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Effects of cheaply available grain diets on development, adult emergence and sex ratio of rice moth, *Corcyra cephalonica* (Stainton)

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Abstract
The milled grains of sorghum (*Sorghum bicolar* L. Moench), maize (*Zea mays* L.), bajra (*Pennisetum typhyoides* L.), alone and in different proportions were mixed to prepared eight diet to rear and maintain the rice moth, *Corcyra cephalonica.* The milled grains were sterilized at 110ºC and all the diets were fortified with 0.1 percent formalin, 2.5 percent w/w yeast powder and streptomycin sulphate @ 0.5 g/3 kg of media grains. The study revealed that among all grains and their combination, evaluated, sorghum proved to be significantly better with shortest average development period of 62.13±0.98 days, with range of 30-141 days and longest (92.25±2.39) on the 'Bajra' days with range of 40-150 days which was at par with 'Bajra' + maize (2:1), (89.22±1.06) days. The sex ratio (males to females) was highest in sorghum (1:1.42) and lowest of (1:1.03) in case of sorghum + 'Bajra' (2:1). Adult emergence was highest from the sorghum grains 87.77 percent and lowest from the 'Bajra' grains 39.00 percent. The adult emergence from sorghum + maize (1:1), 82.47 percent was significantly higher than the maize + sorghum (2:1), 76.17 percent but was significantly lower than the sorghum + maize (2:1) 85.00 percent.

Keywords: *Corcyra cephalonica*, development, grains, egg, emergence, sex ratio, *T. chilonis*

Introduction
The rice moth, *Corcyra cephalonica* is distributed worldwide and a serious pest of stored husked and unhusked rice, other cereals and leguminous grains. It also attacks gingelly, oil-cakes, dry fruits, cocoa, chocolates, biscuits, flax seeds, cream of wheat, flour etc. in many countries of the world (Perveen, 2012) [16]. But another economic importance of this insect is that the eggs of these insects are used as diet to mass multiply the bio-agent like *Trichogramma* spp. In India, Rice meal moth is being utilized in various biocontrol research, developmental and extension units for mass production of number of natural enemies (Jalali and Singh, 1992) [6]. Due to the unavailability of egg masses of different borers throughout the year for mass production of *T. chilonis*, sufficient numbers of *C. cephalonica* eggs are essential. It is very much necessary to select some cost effective food material (s) 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. Rearing of these moths is generally done on wheat or chopped rice in the laboratory. It has been reported that *C. cephalonica* have a shorter development time on millet than on sorghum (Russell *et al.*, 1980) [19] and a shorter development time on maize than on cocoa (Mbata, 1989) [19]. Both male and female reared on mixed diet with a combination of (rice+jowar+maize) had maximum body weight and body length (Bhardwaj *et al.*, 2017) [2]. In an attempt to minimize cost of production by optimizing the grain utilization by *C. cephalonica*, experiment was conducted to find out suitable cheaply available diet for rearing of eggs of Rice moth and an experiment was conducted under laboratory condition to evaluate the diet dependent biological parameters *i.e.* development period, adult emergence and sex ratio of rice moth, *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 percent relative humidity in a

BOD Incubator and relative humidity was maintained by making saturated sodium chloride solution (Winston and Bates, 1960) [24]. The fresh (0-24 h) eggs of rice moth of *C. cephalonica* for infesting grains/media were taken from culture being maintained in the biological control laboratory of the Department of Entomology for observation on developmental period and emergence rate of *C. cephalonica*. The milled grains (3-4 pieces) of sorghum (*Sorghum bicolar* L. Moench), maize (*Zea mays* L.), 'Bajra' (*Pennisetum typhyoides* L.), alone and in different proportions were mixed for feeding. The milled/crushed grains were sterilized in hot air over at 110 ºC for two hours. After cooling, the grains, were sprayed and properly mixed with 0.1 percent formalin, to prevent the growth of mould as well as to increase the grain moisture lost due to heat sterilization. Then in was mixed with 2.5 percent w/w yeast powder and streptomycin sulphate @ 0.5 g/3 kg of media grains. Then 225 g grains of each treatment was put in glass jars (16 x 10.5 cm) making a layer of rearing media 1.5 inch thick in glass jar which was most suitable for development as reported by Medina & Cadapan, 1982 [10]. Then each treatment was infested with 750 fresh eggs (0-24 h) of riche moth *C. cephalonica.*

Each treatment 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±1ºC and relative humidity 75±5 percent 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. The number of adult emerged also recorded daily from each jar and development period was calculated. Time period from infestation of grains with eggs to emergence of adults was considered as developmental period. On the basis of the number of *C. cephaonica* eggs infested and number of adult moth emerged, rate of emergence was calculated in percentage as follows:

$$\text{Adult emergence} = \frac{\text{Number of adults emerged}}{\text{Total number of eggs inoculated}} \text{ x100}$$

(Bordoloi, 1994) [3]

For recording observation on sex ratio, 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 Smit, 1986) [21, 22]. The males have short, blunt labial palps and the female have long and pointed labial palps (Hill, 1990) [5].

