

ENHANCEMENT OF THE REPRODUCTIVE POTENTIAL OF *MALLADA BONINENSIS* OKAMOTO (NEUROPTERA: CHRYSOPIDAE), A PREDATOR OF RED SPIDER MITE INFESTING TEA: AN EVALUATION OF ARTIFICIAL DIETS

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Abstract - Green lacewing *Mallada boninensis* is an important predator of various soft-bodied arthropods, including red spider mites in tea. Efforts were made to develop mass rearing technology for this predator in a cost effective manner. Three combinations of artificial diets (Protinex (AD1), egg yolk (AD2) and royal jelly (AD3) based) were evaluated in comparison with standard diet (Protinex + Honey). All the tested diets influenced the egg-laying capacity of *M. boninensis*. The egg yolk-based diet resulted in more egg production than the other two diets. Survival of all life stages of *M. boninensis* was also observed on each diet and no significant difference was noticed. Results revealed that the egg yolk-based diet is the best of the three diet combinations tested in view of high fecundity and survival rate of *M. boninensis*.

Key words: Artificial diets, *Mallada boninensis*, red spider mite, mass rearing.

INTRODUCTION

Tea, *Camellia sinensis* (L) Kuntze, is a major cash crop in India. Being a monoculture crop, it is attacked by an array of insect and mite pests. Among them, the red spider mite *Oligonychus coffeae* (Acarina: Tetranychidae) is an important pest causing considerable crop loss in southern India (Muraleedharan et al. 2005; Babu et al. 2008). Red spider mite (RSM) management in tea mainly depends on the use of synthetic pesticides which results in undesirable effects such as proliferation of pesticide-resistant generations of pests, environmental contamination, the presence of pesticide residues in tea and the devastation of natural enemies (Roobakkumar et al. 2010). Alternative pest management strategies using natural enemies can potentially overcome these problems. Among the natural enemies that regulate the population of

red spider mite in south India, green lacewings are very important in view of its wide-spread occurrence in tea plantations (Babu et al. 2011).

In recent years, green lacewings are widely recommended for biological control programs (Singh and Jalali, 1991). Larvae feed on aphids, scales, early caterpillars, spider mites etc., infesting a variety of plants. Adults generally feed on nectar, pollen or honeydew but a few of them are predatory (McEven et al. 2001). Green lacewing, *Mallada boninensis*, has been reported as an efficient predator of RSM infesting tea and its biology and predatory potential on RSM has been studied (Babu et al. 2011).

Studies on the effect of inundative releases of laboratory-cultured lacewings against different pests have given satisfactory control (Ridgeway and Jones,

1968, 1969; Lingren et al. 1968; Scopes, 1969) for which large numbers of predators are required. The success of a pest management program using insect predators depends not only on their predatory efficiency but also on the feasibility of their mass multiplication in a cost effective manner (Thomson and Hagen, 1999). This could be achieved either by standardizing the larval rearing technique or by improving the adult diet to obtain maximum fecundity (Krishnamoorthy, 1984). Adult diet is considered as the most important parameter in increasing the egg production for the mass culturing of green lacewings.

Although there are so many reports available on the mass rearing procedures for several species of green lacewings (Venkatesan, 2002; Cohen and Smith, 1998; Vanderzant, 1969; Gautam and Navarajan Paul, 1987), studies focusing on the cost of effective mass rearing techniques for adult the green lacewing, *M. boninensis*, are limited. Keeping this in mind, an attempt was made to develop a simple mass rearing technology for adult *M. boninensis* using three different combinations of artificial diets. The combinations tried in this study are based on earlier investigations on different species of lacewings with slight modifications (Krishnamoorthy, 1984; Ulhaq et al., 2006; Hagen and Tassan, 1965).

MATERIALS AND METHODS

Egg masses of *M. boninensis* were collected from UPASI experimental farm (Valparai, Coimbatore district, Tamil Nadu, south India) and kept in plastic containers. After hatching, the larvae were reared in large plastic containers (4.5 cm×4.5 cm) and fed with the eggs of *Corcyra cephalonica* daily until pupation. Newly emerged adults were sexed and pairs of male and female were introduced into plastic containers (12.5 cm×12.5 cm) provided with different combinations of artificial diets (Table 1). Diets were provided in cotton swabs stuck on the periphery of the container.

