Total life cycle lasted for 109.54 ± 2.47 days (male) and 104.62 ± 1.65 days (female). *Z. bicolorata* consumed 117.56 ± 0.32 mg per individual when reared on *P. hysterophorus w*hereas first and second instar larvae failed to feed on *H. annus* and could not survive. During entire life period, third, fourth instar larvae and adults consumed 14.18 ± 0.28 mg per individual when reared on sunflower.

Key words: *Zygogramma bicolorata, Parthenium hysterophorus, Helianthus annus,* biology, feeding potential

Parthenium hysterophorus L. commonly known as or white top or congress grass in India, is a herbaceous, erect annual plant belonging to the family Asteracae (Compositae). The origin of parthenium is considered to be Mexico, America, Trinidad and Argentina. The weed was first brought to India as an ornamental plant in 1910 but it failed to establish. Later on it was introduced in India in the 1950's along with imported wheat from United States of America under PL-480 Project. In India, it was first reported from Pune in 1955 (Singh, 1997). At present parthenium has invaded about 35 million hectares in India. It is a nuisance on road sides, railway tracks, barren lands, waste lands, industrial areas, on the sides of open drainage system and irrigation canals, besides invading agricultural crops, orchards and forest area. It mainly spreads through seeds. Single plant can produce about 5,000 to 25,000 seeds. Seeds are very small and light in weight so easily carried or transported by wind, water or through various human activities. In general, parthenium is a poisonous, pernicious, problematic, allergic and aggressive weed posing a serious threat to human being and livestock. Besides ill effects, it also causes several other problems like blockage of common pathways and reduces the aesthetic values of parks, gardens and residential colonies (Anonymous, 2010).

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The Mexican beetle, *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) an effective bio-control agent of *P. hysterophorus,* was introduced in 1983 from Mexico to Bangalore. Both adults and larvae of *Z. bicolorata* can feed on leaves, terminal buds and leaf blades of parthenium. Since the first release in the field in 1984 at Bangalore, the beetles became established in most part of the South India and many parts of the Central and North India. In many states of India, beetles have been established and contributing to controlled parthenium very effectively and economically without causing hazards to the existing ecosystem (Anonymous, 2010). Inspite of prosperous biodiversity of this important predator, very scanty information is available on biology of *Z. bicolorata* on congress grass, *P. hysterophorus* and feeding potential on congress grass, *P. hysterophorus* Sunflower, *Helianthus annus.*

Materials and Methods

Studies were conducted at Bio-control Laboratory, Department of Agricultural Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat.

Laboratory culture of P. hysterophorus and Sunflower, Helianthus annus (Linnaeus)

The seeds of parthenium were sown in plots of

2 X 2 M_2 area covered with mosquito net whereas seeds of *H. annus* were sown in pots. These plants were used as a food for further study of biology and feeding potential of *Z. bicolorata.*

Culturing Z. bicolorata

Initial culture of *Z. bicolorata* adults were brought from Rajendra Agricultural University (Pusa), Samastipur, Bihar and reared in Bio-control laboratory, Department of Agricultural Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari. Beetles were confined in transparent glass jar (10 cm in height and 5 cm in diameter); and provided with parthenium leaves as food. The leaves were provided in the form of bouquets, with their cut ends covered with moist cotton swab to prevent the leaves from quick drying. Freshly laid eggs of *Z. bicolorata* as well as first instar larvae were used for further multiplication. Food was changed daily. *Z. bicolorata* laid eggs on the under surface of leaves and under surface of lid of the container. They were removed individually with the help of fine camel hair brush and placed in separate petridishes (110mm) for further rearing. Care was also taken to avoid mechanical injury during transfer of eggs. On hatching larva was also provided with sufficient leaves of parthenium as a food. Continuous supply of parthenium leaves was made for maintaining laboratory culture of *Z. bicolorata.* Full grown larvae were provided with moistened soil for pupation. Freshly laid eggs of *Z. bicolorata* and first instar larvae were used throughout the study of biology and feeding potential.