Statistical analysis

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

Results and discussions

Developmental period

The observations on developmental period of *C. cephalonica* reared on different grains and their combinations are given in Table 1. The average developmental period of *C. cephalonica* was shortest (62.12±0.98) on sorghum days with range of 30-141 days and longest (92.25±2.39) on the 'Bajra' days with range of 40-150 days which was at par with 'Bajra' + maize (2:1), (89.22±1.06) days. The developmental period on sorghum + maize (2:1), maize + sorghum (2:1) and sorghum + maize (1:1) was 67.25±0.51, 65.71±1.53 and 67.69±0.28 days with a range of 32-142, 32-142 and 31-142 days, respectively, which were at par with each other but significantly shorter than the developmental period on maize alone where it was 70.08±0.85 days with a range of 31-142 days. The developmental period on maize + 'Bajra' (2:1), sorghum + Bajra (2:1) and maize + 'Bajra' (1:1) was 74.70±0.27, 72.50±0.47 and 73.65±0.51 days with a range of 34-143, 31-141 and 34-143 days, respectively, and at par with each other and significantly higher developmental period than on maize alone. The developmental period of (79.27±1.23) days with a range of 34-145 days on 'Bajra' + sorghum (2:1) was significantly shorter than on 'Bajra' alone. The present studies are in conformity with results from Pathak (2010) [15] who clearly established the superiority of sorghum over other media in terms of average developmental period, percentage of moth emergence and weight of eggs. However, Uberoi (1960) [23] reported the developmental period 45, 43.4 and 43 days on sorghum, maize and pearl millet, respectively. Murthi and Rao (1945) [11] found the developmental period (39-81) and 55.5 (43-76) days, respectively, on sorghum. In contrary to present findings, Shazali (1986) [21, 22] reported the developmental period of 35±1.6 days on sorghum and Rao *et al.* (1980) [18] observed the developmental period of 44.8 and 46.3 days on sorghum flour and sorghum + 4.0 percent total sugar. It has been reported that *C. cephalonica* have a shorter development time on millet than on sorghum (Russell *et al.* 1980) [19] and a shorter development time on maize than on cocoa (Mbata 1989) [9]. The differences in the duration of developmental period may be due to the difference in the rearing conditions. Whereas Nasrin (2016) [13] showed that *C. cephalonica* revealed extented larval duration (45.9 days), increased larval weight (0.058 gm), survival rate (88.3%) and adult emergence rate (93.5%) when they were reared on chopped wheat as compared to wheat grain, paddy grain, rice grain, maize grain, chopped maize, rice bran, mixture of rice bran and chopped rice. Kumari *et al*. (2014) [8] found rice, wheat and groundnut mixture (5:5:1) to be the superior rearing medium among sex diet tested that enhanced quicker development period of *Corcyra cephalonica*, maximum fecundity and maximum fresh body weight of full grown larva for both summer and winter seasons. The quicker development period of *Corcyra cephalonica* were 36.30±0.58 and 48.80±0.33 in summer and winter, respectively whereas maximum fecundity were 175.60±0.13 and 157.65±2.64 in both the season.

Table 1: Developmental period and adult emergence of *Corcyra cephalonica* on different grains

Sr. No.	Grains	Developmental period (Days)		Adult emergence (%)
		Range	Average	
1.	Sorghum	30-141	62.13±0.98	87.77 (69.51)
2.	Maize	31-143	70.08±0.85	70.75 (57.24)
3.	'Bajra'	40-150	92.25±2.39	39.00 (38.62)
4.	Sorghum + Maize (2:1)	32-142	67.25±0.51	85.00 (67.25)
5.	Maize + Sorghum (2:1)	34-142	65.71±1.53	76.17 (61.77)
6.	Maize + 'Bajra' (2:1)	34-143	74.70±0.27	58.90 (50.10)
7.	'Bajra' + Maize (2:1)	40-150	89.22±1.06	42.85 (40.87)
8.	Sorghum + 'Bajra' (2:1)	31-141	75.50±0.47	68.25 (55.68)
9.	'Bajra' + Sorghum (2:1)	34-145	72.27±1.23	48.57 (44.16)
10.	Sorghum + Maize (1:1)	31-142	67.69±0.28	82.47 (65.24)
11.	Maize + 'Bajra' (1:1)	34-143	73.65±0.51	54.25 (47.41)
12.	Sorghum + 'Bajra' (1:1)	34-144	73.52±0.37	63.25 (52.67)
	C.D. (P = 0.05)k		3.05	1.81
	S.E. (m)		1.06	0.63

