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Vignesh B
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Jeyarajan Nelson S
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Shanmugam PS
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Uma D
Department of Biochemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
Vignesh B
Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Influence of vitamin rich diets on the development and fecundity of factitious host insect (*Corcyra cephalonica*) of entomophages

Vignesh B, Jeyarajan Nelson S, Shanmugam PS and Uma D

Abstract
Corcyra cephalonica (Stainton) (Lepidoptera: Pyralidae) is a factitious host extensively used for rearing entomophages. Experiments were conducted to study the influence of vitamin rich food supplements *viz.*, sunflower seeds and milk powder on the growth and reproduction of *C. cephalonica*. Larval weight, adult weight, average developmental period, moth emergence and weight of eggs were recorded to assess the diet performance. Larval weight was highest in milk powder @ 100 g / 2.5 kg supplemented diet (45.63 mg) followed by sunflower seeds @ 50 g / 2.5 kg supplemented diet (44.95 mg) when compared to control (41.99 mg). Similar trend was observed in the weight of the female and male moths. There was no significant variation in the developmental period of *C. cephalonica* in different diets. Fecundity of *C. cephalonica* was greatly influenced by the vitamin rich supplements. The fecundity of adults emerged from the medium with milk powder @ 100 g / 2.5 kg diet increased to 70.12 per cent when compared to control followed by 62.72 per cent increase in fecundity in case of medium with sunflower seeds @ 50 g / 2.5 kg diet. Among the vitamin rich supplements used in the maize medium, milk powder was found to be the best one for promoting the growth and reproduction of *C. cephalonica.*

Keywords: *Corcyra cephalonica,* sunflower seeds, milk powder

Introduction
Rice meal moth or rice moth, *Corcyra cephalonica* belongs to Pyralidae family. The moths are nocturnal and each female lays 90-200 eggs having 5 days incubation period, 23-25 days larval period, and 10 days of pupal period and adult life span of 1 week (Fenemone and Prakash, 2009) [6]. The rice meal moth is the preferred factitious host for mass culturing of entomophagous insects due to its amenability, adaptability to varied rearing conditions and its positive influence on the progeny of the natural enemies. It is the factitious host for 75 natural enemies of which 60 are parasitoids and 15 are predators including a few that are host-specific in nature. It is also served as a host for nematodes and mites (Manjunath, 2014) [11]. Its broad acceptance has proven to be a benefit for the mass production of bio-control agents. In India, rice meal moth, *C. cephalonica* is most widely used as the factitious host for the mass multiplication of *Trichogramma* spp. (Gauraha and Deole, 2016) [8]. The larger number and better quality of *C. cephalonica* eggs and larvae, and its higher production rate within a given time, are essential attributes, which enhance suitability of these eggs/larvae for mass production of parasitoids in biological control programs (Nathan *et al*. 2006, Nasrin *et al*. 2016) [14, 13].

Mass rearing *C. cephalonica* under controlled conditions is generally simple and affordable. So, it may aid in the cost-effective generation of biocontrol agents, promoting widespread adoption of biological control measures. The quality of the natural enemies in the laboratory mostly depends on the quality of the host, which ultimately depends on the host nourishment. Therefore, the diet of the host is potentially important to the nutritional quality of host and the survival of natural enemies developing on it, released as biological control agents (Finney, 1964 and Hunter, 2003) [7, 9]. Improvement in the larval diets with vitamin rich supplements may enhance growth and reproduction of host insects. Therefore, the present study was carried out by addition of vitamin rich sunflower seeds and milk powder as nutritional supplement and its effect on development and fecundity of moth were evaluated.

Materials and Methodology
The research work was carried out at biological control laboratory at Department of Agricultural Entomology, TNAU, Coimbatore. Maize grains were used for rearing *C. cephalonica* in combinations with sunflower seeds and milk powder.

