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Dietary Composition and Biological Performance of *Corcyra cephalonica* (Stainton) on Maize-based Diets Under Laboratory Conditions

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ABSTRACT

The present investigation was carried out from November, 2024 to January, 2025 at the Hi-Tech Laboratory, Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University (RPCAU), Pusa, Bihar, India, to assess the effect of seven maize-based diets on the biological and economic performance of *Corcyra cephalonica* (Stainton) under laboratory conditions. *Corcyra cephalonica* (Stainton), commonly known as the rice moth, was recognized as a serious stored-grain pest and an important factitious host for the mass production of egg parasitoids and other natural enemies used in biological control programmes. Providing an efficient and economical rearing diet was crucial, as diet quality directly influenced insect development, reproductive potential and the reliability of biocontrol production systems. The treatments included maize alone (standard check) and maize mixed in a 1:1 ratio with wheat, rice, barley, sorghum, bajra and ragi, all fortified with yeast, groundnut, streptomycin sulphate and wettable sulphur. Diet composition significantly influenced developmental and reproductive parameters. Among all treatments, the maize+sorghum diet proved to be the most suitable, as it resulted in the shortest incubation, larval and pupal periods, the shortest total developmental duration in both sexes, higher adult and female emergence, maximum fecundity and greater total egg production. This diet also recorded the highest net profit (₹ 1181) with a favourable benefit–cost ratio (3.31), highlighting its economic viability for mass rearing. In contrast, the maize+barley and maize+ragi diets prolonged development and reduced emergence and reproductive performance. Overall, the study demonstrated that maize+sorghum was an efficient and cost-effective diet for large-scale laboratory rearing of *C. cephalonica*, thereby supporting sustainable biological control programmes.

KEYWORDS: *Corcyra cephalonica*, biology, diet, compositions, mass-rearing, benefit-cost ratio

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1. INTRODUCTION

Nutrition played a fundamental role in determining insect growth, survival, reproduction and overall fitness. In holometabolous insects, dietary quality during the larval stage significantly influenced developmental rate, pupal weight, adult emergence, fecundity and longevity (Nation, 2015; Raubenheimer and Simpson, 2018). Proteins were essential for tissue development and egg production, carbohydrates provided metabolic energy, lipids contributed to membrane structure and hormone synthesis and micronutrients regulated enzymatic and physiological functions (Chapman, 2013; Behmer, 2009). Therefore, variation in dietary composition directly affected life history traits and population dynamics of stored product insects (Jervis et al., 2008; Davidowitz, 2013). Stored grains were highly vulnerable to insect infestation, resulting in significant post-harvest losses globally (Anonymous, 2019). Among major storage pests, *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae), commonly known as the rice moth, was widely distributed across tropical and subtropical regions. It infested cereals such as maize, rice, wheat and sorghum, causing both quantitative and qualitative damage (Hill, 2002; Tadesse, 2020). The larvae preferentially fed on broken or crushed grains and produced dense silken webbing mixed with frass, thereby contaminating stored products and reducing their market value (Phillips and Throne, 2010). Despite its status as a destructive pest, *C. cephalonica* was of considerable economic importance as a factitious host for the mass production of biological control agents. It was extensively used for rearing egg parasitoids such as *Trichogramma* spp. and larval parasitoids like *Habrobracon hebetor*, which were deployed against several lepidopteran pests in agricultural ecosystems (van Lenteren, 2012; Parra and Coelho, 2009). The biological performance and field efficiency of these natural enemies were strongly influenced by host quality, particularly egg size, nutritional reserves and overall vigor (Hunter, 2003). Consequently, optimising the dietary composition for rearing *C. cephalonica* was essential to ensure consistent production of high-quality host stages in commercial insectaries. Maize was commonly used as a principal rearing substrate due to its availability, affordability and favourable nutrient composition. However, solo diets did not always provide optimal nutrient balance required for maximising reproductive performance and colony stability (Behmer, 2009; Raubenheimer and Simpson, 2018). Supplementation or combination with other cereals such as wheat, rice, barley, sorghum, bajra or ragi enhanced amino acid balance, micronutrient diversity and overall dietary quality, potentially improving larval growth, accelerating development and increasing adult fecundity (Nathan et al., 2005; Oonincx et al., 2020). Diet-mediated variations in biological parameters such as developmental duration, survival rate, adult emergence and egg production were reported in several stored product insects (Nayak et al., 2015). In addition to biological performance, economic feasibility was a critical consideration in large-scale mass production systems. Efficient diets not only enhanced growth and reproduction but also reduced production costs per unit output (Parra and Coelho, 2009). However, systematic comparative evaluation of maize-based composite diets under standardised laboratory conditions remained limited. Therefore, the present study aimed to evaluate the effects of different maize-based dietary formulations on the biological performance of *C. cephalonica* under controlled laboratory conditions. Seven dietary treatments comprising maize alone and maize combined (1:1) with wheat, rice, barley, sorghum, bajra or ragi-uniformly supplemented with yeast, groundnut, streptomycin sulphate and wettable sulphur-were assessed. Key biological parameters, including developmental duration, adult emergence, fecundity, egg production and cost effectiveness, were analysed to identify the most suitable and economically viable maize-based diet for sustainable mass rearing of *C. cephalonica*.