The adult male and female kept in each container were fed with the same type of diet continuously

from the day of emergence until death. Pure water was also given in swabs in addition to the diets, as described by Krishnamoorthy (1984). Fresh diets were given every day. The top and peripheral sides of the plastic containers were covered with opaque paper to prevent the penetration of light from outside and as a provision for egg laying. The adult-rearing containers were checked carefully every day until the first egg was laid to determine the pre-oviposition period. Though the lacewings preferred to lay eggs on the surface of the papers used for covering the containers under lab conditions, some eggs were laid on the inner sides of the containers. Egg masses were harvested periodically and placed in separate containers for hatching. Hatchability, survival of larvae and adult emergence were recorded. The number of eggs laid by a single female during the life span was observed to record the fecundity. Data on the oviposition period were also recorded. Experiments were continued until the death of the female to record adult longevity. In the present investigation, no mortality was recorded in females in the first 25 days of experiment, whereas male mortality occurred within 10 days. Dead males were replaced with new males of the same age group from the laboratory stock culture. Experiments were replicated five times.

Data analysis

Multiple comparisons of reproduction and survival data were done by one-way ANOVA followed by a *post hoc* Duncan's Multiple Range Test (SPSS, 10).

RESULTS AND DISCUSSION

There was a marginal difference in the pre-oviposition period when reared on different artificial diets (Table 2; $F=3.458$; $df=3$; $P<0.05$). This can be attributed to variations in the amino acid content in the three different diets provided to the predator (McFarlane, 1985) because the maturation of the ovary and development of eggs occur during the pre-oviposition period (Slansky and Scriber, 1984). Our results on the pre-oviposition period are in line with Lee and Lee (2005) who reported that the pre-oviposition period of *Chrysopa pallens* was influenced by different adult

Table 1. Different combinations of artificial diets tested and their cost economics

Diets	Combinations	Cost (INR*) (for 1 litre)
Standard Diet (SD)	Protinex (60 g)+Glucose (40 g) in 250 ml of water	240
Artificial Diet 1 (AD1)	Protinex (40 g)+Yeast (30 g)+Honey (20 g)+Glucose (10 g) in 250 ml of water	350
Artificial Diet 2 (AD2)	Egg (25 ml)+Milk (50 ml)+Honey (25 ml)	225
Artificial Diet 3 (AD3)	Royal jelly (40 g)+Protinex (30 g)+Honey (20 g)+Glucose (10 g) in 250 ml of water	1800

*Indian Rupee

Table 2. Longevity and reproduction of *Mallada boninensis* reared on artificial diets (Mean*±SE)

Artificial Diets	Pre-oviposition period (Days)	Oviposition period (Days)	Longevity (Days)		No. eggs laid/day	Total No. of eggs laid
			Male	Female		
SD	7.60±0.32b	37.20±2.15a	39.00±4.14a	55.40±3.96a	4.90±0.21	177.60±5.27a
AD1	6.80±0.37ab	36.80±5.08a	39.20±5.84a	59.80±4.32a	6.55±0.52	245.60±6.54b
AD2	6.60±0.24a	36.60±0.40a	37.00±3.18a	58.40±1.17a	10.85±0.49	380.60±10.65c
AD3	6.40±0.24a	34.60±1.69a	37.60±2.38a	53.60±1.44a	8.14±0.54	305.00±2.88d

*Means followed by the same letter are not significantly different at 0.05 level as determined by DMRT

Table 3. Hatchability, survival and adult emergence of *M. boninensis* on different artificial diets

Artificial diets	Hatchability (%)	Larval survival (%)	Adult emergence (%)
SD	91.4±0.81a	91.02±0.68a	97.11±0.27a
AD1	90.2±0.86a	91.13±1.07a	97.07±0.31a
AD2	91.8±0.73a	90.41±0.59a	96.39±0.63a
AD3	92.4±1.66a	92.64±0.64a	94.99±1.69a

*Means followed by the same letter are not significantly different at 0.05 level as determined by DMRT

diets. However, the oviposition period did not significantly differ by different diets (Table 2; $F=1.657$; $df=3$; $P>0.05$).

