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Feeding efficiency and behaviour of different age Groups of *Zygogramma bicolorata* P Mexican Beetle, on *Parthenium hysterophorus* L. in Raipur, Chhattisgarh

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ABSTRACT: The noxious and problematic weed, *Parthenium hysterophorus* belongs to family Asteraceae (Linnaeus), well known worldwide as 'carrot grass' or 'white top' or 'congress grass' and 'gajar ghans' or 'chatak chandni' in hindi. A different combination of integrated approach can be used to manage *Parthenium hysterophorus* effectively. The biological control of *Parthenium* was inspect through a leaf beetle, at laboratory of Biocontrol, Department of Entomology, IGKV, Raipur, Chhattisgarh. *Z. bicolorata* is not yet well established and spread in Chhattisgarh though it is considered as a safe biocontrol agent. Therefore, to investigate the feeding behaviour and feeding efficiency of the Mexican beetle, *Z. bicolorata,* on three different age group of host plant *i.e.* early stage, pre-reproductive and reproductive stage of *Parthenium* present study was carried out by releasing various numbers of beetles *i.e.* 2, 3, 4 and 5 pairs. In the feeding behaviour of Mexican beetle, *Z. bicolorata*, it was observed that the newly hatched grubs initially fed on the leaf area adjoining to the oviposition site and then migrated to the terminal and axillary buds. Later on, the grubs moved onto the leaf blades as they grew. Younger grubs preferred to feed on tender leaves, whereas older grubs fed on matured leaves. The younger grubs started feeding from the leaf margin and moved inwards, while adult beetles started feeding from the leaf margin and moved all over the plants parts. As far as feeding efficiency was concerned, on the basis of overall mean of two years data, minimum time taken was (3.50days) for complete defoliation by 5 pairs of beetles followed by (4.50 days) by three pairs whereas, maximum time was taken by 2 pairs of *Z. bicolorata* (17.00 days) for complete defoliation of a single plant.

Keywords: *Parthenium hysterophorus,* Mexican beetle, *Zygogramma bicolorata,* feeding behaviour, defoliation.

INTRODUCTION

In India *Parthenium hysterophorus* (Linnaeus) is well known as 'carrot grass' or 'white top' or 'congress grass' and 'gajar ghans' or 'chatak chandni' in hind. It belongs to family Asteraceae. It is native of tropical and sub-tropical South and North America and found to invade into Africa, Australia and Asia. It is a herb of geotropical origin which has now spread in too many parts of the world (Adkins and Shabbir 2014), and has become one of the main weeds in almost all types of agricultural lands besides infesting wasteland, community land, road and railway track sides including forests (Navie *et al*., 1996; Jaiswal and Ganguli 2020; Jaiswal and Ganguli 2021). In India and Australia it has achieved the status of major weed (Bhateria *et al*., 2015). It is an aggressive weed posing a serious threat to the environment and biodiversity (Khaket *et al*., 2015). *Parthenium* is an annual herb with a deep-penetrating taproot and an erect shoot system. As it matures, the plant develops many branches on its upper half, and may eventually grow up to two meters (McFadyen, 1992). With good rainfall and warm temperature, *Parthenium* has the ability to germinate and establish at any time of the year (Navie *et al*., 1996; Tamado *et al*., 2002). Flowering usually commences 6–8 weeks after germination and soil moisture seems to be the major contributing factor for flowering (Navie *et al*., 1996). Pollination is primarily governed by wind (Lewis *et al*., 1988). *Parthenium* by allelopathic effects inhibits germination and growth of the other plants (Srivastav *et al.,* 1985). According to Kumari *et al.* (1985), crop plants cell survival and chlorophyll content were markedly reduced when *Parthenium* extracts were directly sprayed on them. In artificial feeding tests on live stock, majority of buffaloes, bulls and calves developed severe dermatitis and died with 8-30 days (Narsimhan *et al.,* 1977). In 1983 the Mexican beetle, *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae) was imported into India for the

