Research Paper :

Influence of artificial diets on the biology of *Mallada boninensis* (Okamoto)

A.B. PATIL, T.B. UGALE AND D.B. UNDIRWADE

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See end of the article for authors' affiliations

Correspondence to :
T.B. UGALE
Department of Entomology, K.K. Wagh College of Agriculture, NASIK (M.S.) INDIA
Email : tushargrapes@gmail.com

SUMMARY

The present investigation were carried out at Entomology Section, College of Agriculture, Nagpur, during the year 2004-2005, with a view to standardize mass rearing techniques of *Mallada boninensis.* Attempts were made to evaluate the ten artificial diets along with standard laboratory host (factitious host) *i.e.* eggs of *Corcyra cephalonica.* The least larval duration (8.90 days), highest larval weight (8.50 mg) at the end of last instar, maximum pupation (94 %) with least pupation duration (7.98 days), highest pupal weight (6.73 mg) were recorded on *Corcyra* eggs. Also, lowest pre-mating period of 3.53 days and 1.09 hours of mating period was recorded on *Corcyra* eggs. The highest male longevity of 46.30 days, highest fecundity of 295 eggs/female, minimum incubation period of 3.10 days with highest per cent viable eggs of 94% of *M. boninensis* were recorded on *Corcyra* eggs. While the minimum pre-oviposition period of 6.80 days was observed on Pushpalatha's diet and Venkatesan's diet-3, highest oviposition period of 50.50 days was recorded on Venkatesan's diet-3, while highest female longevity of 55.89 days recorded on Venkatesan's diet-1. Considering all these aspects together, standard laboratory host (inactivated eggs of *Corcyra cephalonica)* performed the best followed by Venkatesan's diet-2, Proposed diet-3, Venkatesan's diet-1, Proposed diet-1, and Pushpalatha's diet. The predator grew faster on eggs of *Corcyra* than artificial diets.

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Crop protection is very important aspect in agriculture. No doubt till date use of synthetic pesticides is the choicest method of pest management which results in the development of pesticides resistance, pest resurgence, residual toxicity, imbalance in ecological equilibrium, environmental pollution etc. Due to these ill effects, the concept of pest management is changing from chemical control to the Integrated Pest Management (IPM). These include the use of natural enemies as one of the important components for pest management because they are ecologically safer, ecologically viable, self-perpetuating and long term effective against crop pest. During the last two decades, the role of chrysopids (green lacewings) as a predator of pest has been appreciated all over the world in IPM programme.

In Vidarbha, citrus growers are facing serious problem from last two decades due to heavy attack of citrus blackfly (*Aleurocanthus woglumi* Ashby). The citrus is also attacked by various pests *viz.,* citrus psylla, aphid, white fly mealy bugs etc. The occurrence of citrus black fly has been noticed throughout the year. It has been observed that *Mallada boninensis* (Okamoto) predates on the citrus blackfly (Naib, 1986 and Satpute, 1992). The larvae of *Chrysopa* spp. have been reported predating on all the stages of *A. woglumi* Ashby (Dietz and Zetak, 1920). *Mallada boninensis* (Okamoto) has also ageist potential to use as biocontrol agent against citrus aphids, whiteflies, citrus psylla and mealy bugs (Anonymous, 1997).

There are number of natural enemies of insect pests which co-exist with them in different ecosystems. Amongst a very complex network of bioagents, the Chrysopid is known to be the most effective predator. Out of 13 Chrysopids reported from India, *Mallada boninensis* (Okambto) (Neuroptera :Chrysopidae) is the predominant species.

Rearing in captivity needs good diet. In the efforts to mass rear them, investigations on dietary requirements and artificial diets with varying degrees of success for rearing of C. *carnea* have been reported (Pushpalatha, 1994; Venkatesan, 2000 Palsingh and Verma, 1989).

However,still concentrated efforts were not made for the comprehensive studies of these groups in India to serve as the base for its effective utilization as a predator, throughout the year when natural host (*C. cephalonica)* was not available. Attempts were therefore made to develop artificial diet for mass multiplication of *M. boninensis* in laboratory.