Biology of Z. bicolorata on P. hysterophorus

The study on biology of *Z. bicolorata* on *P. hysterophorus* was carried out in the laboratory during March 2010 to July 2010 at 29.41 ± 1.74 $_0$C and 58.32 ± 2.82 per cent relative humidity. A set of 50 eggs was used to study the biology of *Z. bicolorata*. Egg period was assessed as a time between date of egg laying and date of egg hatching. The colour and shape of eggs were also observed. With a view to determine the number and duration of larval instars, the newly hatched larvae of were transferred and kept individually in the plastic petridishes (110mm) and fed with parthenium leaves. The size of eggs and each instar larva were measured under microscope with the help of occular and stage micrometers. The total larval period was calculated from the date of egg hatching to the date of formation of pre-pupa. For the pre-pupal period, the larva was observed from the time when it stopped feeding and became sluggish when it turned to pupa. The duration between formation of pupa to the emergence of adult was considered as pupal period. The length and breadth of pupa were measured with the help of scale. Adults were observed for their colour, shape and size with the help of scale. In order to determine the pre-oviposition period, the newly emerged 25 pairs adults of *Z. bicolorata* were kept separately in plastic container (10 cm in height and 5 cm in diameter). A bouquet of parthenium leaves was provided as food. The period between the emergence of adult female and commencement of egg laying was recorded as the pre-oviposition period. Period between commencement the egg laying and ceasing of the egg laying by individual female was recorded as oviposition period and period between ceasing of egg laying to death of female was considered as post-oviposition period. Eggs laid by female were collected and counted daily in the morning (8:00 to 10:00 am). The total number of eggs laid during the life span of the adult female was considered as its fecundity. Longevity of male and female *beetles* was calculated separately from the date of emergence to death of adults. Total life cycle was considered as the period between the date of egg laying to the death of adults. In order to determine the sex ratio (Male: Female) under laboratory condition, counted number of earthen cocoons were kept in plastic containers (10 cm in height and 5 cm in diameter) and the numbers of male and female beetles emerged were recorded.

Feeding potential of Z. bicolorata on P. hysterophorus and H. annus

The study of feeding potential were carried out in the laboratory during September, November 2010 at 28.42 ± 1.43 $_0$C and 60.74 ± 2.36 per cent relative humidity. Set of 50 first instar larvae and newly emerged adults were used for study.

Larva

A set of ten first instar larvae were confined in the petridishes (110mm). The larvae were provided with leaves of parthenium and sunflower separately on weight basis during morning hours (8:00 to 10:00 am). For recording the water loss from food (leaves of parthenium and sunflower) the same procedure was followed for control without larvae. For calculation of feeding potential of grub, fresh food was supplied to each container with 10 numbers of larvae on weight basis. The weight of consumed food was calculated by subtracting the weight of remaining food after feeding in 24 hours and control from the weight of supplied food. In case of *H. annus*, first and second instar larvae failed to feed on *H. annus* and could not survive hence, these instars were reared on *P. hysterophorus* and from third instar onwards they were transferred to *H. annus*.

Adult

The newly emerged beetles of *Z. bicolorata* were kept in glass jar (10 cm in height and 5 cm in diameter) . A set of ten adults were provided with leaves of parthenium and sunflower separately on weight basis during morning hours. For recording the water loss from food (leaves of parthenium and sunflower) the same procedure was followed for control in which adults were not released. The calculation of feeding potential of adult, fresh food was supplied to each container with 10 numbers of

adults on weight basis. The weight of consumed food was calculated by subtracting the weight of remaining food after feeding in 24 hours and control from the weight of supplied food.

Results and Discussion

Biology of Mexican beetle, Z. bicolorata on congress grass, P. hysterophorus

Egg: Eggs were generally laid singly or in clusters of 4 to 5 on leaf surface, occasionally on stem and flowers. While in laboratory condition, the eggs were laid on surface of the lid of the container. The eggs were small, oblong, elongated, smooth and light yellow. The eggs turned deep yellow a day before hatching. Individual egg measured 0.59 ± 0.03 mm in breadth and 1.51 ± 0.05 mm in length. The incubation period of *Z. bicolorata* under laboratory condition varied from 4 to 5 days and the hatching percentage varied from 63.41 to 70.45 per cent was reported by Parise *et al*. (2010).