biological control of the noxious *Parthenium* weed, *P. hysterophorus* L. Grubs and adult beetles feed voraciously on the foliage and inflorescence and remains confined to congress weed (Annadurai 1990; Jayanth and Nagarkatti 1987). The bio-ecology (Dhiman and Bhargava 2005) and *in vitro* rearing of the beetle on *Parthenium* has been well documented (Jayanth *et al*., 1996; Kulkarni *et al*., 2000). Although the insect established readily, population build-up was noticed only in 1988 and by 1994, it had spread over 200000 sq km area in and around Bangalore from the epicenter (Jayanth and Visalakshy 1994). The beetle is known to occur throughout the year but the insect diapauses over an extended period of time in nature (Jayanth, 1987) resulting in extensive proliferation of the weed in its absence. Biological control of *Parthenium* weed is considered to be the most cost effective, environmentally safe and ecologically viable method (Dhileepan *et al*., 2000a). It was documented to control *Parthenium* worth of Rs 10 million in terms of herbicide cost after initial release of bioagent, *Z. bicolorata* P. at Jabalpur, India (Sushil Kumar, 2006) and it was estimated that this bioagent had checked the spread of *Parthenium* in about eight million hectares of land since its release in India. Mexican beetle was found to be effective bio-control agent of *P. hysterophorus*, introduced from Mexico to Bangalore in 1983. Field releases of the beetles were initiated at Bangalore in 1984.

MATERIALS AND METHODS

A. Experimental details

(a) Location of study: Feeding potential of Mexican beetle, *Zygogramma bicolorata* P. were conducted in the Bio-control laboratory, Department of Entomology, IGKV, Raipur, Chhattisgarh, India (Plate 1)

(b) Collection and Rearing of *Zygogramma bicolorata* P.: *Z. bicolorata* adult beetles were collected from *Parthenium* plants at Raipur in the range of 2.0 km around Indira Gandhi Krishi Vishwavidyalaya, University campus, during 2018 from June - July, as the beetles emerged after diapuase during these months. The collected beetles were reared under net house as well as in the Biocontrol laboratory.

Beetles were placed in plastic basins. The basins were filled with soil up to 10 cms. Three fresh *Parthenium* plants of an average height of 24.60cms having flowers was planted in the basins for feeding of beetles. Plastic net covers were used for covering basins. On both, plastic net and leaves, egg laying, (both upper and lower side) were observed. Mated pairs of beetles were selected and transferred to new plastic basins of the same size with *Parthenium* plant. The basins were replenished with fresh *Parthenium* plant till the female beetle survived. Temperature was maintained at an average of 25±5°C during the experimental period.

B. Feeding potential of Mexican beetle, Z. bicolorata P.

(a) Observations recorded: Adult Mexican beetles were collected from the IGKV fields and maintained in the Bio-control laboratory and its mass multiplication was done and maintained on potted plants of *Parthenium* under net. For this, experiment was set up under completely randomized design (CRD) comprising of three different age groups of *Parthenium* plants *i.e.* early stage (mean height of plant 20.05 cm and mean number of leaves 8.42/plant), pre-reproductive (non-flowering, mean height 35.09 cm and mean number of leaves 20.79/plant) and reproductive (flowering, mean height 53.70 cm and mean number of leaves 33.42/plant) and replicated thrice (Plate 2). On each potted plant four treatments comprising of 2, 3, 4 and 5 pairs of beetles were released. Observations were recorded on alternate days for the number of insects established and time taken (number of days) for complete defoliation of plants at each stage. The data obtained from the experiment was transformed accordingly and analyzed statistically.

RESULTS AND DISCUSSION

Feeding behaviour of Mexican beetle, *Z. bicolorata* P.

For testing the feeding behaviour of Mexican beetle, *Z. bicolorata*, different numbers of beetles *viz.*, 2, 3, 4 and 5 pairs were released on three different stages of host plant *i.e.* early stage, pre-reproductive and reproductive stage of *Parthenium* weeds. Observations were recorded on every alternate day for the number of insects established and time taken (number of days) for complete defoliation of plant at each stage. The experiment was conducted in 2018 -19 and repeated in 2019-2020.