2. MATERIALS AND METHODS

2.1. Experimental details

The present investigation was conducted at Hi-Tech laboratory, Sugarcane Research Institute, RPCAU, Pusa, to study "Biology of *Corcyra cephalonica* (Stainton) on different diet compositions" The detailed methodology used for the investigation is described as under:

2.2. Selection of diets for Corcyra cephalonica

An efficient and low-cost diet was selected for rearing *Corcyra cephalonica*. Several cereal-based artificial diets such as maize, barley, rice, ragi, wheat, bajra and sorghum, were used.

2.2.1. Effective media preparation for Corcyra cephalonica rearing

The rearing diets consisting of different varieties of cereals (sorghum, bajra, maize, wheat, rice, barley, ragi) were combined with other components (5 g yeast, 0.05 g streptomycin sulphate, 1 g wettable sulphur) to improve the diet, along with 100 g of groundnut. At first, all of the grains were placed to dry in the sun separately to eradicate all pre-infestation. Then the grains were sterilised for 30 min. at 100°C in the oven. After that, the grains were broken in a mixer grinder to ensure that the larvae could feed on them effectively. The plastic rearing containers were cleaned and kept in the shade for drying. A cotton soaked in 1% formalin solution was used to sanitise the plastic rearing containers. A total of 7 treatments were subjected to this investigation, each consisting of 3 replications.

2.2.2. Procedures for the rearing of Corcyra cephalonica

After preparation of the diets, 2.5 kg of diet mixture was placed in each container. Around ¼ cc of *C. cephalonica* eggs were spread on top of the mixture in each box. Each plastic container was covered, labelled with the inoculation date and placed on racks. In order to keep ants away from the boxes, water-filled bowls (ant wells) were placed at the bottom of the racks. The boxes were inspected regularly over 30 days to ensure healthy host development and to monitor for any pest infestations.

2.2.3. Methods for collecting Corcyra cephalonica eggs

After 40-45 days, adult moths emerged from the rearing boxes. These adults were collected from the various diet treatments in the rearing boxes and transferred to an oviposition chamber. In the oviposition chamber, the adults were provided with a solution of 5% honey on a cotton swab as nourishment. After 2-3 days of mating, eggs were collected and passed through 15, 30 and 40 mesh sieves to remove dust particles. These cleaned eggs were then used for experimental purposes and for further breeding of *C. cephalonica*.

3. RESULTS AND DISCUSSION

In order to investigate the impact of different diets on the biology of *C. cephalonica*, a total of seven dietary treatments were formulated and evaluated under laboratory conditions, and each treatment was replicated three times to ensure the accuracy of the results. The following key biological observations were recorded for each treatment:

3.1. Incubation period

The incubation period was defined as the duration from egg-laying to the date of hatching. 50 Eggs from each treatment were individually transferred to separate Petri plates using a moist camel hair brush and the emerging larvae were monitored twice a day.