MATERIALS AND METHODS

The influence of different artificial diets on the biology of *Mallada boninensis* (Okamoto) was done. The rearing of *M. boninensis* was studied on different artificial diets in the laboratory at a constant room temperature 24 ± 2^0C and relative humidity 60 ± 5% in the bio-control laboratory. Ten artificial diets were prepared and divided in ten treatments with Completely Randomized Design along with three replications *viz.,* Venkatesan's diet-1(T_1), Venkatesanis diet-2 (T_2), Venkateran's -3 (T_3), Pushpalatha's diet (T_4), Proposed diet-1(T_5), Proposed diet-2 (T_6), Proposed diet – 3 (T_7), Proposed diet – 4 (T_8), Proposed diet – 5 (T_9), and inactivated eggs of *C. cephalonica* (T_{10}) as a factitious host (diet) were utilized for rearing the larvae of test predator. (Table 1). Hydrolyzed soybean powder was prepared by autoclaving freshly ground soybean powder and water (1 :4 ratio) at 15 kg/cm^2 for 30 min. *Corcyra cephalonica* adult abdomen powder was prepared by cutting abdomen of dead *Corcyra* adults and drying them in an oven at 100^0C for 30 to 90 minutes. Powder was prepared by grinding the abdomen then this powder was passed through muslin cloth to get fine *Corcyra* powder devoid of debris.

The culture of rice moth was maintained in the plastic tubs (30 x 20 cm) containing food stuff. This food stuff was prepared by mixing the following ingredients.

- Broken / crushed jowar grains - 2.5 kg
- Groundnut kernel 100 g (to enrich the diet with protein)
- Yeast -5.0 g
- Streptomycin sulphate 0.05% @ 15 ml / tub (for preventing bacterial infection in food stuff. It was sprayed with hand sprayer).
- Micronised wettable sulphur 80% @ 5.9 g/tub (as a prophylactic measures against mites).

In this way, the food stuff was prepared for rearing of rice moth larvae. To this food stuff 0.5 cc of fresh and live rice moth eggs were added to each plastic tub as a nucleus culture and thorough mixing was done.

The tubs were closed tightly with lid having wire mesh at the centre for providing aeration. The hatched larvae of rice moth were subjected to feed on food stuff and they were allowed to remain in the same plastic tub till the emergence of adults. The moths were emerged around 40 days after inoculation of eggs.

The newly emerged rice moth adults were collected daily by opening the tubs under the net with the help of specimen tubes and release them into mating chamber which was made up of plastic buckets with fine mesh screen at the bottom. Adults in the mating chamber were provided with 10% honey + protinex solution as diet. After

Table 1 : Ingredients required for the preparation of 100 g artificial diet used for rearing of *Mallada boninensis* larvae (in g)

Sr. No.	Ingredients	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9
1.	Hydrolyzed soybean powder	1.30	-	-	-	-	2.00	-	-	-
2.	Soybean powder	-	1.30	-	-	-	-	2.50	-	3.70
3.	Multivitamin	0.60	-	-	-	1.0	1.0	1.0	0.80	0.40
4.	Vitamin-E	0.60	-	-	-	1.0	1.0	1.0	0.80	0.40
5.	Egg yolk	31.9	32.3	32.3	42.01	41.9	25.00	25.00	25.00	26.00
6.	Honey	15.91	16.10	16.10	4.20	15.11	15.00	15.00	15.00	15.00
7.	Yeast extract	1.30	1.30	1.30	1.68	1.30	1.40	1.40	1.50	1.40
8.	Petroleum jelly	0.60	0.70	0.70	-	0.60	0.60	0.60	0.70	0.60
9.	Paraffin wax	9.50	9.60	9.60	-	9.50	9.50	9.50	9.60	9.50
10.	Wheat germ powder	-	-	1.3	-	-	-	-	2.10	-
11.	Wheat flour				-	1.3	-	-	-	-
12.	*C. cephalonica* abdomen powder	-	-	-	1.68	-	-	-	-	-
13.	Albumin (white of egg)	-	-	-	-	-	6.50	6.00	6.50	3.50
14.	Water (ml)	38.20	38.70	38.70	50.42	38.29	38.00	38.00	38.00	40.00

mating, female rice moth started egg laying. The eggs were collected daily and passed through 30 mesh sieve to eliminate the moth scales and other fragments of adults of rice moth. Then these eggs were spread as a very thin layer in an iron trey having black album sheet at the bottom for irradiation with U.V. rays (15 watt U.V. lamp) by keeping 20 cm. distances apart between lamp and eggs for a period of 45 minutes in order to make them inactivated. The eggs were used as a laboratory host for rearing of *M. boninensis.* Mass multiplication of *M. boninensis* was done in the laboratory.