In the studies on feeding behaviour of Mexican beetle, *Z. bicolorata*, it was observed that the newly hatched grubs initially fed on the leaf area adjoining to the oviposition site and then migrated to the terminal and axillary buds. Later on, the grubs moved onto the leaf blades as they grew. Younger grubs preferred to feed on tender leaves, whereas older grubs fed on matured leaves (Plate 3). The younger grubs started feeding from the leaf margin and moved inwards, while adult beetles started feeding from the leaf margin and moved all over the plants parts.

1. Young stage (early stage). The experiments conducted for testing the feeding efficiency of *Z. bicolorata* during 2018, revealed that all the treatments showed significant differences between each other. Minimum time taken for complete defoliation was (3.66 days) by 5 pairs followed by (4.33 days) by 4 pairs while maximum time taken was (7.66 days) by 2 pairs (Table 1).

In the second year *i.e.* in 2019, the minimum time taken for complete defoliation was (3.33 days) by 5 pairs followed by (4.66 days) 4 pairs whereas, maximum time taken was (8.00 days) by 2 pairs (Table 2).

2. Pre-reproductive stage (pre- flowering). Results of the studies on feeding efficiency of *Z. bicolorata* at pre- reproductive stage of host plants conducted during 2018, revealed that the minimum time taken for complete defoliation was (4.66 days) by 5 pairs

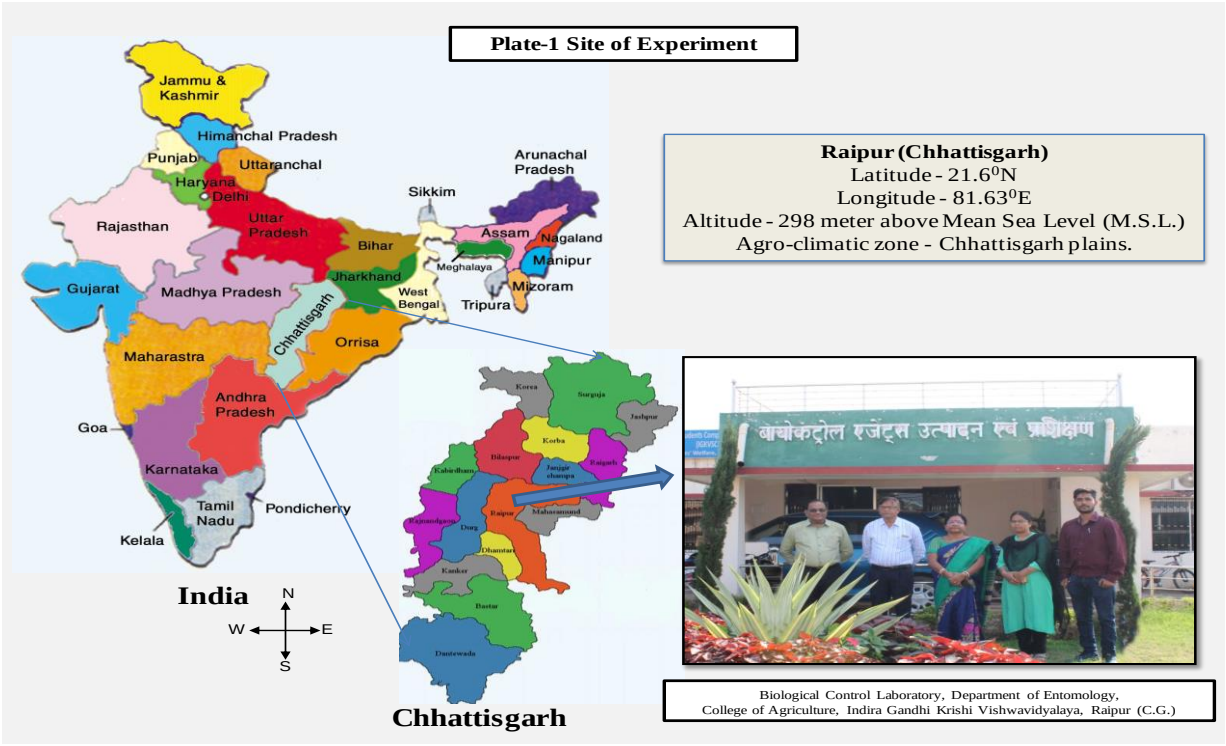
followed by (7.33 days) by 4 pairs while maximum time taken was (12.33 days) by 2 pairs.