Rearing procedure
Bucket rearing

C. cephalonica was reared in the plastic bucket which has provisions for observing the moth emergence (19 cm × 16 cm nylon film) (PLATE 1) and collection of moth (10 cm × 15 cm khada cloth with zip) (PLATE 2). The buckets were thoroughly cleaned with 0.5% detergent and rinsed in tap water followed by treatment with 2% formaldehyde and dried. Healthy grains of maize, free from insecticides along with the other ingredients *viz*., groundnut kernel powder, yeast, streptomycin sulphate and sulphur were used as the basal diet for the larva. The maize grains were milled to make 3-4 pieces and sterilized in an oven at 100 ^{0}C for 30 minutes to kill the insects present in the grain which may otherwise compete for food and space with rice moth. Heat sterilized broken grains were taken at the rate of 2.5 kg per plastic bucket to which 100 gm groundnut kernel powder and 5 gm yeast powder were added. Streptomycin sulphate (0.05% solution) @ 10-20 ml per bucket was added to prevent bacterial infection in the food medium. Sulphur WP was added @ 5 g per bucket to prevent storage mite infestation. Broken sunflower seeds at various proportions *viz*., 50gm, 100gm, 150gm, 200gm and milk powder at 100 gm were added to the basal diet in 4 replications. Basal diet served as control. 0.5cc of *Corcyra* eggs was sprinkled in each bucket. The buckets were kept in the racks and treatments observed daily for the emergence of moths. The treatment details are given below in table 1.

Table 1: Treatment details

Treatments	Diet composition
T1	Basal diet + 50gm sunflower seeds
T2	Basal diet + 100gm sunflower seeds
T3	Basal diet + 150gm sunflower seeds
T4	Basal diet + 200gm sunflower seeds
T5	Basal diet + 100gm milk powder
T6	Basal di*et al*one (control)

Larval weight: Twenty days after charging the trays with eggs, 20 larvae per treatment were randomly weighed on precision balance (accuracy 0.001g) and the mean larval weight was worked out.
Adult weight: Ten adult females and males were randomly collected from each replicate and immediately kept in refrigerator for about 15 minutes at 0 ^{0}C for immobilization. Each female and male was weighed separately on precision balance and the mean female and mean male weight was worked out.

Total Number of moths emerged: The moths were collected from each bucket on daily basis and summed up to get the total number of moths.

Fecundity: The moths were collected on daily basis and transferred to specially designed oviposition cages (plate 3). Cotton wad was saturated with adult food (50 ml honey with 50 ml water and four vitamin E (Evion) pills) and hung via thread inside the oviposition cage. The cotton wad was changed for every two days. Eggs in oviposition cages were collected daily at 8.00 AM up to four days. The eggs were then passed through a series of sieves to remove the scales and eggs without scales were taken.

Plate 1: Nylon film

Plate 2: Khada cloth

Plate 3: Oviposition cage

Statistical analysis: Statistical analysis was performed with version 3.01 (AGRES). The observed biological parameters were normalized using square root transformation and subjected to ANOVA and means were compared by LSD.

Results and Discussion
Effect of diet on larval and adult weight
Larval weight
The mean larval weight of 20-day-old *C. cephalonica* larvae was highest (45.63 mg) in diet T5 (basal diet + milk powder 100g). However, the lowest larval weight (41.9 mg) was observed in diet T2 (basal diet + sunflower seeds 100g) (Table 2). In the present study, maize medium in combination with sunflower seeds which contains vitamin E (37.8 mg/100 g) and milk powder which is rich in vitamin A (as retinol 350µg / 100g) and protein (22g / 100g) produced the maximum larval weight which is in corroboration with findings of Begum & Qamar (2015) [3] who reported highest larval weight (60.4 mg) in their diet added with vitamin E (0.5%). These results could also be corroborated with a report on protein rich diet by Mehandale *et al*., (2014) [12] who recorded the highest larval weight (54.50 mg) in (sorghum + cowpea + powdered yeast) diet mixture and the lowest larval weight (43.50 mg) in (sorghum + black gram + powdered yeast) diet mixture.

Rao *et al*., (1980) [15] found that sorghum flour combined with glucose at 3.0, 3.5, and 4.0 per cent resulted in 22.75, 23.40, and 23.89 mg larval weight, respectively; sorghum flour + protein at 50, 55, and 60 per cent resulted in 21.16, 22.69, and 22.19 mg larval weight, respectively. It was found that supplementing sorghum with sugar or protein increased the efficiencies of the media.