The longevity of male and female *M. boninensis* (Table 2; Male: $F=0.068$; $df=3$; $P>0.05$ Female: $F=0.840$; $df=3$; $P>0.05$) did not differ significantly on the different diets. This observation is in contrast to the findings of Ulhaq et al. (2006) on *Chrysoperla carnea* reared on different artificial diets. The relationship between diets and the adult life of several predators has been established by McEven and Kidd (1995) and Krishnamoorthy (1984). The relationship

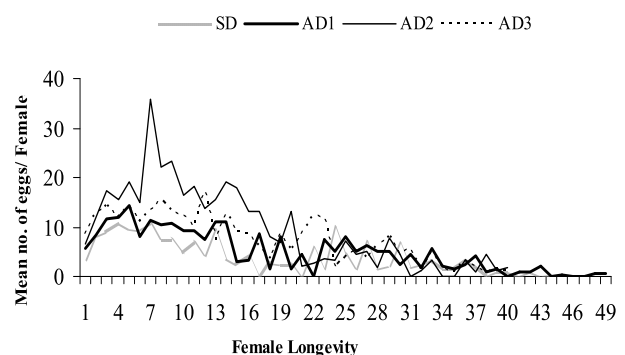


Fig. 1. Relationship between female longevity and fecundity in different artificial diets.

between fecundity and female longevity of *M. boninensis* is presented in Fig. 1. The number of eggs laid by the females increased up to a certain period and thereafter it decreased. A similar trend was noticed in the hymenopteran parasitoid *Diapetimorpha introita* when reared on an artificial diet. (Carpenter et al. 2000).

The number of eggs laid by a single *M. boninensis* was significantly influenced by the different artificial diets tested (Table 2; $F=155.29$; $df=3$; $P<0.05$). The egg yolk-based diet resulted in a higher fecundity than the other diets. A similar result was reported by Ulhaq et al. (2006) in *Chrysoperla carnea* when it was reared on an egg yolk-based artificial diet. The reason for the higher fecundity may be the presence of large amount of essential components like amino acid and the folic acids responsible for egg production as described by Ulhaq et al. (2006).

In the present investigation, when reared on an egg yolk-based diet, the maximum number of eggs laid by *M. boninensis* was 35.8 eggs per day (Fig. 1). Lee and Lee (2005) reported that *Chrysopa pallens* laid a maximum of 48.8 eggs per day and a minimum of 19.3 when maintained on different artificial diets. Several authors reported that the egg laying capacity of adults was influenced by artificial diets (Sundby, 1967; Gan et al. 2011; Unnithan and Mathenge, 1983). However, hatchability (Table 3; $F=0.735$; $df=3$; $P>0.05$), pupation (Table 3; $F=1.474$; $df=3$; $P>0.05$) and adult emergence (Table 3; $F=0.509$; $df=3$; $P>0.05$) of *M. boninensis* were not significantly affected by the different diets tested. This indicates the importance of the nutritional quality of a diet on the development of *M. boninensis*. Krishnamoorthy (1984) reported that the egg hatchability of green lacewing *Chrysopa scelestes* was not affected when this predator was fed with artificial diets.

Results of the present study indicate that, among the three different diets tested, the egg yolk-based diet (AD2) caused higher fecundity. The cost required for preparation was cheaper compared to the other diets. The capacity for higher fecundity and cost effectiveness make AD2 a suitable diet for the

mass multiplication of *M. boninensis*. Further studies on the addition and deletion of certain components to improve the egg laying capacity and survival of *M. boninensis* are needed to make it an economically viable method for the mass multiplication of this species for utilizing them in an Integrated Pest Management program for red spider mite.

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