In the second year 2019, the minimum time taken for complete defoliation was (5.33 days) by 5 pairs followed by (7.66 days) 4 pairs whereas, maximum time taken was (13.33 days) by 2 pairs.

3. Reproductive stage (flowering stage). Results of the feeding efficiency of *Z. bicolorata* at reproductive stage of host plants conducted during 2018, revealed that the minimum time taken for complete defoliation was (6.33 days) by 5 pairs followed by (10.00 days) by 4 pairs while maximum time taken was (17.33 days) by 2 pairs.

In second year 2019, the minimum time taken for complete defoliation was (6.33 days) by 5 pairs followed by (10.33 days) 4 pairs whereas, maximum time taken was (17.00 days) by 2 pairs.

The results of these experiments differed significantly among treatments. On the basis of overall mean of two years data indicated that, the feeding efficiency of Mexican beetle on different age of host plant *i.e.* early stage, pre- reproductive and reproductive treatments differed significantly.



A. **B.**

Plate 2. Feeding of Mexican beetle, *Z. bicolorata* Pallister in *Parthenium* weeds during 2018-2019. **A.** Grubs of Mexican beetle, *Z. bicolorata* Pallister feeding on leaf margin of *Parthenium.* **B.** Adults of Mexican beetle, *Z. bicolorata* Pallister feeding on leaf margin of *Parthenium.*

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Pairing different number of Mexican beetle, *Z. bicolorata*

Planting *Parthenium* plants of different age groups in pots under Semi-field conditions

Treatments wise experimental setup

Releasing beetles of *Z. bicolorata* on potted *Parthenium* plants

Recording observations on feeding efficiency of *Z. bicolorata* at different stages of *Parthenium* plants

Plate 3. Testing for complete defoliation of different age groups of *Parthenium* plants by releasing different number of paired *Z. bicolorata* beetles.

Table 1: Feeding efficiency of Mexican beetle, *Z. bicolorata* (P) for complete defoliation of different age of *Parthenium* by different number of beetles under laboratory condition during 2018- 19.

Sr. No.	Treatments	Early stage		Pre- flowering stage		Flowering stage		Mean
		Mean Height (cm)	Mean number of leaves	Mean Height (cm)	Mean number of leaves	Mean Height (cm)	Mean number of leaves	
		20.11	8.33	34.97	21.16	55.47	34.08	
1.	2 pairs	7.66 (2.86)		12.33 (3.58)		17.33 (4.22)		12.44
2.	3 pairs	6.33 (2.61)		10.66 (3.34)		15.33 (3.98)		10.78
3.	4 pairs	4.33 (2.20)		7.33 (2.80)		10.00 (3.24)		7.22
4.	5 pairs	3.66 (2.04)		4.66 (2.27)		6.33 (2.61)		4.89
Total		**21.98**		**34.98**		**48.99**		
SEm±		**0.083**		**0.079**		**0.085**		
CD @5%		**0.274**		**0.262**		**0.283**		
CV(%)		**5.665**		**4.454**		**4.131**		

The figures in parentheses represent square root transformed values

Table 2: Feeding efficiency of Mexican beetle, *Z bicolorata* (P) for complete defoliation of *Parthenium* by different number of beetles / plant under laboratory condition during 2019- 2020.