A set of 10 larvae of *Mallada boninensis* were replicated three times for each treatment and was subjected to record observations, with Completely Randomized Design. The diet ingredients were measured with digital electronic balance and mixed in a beaker as per composition of diet. These beakers transferred in hot water bath at 50 ± 5^0C for 15 to 20 min. Petroleum jelly and paraffin wax was added in this diet with ratio of 1:16. These diets were placed on polythene sheet to retain water and allowed to semisolid. These diets were fed to test predator everyday with droplets in vial. Diet was stored at 4^0C in refrigerator. The various biological observations were recorded daily. The individual larval duration was noted separately during the entire course of experiment. In order to evaluate the performance of artificial diets, studies on different biological parameters *viz.,* larval, pupal, adult and egg stages were undertaken. Observations were recorded for larval duration, larval weight, pupal weight, pupal duration, per cent pupation, adult longevity, pre-oviposition period, mating period, incubation period, fecundity, viability of eggs and economics of diet.

The data of all biological parameters were subjected for statistical analysis for interpretation of results.

RESULTS AND DISCUSSION

In pursuance of aims and objectives, the present investigations were conducted on influence of artificial diets on the biology of *Mallada boninensis* (Okamoto). Due to want of literature on *M. boninensis,* the present results are discussed here in the light of available literature on *Chrysoperla carnea* in accordance with the objectives of this study.

Influence of artificial diets on the biology of *M. boninensis* :

Larval duration:

In the present studies, the least larval duration was recorded in all instars of *M. boninensis* when reared on standard laboratory host *i.e.* eggs of *C. cephalonica,* with total larval duration of 8.90 days. Among the artificial diet tested, the Proposed diet-5 and Venkatesan's diet-2 were found superior for larval duration *i.e.*15.56 and 15.86 days, respectively. (Table 2)

The results of present findings on Venkatesan's diet-2 were nearer to similar with results of Venkatesan *et al.* (2000) and Katole (2003) who reported larval duration of 17.00 and 16.70 days, respectively of *C. carnea* when reared on Venkatesan's diet-2.The longest larval developmental period (18.49 days) was recorded on Venkatesan's diet-1.

The results of the present findings when *M. boninensis* reared on artificial diet were nearer to similar with the findings of Venkatesan (2000) and Katole *et al.*

Table 2 : Influence of different artificial diets on larval and pupal stage of *M. boninensis*

Sr. No.	Treatments	Total larval duration (Day)	Avg. weight of full grown larvae (mg)	Pupation (%)	Weight of pupa (mg)	Pupal duration (Day)
T_1	Venkatesan's diet-1	18.49	8.00	59.53 (50.49)	4.53.	10.90
T_2	Venkatesan's diet-2	15.83	8.03	41.56 (40.14)	3.90	10.00
T_3	Venkatesan's diet-3	16.23	7.80	35.00 (36.31)	4.26	9.70
T_4	Pushpalata's diet	16.20	6.20	27.60 (31.96)	4.13	10.63
T_5	Proposed diet-1	16.41	8.40	44.40 (41.78)	5.00	9.63
T_6	Proposed diet-2	17.40	5.30	22.73 (28.47)	4.20	8.70
T_7	Proposed diet-3	16.56	5.51	25.56 (30.37)	4.13	9.13
T_8	Proposed diet-4	17.96	6.43	40.70 (39.64)	4.00	9.42
T_9	Proposed diet-5	15.56	5.46	28.50 (32.26)	4.30	9.11
T_{10}	*Corcyra* eggs	8.90	8.50	94.00 (75.46)	6.73	7.98
	'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
	S.E. ±	0.25	0.06	0.09	0.07	0.13
	C.D. (P=0.05)	0.76	0.19	0.27	0.21	0.39

(Figures in parenthesis are arc sin transformed values)

(2003) who reared *C. carnea* on same artificial diets. It may be due to same order (Neuroptera), family (Chrysopidae) and even habitat also of *M. boninensis* and *C. carnea.*

Larval weight:

In present studies, highest larval weight of 8.50 mg was recorded on *Corcyra* eggs followed by Proposed diet-1 (8.40 mg), Venkatesan's diet-2 (8.03 mg), Venkatesan's diet-1 (8.00 mg). Venkatesan's diet-3 recorded the larval weight of 7.80 mg. While Pushpalatha's diet showed larval weight of 6.20 mg. The lowest larval weight of 5.30 mg was noticed on Proposed diet -2. (Table 2)

The results of the present findings on larval weight of *M. boninensis* when reared on *Corcyra* eggs *i.e.* 8.50 mg is corroborated with findings of Katole (2003) who reported the larval weight of 8.40 mg on *C. carnea.*

Influence of different diets on per cent pupation, pupal weight and pupal duration of *M. boninensis:*

The highest per cent pupation (94.00 %) was recorded on *Corcyra* eggs. It was followed by the diets Venkatesan's diet-1, Proposed diet-1 and Venkatesan's diet-2 with per cent pupation of 59.53, 44.40 and 41.56%, respectively (Table 2).

The maximum pupal weight (6.73 mg) was noticed on *Corcyra* eggs. The next superior diets were Proposed diet-1, Venkatesan's diet-1 and Proposed diet-5 with pupal weight of 5.00, 4.53 and 4.30 mg, respectively.

The least pupal duration (7.98 days) was observed on *Corcyra* eggs, whereas the next best diets were Proposed diet-2 and Proposed diet-5 recorded the 8.70 and 9.11 days of pupal duration, respectively.

The results of present findings on per cent pupation, pupal weight and pupal duration when *M. boninensis* reared on *Corcyra* eggs are corroborated with the results of Katole (2003) with per cent pupation (90.00%), pupal weight (6.80 mg) and pupal duration of 7.93 days who reared *C. carnea* on *Corcyra* eggs.

Among the artificial diets, the present findings of Pushpalatha's diet (4.13 mg) and Venkatesan's diet-3 recorded 4.26 mg of pupal weight of *M. boninensis* ,are similar with the findings of Katole (2003) who reported the pupal weight of 4.13 and 4.23 mg, respectively on the same diet for *C. carnea.*

Whereas the present findings on Venkatesan's diet-1 (10. 90 days), Venkatesan's diet-2 (10.00 days), Venkatesan's diet-3 (9.70 days),Pushpalatha's diet (10.63 days) and Proposed diet-1 recorded 9.63 days of pupal duration for *M. boninesis* are similar with the findings of Katole (2003) who reared *C. carnea* on the same diets and reported the 10.77, 9.76, 9.96, 10.43 and 9.63 days of pupal duration, respectively.

Influence of different diets on adult behavior and fecundity of *Mallada boninensis:*

Pre-mating and mating period:

The data on pre-mating and mating period indicated that the lowest pre-mating period (3.53 days) and lowest mating period (1.09 hours) was recorded on *Corcyra* eggs, whereas Pushpalatha's diet recorded the premating period of 3.96 days with mating period of 1.23 hours. Venkatesan's diet-1, Venkatesan's diet-3, Venkatesan's diet-2, Proposed diet-1, Proposed diet-4 and Proposed diet-3 recorded the pre-mating period of 4.30, 4.36, 4.50, 5.10, 5.20 and 5.20 days with mating period of 1.36, 1.13, 1.30, 1.30 and 1.20 hours, respectively. (Table 3).

Pre-oviposition and oviposition period:

The data on pre-oviposition period recorded that lowest and equal preovipostion period (6.80 days) on Pushpalatha's diet and Venkatesan's diet-3, whereas highest oviposition period (50.50 days) was noticed on Venkatesan's diet-3. *Corcyra* eggs, Proposed diet-1, Venkatesan's diet-1, Proposed diet-4 and Proposed diet-5 recorded the pre-ovipostion period of 8.35, 8.90, 9.10, 9.23 and 9.70 days and oviposition period of 41.70, 21.20, 45.30,38.06 and 22.30 days, respectively (Table 3). The pre-oviposition period (10.80 days) and oviposition period (40.35 days) were recorded in Venkatesan's diet-2.

The results of the present investigation on pre-oviposition period (8.35 days) of *M. boninensis* are corroborated with the findings of Katole (2003) who reported 8.23 days of pre-oviposition period of *C. carnea* when reared on *Corcyra* eggs.