Adult weight
Newly emerged males and females were sexed based on labial palpi as proposed by Ayyar (1934) (PLATE 4). The mean weight of *C. cephalonica* female (Table 2) was maximum (25.15 mg) in diet T5 (basal diet + milk powder 100g). The lowest female weight (21.45 mg) was recorded in T3 **(**basal diet + sunflower seeds 150g). It is comparable with work of Mehandale *et al.,* (2014) [12] who recorded female weight in range 24 – 40 mg in different diet combinations. The mean weight of *C. cephalonica* male was the highest (15.08 mg) in diet T5 (basal diet + milk powder 100g). The lowest male weight (13.13 mg) was recorded in T3 **(**basal diet + sunflower seeds 150g). The results are in accordance with work of Bernardi *et al.,* (2000) [4] who reported maximum mean female and male adult weight as 33.73 mg and 17.33 mg respectively and minimum mean female and male adult weight as 21.38 mg and 12.22 mg respectively.

Table 2: Effect of vitamin rich diet on growth and development of larva and adult

Treatments	**Weight of larva (in mg)**	**Weight of adult**		**Developmental period (EGG – ADULT) (in days)**
		Female (in mg)	**Male (in mg)**	
T1	44.95 (6.74)[ab]	23.725 (4.92)[ab]	14.40 (3.86)[ab]	50.75
T2	41.9 (6.51)c	21.925 (4.74)[bc]	13.38 (3.72)[c]	52.25
T3	42.35 (6.55)[bc]	20.975 (4.63)[c]	13.13 (3.69)[c]	53.5
T4	42.94 (6.59)[abc]	21.9 (4.73)[bc]	13.78 (3.78)[bc]	51.5
T5	45.625 (6.79)[a]	25.15 (5.06)[a]	15.08 (3.95)[a]	51.25
T6	41.987 (6.52)[c]	23.10 (4.86)[abc]	13.70 (3.77)[bc]	50.25
SEd	0.1009	0.1304	0.0583	NS
CD(.05)	0.2120	0.2740	0.1225	NS

Figures within parenthesis are $\sqrt{(X + 0.5)}$ values.

Means followed by letter(s) in common are not significantly different at five per cent level (LSD)

Effect of diet on moth emergence and fecundity
The buckets were charged with 0.5cc eggs during last week of November and the adults began to emerge from various treatments during second week of January, lasting until April second week. The average developmental period (egg – adult) is given in Table 2 in which the longest developmental period was recorded in T3 (53.5 days) while the shortest developmental period was seen in control T6 (basal di*et al*one) (50.25 days). It was in accordance with work reported by Chauduri *et al*., (2016) [5] where the longest developmental period was 64.71 days in scented rice and shortest was in maize-dextrose (45.00 days). Allotey and Azalekor, (2000) [1] found that the average developmental period ranged from 33.2 to 45.3 days, which can be corroborated with the findings of the current study, in which the average developmental period ranged from 50.25 to 53.5 days in different rearing media.

The number of adults emerged per week and weight of eggs obtained per week has been presented in the Table 3 & Table 4 respectively. The peak emergence of moth was seen during 3rd week in all treatments and thereafter it declined (Figure 1). It was found that the highest emergence and maximum egg weight was recorded from T5 (basal diet + milk powder 100g) with 1153.75 adults and 3650.95 mg of eggs, followed by T1 (basal diet + sunflower seeds 50g) with 1125.75 adults and 3492.06 mg of eggs, T3 **(**basal diet + sunflower seeds 150g) with 838.75 adults and 1983.7 mg of eggs and T2 (basal diet + sunflower seeds 100g) with 807.75 adults and 1961.84 mg of eggs. In basal di*et al*one 807.25 adults and 2146.01 mg of eggs were recorded (Figure 2). The results indicated that maize in combination with supplementation enhanced the moth emergence and fecundity. The findings are in accordance with Lavanya *et al*., (2021) [10] who reported that adult emergence from maize alone and maize + sorghum + additives are 824 and 1007 respectively.