Larvae: The larvae moulted thrice and passed through four larval instars. The freshly hatched larvae were pale yellow, turned creamish white as they grew. The body of larva was slightly curved with a protrusible proleg-like structure at the posterior end

Table 1. Morphometrics of life stages of *Z. bicolorata*

Stage	N=20	
	Breadth (mm) Av. ± S.D.	Length (mm) Av. ± S.D.
Egg	0.59 ± 0.03	1.51 ± 0.05
Larva- 1st Instar	0.55 ± 0.02	1.61 ± 0.14
2nd Instar	0.71 ± 0.03	2.38 ± 0.26
3rd Instar	1.07 ± 0.06	4.03 ± 0.40
4th Instar	1.40 ± 0.07	5.63 ± 0.53
Pre-pupa	1.88 ± 0.10	5.72 ± 0.27
Pupa	2.28 ± 0.07	5.65 ±0.11
Adult- Male	2.97 ± 0.13	5.91 ± 0.10
Female	2.50 ± 0.10	5.66 ± 0.15

used for locomotion. The head was distinctly visible, body elongated, legs visible while moving. The first and second instars looked alike, except for size. Likewise third and fourth instar had similar appearance. The third and fourth instars could be differentiated from the earlier stages by their spiracles, which were seen as dark spots after the second moult. The 1st, 2nd , 3rd and 4th instars measured 0.55 ± 0.02, 0.71 ± 0.03, 1.07 ± 0.06 and 1.40 ± 0.07 mm in breadth while 1.61 ± 0.14, 2.38 ± 0.26, 4.03 ± 0.40 and 5.63 ± 0.53 mm in length. The four larval instars duration were, 3.02 ± 0.51, 2.88 ± 0.33, 2.40 ± 0.49 and 3.48 ± 0.73 days, respectively, with total larval duration of 11.78 ± 1.01 days, these findings conform to reports of Parise *et al.* (2010).

Pupa: The larvae remained as pre-pupae for about a day before entering the pupal stage. When they were about to pupate, they turned transparent creamish white to light yellow colour and buried 1 to 3 cm deep in the soil for pupation after forming a spherical earthen cocoon around. They remained within soil for 6 to 7 days before emerging as fully formed adult. The pupa measured 2.28 ± 0.07 mm in breadth and 5.65 ± 0.11 mm in length.

Adult: The newly emerged adults were soft, light brown and remained one day in the pupal cases during which their body hardened and the elytra turned shining brown. The beetle was oval, convex dorsally and flat ventrally. The adults were attractive in colour. The elytra were marked with undulating dark brown lines that run longitudinally over an off white background. The rest of body and appendages were dark brown, except that the pronotum had off white patches at the anterior edges.

Males were smaller (5.91 ± 0.10 mm) than females (5.66 ± 0.15 mm). The breadth of male was 2.97 ± 0.13 mm and that of female was 2.50 ± 0.10 mm. The posterior margin of the female was smooth while it was slightly serrated at the tip in the male. In addition, the males also had a faint depression at the center of the last abdominal sternite. The per cent adult emergence varied from 60 to 70 %. Freshly emerged adults mated from 5th day. Mating lasted for 3 to 4 hours. The pre-oviposition period was around 8 to 10 days. The egg laying (oviposition) continued for 50 to 56 days. The post oviposition period varied from 17 to 20 days. The number of eggs laid by female during its entire life span ranged from 988 to 1054 eggs (mean 1019.08 ± 18.37 eggs) which was similar to the reports of Viraktamath *et al.* (2004). The male beetles could live for 81 to 89 days while the female for 77 to 84 days, but according to Kour and Shenhmar (2008) the male and female lived for 74.33 and 64.93 days, respectively. The differences accounted here may be due to the environmental condition prevailing in the area. Based on the morphological characters mentioned earlier the adults were differentiated into their sexes. Out of 336 adults emerged from laboratory mass culture during the period of study, 189 were females and 147 were males which revealed female preponderance over male. The sex ratio (Male: Female) varied from 1: 1.00 to 1: 1.43

Table 2. Biological parameters of *Z. bicolorata* on *P. hysterophorus* under laboratory condition

Particulars	Av. ± S.D.
Incubation period (Days)	4.40 ± 0.49
Hatching percentage (%)	66.82 ± 2.17
Larval period (Days)	
1st Instar	3.02 ± 0.51
2nd Instar	2.88 ± 0.33
3rd Instar	2.40 ± 0.49
4th Instar	3.48 ± 0.73
Total larval period (Days)	11.78 ± 1.02
Pre-pupal (Days)	1.32 ± 0.47
Pupal period (Days)	6.56 ± 0.50
Pre-oviposition period (Days)	8.68 ± 0.65
Oviposition period (Days)	53.30 ± 1.53
Post-oviposition period (Days)	18.58 ± 0.81
Adult emergence (%)	64.44 ± 2.81
Sex ratio (Male: Female)	1: 1.29
Adult longevity (Days)	
Male	85.48 ± 2.17
Female	80.56 ± 1.47
Total life cycle (Days)	
Male	109.54 ± 2.47
Female	104.62 ± 1.66
Fecundity	1019.08 ± 18.37

