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Effect of adult diet and egg density on adult longevity, fecundity and sex ratio of *Corcyra cephalonica* (Stainton)

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Abstract
The experiment on the four different egg density of rice moth *i.e.* 375, 750, 1125 and 1500 eggs/225g of maize grains and different adult diets such as honey solution 10 and 5 per cent, sugar solution 10 and 5 per cent and water under laboratory condition showed the highest fecundity of 263.60 eggs/female and total number of eggs 51823.76 was observed with egg density 375 eggs/225 g grains and lowest fecundity of 145.03 eggs/female and total number of eggs 40390.85 with egg density of 1500 egg/225 g grains. All the fecundity value for different egg density were statistically different with each other but there was no significant difference in the fecundity of *Corcyra cephalonica* in all adult diets but were significantly higher than the control. The shortest adult male and female longevity of 6.30 days and 6.23 days respectively observed with egg density of 1500 eggs/225 g of grains which was at par with egg density of 1125 eggs/225 g grains with adult female longevity of 7.00 days. The longest adult male and female longevity of 9.53 days and 7.46 days was observed with egg density of 375 eggs/225g grains respectively. There was no effect of adult diets on male and female longevity of rice moth. The sex ratio (males to females) was highest (1:1.35) with egg density of 375 eggs/225 g grains while lowest (1: 1.12) with egg density of 1500 eggs/225 g grains.

Keywords: *Corcyra cephalonica*, development, egg, emergence, fecundity, grains, honey, longevity

Introduction
Biological control is a backbone of any IPM programme and about 90% of all potential pests are already under biological control (Shukla and Jadhav, 2014) [13]. In scarcity or absence of original host of natural enemies, the rearing of alternative laboratory hosts becomes prerequisite for the mass production of predators and parasitoids under laboratory conditions. Such host should have attributes like acceptability by the beneficial species that is to be cultured, rapid rate of increase and immunity to diseases. It should be a general feeder and devoid of producing detrimental by-products such as wax (Singh 1982) [14]. For rearing of biocontrol agent diet is potentially of importance to the nutritional quality of host and for the survival of bio agents released into the environment (Hunter, 2003) [5]. The Corcyra cephalonica distributed worldwide and a serious pest of stored rice, other cereals and leguminous grains (Perveen, 2012) [10]. Besides, many damaging properties its eggs serve as an important medium for the successful breeding and rearing of *trichogramma* spp. which are used for biological control programme of different destructive borers in many countries of the world (Cadapan, 1998; Mukhukrishnan *et al*,1996) [2, 8]. In India, this pest is being utilized in various biocontrol research, developmental and extension units for mass production of many natural enemies (Jalali and Singh, 1992) [6]. The fundamental aim in mass production of natural enemies' viz., *Trichogramma chilonis* (Ishii) in is their quality production at faster and cheaper rate. The quality of host in laboratory determine the qualiity of the natural enemies in the laboratory (Finney and Fisher, 1964; Hunter, 2003) [3, 5]. For the the commercial production of various natural enemies including coccinellids, lacewings, predaceous heteropterans, and egg parasitoids of the genus Trichogramma the eggs of certain lepidopterans like *Ephestia kuehniella* Zeller, *Corcyra cephalonica* (Stainton) and *Sitotroga cerealella* (Olivier) have been exploited worldwide as alternative hosts in (De Clercq 2003) [4]. Among these, rice moth, *C. cephalonica* has been widely utilized as an efficient alternative host for mass rearing of various biological control agents. The main objective of such mass production in any biological control programme is to have the maximum number of superior individuals at minimum cost. Therefore, worldwide several attempts have been made on modifications of mass rearing

system of *C. cephalonica* for the optimization of larval diet, egg dosages and automated system of moth collection. It is very much necessary to select some cost effective adult diets and egg density which can ensure proper development of *C. cephalonica* and production of its significant number of eggs for successful rearing of the egg parasitoid, Trichogramma spp. Keeping all these points in view, experiment were conducted under laboratory condition in the biological control laboratory of the Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University, Hisar to find out the appropriate number of eggs density and effect of different adult diets on the adult moth longevity, female fecundity and sex ratio of *Corcyra cephalonica* (Stainton).

