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Stage Specific food consumption and utilization by the Mexican beetle, *Zygogramma bicolorata* Pallister (Coleoptera: Chysomelidae) on *Parthenium hysterophorus* Linnaeus

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ABSTRACT

The food is the foremost need for the existence of all living organisms and the fluctuations in its availability strongly affects the population dynamics of both the primary and secondary consumers. In the present study we have investigated the effect of food (*Parthenium* weed) resource fluctuations, in terms of quality, on the feeding attributes of the *Parthenium* beetle, *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae). Quantitative food utilization indices were measured in different larval instars and physiological ages of adult *Zygogramma bicolorata* Pallister. Among the larval and adult stages of the beetle, third instar larvae and egg laying females ingested maximum food. Various growth parameters like relative consumption rate (RCR), relative growth rate (RGR) and approximate digestibility (AD) were relatively higher in the first, third and fourth instar and egg laying females. Efficiency of conversion of ingested food (ECI) and efficiency of conversion of digested food (ECD) were maximum in first, third and fourth instar larvae and decreasing trend was observed in second instar larvae. During pre-oviposition stage adult, these parameters increased tremendously in contrast to senescent stage. However, the fourth instars had higher feeding attributes than the adult females, proving them to be the better bio-control agents of Parthenium weed than the adult females. However, field based studies are still needed to validate the present findings.

Key words : *Zygogramma bicolorata, Relative growth rate, Approximate digestibility, Parthenium weed*

Introduction

Food is the foremost need for the existence of all living organisms, through its availability is rarely constant in the natural environment. The variation in the frequency and magnitude of food supply leads to the alternation of low and high food availability. (Rosenzweig, 1995; Ostfeld and Keesing, 2000). As a result, the population dynamics of both the primary and secondary consumers are strongly influenced, because the fluctuations in food availability significantly affect their growth and development (Ostfeld and Kessing, 2000; Beiber and Ruf, 2005).

In the present study we have investigated the ef-

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fect of food (Parthenium weed) resource fluctuations in terms of quality on the feeding attributes of the parthenium beetle, *Z. bicolorata.* This beetle is an effective biological control agent of the noxious weed, *Parthenium hysterophorus* L. (Family-Asteraceae) (Jayanath, 1987; Dhileepan *et al.*, 2000), which is native to tropical and South America and certain parts of Asia and Australia (Navie *et al.*, 1996). This weed possibly got entry into India from USA through imported food grains (Vartak, 1968) or through cereals obtained for experimental purposes (Lonkar *et al.,* 1974). It causes hay fever, asthama, nasal-dermal and naso-bronchial diseases, allergic rhinitis, allergic reactions, allergic popules, fatigue and severe dermatitis in humans (McFadyen, 1995; Das *et al.,* 2007). Moreover, the weed is not palatable to livestock due to its irritating odour, taste and presence of trichomes.

In India, the Parthenium beetle, *Zygogramma bicolorata* was introduced first in 1983 by the Indian Institute of Horticultural Research (IIHR), Bangalore for the management of Parthenium weed (Jayanath and Nagarkatti, 1987). The newly hatched larvae of *Z. bicolorata* feed voraciously on apical young leaves of Parthenium, burrow into the soil for pupation and complete their life cycle in about 23-33 days (Dhileepan *et al.,* 2000). In the study, we observed the effect of sudden change of food on their consumption rate, conversion efficiency and growth rates. It was assumed that the larvae reared on mature leaves would have better feeding attributes when switched over to early leaves than in the reverse scenario. Therefore, the study would not only provide information on the behavior of the feeding stages of *Z. bicolorata,* but would also help in assessing their energy budget for various biological activities. Moreover, the study would facilitate the mass multiplication of these Chrysomelid beetles in laboratories for the biological control of the parthenium weed.

Materials and Methods

Stock Maintenance

Adult males and females of *Z. bicolorata* were collected from the Faculty of Agricultural Sciences, Bhubaneswar, Odisha (Altitude) and paired randomly in plastic petridishes (9.0 × 1.5 cm^2). They were reared under constant abiotic conditions (27 ± 2°C; 65±5% relative humidity; 14:10 light: dark hours) in BOD incubator (Faculty of Agricultural Sciences, Bhubaneswar, Odisha) on daily replenished supply of the leaves of Parthenium weed. The eggs laid were collected every 24 hours and subsequent first instars were used for further experimentation.

Ten larvae each of different instars (maintained separately as stock culture) were provided with a cotton swab soaked in distilled water for a period of 16 h to clear the gut contents. After measuring the initial weight, the larvae were introduced into a 5 x 12 em rectangular plastic container. Before introduction of larvae, pre-weighed tissue paper (5 x 12 cm) was kept inside the bottom of the container to absorb semiso1id faecal material from the larvae.

Premeasured parthenium leaf (measured by Leaf area analyser) was provided to the larvae and allowed to feed for 24 h. At the end of each day of the experiment, the side wall of the container was cleaned with a fine camel hair brush to collect the excrement and kept on tissue paper. The tissue paper was dried at 80°C for a day. The difference in the weight of the tissue paper gave dry weight of the excreta while the difference in weight of the larvae gave the weight gain during the feeding period.

Experimental Design: Completely Randomized Design (CRD)

The first instars of *Z. bicolorata* were individually rared on parthenium leaves or the early leaves up to the third instar stage under abiotic conditions similar to that of the stock culture. After the instars moulted to fourth instars, they were weighed prior to the experiment (using CRD).