Table 3: Effect of medium with vitamin rich supplements on moth emergence

Treatments	Number of moths emerged / week							Total
	Days after inoculation of eggs in medium							
	(50^{th} – 56^{th} day) week 1	(57^{th} – 63^{rd} day) week 2	(64^{th} - 70^{th} day) week 3	(71^{st} - 77^{th} day) week 4	(78^{th}-84^{th} day) week 5	(85^{th} – 91^{st} day) week 6	(92^{nd} – 99^{th} day) week 7	
T1	73.25 (8.59)	179.25^{a} (13.41)	320.75^{a} (17.92)	262.5^{a} (16.22)	159.25^{ab} (12.64)	93.75^{ab} (9.71)	37^{b} (6.12)	1125.75^{a} (33.56)
T2	40.25^{c} (6.38)	114.5^{bc} (10.72)	226.75^{bc} (15.07)	166.75^{bc} (12.93)	122^{c} (11.07)	94.5^{ab} (9.75)	43^{ab} (6.60)	807.75^{b} (28.43)
T3	50.5b^{c} (7.14)	116.25^{bc} (10.81)	227^{bc} (15.08)	188.25^{b} (13.74)	116^{c} (10.79)	85^{b} (9.25)	55.75^{a} (7.50)	838.75^{b} (28.97)
T4	57.5^{abc} (7.62)	111^{c} (10.56)	214.5^{c} (14.66)	136.25^{c} (11.69)	75.5^{d} (8.72)	51^{c} (7.18)	34^{b} (5.87)	679.75^{b} (26.08)
T5	77.5^{a} (8.83)	165.5^{ab} (12.88)	293.25^{ab} (17.14)	246^{a} (15.70)	188.75^{a} (13.76)	124.5^{a} (11.18)	58.25^{a} (7.66)	1153.75^{a} (33.97)
T6	48.5^{c} (7.00)	106.75^{c} (10.36)	197.75^{c} (14.08)	186.75^{b} (13.68)	136.5^{bc} (11.70)	92.25^{ab} (9.63)	38.75^{b} (6.26)	807.25^{b} (28.42)
SEd =	0.7255	1.129	1.000	0.7983	0.6461	0.8972	0.5867	1.7055
CD(0.05) =	1.524	2.3738	2.1009	1.6772	1.3574	1.8849	1.2325	3.5832

Figures within parenthesis are √ (X + 0.5) values.
Means followed by letter(s) in common are not significantly different at five per cent level (LSD)

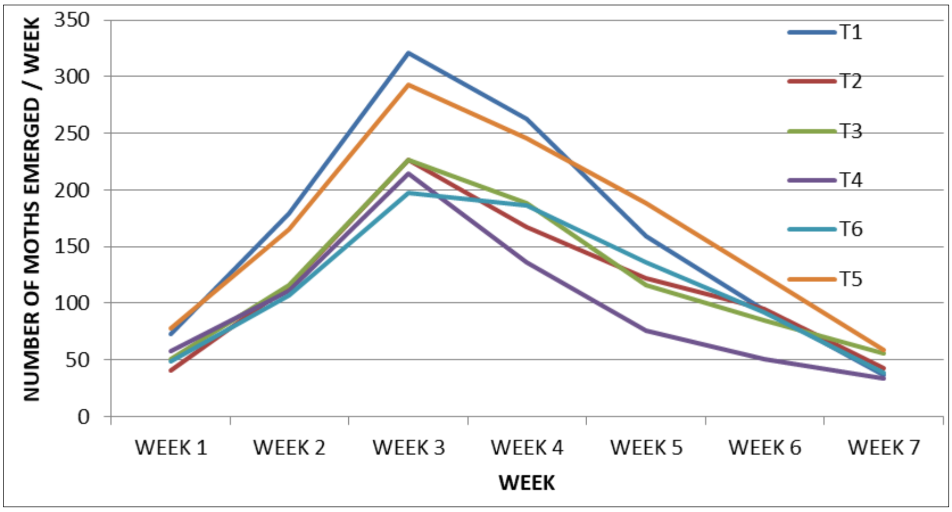

Fig 1: Number of moths / week of *C. cephalonica* emerged in various treatments

Table 4: Effect of medium with vitamin rich supplements on fecundity of *C. cephalonica*