Materials and Methods

The present studies were carried out in the biological control laboratory of the Department of Entomology, Chaudhary Charan Singh Haryana Agricultural University, Hisar (Latitude 29º to 29-25´ N, longitude 75-25´E, altitude 215 meter above sea level). The studies were conducted from September, 2003 to January, 2004 at 30±1 ºC and 75±5 per cent relative humidity in a BOD Incubator and relative humidity was maintained by making saturated sodium chloride solution (Winston and Bates, 1960) [16]. The fresh (0-24 h) eggs of rice moth of *Corcyra cephalonica* for infesting grains/media were taken from culture being maintained in the biological control laboratory of the Department of Entomology The milled/crushed grains of maize were sterilized in hot air over at 110ºC for two hours. After cooling, the grains, were sprayed and properly mixed with 0.1 per cent formalin, to prevent the growth of mould as well as to increase the grain moisture lost due to heat sterilization. Then it was mixed with 2.5 per cent w/w yeast powder and streptomycin sulphate @ 0.5 g/3 kg of media grains. The rearing media (maize grains, 225 g) was put in glass jar (16 x 10.5 cm) making a layer of 1.5 inch thick. Then each culture containing 225 g of grains were infested with 375, 750, 1125, 1500 freshly (0-24 h old) eggs of *C. cephalonica.* Each culture was replicated four times. The jars were covered with fine muslin cloth, guarded with rubber band. All the jars were set up in trays of the BOD Incubator maintained at 30±1 ºC and relative humidity 75±5 per cent maintained with saturated sodium chloride solution. The jars with charged media/grains placed in the incubator were observed daily for moth emergence after 25 days of placement. The adult emerged were recorded daily and moths were collected in vials and placed in oviposition cages till the last emergence.

For recording the fecundity and longevity of the adult moth, newly emerged males and females from each treatment were paired and placed in glass vials. At the bottom of each glass vial folded strips of white paper were placed to facilitate mating and egg lying. The open end of the glass vial was covered with a muslin cloth held in place by a rubber band to allow for aeration. These paired moths were provided with different adult diets such as honey solution 10 and 5 per cent, sugar solution 10 and 5 per cent and water only. Cotton swab soaked in different food solution were hung in each glass vial using the pins through the muslin cloth. These swabs were recharged daily with food solution and changed after three days. The glass vials were kept in BOD Incubator maintained at temperature of 30±1 ºC and relative humidity of 75±5 per cent. The eggs laid by each female moth on paper strips and sometime the eggs were also laid on the muslin cloth were removed daily with the help of camel hair brush and were taken into account for computing fecundity. The total number of eggs laid by each female fed on adult diets and in control were calculated. Time period from date of emergence of paired moth till death of these moths, males and females were noted and adult longevity was calculated.

The emerged moth, which were put up in oviposition cages were allowed to die. After a gap of 7 days, 20 moths from each treatment were observed for sex determination under binocular microscope and sex ratio was calculated. The sex was confirmed by observing the tip of the abdomen which is smooth rounded in the male while the small, brownish ovipositor is visible in the female (Shazali and Smith, 1986) [12]. The males have short, blunt labial palps and the female have long and pointed labial palps.

To find out the optimum egg density, the culture (of maize grains) required to infest grains was prepared in same manner as in above given. The rearing media (maize grains, 225 g) was put in glass jar (16 x 10.5 cm) making a layer of 1.5 inch thick. Then each culture containing 225 g of grains were infested with 375, 750, 1125, 1500 freshly (0-24 h old) eggs of *C. cephalonica.* Each culture was replicated four times. So on the basis of these parameters fecundity, longevity, and sex ratio, optimum number of eggs required to infest per unit of grains was worked out.

Statistical analysis

The data were subjected to the analysis of variance. The per cent values were transformed to angular transformation.