Sr. No.	Treatments	Early stage		Pre- flowering stage		Flowering stage		Mean
		Mean Height (cm)	Mean number of leaves	Mean Height (cm)	Mean number of leaves	Mean Height (cm)	Mean number of leaves	
		19.99	8.50	35.20	20.41	51.93	32.75	
1.	2 pairs	8.00 (2.92)		13.33 (3.72)		17.00 (4.18)		12.78
2.	3 pairs	5.66 (2.48)		11.00 (3.39)		16.00 (4.06)		10.89
3.	4 pairs	4.66 (2.27)		7.66 (2.86)		10.33 (3.29)		7.56
4.	5 pairs	3.33 (1.96)		5.33 (2.42)		6.33 (2.61)		5.00
Total		**21.67**		**37.32**		**49.66**		
SEm±		**0.079**		**0.101**		**0.103**		
CD @5%		**0.111**		**0.335**		**0.341**		
CV(%)		**5.439**		**5.524**		**4.943**		

The figures in parentheses represent square root transformed values

Table 3: Pooled mean feeding efficiency (days) of Mexican beetle, *Z. bicolorata* (P) for complete defoliation of *Parthenium* plant by different number of beetles under laboratory condition during 2018- 2020.

Sr. No.	Treatments	Early stage			Pre- flowering stage			Flowering stage			Grand total
		Mean Height (cm)		Mean number of leaves	Mean Height (cm)		Mean number of leaves	Mean Height (cm)		Mean number of leaves	
		20.05		8.42	35.09		20.79	53.70		33.42	
		2018-2019	2019-2020	Mean	2018-2019	2019-2020	Mean	2018-2019	2019-2020	Mean	
1.	**2 pairs**	7.66 2.86)	8.00(2.92)	**7.833**	12.33(3.58)	13.33(3.72)	**12.833**	17.33(4.22)	17.00(4.18)	**17.167**	**12.611**
2.	**3 pairs**	6.33 2.61)	5.66(2.48)	**6.000**	10.66(3.34)	11.00(3.39)	**10.833**	15.33(3.98)	16.00(4.06)	**15.667**	**10.833**
3.	**4 pairs**	4.33(2.20)	4.66(2.27)	**4.500**	7.33(2.80)	7.66(2.86)	**7.500**	10.00(3.24)	10.33(3.29)	**10.167**	**7.389**
4.	**5 pairs**	3.66(2.04)	3.33(1.96)	**3.500**	4.66(2.27)	5.33(2.42)	**5.000**	6.33(2.61)	6.33(2.61)	**6.333**	**4.944**
Total		**21.98**	**21.67**	**21.83**	**34.98**	**37.32**	**36.17**	**48.99**	**49.66**	**49.33**	**35.78**
SEM±		**0.083**	**0.079**		**0.079**	**0.101**		**0.085**	**0.103**		
CD @5%		**0.274**	**0.111**		**0.262**	**0.335**		**0.283**	**0.341**		
CV(%)		**5.665**	**5.439**		**4.454**	**5.524**		**4.131**	**4.943**		

The figures in parentheses represent square root transformed values

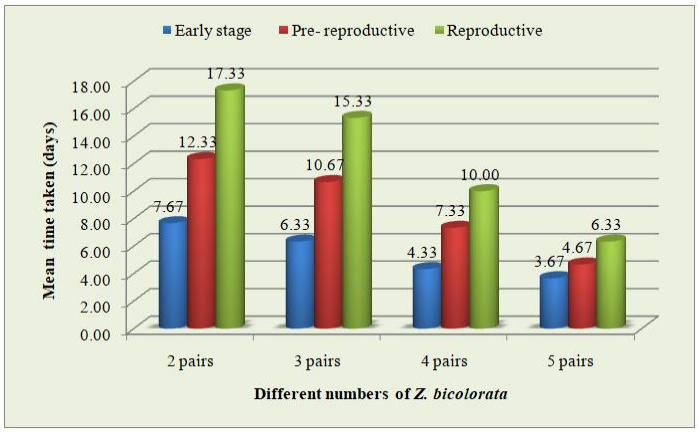

Fig. 1. Feeding efficiency of *Z. bicolorata* (days) for complete defoliation of *Parthenium* plant by different number of beetles / plant under laboratory condition during 2018-19.