3.2. Larval period

Ten newly hatched larvae from a Petri plate were carefully transferred to a separate small plastic box using a moist camel hair brush, each box containing 100 g of rearing medium. The larval period was recorded from the date of hatching to the time 50% of the larvae started to spin cocoons in each treatment.

3.3. Pupal period

Ten larvae that were about to pupate were selected and kept under observation to record the pupal period. Each individual was monitored daily until adult emergence. The pupal period was calculated from the date of pupation to the date of adult emergence and the average pupal period was calculated based on these observations.

3.4. Male and female longevity

Ten male and ten female moths from each diet were selected after emergence and placed individually in a clean plastic box and covered with muslin cloth and secured with rubber bands. A 5% honey solution was provided as a food source. Longevity was recorded daily from the day of emergence until death to evaluate the effect of diet on adult lifespan.

3.5. Total development period

The total life cycle of *C. cephalonica* was determined by the summation of the incubation period, larval period, pupal period and adult longevity. This indicates the total development period from the day of egg-laying to the death of the adult.

3.6. % adult emergence

For each treatment, 50 pupae were selected and individually placed in separate plastic boxes to monitor adult emergence. The experiment was conducted with three replications. The number of adults that successfully emerged from the pupae was recorded from each replication. The adult emergence percentage was calculated using the formula:

Adult emergence percentage=(Number of adult emerged/ Total number of pupae)×100

3.7. % female emergence

50 adults were randomly collected from each treatment after emergence. Sex determination was carried out based on morphological features, specifically the structure of the labial palpi. The experiment was conducted with three replications. Female emergence percentage was calculated using the following formula:

Percent female emergence=(Number of female emerged/ Total number of collected)×100

3.8. Fecundity

Ten pairs of adult male and female moths from each diet were transferred to individual egg-laying cages. They were provided with a 5% honey solution. Eggs were collected daily and cleaned by passing them through fine sieves to remove any debris. Fecundity was assessed by counting the total number of eggs laid by each female throughout its lifespan. Fecundity was assessed by counting the total number of eggs laid and dividing it by the total number of females in the experiment.

3.9. Egg hatching percentage

To determine the hatching percentage, 50 freshly laid eggs of *C. cephalonica* were placed in clean Petri dishes. The eggs were observed daily and the number of hatched eggs was counted.

Egg hatching percentage=(Number of hatched eggs/Total number of eggs)×100

3.10. Total egg production

Total egg production per treatment was estimated by multiplying the mean fecundity by the emerged female percentage.

It was calculated by using the formula;

B:C ratio=Net profit (in Rs.)/Total cost for preparing diet (in Rs.)

3.11. Statistical analysis

The statistical analysis was carried out to determine the effect of different feeding diets on the *C. cephalonica* using the OP stat software. The one-way ANOVA was carried out for different observations, viz., incubation period, larval period, pupal period, total development period of male and female, adult longevity of male and female, egg hatching %, adult emergence, female emergence and fecundity.

Diet-related differences in insect development and reproduction were expected, as nutrient balance directly influences larval growth, energy reserves, adult longevity and reproductive capacity. In the present study, the maize+sorghum diet consistently supported faster development, higher adult and female emergence and maximum fecundity and egg production, indicating a more favourable nutritional profile and feeding conditions. From a biological control perspective, improving the efficiency and stability of factitious host production was essential, since mass-rearing diets should not compromise downstream natural-enemy performance (Wang et al., 2021). Economically, maize+sorghum yielded the highest net profit due to greater egg output, whereas maize alone showed a slightly higher benefit-cost ratio because of lower inputs. Overall, prioritising biological quality and egg production makes maize + sorghum the more practical option for routine biocontrol use.

The duration of different life stages, viz., incubation period, larval and pupal duration, adult longevity (male and female) and total developmental period (male and female), all expressed in days, was presented in Table 1.