Results and Discussions

Fecundity

Effect of egg density and adult diet on fecundity of *C. cephalonica* are presented in Table 1. The highest fecundity of 263.60 eggs/female and total number of eggs 51823.76 was observed with egg density 375 eggs/225 g grains and lowest fecundity of 145.03 eggs/female and total number of eggs 40390.85 with egg density of 1500 egg/225 g grains. The fecundity of 220.76 and 171.03 eggs/female was observed with egg density of 750 and 1125 eggs/225 g grains and total number of eggs 65256.65 and 66701.72, respectively. On the basis of total number of eggs obtained egg density of 1125 eggs/225 g was found best (Table 2). All the fecundity value for different egg density were statistically different with each other but there was no significant difference in the fecundity of *C. cephalonica* in all adult diets but were significantly higher than the control. The present results are near conformity with Sreekumar and Paul (2000) [15] who recorded the fecundity of 200.6 and 203.8 eggs on maize and sorghum when infested with egg density of 4500-5000/2 kg feed. However, Xang *et al.,* (1990) [17] reported the fecundity of 354 eggs/female on mixture of maize flour + wheat bran in ratio 7.3 when infested with egg density of 2000 eggs/kg feed. The present findings are in contrary with Jalali and Singh (1992) [6] reported the fecundity of 142, 65 and 24 egg density of 1500, 3000 and 5000 eggs/kg sorghum grains.

Table 1: Effect of egg density and adult diets on fecundity of *Corcyra cephalonica*

Egg density (per 225g grains)	Mean number of eggs/female						
	Adult diets						
	Honey 5%	Honey 10%	Sugar 5%	Sugar 10%	Water	Control	Mean
375	266.00	264.60	275.60	247.60	270.60	257.20	263.60
750	224.40	222.40	221.20	224.00	221.40	211.20	220.76
1125	172.80	177.40	170.40	173.60	172.00	160.00	171.03
1500	147.00	144.20	151.00	148.00	147.20	132.80	145.03
Mean	202.55	202.15	204.55	198.30	202.80	190.30	-----

CD (P=0.05) for egg density 6.03
C.D. (P=0.05) for Adult diet 7.39
C.D. (p=0.05) for egg density x adult diet N.S.

Table 2: Yield of *Corcyra cephalonica* eggs from maize grains infested with different egg density

Egg density	Average number of adult moth emerged	Average number of female	Average fecundity	Total number of eggs
375	342.37	196.6	263.60	51823.76
750	530.25	295.6	220.76	65256.65
1125	722.25	390.09	171.03	66701.72
1500	527.25	278.05	145.03	40390.85

Adult longevity

The data on longevity of adult female and male reared with different egg density and adult diets are presented in Table 3 and 4, respectively. The shortest adult female longevity 6.23 days was observed with egg density of 1500 eggs/225 g of grains which was at par with egg density of 1125 eggs/225 g grains with adult female longevity of 7.00 days. The longest adult female longevity of 7.46 days was observed with egg density of 375 eggs/225g grains followed by longevity of 7.26 days in case of 750 eggs/225g grains but was statistically higher with the egg density of 1500 eggs/225 g grains with longevity of 6.23 days.

In case of male, the longest adult male longevity was 9.53 days with egg density of 375 eggs/225 g grains and was significantly higher than with egg density of 750 eggs225 g grains with longevity of 7.53 days. The shortest adult male life 6.30 days with egg density of 1500 eggs/225 g grains was at par with egg density of 1125 eggs/225 g of grains with longevity of 6.9 days. There was no effect of adult diets on male and female longevity of rice moth. The present findings are in close proximity with Sreekumar and Paul (2000) [15] where they reported the female longevity of 6.88 days and male longevity of 8.66 days on maize with egg density of 45000-50000/2 kg of feed. Also, it confirms the results obtained by Pajni *et al.* (1977) [9] who reported that moth provided with sugar solution continued to live as long as those which are not given any food. Arun *et al.* (2018) [1] also reported that diet (sorghum 1000 g + groundnut 50 g) among nine experimental dietary formulations was found to outperform other dietary formulations with highest male longevity (8.33 days), highest female longevity (9.67 days) and highest fecundity (312.33).

However, Shazali and Smith (1986) [12] reported the longevity of 8.3 and 4.8 days for male and female, respectively, on sorghum infested with 1 larva/1 g feed.

