Comparison of different diets on biology of *Corcyra cephalonica* (Stainton) under laboratory condition

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ABSTRACT

The study aimed to evaluate different rearing media for mass production of rice moth *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae), an important host insect for several bio-control agents. The development and reproductive performance of *C. cephalonica* was evaluated on six different combinations of rearing media containing maize, wheat, rice, jowar, ragi, sugar and groundnut. Results showed that the larval period, pupal period, adult emergence fecundity, adult longevity and fecundity were highest and true generation time was shortest in Diet VI (Wheat, yeast, groundnut). Hence, Diet VI is the most suitable rearing media for mass production of *C. cephalonica*.

Keywords: *Corcyra cephalonica*, artificial diets, mass rearing, Trichogramma.

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INTRODUCTION

Corcyra cepalonica (Stainton) (Lepidoptera: Pyralidae) has economic importance in Asia, Africa, North America, and Europe (Atwal and Dhaliwal, 2008). Even though it is commonly called as rice moth, it also feeds on wheat, maize, sorghum, groundnut, cotton seeds, coffee, cocoa beans, millet and spices (Cox *et al*., 1981; Alloy, 1991; Kumar and Kumar, 2001). *Corcyra cephalonica* is not only a pest, but it is also a laboratory host for several biocontrol agents, including *Habrobracon hebetor* Say (Hymenoptera: Braconidae), *Trichogramma toidea eldanae* Viggiani (Hymenoptera: Trichogrammatidae), *Trichogramma chilonis* Ishii (Hymenoptera: Trichogrammatidae), predatory mites, and predatory nematodes (Nathan *et al*., 2006; Manjunath 2013; Amit Vincent *et al*., 2021). As of now, it has been reported as a factitious host for 75 natural enemies, including 60 parasitoids and 15 predators. Its broad acceptance as a host for bio-control agents has proven to be a boon for mass production (Nasr *et al*., 2015). Due to its mass production feasibility, it has become an alternative host rather than the original biocontrol agent that is scarce, unable to be mass-produced, or expensive.

Biological control is a safer and environmentally sustainable method for managing harmful insect pests, entailing the production and distribution of natural enemies in the ecosystem to control insect populations. Biocontrol agents such as predators, parasitoids, and pathogens manage about 90% of all insect pests (Omkar *et al*., 2016) and may play a significant role in stored-product Integrated Pest Management.

Due to the ease and affordability of mass rearing *C. cephalonica* under controlled conditions, it may facilitate the production of biocontrol agents at a much lower cost, thus facilitating the adoption of biological control practices at a broad scale, particularly in developing nations where these practices are often not fully utilized due to high costs (Smith 1996).

In biological control programs, Trichogramma is used against a variety of lepidopteran pests (Smith 1996). In this genus, approximately 650 species of egg parasitoids exist, of which approximately 200 species have been mass produced and released against lepidopterous pests of different crops (Desneux *et al*., 2010; Tabone *et al*., 2010; Yuan *et al*., 2012; Chailleux *et al*., 2013a; El-Arnaouty *et al*., 2014). Since these Trichogramma parasitoids have been consistently released in specific areas for several years, great economic and biological benefits have been gained (Wang *et al*., 2014). It is essential to develop a mass production system and maintain high-quality Trichogramma species for biological control programs to be successful (Zhang *et al*., 2018). There are a number of species of Trichogramma parasitoids that are produced in large quantities on the small eggs of *C. cephalonica* (Wan *et al*., 2000; Huang *et al*., 2013).

Corcyra cephalonica is industrialized for mass rearing of many of the natural enemies a number of bio-control research and extension units in India. These natural enemies are reared either on egg or larval stages of *C. cephalonica* (Kumar and Murthy, 2000; Kumar and Jalali, 1993; Kumar and Murthy, 2000; Kalyanakumar *et al*., 2013). There are several species of rice meal moth, *C. cephalonica*, which are vital to producing quality host eggs, so turn is the most commonly used factitious host for the mass multiplication of Trichogramma spp. in India. (Gauraha and Deole, 2016; Bernardi *et al*, 1999). At different commercial insectaries in South Asia, the rice moth is raised as hosts for the egg parasitoids of the Trichogramma genus, the larval parasitoids of the Braconidae (Hymenoptera), and predators like *Chrysoperla carnea* (Stephens) (Neuroptera) (Parra, 1997). Each adult female of *C. cephalonica* lays 90-200 eggs, which hatch after five days, it takes 23-25 days to pupate and live for one week as adults (Fenemone and Prakash, 2009; Mojammil Abedin, 2020).