3.12. The incubation period of *C. cephalonica*

C. cephalonica varied significantly across dietary treatments, ranging from 3.15 to 6.30 days. The shortest incubation period was observed in the maize+sorghum diet (3.15 days), indicating a nutritionally optimal medium for embryonic development and 6.30 days in the diet containing Maize+Ragi treatment. These results were in agreement with Kaur et al. (2024), who observed an incubation period of 4.50 days on a maize+sorghum combination. Comparable findings were reported by Ravichandran et al. (2025), who recorded the shortest egg incubation period (3.54 days) on sorghum and 4.18 days on maize, indicating that sorghum and maize-based diets promote faster embryonic development in *C. cephalonica*.

Table 1: Effect of different diet compositions on the biology of *Corcyra cephalonica*

Tr. No.	Treat-ments	Incubation period (Days)	Larval duration (Days)	Pupal duration (Days)	Adult longevity (Male) (days)	Adult longevity (Female) (days)	Total development period (Male) (days)	Total development period (Female) (days)
T_1	Maize	4.00±0.94	31.70±2.53	7.85±0.82	5.85±1.00	7.30±1.09	49.40±3.37	50.85±3.53
T_2	Maize+ wheat	5.15±0.75	34.05±2.06	8.65±0.94	5.25±0.89	6.75±1.57	53.10±3.36	54.60±3.53
T_3	Maize+ rice	5.35±0.75	36.40±1.74	9.10±0.74	4.20±0.92	5.60±1.05	55.05±2.51	56.45±2.93
T_4	Maize+ barley	5.80±0.63	38.20±3.46	10.45±0.93	3.20±0.63	5.05±0.86	57.65±3.63	59.50±3.65
T_5	Maize+ sorghum	3.15±0.67	32.10±2.44	7.45±0.64	6.05±0.93	7.50±1.05	48.75±2.99	50.20±3.04
T_6	Maize+ bajra	4.60±0.84	34.60±2.20	8.10±0.81	4.55±1.14	6.20±1.06	51.85±3.06	53.50±3.36
T_7	Maize+ ragi	6.30±0.82	37.25±3.69	10.70±0.82	3.10±0.77	4.90±0.66	57.35±3.96	59.15±3.39
SEm±		0.08	0.53	0.14	0.06	0.08	0.81	0.84
CD (p=0.05)		0.25	1.63	0.44	0.19	0.26	2.48	2.56

3.13. Larval duration

Larval duration ranged between 31.70 days (Maize) and 38.20 days (Maize+barley). These results were partially supported by Chandrakar et al. (2021), who reported a larval duration of 32.00 days on maize. Kaur et al. (2024) observed 33.33 days on maize+sorghum; in maize, the shortest larval duration was found, which may be due to the high starchy material that was easy to digest and may support fast larval growth. While Manjunath (2014) reported a general larval period ranging from 28 to 36 days, depending on diet type and environmental conditions.

3.14. Pupal duration

Pupal duration was shortest in Maize+Sorghum (7.45 days) and longest in Maize+Ragi (10.70 days). These findings were partially supported by Lande et al. (2024), who reported a pupal period of 7.90 days on a Sorghum +Groundnut diet. Similarly, Mawthoh et al. (2025) recorded the shortest pupal duration (9.00 days) in *Corcyra cephalonica* reared on sorghum, highlighting the role of sorghum-based diets in promoting faster pupal development.

3.15. Adult male longevity

Adult male longevity ranged from 3.10 to 6.05 days, with the longest observed in Maize+Sorghum. The enhanced longevity in this treatment suggests superior metabolic health and reserves built during immature stages. These findings were partially in agreement with Kaur et al. (2023) who reported 12.50 days of male longevity on combination of maize (48.5%)+sorghum (48.5%)+groundnut (3%).