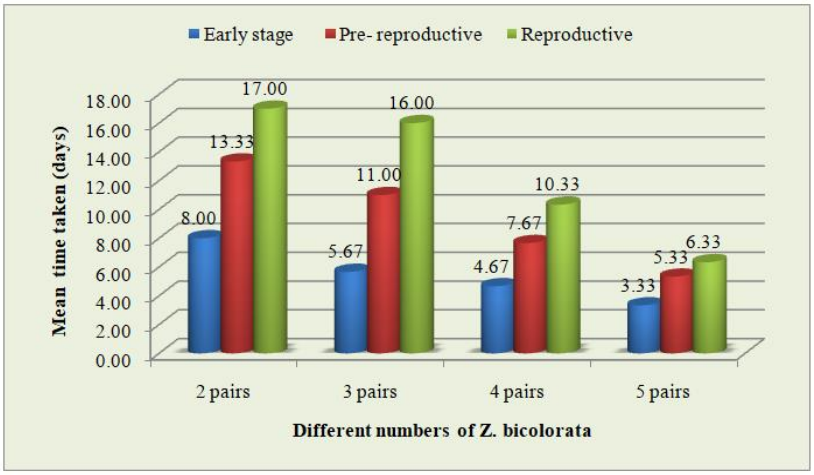

Fig. 2. Feeding efficiency of *Z. bicolorata* (days) for complete defoliation of *Parthenium* plant by different number of beetles/plant under laboratory condition during 2019-20.