Healthy herbivorous insects develop from highly nutritious plants, which in turn results in high quality parasitoids and predators reared on such herbivorous host insects. Insect growth, development and reproduction are highly affected by the quality and quantity of food ingested by the host insects (Pandi *et al*., 2012; Nathan *et al*, 2006). The artificial rearing of host insects on nutritionally balanced food media will contributes to the quality and survival of the parasitoids released into the environment as biological control agents (Hunter, 2003). An important criterion for assessing the health of an insect is its egg size. Hence it is important to use robust host insect eggs for the rearing of egg parasitoids (Pathak *et al*., 2010).

The economics of *C. cephalonica* mass multiplication on several food crops, including rice, maize, wheat, sorghum and pearl millet have been investigated in India with different results (Gauraha and Deole, 2016). The effect of various diet formulations on the growth and development of *C. cephalonica* was investigated to optimize current techniques for mass rearing and to increase the production Trichogramma. The present study aims to compare the development and reproductive efficiency of *C. cephalonica* on the different artificial media. The current study also helps to evaluate the quality of different locally available grains in Karnataka, India, in order to identify the most efficient and economic rearing media for its mass production.

MATERIALS AND METHODS

The experiment was carried out at the Zoology laboratory of Jyoti Nivas College Autonomous, Bangalore, India during 2022-23. Each treatment was replicated five times.

Rearing media

Four different types of food grains namely, wheat, rice, ragi, and jowar were used in different combinations. The experiment comprised six treatments (diet trials) as listed in the Table 1. All the food grains were coarsely crushed for the present experiment.

Table 1. Composition of different artificial diets tested

Diets	Composition	Percentage
I	Wheat, Rice	97.00, 3.00
II	Wheat, Ragi	97.00, 3.00
III	Jowar, Ragi	97.00, 3.00
IV	Jowar, ragi, sugar	48.50, 48.50, 3.00
V	Jowar, yeast, groundnut	48.50, 48.50, 3.00
VI	Wheat, yeast, groundnut	48.50, 48.50, 3.00

Maintenance of nucleus culture

The nucleus culture of *C. cephalonica* was collected from ICAR-National Bureau of Agricultural Insect Resources (ICAR-NBAIR), Bangalore, India. *Corcyra cephalonica* were continuously reared in the laboratory throughout the study period using broken jowar grains and crushed groundnut media. The plastic buckets used for *C. cephalonica* multiplication are thoroughly cleaned with 0.5% detergent wash and rinsed in tap water followed by wiping with dry, clean – used towel and shade drying. Whenever the buckets are emptied after a cycle of rearing, they were cleaned with two per cent formaldehyde.

The required quantities of jowar grains and groundnut kernel were coarsely milled and sun dried to eliminate the residual population of stored product insects *viz., Rhizopertha dominica*, *Sitotroga cerealella*, *Tribolium castaneum* and fungal contaminants. The sterilized grains then transferred to rearing bucket in the ratio of 4kg jowar and 100 g of the broken kernel per bucket. A spray of 10 ml of 0.01-0.05% streptomycin sulphate was given followed by thorough mixing of the contents. Freshly collected Corcyra eggs were sprinkled freely on the surface of the medium in individual buckets @ 0.25cc eggs (4000 eggs). The containers were then covered with clean muslin cloth and held tightly with rubber fasteners. The containers were carefully transferred to the racks and kept undisturbed for a month.

The adult moths were collected using specimen tubes after 28-30 days and were transferred to the oviposition cage@ 1000 pairs per cage at a time. These adult moths were provided cotton soaked with 20% honey solution as food. The culture so maintained was used for various investigations under the current study.

Different hosts on the biology of *C. cephalonica*

Biology of *C. cephalonica* was studied on different hosts using 250g samples of each food grain. After crushing the grains, they were placed in an oven at 60ºC for two hours to disinfest them. We treated the grains with 0.1% formaldehyde at 2.5mL per 250g and air dried them. In a petri dish covered with blotting paper, about 1000 eggs (0-6 hrs old) were kept for hatching. A wet brush was used to release twenty neonate larvae of *C. cephalonica* into each container containing a different host as a food source. Muslin cloth was used to cover the mouth of each container and rubber bands were used to secure it. Regular observations were made of the containers and the following observations were recorded.

