EFFECT OF GINGER BASED ARTIFICIAL DIET ON SURVIVAL, DEVELOPMENT AND REPRODUCTION OF GREEN LACEWING, *Chrysoperla nipponensis* (NEUROPTERA: CHRYSOPIDAE)

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ABSTRACT: The genus Chrysoperla contains many potential predators of many soft bodied insect pests. However, considering the problems with natural diets for rearing and maintenance of predator populations, comparative study on artificial and natural diets of C. nipponensis was conducted. Two types of artificial diets along with two natural diets, Aphis craccivora and eggs of Corcyra cephalonica were evaluated. Composition of artificial diets was same except addition of whole hen eggs and ginger in diet 1 and hen egg yolk and chemical antimicrobials in diet 2. Results indicated that larval duration, fecundity and adult longevity were significantly higher on diet 1, whereas survival and weight of larvae and pupae were higher when feeding on C. cephalonica eggs. Only higher pupal duration was recorded on diet 2. No significant difference was recorded for measurement of body length and head capsule of 1st and 2nd larval instars of C. nipponensis when reared on various diets. However, significantly higher body length of third instar larvae was recorded when reared on C. cephalonica eggs and diet 1. No difference was found in % adult emergence reared on C. cephalonica eggs, diet 1 and aphid. Results of the study showed the potential of artificial diet 1 for the mass rearing of C. nipponensis due to its positive effects on larval duration, emergence, fecundity and adult longevity.

***Keywords**: Chrysoperla nipponensis, green lacewing, artificial diets, Corcyra cephalonica, biological control, mass rearing.*

INTRODUCTION

Green lacewings are cosmopolitan polyphagous predators of different noxious insect pests like aphids, thrips, whiteflies, leafhoppers and lepidopteron eggs [1]. Accordingly, lacewings are generally involved in many biological control programs with inundative and augmentative releases [2]. However, the use of lacewings for the biological control programs necessitates the maintenance of large enough predator population to be released when needed.

So far, mass-rearing of lacewings is mainly based on lepidopteron eggs of genus *Sitotroga*, *Ephestia* and *Corcyra* [2, 3]. However, natural diets used for the rearing of predators, especially for lacewings failed to achieve desired success either due to higher cost or difficult to manage. Therefore, many artificial diets have been evaluated for the rearing of lacewings not only due to their cost effectiveness and easy preparation, but also their positive effects on the predatory potential of lacewings against their prey species [4, 5, 6]. Although, artificial diets are comparatively cheaper than natural diets, however, chemically defined artificial diets are comparatively more expensive; hence, require further research to make them more economical [7].

Green lacewing, *Chrysoperla nipponensis* (Chrysopidae) is one of the important native natural predators widely distributed in China, South Korea and Japan [8]. *Chrysoperla nipponensis* is known to be a prospective candidate of many serious pests because of its potential as biological control agent of aphids and have high predatory capability [9]. This species is newly record in Malaysia. However, other species of the family Chrysopidae such as, *Chrysopa* sp., *Ankylopteryx trimaculata* Gerst., *Ankylopteryx octopunctata* F., *Nothochrysa evanescens*, Mch., *Apertochrysa* sp., and *Italochrysa aequalis* Walk, have already been recorded from Malaysian agro-ecosystem [10, 11].

There is no information available on various aspects of *C. nipponensis* in Malaysia, therefore studies were undertaken to evaluate the relative efficiency of natural and artificial diets for the mass rearing of *C. nipponensis* and their effects on its various biological parameters. It is expected that artificial diets evaluated could show potential for the mass rearing of *C. nipponensis* to manage sufficient predator populations for the augmentative and inundative releases to control numerous noxious pests.

MATERIALS AND METHODS

Culture of green lacewing, *C. nipponensis*

The culture of *C. nipponensis* was started from eggs collected from the surrounding agricultural fields of Universiti Putra Malaysia. Culture was maintained in laboratory condition at 25 ± 2 °C, 55-85% RH and 12L: 12D photoperiod. Larvae were reared separately in order to avoid cannibalism. The adults were provided artificial diet on plastic strips. The eggs laid by the females were collected daily using razor blade and transferred to experimental units as colony sources.

Culture of rice moth, *C. cephalonica*

To establish the culture of *C. cephalonica*, the ingredients such as maize, rice, wheat and semolina (1:1:1:1) were autoclaved to prevent any unwanted infestation and/ or pathogens. Approximately after one hour of cooling the sterilized ingredients, they were mixed and placed in plastic cages measuring 37 x 28cm x 22cm**.** Eggs of *C. cephalonica* were spread over the diet inside the cage. Rearing conditions for culture were 25 ± 2 °C, 55-85% RH and 12L: 12D photoperiod to develop *C. cephalonica* to adult stage that was collected for matting in a plastic cage. The eggs produced were collected in a glass plate, and placed in the freezer to exhaust egg viability.