Table 3: Effect of egg density and adult diets on female longevity of *Corcyra cephalonica.*

Egg density (Per 225 g grains)	Female longevity (days)						
	Adult diets						
	Honey 5%	Honey 10%	Sugar 5%	Sugar 10%	Water	Control	Mean
375	4-10 (6.80)	5-10 (7.20)	6-9 (6.80)	6-10 (7.60)	7-10 (8.20)	6-11 (8.20)	7-46
750	6-9 (7.20)	5-9 (7.20)	5-11 (7.60)	5-9 (7.00)	6-12 (8.00)	5-8 (6.60)	7.26
1125	6-10 (7.80)	5-8 (6.60)	7-9 (8.00)	6-9 (7.00)	5-8 (6.20)	6-7 (6.40)	7.00
1500	5-10 (6.60)	5-9 (6.80)	4-10 (6.40)	4-9 (6.00)	4-7 (6.00)	4-7 (5.60)	6.23
Mean	7.10	6.95	7.20	6.90	7.10	6.70	

Figures in the parentheses are average value
C.D. (P = 0.05) for egg density 0.87
C.D. (P = 0.05) for adult diet N.S.
C.D. (P = 0.05) for egg density x adult diet N.S.

Table 4: Effect of egg density and adult diets on male longevity of *Corcyra cephalonica.*

Egg density (per 225 g grains)	Male longevity (days)						
	Adult diets						
	Honey 5%	Honey 10%	Sugar 5%	Sugar 10%	Water	Control	Mean
375	7-13 (9.40)	8-11 (9.00)	7-13 (9.40)	7-15 (9.60)	8-14 (10.00)	8-13 (9.80)	9.53
750	7-10 (8.00)	5-10 (7.80)	5-9 (6.80)	6-9 (7.40)	5-11 (7.40)	6-10 (7.80)	7.53
1125	5-11 (7.40)	4-9 (6.20)	4-6 (5.20)	8-11 (9.20)	5-10 (7.20)	4-9 (6.20)	6.9
1500	6-11 (7.80)	4-7 (5.60)	5-9 (6.60)	4-6 (5.40)	4-9 (6.40)	5-7 (6.00)	6.30
Mean	8.15	7.15	7.00	7.90	7.75	7.45	-

Figures in the parentheses are average value
C.D. (P = 0.05) for egg density 0.98
C.D. (P = 0.05) for adult diet N.S.
C.D. (P = 0.05) for egg density x adult diet N.S.

Sex ratio

The observation on sex ratios of emerged *C. cephalonica* from different egg density are presented in Table 5. The sex ratio (males to females) was highest (1:1.35) with egg density of 375 eggs/225 g grains while the sex ratio of (males to females) was lowest (1: 1.12) with egg density of 1500 eggs/225 g grains. Also, the sex ratio of 1: 1.26 and 1:1.18 of males to females was observed with 750 and 1125 eggs/225 g grains, respectively. The present results are in accordance with Sharma *et al.* (1978) [11] reported the male to female ratio of 1:1.22 on maize infested @ 20 larvae / 100 g food.

Table 5: Sex ratios of *Corcyra cephalonica* with different egg density

Egg density (per 225 g grains)	Total moth observed	Sex		Sex ratio (Male to Female)
		Male	Female	
375	160	68	92	1: 1.35
750	240	106	134	1: 1.26
1125	240	110	130	1: 1.18
1500	240	113	127	1: 1.12

Conclusion

All the fecundity value for different egg density *i.e.* 375, 750, 1125 and 1500 eggs/225g of maize grains were statistically different with each other but there was no significant difference in the fecundity of *Corcyra cephalonica* in all adult diets *i.e.* honey solution 10 and 5 per cent, sugar solution 10 and 5 per cent and water, but were significantly higher than the control. Highest fecundity (263.60 eggs/female) was observed with egg density 375 eggs/225 g grains a, while lowest fecundity (145.03 eggs/female) recorded with egg density of 1500 egg/225 g grains. The shortest adult male and female longevity of 6.30 days and 6.23 days respectively observed with egg density of 1500 eggs/225 g of grains. The longest adult male and female longevity of 9.53 days and 7.46 days was observed with egg density of 375 eggs/225g grains respectively. The sex ratio (males to females) was highest (1:1.35) with egg density of 375 eggs/225 g grains while lowest (1: 1.12) with egg density of 1500 eggs/225 g grains. There was no effect of adult diets on male and female longevity of rice moth.

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