3.16. Adult female longevity

Adult female longevity followed the same trend as males, with the highest longevity recorded on the maize + sorghum diet (7.50 days), followed by maize alone (7.30 days). Ragi-based diets yielded the shortest female longevity. Similar trends have been reported in recent studies, which demonstrated that maize+sorghum-based diets enhance the biological performance and adult longevity of *C. cephalonica*. Kaur et al. (2024) reported the longest female lifespan (8.67 days) on a maize (48.5%)+sorghum (48.5%)+groundnut (3%) diet, while a recent demographic study identified sorghum as the most suitable substrate for improving the development and population growth of *C. cephalonica*.

3.17. Total developmental period of male and female

The total development period for males was minimum in Maize+Sorghum (48.75 days), followed by maize (49.40 days), while the maximum was in maize+barley (57.65 days). Female development mirrored male patterns, with the shortest duration in maize+sorghum (50.20 days) and the longest in maize+barley (59.50 days) (Table 1). These results demonstrate the positive influence of sorghum-based diets on overall insect development. These findings were in agreement with the results of Lande et al. (2024), who reported a total developmental period of 49.73 days when *C. cephalonica* was reared on a Sorghum+Groundnut-based diet. Similar trends were reported by Ravichandran et al. (2025), who found that sorghum supported the shortest pre-adult developmental duration and the highest population growth parameters of *C. cephalonica* compared with maize, rice and wheat, indicating the superior suitability of sorghum-based diets for rapid development.

3.18. Adult emergence

Adult emergence was highest in maize+sorghum (86.67%), where maize+barley (68.00%) and maize+ragi (69.33%) showed significantly lower emergence. These results were partially supported by the findings of Kaur et al. (2024), who reported an adult emergence rate of 88.33% when *C. cephalonica* was reared on a composite diet comprising maize (48.5%), sorghum (48.5%) and groundnut (3%) (Table 2). Similarly, Soumya (2023) observed an adult emergence rate of 85.00% on sorghum-based diets.

Table 2: Effect of different diet compositions on adult and female emergence (%) of *Corcyra cephalonica*

Tr. No.	Treatments	Adult emergence (%)	Female emergence (%)
T_1	Maize	84.00	51.33
T_2	Maize+wheat	73.33	50.00
T_3	Maize+rice	78.00	49.33
T_4	Maize+barley	68.00	48.00
T_5	Maize+sorghum	86.67	52.00
T_6	Maize+bajra	80.67	50.67
T_7	Maize+ragi	69.33	47.33
SEm±		1.38	0.72
CD (p=0.05)		4.23	2.20

3.19. Female emergence

The highest percentage of female emergence was noted in maize+sorghum (52.00%), followed by maize (51.33%) (Table 3). Lower female emergence in Ragi and Barley-based treatments. These observations were partially supported by Chaudhuri and Senapati (2017) documented a 50.89% female emergence on a maize+yeast diet. Similar trends have also been reported by Allotey and Azalekor (2000), who observed female-biased sex ratios in *C. cephalonica* reared on nutritionally suitable diets, suggesting that diet composition plays a significant role in determining female emergence.

3.20. Egg hatching

Egg hatching was significantly higher in maize+sorghum

Table 3: Effect of different diet compositions on egg hatching percentage, fecundity and total egg production of *Corcyra cephalonica*

Tr. No.	Treatments	Egg hatching (%)	Fecundity (No. of eggs female^{-1})	Total egg production (in cc)
T_1	Maize	84.00	271.40	27.39
T_2	Maize+ wheat	75.33	236.33	21.07
T_3	Maize+ rice	72.00	225.67	20.59
T_4	Maize+ barley	69.33	207.87	16.30
T_5	Maize+ sorghum	86.67	285.87	30.72
T_6	Maize+ bajra	86.00	256.23	24.67
T_7	Maize+ ragi	65.33	214.77	16.94
SEm±		1.45	3.49	
CD (p=0.05)		4.45	10.69	

(86.67%), maize+bajra (86.00%) and maize (84.00%). These results indicate a positive effect of these diets on embryonic viability. Comparable trends were reported by Rajulwar et al. (2008), who observed improved egg hatching on maize and maize-supplemented media. In contrast, the lowest hatchability recorded on the maize+ragi diet (65.33%) suggests inadequate nutritional support for embryonic development. The present findings were also supported by Kaur et al. (2024), who reported a hatchability rate of 87.50% on a composite diet comprising maize, sorghum, and groundnut.