Preparation of diets

Two types of artificial diets were used in this study as per composition in Table 1. All the ingredients used were weighed carefully by using Digital Analytical Balance (Sartorious, BT-224S, Germany). The ground beef and ground beef liver were cut in small pieces using knife and kept in refrigerator for 24 hours. The mixture of meat, honey, water, preservatives (including antibiotics) and brewer's yeast were blended in a food processor (Panasonic, MK-5087M, Japan). In a beaker, 20 ml of

water was heated at 80-90°C on hot plate (IKA-COMBIMAG RCT 31197, China) and 15 gm sucrose, 5 ml of acetic acid and antibiotics were added and stirred with magnetic stirrer. Then 100 gm of blended eggs were added. All ingredients were blended (BRAUN, ZK-200, Germany) for 5-6 minutes until the entire mixture was of a stringy paste-like consistency and diet was ready to feed the larvae in trays of ELISA wells.

Table 1: Composition of artificial diets

Ingredients	Diet 1	Diet 2
Ground beef	100 g	100 g
Ground beef liver	100 g	100 g
Hen eggs	100 g (whole)	100 g (yolk)
Honey (5g dissolved in 15 ml water)	20 g	20g
Sucrose (sugar)	15 g	15 g
Brewers yeast	14 g	12 g
Propionate	0.5 g	0.6 g
Potassium sorbate	0.5 g	0.6 g
Streptomycin sulphate	-	0.1 g
Chlortetracycline	-	0.1 g
Ginger	0.5 g	-
Distilled water	10 ml	10 ml
Acetic acid	05 ml	05 ml
Vitamin solution (Ascorbic acid and vitamin B-complex)	05 ml	05 ml

Culture of aphid, *A. craccivora*

The aphids *A. craccivora*, were collected from long-bean cultivated in the agricultural field of University Putra Malaysia (UPM). The prey used in this study was reared in cage 37 x 28cm x 22cm under laboratory conditions. The rearing was carried out for two months to obtain sufficient number of the prey for predatory larvae.

Data collection

Eggs of *C. cephalonica* were used as a control and eight replications per treatment were maintained. The performance of *C. nipponensis* reared on different artificial and natural diet were recorded and the biological parameters for this study were larval survival (%), duration of larva and pupa, larval and pupal weights, body length and head capsule measurement of larvae, longevity and fecundity. Larval and pupal weights were taken by using same digital analytical balance (Sartorious BT224S).

Statistical analysis

The experiment design was based on Completely Randomized Design (CRD) with 8 replications per treatment. Collected data were analysed using one way analysis of variance (ANOVA) whereas Least Significant Difference (LSD) at 0.05 probability was used to separate means with significant difference. All the analysis were done using Statistical Analysis Software version 9.4 (SAS Institute Inc. 2014).

RESULTS

The results regarding different biological parameters of *C. nipponensis* are given in Table 2. The individuals of *C. nipponensis* reared on natural and artificial diets showed significant difference for various parameters recorded ($P<0.05$). Significantly the highest larval duration of *C. nipponensis* was recorded on artificial diet 1 as compared to other diets. However, the highest larval and pupal weight along with maximum percent larval survival was recorded when reared on *C. cephalonica* eggs followed by diet 1. Moreover, higher pupal duration of *C. nipponensis* was recorded when reared on diet 2 ($P<0.05$). No difference in percent emergence of *C. nipponensis* was recorded when reared on *C. cephalonica* eggs, diet 1 and *A. craccivora*. Significantly higher fecundity of *C. nipponensis* along with male and female longevity was recorded on diet 1 as compared to individuals reared on other diets. No significant difference was recorded in body length and head capsule measurement of different larval instars of *C. nipponensis* (Figures 1 & 2). However, significantly higher difference was recorded in body length of third instars larvae fed on *C. cephalonica* eggs followed by diet 1 (Figure 1).

Table 2. Effect of different natural and artificial diets on biological parameters of *C. nipponensis* under laboratory conditions.