Larval period (days)

From the introduction of newly hatched larvae to the formation of silken web in each container, the larval period of *C. cephalonica* was carefully observed and recorded.

Pupal period (days)

In each container, the pupal period was measured from the formation of pupa or silken webs to adult emergence.

Adult emergence

Counting the number of adults emerging in each replication was used to calculate adult emergence and calculating adult emergence as a percent was done by using the equation below.

Fecundity

Females were collected from each host and placed in separate jars for egg laying to determine fecundity. The labial palpi of females were long, pointed and comparatively larger than those of males. Until the death of a female, eggs were counted daily.

Adult longevity (days)

In each replication of the host, adult longevity was measured from the time of adult emergence until the time of adult death.

Hatching period (days)

Female moth eggs laid in petri dishes were used to record hatching period. For this study, 50 eggs of *C. cephalonica* were collected from replicated treatments. During each replication, time was recorded between the laying of eggs and hatching.

Developmental period (days)

To estimate the insect's developmental period, we recorded how much time the eggs took to hatch and when the adults emerged.

Statistical Analysis

One-way Analysis of Variance (ANOVA) was utilized to analyse survival rates, egg hatching, developmental durations of immature life stages and longevity of the adult, and Duncan's multiple range test ($p < 0.05$) was used to compare the means.

RESULT

Six different food components were studied to determine their comparative effects. In order to determine the diet preference, we assessed the hatching period, larval period, pupal period, adult emergence, fecundity and adult longevity.

Larval and pupal periods

The larval period was significantly shorter in Diet VI compared to all other diets ($F = 8.21$, $p <0 .0001$). The time taken for larval development in Diet I was the longest ($F = 10.59$, $p < 0.0001$) and there was no significant difference in the larval period among the Diets II, III, IV and V. The pupal period varied from 9 to 12 days. Diet VI had the shortest pupal period ($p < 0.0001$, $F = 7.59$). Whereas, it was maximum on Diet I ($p < 0.0001$, $F = 9.50$) and there was no significant difference in the pupal periods among the Diets II, III IV and V.

Fecundity

The average number of eggs laid per single female was 210 - 310. There was a significant difference in the number of eggs laid between Diet VI and Diet I ($p < .0001$, $F = 8.29$) whereas there was no significant difference between diet V and VI ($p < .0001$, $F = 7.10$).

Hatching period

The numbers of young ones hatched in Diet VI and that in Diet V were comparable and significantly greater than the number of young ones hatched in all other diets tried in the current experiment ($p < .0001$, $F = 7.50$).

Adult longevity

The adult longevity of the parasitoid was affected by the age of the host. There was no significant difference in the adult longevity between diets II and III and also between IV and V. Whereas Diet VI was superior to all the other larval stages in terms of adult longevity $p < .0001$, $F = 11.20$).

Adult emergence

The percent adult emergence on different host grains was in the range of 68.00 to 86.00. But the extent of adult emergence was significantly greater among the Diet V and VI than any the other diets ($p < .0001$, $F = 12.21$).

Developmental Period

The time taken for development from egg to cocoon of *C. cephalonica* varied significantly between diet VI and diet I ($p < .0001$, $F = 5.89$), whereas there was no significant difference between Diet V and VI.

DISCUSSION

The comparative study of four different hosts viz., jowar, rice, wheat and ground nut on biological parameters of *C. cephalonica* was conducted. The purpose of this study was to find out the most preferred host by *C. cephalonica*. The preference of the host was assessed on the basis of their effects on the hatching period, larval period and weight, pupal period, adult emergence, fecundity, adult longevity and adult developmental period.

The results regarding pupal period were found to be in line with the work of Patel and Mehta (2011) and Patel and Patel (2007) who had reported the minimum pupal period of 8.14 days on sorghum.