The findings of the present investigation on the artificial diets like Venkatesan's diet-2, Venkatesan's diet-3, Proposed diet-1 and Proposed diet-2 recorded 10.80, 6.80, 8.90 and 10.20 days of pre-oviposition period of *M. boninensis,* respectively and these findings are nearer to similar with the results of Katole (2003) who tested *C. carnea* on same diets with 11.00 6.63, 8.60 and 10.73 days of pre-oviposition period, respectively.

However, in respect to oviposition period of the present findings, the Venkatesan's diet-2 (40.35 days) and Pushpalatha's diet (28.40 days) are similar to findings of Katole (2003) who reported the oviposition period of 39.66 and 28.33 days, respectively for *C. carnea* with same diets.

Table 3 : Influence of different artificial diets on adult behaviour of *M. boninensis*

Sr. No.	Treatments	Pre-mating period (Day)	Mating period (Hours)	Pre-ovi position period (Days)	Ovi position period (Days)	Male longevity (Day)	Female longevity (Day)	Fecundity (eggs/female)	Incubation period of eggs (Day)	Viable eggs (%)
T_1	Venkatesan's diet 1	4.30	1.36	9.10	45.30	26.50	55.89	180.00	3.60	86.00 (9.27)
T_2	Venkatesan's diet 2	4.50	1.30	10.80	40.35	36.06	52.06	110.00	4.00	85.00 (9.21)
T_3	Venkatesan's diet 3	4.36	1.13	6.80	50.50	35.10	53.06	195.00	4.05	83.00 (9.10)
T_4	Pushpalata's diet	3.96	1.23	6.80	28.40	17.43	43.16	113.33	4.60	74.66 (8.64)
T_5	Proposed diet 1	5.10	1.33	8.90	21.20	21.50	35.15	174.00	4.25	86.00 (9.27)
T_6	Proposed diet 2	6.06	1.13	10.20	16.65	16.36	32.15	93.66	4.20	86.00 (9.27)
T_7	Proposed diet 3	5.20	1.20	10.00	40.30	25.06	35.35	106.66	3.13	80.66 (8.98)
T_8	Proposed diet 4	5.20	1.30	9.23	38.06	32.23	49.20	180.66	3.30	88.20 (9.39)
T_9	Proposed diet 5	6.13	1.32	9.70	22.30	20.96	28.00	170.00	3.50	63.00 (7.93)
T_{10}	*Corcyra* eggs	3.53	1.09	8.35	41.70	46.30	53.00	295.00	3.10	94.00 (9.69)
	'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	S.E. (±)	0.08	0.07	0.12	0.41	0.07	0.19	1.48	0.05	0.04
	C.D. (P=0.05)	0.23	0.21	0.36	1.23	0.23	0.56	4.38	0.17	0.13

(Figures in parenthesis are square root transformed values)

However, the findings of present investigations on various artificial diets could not be discussed thoroughly for want of literature on *M. boninensis* and *C. carnea.*

Fecundity of *Mallada boninensis* :

In present findings the highest fecundity of 295.0 eggs /female (Table 3) was recorded on *Corcyra* eggs which is more than all artificial diets followed by 195.0 eggs /female on Venkatesan's diet-3 and 180.6 eggs / female on Venkatesan's diet-1. The diets Proposed diet-1, Proposed diet-5 and Venkatesan's diet-3 recorded the fecundity of 174.0, 170.0 and 113.3 eggs /female, respectively.

The results of the present investigation on fecundity (295.0 eggs /female) of *M. boninensis* are nearer to similar with the findings of Katole (2003) and Sarode and Sonalkar (1999) who reported 285.0 and 254.0 eggs /female of *C. carnea* when reared on *Corcyra* eggs.

The findings of the present investigation on various artificial diets like Venkatesan's diet-2 and Proposed diet-2 recorded 110.0 and 93.6 eggs/female of fecundity of *M. boninensis,* respectively and these findings are nearer to similar with the results of Katole (2003) who tested *C. carnea* on the same artificial diets with fecundity of 115.0 and 96.0 eggs/female, respectively.