Adult emergence

The data on adult emergence of *C. cephalonica* from different grains in Table 1 indicated that the adult emergence was highest from the sorghum grains 87.77 percent and lowest from the 'Bajra' grains 39.00 percent. The adult emergence from sorghum + maize (1:1), 82.47 percent was significantly higher than the maize + sorghum (2:1), 76.17 percent but was significantly lower than the sorghum + maize (2:1) 85.00 percent. No significant difference was observed for adult emergence from maize and sorghum + 'Bajra' (1:1) was significantly lower. The adult emergence of 54.25 percent on maize + 'Bajra' (1:1) was significantly lower 58.90 percent, than from maize + 'Bajra' (2:1) but more than from 'Bajra' + sorghum (2:1), 48.57 percent. The adult emergence of 39.00 percent on 'Bajra' was significantly lower than from 'Bajra' + Maize (2:1), 42.85 percent. The present findings were almost supported by Shazali and Smith (1986) [21, 22] where they reported the adult emergence of 80 percent on sorghum grains. However, Sharma *et al.* (1978) reported the adult emergence of 93.3 and 81.67 percent on sorghum and maize, respectively. Murthi and Rao (1945) [11]. In contrary to the present findings, Punj (1967) [17] reported the emergence of 98, 33, 22 percent on pearl millet, sorghum and maize, respectively. Murugesan *et al.* (1997) [12] reported the adult emergence of 72.8 percent on pearl millet variety MH-179. Madina and Cadapan (1982) [10] reported the emergence of 19 percent on maize meal. Arun *et al.* (2018) [1] reported that the diet containing (sorghum 1000 g + groundnut 50 g) was found to outperform other dietary formulations as it resulted in lowest total development period (47.33 days), highest adult emergence (82%). Whereas in contrary to present finding Nathan *et al.* (2006) [14] proved that for *C. cephalonica*, the percentage adult emergence were significantly higher for millet-reared than for sorghum-reared larvae. The percentage adult emergence and percentage 24-h survival of *T. chilonis* were significantly higher on eggs of *C. cephalonica* hosts reared on millet than on eggs of those reared on sorghum.

Sex ratio

The sex ratio merged *C. Cephalonica* on different grains are presented in Table 2. The sex ratio (males to females) was highest in sorghum (1:1.42) and lowest of (1:1.03) in case of sorghum + 'Bajra' (2:1). A sex ratio of (Males to Females) 1: 1.25, 1: 1.06, 1:1.34, 1: 1.26 and 1: 1.09 was observed in the maize, 'Bajra', sorghum + maize (2:1), maize + 'Bajra' (2:1) and maize + 'Bajra (1:1), respectively. Also the sex ratio of (Males to female) was 1:1.31, 1:1.161:1.21 and 1: 1 on 'Bajra' + maize (2:1), 'Bajra' + sorghum (2:1), sorghum + maize (1:1), and maize + 'Bajra' (1:1), respectively, while on sorghum + 'Bajra' (1:1), male to female ratio was 1:1.37.

Table 2: Sex ratios of *Corcyra cephalonica* on different grains

Grains	Total moth observed	Sex		Sex ratio (Male to Female)
		Male	Female	
Sorghum	230	95	135	1:1.42
Maize	230	102	128	1:1.25
'Bajra'	260	126	134	1:1.06
Sorghum + Maize (2:1)	560	111	149	1:1.34
Maize + Sorghum (2:1)	240	106	134	1:1.26
Maize + 'Bajra' (2:1)	230	110	120	1:1.09
'Bajra' + Maize (2:1)	250	108	142	1:1.31
Sorghum + 'Bajra' (2:1)	260	128	132	1:1.03
'Bajra' + Sorghum (2:1)	260	120	140	1:1.16
Sorghum + Maize (1:1)	230	104	126	1:1.21
Maize + 'Bajra' (1:1)	260	120	140	1:1.16
Sorghum + 'Bajra' (1:1)	240	101	139	1:1.37

The present studies in close proximity with Sharma *et al.* (1978) [20], where they reported the male to female ratio of 1: 1.14 and 1: 1.22 on sorghum and maize, respectively. However, Murugesan *et al.* (1990) reported the male and female ratio of 1:3.02) on 'Bajra' variety MH-179. However Kamble *et al.* (2006) [7] reported that the percent female obtained from different cereal grains varied from 13.20 to 38.70 on different cereal grains. As per Chaudhuri (2015) [4] the sex ratio showed female dominance when reared on four different types of locally available grains namely maize, wheat, Italian millet and scented rice.

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