3.21. Fecundity

Fecundity was highest in maize+sorghum (285.87 eggs female^{-1}), followed by maize (271.40) and maize+bajra (256.23). Enhanced reproductive performance under sorghum-based diets may be attributed to optimal protein, lipid and carbohydrate balance (Malik et al., 2018). The low fecundity observed in the maize+barley and maize+ragi treatments was consistent with the findings of Sathpathy et al. (2003), highlighting diet-induced fecundity variations. These findings were partially supported by Mawthoh et al. (2025), who reported the highest fecundity (302.30 eggs female^{-1}) in *C. cephalonica* reared on a sorghum-based diet. Similarly, Soumya (2023) reported a fecundity of 300 eggs female^{-1} when *C. cephalonica* was reared on a sorghum+groundnut diet fortified with yeast. These observations collectively indicate that sorghum-containing diets provide superior nutritional suitability for enhancing the reproductive performance of *C. cephalonica*.

3.22. Total egg production

Total egg production per treatment also peaked in the maize+sorghum diet (30.72 cc treatment^{-1}), followed by maize (27.39 cc treatment^{-1}) (Table 4). Nasrin et al. (2016) emphasised the need for cost-effective and highly productive diets, such as sorghum, to support biological control programmes. Similarly, Kaur et al. (2024) reported that a maize (48.5%)+sorghum (48.5%)+groundnut (3%) diet resulted in superior reproductive performance and the highest fecundity in *Corcyra cephalonica*, indicating the enhanced suitability of sorghum-containing diets for mass rearing. These findings corroborate the present results, which demonstrated increased egg production on the maize+sorghum diet.

3.23. Economic evaluation

The highest net profit (₹ 1180.75) and cost-benefit ratio (3.31) were recorded in the maize+sorghum treatment, closely followed by maize alone, which yielded a net profit of ₹ 1057.00 with a higher cost-benefit ratio of 3.38 (Table 4). Similar economic advantages of sorghum and maize-based media were discussed by Kumar et al. (2001). Likewise, Amadou et al. (2019) demonstrated that optimising cereal-based diets with sorghum significantly improved the cost efficiency and productivity of *Corcyra cephalonica* mass rearing systems, highlighting the importance of selecting nutritionally suitable and economically viable rearing media.

Table 4: Economic evaluation of different diet compositions for the mass rearing of *Corcyra cephalonica*

Tr. No.	Treatments	Total income (₹)	Total cost for preparing diet (₹)	Net profit (₹)	B:C ratio
T_1	Maize	1370.00	313.00	1057.00	3.38
T_2	Maize+wheat	1054.00	319.00	735.00	2.31
T_3	Maize+rice	1030.00	319.00	712.00	2.23
T_4	Maize+barley	816.00	332.00	485.00	1.46
T_5	Maize+ sorghum	1537.00	357.00	1181.00	3.31
T_6	Maize+bajra	1234.00	344.00	890.00	2.59
T_7	Maize+ragi	844.00	369.00	476.00	1.29

1US$= INR 86.22 (average value of January, 2025); Maize:-25 ₹/kg., Wheat: -30 ₹/kg., Rice:-30 ₹/kg., Barley:- ₹/kg., Sorghum:-60 ₹/kg., Bajra:-50 ₹/kg., Ragi:-70 ₹/kg., Price of 1cc of Corcyra eggs:-60 ₹/cc, other expenditure:-240 ₹/ treatment, 1US$= 86.45 ₹

4. CONCLUSION

Among seven maize-based diets tested, maize+sorghum (1:1) fortified with yeast, groundnut, streptomycin sulphate and wettable sulphur produced the best overall biological performance of *C. cephalonica*, faster development, higher emergence and maximum fecundity, egg production and also generated the highest net profit. Therefore, maize+sorghum was recommended for cost-effective mass production of *C. cephalonica* eggs under laboratory conditions.

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