The experimental conditions were maintained for 24 hours. Thereafter, the larvae and food left were weighed in each petri dish. Thereafter, the food of the larvae was switched back to their respective rearing conditions. The same experiment was replicated for 10-day-old unmated adult females from each rearing condition under the above mentioned abiotic conditions.

All consumption and growth parameters were measured on dry weight basis. Utilization efficiencies and rates were determined according to Waldbauer (1968). The indices used were: Relative Consumption Rate (RCR), Relative Growth Rate (RGR), Approximate Digestibility (AD), Efficiency of Conversion of Ingested Food (ECl) and Efficiency of Conversion of Digested Food (ECD) to Biomass. These indices were calculated as follows:

$$RCR = \frac{\text{Wt of food eaten}}{\text{Duration of Experiment} \times \text{Mean wt of larvae}}$$

$$RGR = \frac{\text{Wt gain}}{\text{Duration of experiment} \times \text{Mean Wt of Larvae}}$$

$$AD = \frac{\text{Wt of food eaten} - \text{Wt of faeces}}{\text{Wt of food eaten}} \times 100$$

$$ECI = \frac{\text{Wt gain}}{\text{Wt of food eaten}} \times 100$$

$$ECD = \frac{\text{Wt of gain}}{\text{Wt of food eaten} - \text{Wt of faeces}} \times 100$$

$$\text{Consumption rate (mg-day}^{1}) = \frac{\text{Leaf biomass consumed by the larva/adult (mg)}}{\text{Feeding duration of the Larva/adult (days)}}$$

Results and Discussion

In the present study, four different larval instars and three different physiological ages of adults viz., preoviposition, oviposition and senescent (stage incapable of egg production) were taken for the study of food utilization. The amount of food consumption varied among the different stages. Data on comparative food utilization of *Zygogramma bicolorata* are presented in Table 1. Among the grub and adult stages, the maximum amount of food ingested was seen in third instar (10.44 ± 1.27 mg/day/grub) grub and egg laying adult (0.66 ± 0.20 mg/day/adult). The various growth parameters computed viz., RCR, RGR, AD, ECI and ECD were in accordance with different stages but with some exceptions. The relative consumption rate was higher in forth instar (0.91 ± 0.02) and third instar (0.76 ± 0.15) followed by second instar (0.51 ± 0.16), preovi positioning adult (0.26 ± 0.07) and ovipositioning adult (0.22 ± 0.06). While RGR and AD were higher during third instar (0.28 ± 0.23) and (81.1 ± 2.05) respectively. ECI and ECD were maximum during second and third instar, namely, 68.26 ± 2.75 and 69.95 ± 2.09 and least in first instar (29.36 ± 1.94) and fourth instar (39.69 ± 1.91) respectively. In adult stages, ECI was higher in pre-ovipositioning period (26.56 ± 5.95) compared to senescent stage adult (13.92 ± 1.75) (Table 1).

Moreover, the higher conversion efficiency, growth rate, ECI, AD% of fourth instars over the adult (ovipositioning adult) have also been reported earlier in ladybird beetles, but on a constant food resourses (Mishra *et al.*, 2011; Kumar *et al.*, 2013). Similarly Kchler *et al.* (1987) reported higher conversion efficiency for the nymphs of Central European grasshoppers than the adults. Omkar and Afaq (2011) reported higher consumption rates of fourth instars than the early instars and the conversion efficiencies and growth rates of early instars than the fourth instar in the Parthenium beetle, *Z. bicolorata.*

Conclusion

In brief, the present study demonstrates that the feeding habits of fourth instars and adult of *Z. bicolorata* are not significantly influenced by the sudden fluctuations in the food quality. But the fourth instars have higher feeding attributes than the adult proving them to be the better biocontrol agents of Parthenium weed than the adult females. The present result may further be exploited to mass multiply this Chrysomelid beetles in laboratories for the biological control of Parthenium weed. Nevertheless, field based studies are still needed to validate the present findings.

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Table 1. Consumption and food utilization parameters of *Zygogramma bicolorata* on *Parthenium hysterophorus*

Life stage	Consumption 1(mg/day/ind.)	RCR	RGR	AD%	ECI%	ECD%
I instar	2.6 ± 0.5	0.17 ± 0.03	0.02 ± 0.01	63.57 ± 4.01	29.36 ± 1.94	43.5 ± 2.45
II instar	4.93 ± 0.15	0.51 ± 0.16	0.26 ± 0.26	79.53 ± 3.39	68.26 ± 2.57	65.83 ± 2.10
III instar	10.44 ± 1.27	0.76 ±0.15	0.28 ± 0.23	66.86 ± 4.33	59.51 ± 9.06	69.95 ± 2.09
IV instar	8.6 ± 0.7	0.91 ± 0.02	0.08 ± 0.04	81.1 ± 2.05	32.86 ± 7.58	39.69 ± 1.91
Preovipositioning adult	0.80 ± 0.73	0.26 ± 0.07	0.15 ± 0.12	62.9 ± 4.33	26.56 ± 5.95	33.2 ± 5.72
Ovipositioning adult	0.66 ± 0.20	0.22 ± 0.06	0.17 ± 0.06	75.91 ± 2.01	20.96 ± 2.93	34.8 ± 4.27
Senescent adult	0.53 ± 0.31	0.10 ± 0.08	0.01 ± 0.02	39.1 ± 3.20	13.92 ± 1.75	48.9 ± 2.78

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