		Natural diets		Artificial diets	
Biological Parameters		***C. cephalonica* eggs**	***Aphis craccivora***	**Diet 1**	**Diet 2**
Larval duration (days)		11.12±0.51b	11.37±0.53b	13.62±0.59a	14.25±0.72a
Pupal duration (days)		6.75±0.31c	7.87±0.39b	7.37±0.32cb	9±0.42a
Larval weight (mg)		8.69±0.29a	7.75±0.28b	7.82±0.28b	6.84±0.26c
Pupal weight (mg)		8.06±0.28a	7.09±0.26b	7.12±0.27b	6.28±0.26c
Larval survival (%)		91.25±2.95a	82.5±2.5ba	85±±2.67b	73.75±2.63c
Emergence (%)		68.37±2.57a	64.87±2.24a	67.12±2.23a	54.87±2.10b
Fecundity (eggs per female)		631.6±15.36ab	616.8±14.72b	674.6±16.06a	565±14.66c
Longevity (days)	**Male**	40.2±1.93c	45.6±2.20bc	55.2±2.22a	49.4±2.11ab
	Female	50.4±2.4c	56.6±2.50bc	67.4±2.74a	60.8±2.51ab

Means followed by same letters within column are not significantly different ($P<0.05$)

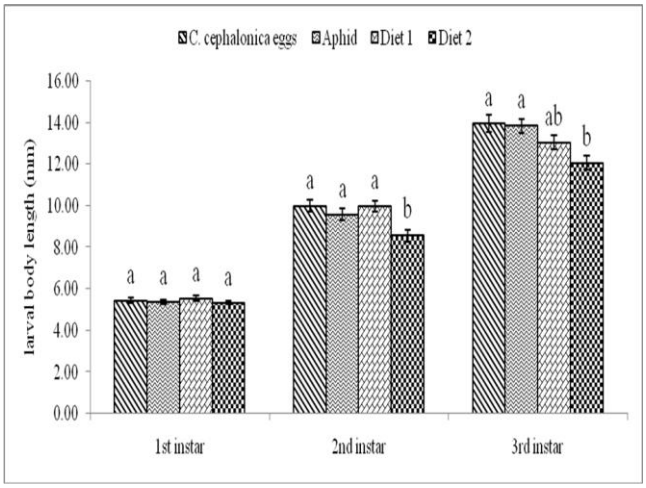

Figure 1: Body length (mm) of *C. nipponensis* larvae produced on natural and artificial diet (Means ± S.E)

DISCUSSION

Results of the study showed that artificial diet 1 is a suitable alternative for the rearing of *C. nipponensis* larvae. Artificial diet 1 is a semisolid diet for the culture of green lacewing larvae, because the rearing system based on an artificial diet would be useful from economic point of view for mass rearing. Penny [12] reported that artificial diet reared individuals of chrysopids could give compatible performances with natural diets with respect to larval survival, pupation and adult emergence. Therefore, provision of a solid diet would improve performance in *Chrysoperla* spp. reared on artificial diet [13].

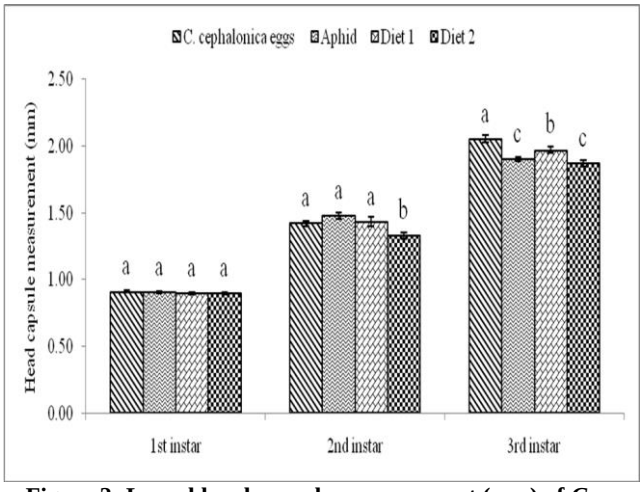

Figure 2: Larval head capsule measurement (mm) of *C. nipponensis* produced on natural and artificial diet (Means ± S.E)

Artificial diet 1 reared females laid significantly more eggs than those developed on other natural and artificial diets. The findings of the current study are in consistent with many previous studies who reported that the performance of *Chrysoperla* sp. reared on artificial diet was generally superior or equal to that on the factitious host [14, 15, 16]. The semi artificial diet 1 consists of different components as each component has the promoting effect on fecundity. It has been suggested that sugar is the most important component in diet formula for the insects and has pronounced effect on the egg production [17]. Similarly, significant affect of yeast, sugar and honey on egg production of *C. carnea* has been reported by [18, 6].

In summary, *C. nipponensis* individuals reared on artificial diet 1 showed the potential to perform compatible with natural diets of *C. cephalonica* and *A. craccirvora* with respect to various biological parameters. Moreover, diet 1 incorporated with ginger as antibiotic is cost-effective and easy to prepare for maintaining the shelf life of artificial diet and has the potential to be widely used for the mass rearing of *C. nipponensis.*

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