Fecundity is an important parameter when estimating egg production. We found that diets VI and V had the highest fecundity, followed by diets IV, III, II, and I. According to the findings, adding protein additives to the rearing media increased fecundity in females when compared with millet alone. A combination of carbohydrates and protein in the rearing medium resulted in healthier and heavier female moths, which in turn produced more eggs. According to *Jacob et al* (1966), fecundity was increased in *C. cephalonica* reared on protein rich diets like pulses over low protein diets. Tiwari and Khan (2003) found higher egg laying in protein-rich media. In groundnut alone, Haritha *et al.,* (2000) found an average fecundity of 211 eggs per female. Possibly, Corcyra fed with diet I laid fewer eggs due to the absence of yeast as a protein source. Similarly, Bhandari reported in 2014 that Bajra-based medium was most efficient in producing robust females with high fertility. The current study recorded minimum hatching period in Diet VI and which was at par with Diet V. The maximum hatching period recorded in maize. Patel and Mehta (2011) recorded minimum hatching period on jowar. While Prakash and Senthilkumar (2005) reported that the shortest

Table 2. Influence of different host on larval period and larval weight of *Corcyra cephalonica*

Diets	Composition	Larval period (days)	Pupal period (days)
I	Wheat, Rice	48.75 ± 1.63[d]	11.90 ± 1.22 [c]
II	Wheat, Ragi	43.15 ± 1.27 [c]	11.10 ± 3.10 [c]
III	Jowar, Ragi	42.90± 2.07[c]	10.45 ± 2.28 [b]
IV	Jowar, Ragi, Sugar	34.78 ± 1.22 [b]	10.20 ± 2.99 [b]
V	Wheat, Yeast, roundnut	35.90 ± 1.11[b]	10.20 ± 1.97 [b]
VI	Jowar, Yeast, roundnut	31.33 ± 1.98[a]	9.80 ± 1.10 [a]

Table 3. Influence of different host on different parameters of biology of *Corcyra cephalonica*

Diets	Composition	Fecundity (No. of eggs /female)	Hatching Period (days)	Adult longevity (days)	Adult Emergence (%)	Developmental Period (days)
I	Wheat, Rice	210 .00± 10.53[d]	5.98 ± 0.13[b]	7.10 ± 0.12[d]	68.00 ± 5.63[c]	61.00 ± 2.64 [d]
II	Wheat, Ragi	229.60 ± 11.66[c]	6.00 ± 0.11[b]	8.25 ± 0.63[c]	65.00 ± 4.99[c]	60.00 ± 1.98[c]
III	Jowar, Ragi	230.00 ± 9.13[c]	5.99 ± 0.90[b]	8.65 ± 0.60[c]	78.00 ± 4.67[b]	59.76 ± 1.43[c]
IV	Jowar, ragi, sugar	291.25 ± 10.12[b]	5.50 ± 0.89[c]	9.50 ± 0.50[b]	75.00 ± 3.96[b]	57.80 ± 1.69[b]
V	Wheat, yeast, groundnut	298.79 ± 9.89[a]	4.21 ± 0.78[a]	9.80 ± 0.78[b]	86.00± 6.00[a]	54.90 ± 2.63[a]
VI	Jowar, yeast, groundnut	300.10 ± 10.00[a]	4 .00 ± 0.55[a]	10.50 ± 0.90[a]	85.00 ± 3.00[a]	55.78 ± 1.99[a]

incubation period of 4.21 days was recorded on pearl millet. The difference in results may be due to uncontrolled rearing environment. Results regarding larval period was in agreement with Patel and Mehta (2011) who recorded minimum larval period on jowar. Whereas Deulkar *et al.*, (2012) reported that the least larval development in Bajra based diet.

Among the diets with jowar + additives, diet V had the highest adult emergence followed by diet VI with wheat + additives, and diet I with rice + additives had the least, which is consistent with the experiment conducted by Mehendale *et al* (2014). Also, the results are in agreement with Senthil *et a*l (2006), who stated that for *C. cephalonica*, millet-reared larvae were more likely to emerge as adults than sorghum-reared larvae.

Bernardi *et al*., (2000) reported that fresh weight of females was greatly influenced by diet, and also diets containing wheat plus yeast and rice bran plus yeast media were most effective. As well as Ingle *et al*., (2000) reported higher weights of Corcyra females from media combinations that included cotton mustard and groundnut. These components contributed to better larval development, which resulted in heavier females, according to him. In accordance with the findings of the previous study, the present study has produced similar results.

On different host grains, 68.00 to 80.00 percent of adults were emerged. A maximum number of adults emerged from jowar in the present study. Sorghum also had the maximum adult emergence of *C. cephalonica*, as reported by Pathak *et al.* (2010).

Diet I had the longest development period and the lowest percentage of moth emergence. In foxtail millet, Jagadish *et al*., (2009) found that the developmental period ranged between 28 and 36 days. In 1993, Manjunatha also observed the same trend in larval duration. In all treatments except rice husk, Kumar and Kumar (2002) observed an earlier emergence of moths.

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