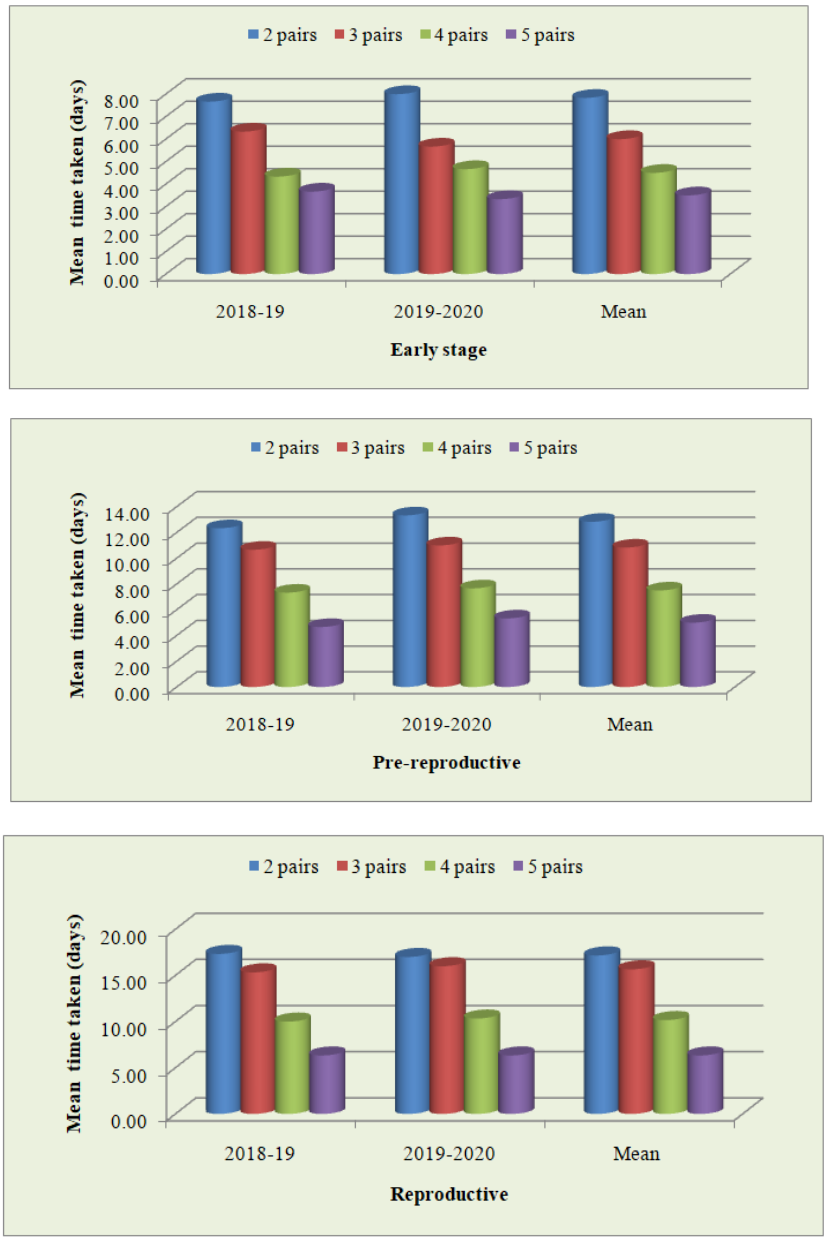

Fig. 3. Mean feeding efficiency (days) of *Z. bicolorata* for complete defoliation of *Parthenium* plant by different number of beetles/per plant under laboratory condition during 2018-2020.

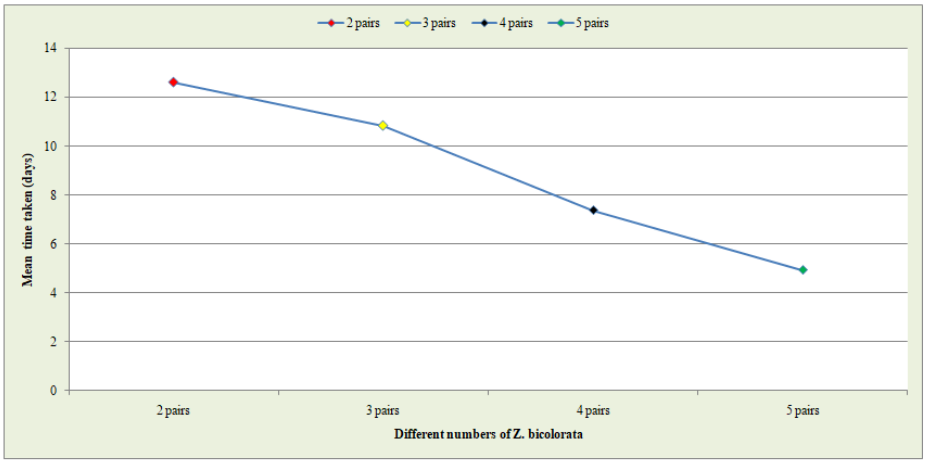

Fig. 4. Pooled mean feeding efficiency (days) of *Z. bicolorata* for complete defoliation of *Parthenium* plant by release of different number of beetles/plant under laboratory condition during 2018-2020.

The minimum time taken was (3.50days) for complete defoliation by 5 pairs of beetles in young stage, followed by (4.50 days) four pairs whereas, highest time was taken by 2 pairs of *Z. bicolorata* (17.00 days) for complete defoliation in flowering stage (Table 3).

The present findings are in agreement with Chandravanshi *et al.* (2018); Jaiswal and Ganguli (2021) who also reported that the feeding potential of Mexican beetle, *Z. bicolorata* P. was more pronounced at the early stage of the plant.

CONCLUSIONS

Thus, on testing the feeding of Mexican beetle, *Z. bicolorata,* by releasing various numbers of beetles *viz.*, 2, 3, 4 and 5 pairs on three different age groups of host plant *i.e.* early stage, pre-reproductive and reproductive stage of the noxious and problematic weed *P. hysterphorus* for two years, results revealed that, minimum time taken was (3.50 days) for complete defoliation by 5 pairs of beetles followed by (4.50 days) by three pairs whereas, maximum time was taken by 2 pairs of *Z. bicolorata* (17.00 days) for complete defoliation. Hence, for the biological control of *Parthenium* weed, 3 to 5 pairs of beetles/plant can be recommended.

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Conflict of Interest. None.

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