Adult longevity of *M. boninensis* :

Maximum male longevity of 46.30 days was on *Corcyra* eggs followed by 36.06 days on Venkatesan's diet-2, 35.10 days on Venkatesan's diet-3, 32.23 days on Proposed diet-4, 26.50 days on Venkatesan's diet-1, 25.06 days on Proposed diet-3, Proposed diet-1 recorded the male longevity of 21.50 days. Proposed diet-5 and Pushpalatha's diet recorded the male longevity of 20.96 and 17.43 days, respectively. (Table 3)

Considering the female longevity, it was highest (55.89 days) on Venkatesan's diet-1 followed by 53.06 days on Venkatesan's diet-3, 53.00 days on *Corcyra* eggs, 52.06 days on Venkatesan's diet-2, 49.20 days on Proposed diet-4, 43.16 days on Pushpalatha's diet, 35.35 days on Proposed diet-3. Proposed diet-1 recorded the female longevity of 35.15 days followed by Proposed diet-2 (32.145 days).

In the present investigation the male and female longevity of *M. boninensis i.e.* 46.30 and 53.00 days and are corroborated with findings of the Katole (2003) who reported the male and female longevity of 45.25 and 54.94 days for *C. carnea* when reared on *Corcyra* eggs.

The results of the present investigation on male longevity of *M. boninensis* for Ventkatesan's diet-1

(26.50 days), Venkatesan's diet-2 (36.06 days), Venkatesan's diet-3 (35.1 0 days) and Proposed diet-1 (21.50 days) are similar with the findings of Katole (2003) who reported 25.50, 34.66, 34.33 and 20.83 days of male longevity, respectively on same diets for *C. carnea.*

Influence of different diets on eggs of *M. boninensis:* Incubation period:

The least incubation period of 3.10 days was recorded on *Corcyra* eggs. (Table 3). The next best diets were Proposed diet-3 and Proposed diet-4 on which 3.13 and 3.30 days of incubation period was noticed.

The results of the present investigation on incubation period (3.10 days) of *M. boninensis* are similar with the findings of Katole (2003), Dhepe (2001) and Mangurle (2002) who reported the incubation period of 3.01, 3.01 and 3.08 days, respectively for C. *carnea* when reared on *Corcyra* eggs.

The findings of the present investigations on various artificial diets, Venkatesan's diet-1 (3.60 days) and Pushpalatha's diet 4.60 days of incubation period of *M. boninensis* are similar with the findings of Katole (2003) who tested *C. carnea* a on the same diets with incubation period of 3.12 and 4.08 days, respectively.

Per cent viable eggs:

The highest per cent viable eggs (94.00%) was noticed on *Corcyra* eggs, whereas the next superior diets were Proposed diet-4, Venkatesan's diet-1 and Proposed diet-1 recorded they 88.20, 86.00 and 86.00 % of viable eggs. (Table 3)

The result of present investigation on per viable eggs (94.00%) of *M. boninensis* are nearer to similar with the findings of Katole (2003) who reported the per cent viable eggs of 92.00 % on *Corcyra* eggs.

Among the artificial diets, the present findings on Venkatesan's diet-1 (86.00%), Venkatesan's diet-2 (85.00%), Venkatesan's diet-3 (83.00), Pushapalatha's diet (74.66 %), Proposed diet-1 (86.00%) and Proposed diet-2 86.00 % of viable eggs of *M. boninensis* are corroborate with the results of Katole (2003) who reported the per cent viable eggs of 87.00, 85.00, 82.00, 70.00, 86.00 and 86.00 %, respectively for *C. carnea* when reared on the same diet.

The results of some artificial diets tested in the present investigation for the various parameters of *M. boninensis viz.*, larval duration, larval weight, per cent pupation, pupal weight, pupal duration, pre-oviposition and oviposition period, fecundity, adult longevity of male and female, incubation period and per cent viable eggs are corroborated with the findings of the workers Katole (2003), Venkatesan *et al.* (2000), Sarode and Sonalkar (1999), Dhepe (2001) and Mangrule (2002) even they tested same artificial diets for *C. carnea.* It may be due to the same family (Chrysopidae) under the order Neuroptera and habitat of both the insect *i.e. M. boninensis* and *C. carnea* G.

However, the results of present findings on biological parameters on artificial diets could not be discussed thoroughly for want of literature on *M. boninensis* and *C. carnea*.

Authors' affiliations:
A.B. PATIL AND D.B. UNDIRWADE, Entomology Section, College of Agriculture, NAGPUR (M.S.) INDIA

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