Treatments	Eggs obtained (in mg)							Total (in mg)	Weight of 1000 eggs (in mg)
	Days after inoculation of eggs in medium								
	(50^{th} – 56^{th} day) Week 1	(57^{th} – 63^{rd} day) Week 2	(64^{th} - 70^{th} day) Week 3	(71^{st} - 77^{th} day) Week 4	(78^{th} -84^{th} day) Week 5	(85^{th} – 91^{st} day) Week 6	(92^{nd} – 99^{th} day) Week 7		
T1	268.75^{ab} (16.41)	563.50^{a} (23.75)	909.88^{a} (30.17)	788.38^{a} (28.09)	632.75^{a} (25.16)	265.06^{ab} (16.30)	63.75^{b} (8.02)	3492.06^{a} (59.10)	35^{b}
T2	112.23^{d} (10.62)	326.00^{b} (18.07)	495.50^{b} (22.27)	444.50^{bc} (21.10)	292.23^{c} (17.11)	227.25^{bc} (15.09)	64.14^{b} (8.04)	1961.84^{b} (44.30)	34^{c}
T3	99.88^{d} (10.02)	342.38^{b} (18.52)	454.69^{b} (21.34)	472.75^{b} (21.75)	329.69^{bc} (18.17)	194.98^{bc} (13.98)	89.32^{ab} (9.48)	1983.67^{b} (44.54)	33^{d}
T4	196.4^{bc} (14.05)	269.00^{b} (16.42)	544.13^{b} (23.34)	351.63^{c} (18.76)	218.63^{d} (14.80)	146.75^{c} (12.13)	69.91^{b} (8.39)	1796.88^{b} (42.40)	32^{e}
T5	343.25^{a} (18.54)	632.08^{a} (25.15)	849.75^{a} (29.16)	722.63^{a} (26.89)	603.81^{a} (24.58)	373.38^{a} (19.34)	126.06^{a} (11.25)	3650.95^{a} (60.43)	39^{a}
T6	143.96^{cd} (12.02)	322.75^{b} (17.98)	513.38^{b} (22.67)	460.25^{bc} (21.47)	410.31^{b} (20.27)	214.13^{bc} (14.65)	81.24^{b} (9.04)	2146.01^{b} (46.33)	36^{b}
S.Ed =	1.2980	1.9268	1.6366	1.2844	1.1106	1.4450	0.9844	2.7276	0.0113
CD(0.05) =	2.7271	4.0481	3.4384	2.6985	2.3333	3.0359	2.0682	5.7306	0.0238

Figures within parenthesis are √ (X + 0.5) values.
Means followed by letter(s) in common are not significantly different at five per cent level (LSD)

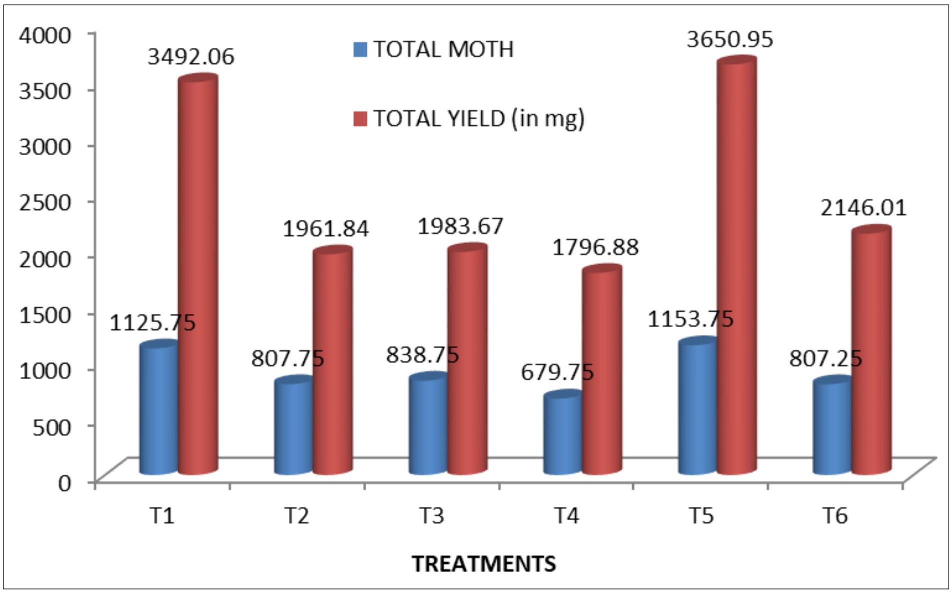

Fig 2: Number of moths emerged and eggs obtained (in mg)

Conclusion

C. cephalonica is a factitious host of many entomophages. Fecundity of *C. cephalonica* is of prime importance because the eggs are used in mass production of many egg parasitoids and predators. The present study revealed the effect of maize medium with milk powder and sunflower seeds in improving the moth emergence and fecundity. Maize medium with milk powder can be used as a cost-effective choice for enhancing the quantity of egg production in mass culturing of *C. cephalonica*.

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