Table 3. Feeding potential of *Z. bicolorata* on *P. hysterophorus* and *H. annus*

Stage	*P. hysterophorus*			*H. annus*	
	No. Observations	Wt. of Consumed Food per Day (mg/ individual) Av. ± S.D.	Total Wt. of Consumed Food (mg/ individual) Av. ± S.D.	Wt. of Consumed Food per Day (mg/ individual) Av. ± S.D.	Total Wt. of Consumed Food (mg/ individual) Av. ± S.D.
Larva					
I instar	50	2.93 ± 0.01	8.80 ± 0.04	0	0
II instar	50	6.13 ± 0.04	18.38 ± 0.11	0	0
III instar	50	9.62 ± 0.03	28.85 ± 0.01	0.56 ± 0.03	1.68 ± 0.09
IV instar	50	76.44 ± 0.37	30.58 ± 0.15	2.00 ± 0.06	7.99 ± 0.25
Total consumption	200	26.32 ± 0.06	86.60 ± 0.18	2.56 ± 0.05	9.67 ± 0.22
Adult	50	0.37 ± 0.00	30.96 ± 0.17	0.13 ± 0.00	4.51 ± 0.01
Total consumption during entire lifespan	250	26.69 ± 0.06	117.56 ± 0.32	2.69 ± 0.05	14.18 ± 0.28

with an average of 1: 1.29. Similarly, Jayanth and Bali (1993) and Kour and Shenhmar (2008) reported sex ratio (Male: Female) which was 1: 2.5 and 1: 3, respectively.

Feeding potential of Z. bicolorata on P. hysterophorus and H. annus

Larva reared on P. hysterophorus and H. annus

The larva of *Z. bicolorata* was voracious feeder and active during feeding. The young larva fed on young leaves of plant while that of older instars damage all plant parts leaving behind midribs. They fed on leaves, terminal buds but very often on the young leaves of the *P. hysterophorus*. The total consumption on leaves of *P. hysterophorus* by the larva during its first, second, third and fourth instars were; 8.74 to 8.86 (Av. 8.80 ± 0.04), 18.19 to 18.49 (Av. 18.38 ± 0.11), 28.70 to 28.95 (Av. 28.85 ± 0.01) and 30.37 to 30.74 (Av. 30.58 ± 0.15) mg per individual, respectively (Table 3). The feeding capacity of *Z. bicolorata* during entire larval duration varied from 86.38 to 86.86 mg with an average of 86.60 ± 0.18 mg per individual. Bhumannavar and Balasubramanian (1998) reported that per day consumption of first, second, third and fourth instar larva of *Z. bicolorata* were ; 2.67 ± 0.48, 5.08 ± 0.25, 11.01 ± 5.81 and 8.10 ± 0.37 mg per individual, respectively when reared on *P. hysterophorus.* The first and second instar larvae of *Z. bicolorata* failed to feed on *H. annus* and could not survived while total consumption by the third and fourth instars larva varied from 1.56 to 1.80 (Av. 1.68 ± 0.09) and 7.75 to 8.37 (Av. 7.99 ± 0.25) mg per individual, respectively.

Beetle reared on P. hysterophorus and H. annus

Data on per day consumption of *Z. bicolorata* adults revealed that the adults consumed 0.37 to 0.38 (Av. 0.37 ± 0.00) and 0.13 to 0.14 (Av. 0.13 ± 0.00) mg per day per individual whereas adults consumed 30.66 to 31.09 (Av. 30.96 ± 0.17) and 4.40 to 4.63 (Av. 4.51 ± 0.01) mg per individual during its lifespan on *P. hysterophorus* and *H. annus*, respectively.

Total feeding potential of Z. bicolorata on P. hysterophorus

Total feeding potential of mexican beetle varied from 117.05 to 117.86 (Av. 117.56 ± 0.32) and 13.93 to 14.64 (Av. 14.18 ± 0.28) mg per individual on *P. hysterophorus* and *H. annus* during their entire lifespan, respectively. When the freshly emerged beetle were continuously exposed to *H. annus*, feeding was noticed but at a lower rate when compared to feeding parthenium. Besides, it was also evident that parthenium was more preferred host rather than *H. annus* as reported by Swamiappan *et al.* (1997).

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