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BIOLOGY AND LIFE CYCLE OF RICE MOTH *Corcyra cephalonica, Lepidoptera, Pyralidae*

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Abstract

The rice moth, *Corcyra cephalonica*, is a significant pest of stored food commodities, causing both quantitative and qualitative damage to grains through its larvae, which feed on cereals, pulses, oilseeds, spices, and dried fruits. The species exhibits complete metamorphosis with a life cycle including an egg incubation period of 5 days, a larval period of 23-25 days, a pupal period of 10 days, and an adult lifespan of approximately 1 week. The larvae damage grains by feeding within silken webs, often converting stored grain into a webbed mass, rendering it unfit for human consumption (Bhandari *et al.*, 2009). Efforts to rear *C. cephalonica* on efficient food media resulted in the production of robust moths and eggs, which are crucial for rearing egg parasitoids (Pathak *et al.*, 2010).Recent studies have focused on alternative pest control methods, given the growing concerns over chemical pesticide use. Fenoxycarb, a juvenile hormone analog, has shown promising results in controlling *C. cephalonica*. Six different concentrations of fenoxycarb (0.025%, 0.05%, 0.1%, 0.25%, 0.5%, and 1.0%) were tested on last instar larvae, with concentration-dependent mortality observed. Higher concentrations (0.5% and 1.0%) resulted in larval mortality before reaching the adult stage, while lower concentrations (0.025% and 0.05%) led to developmental delays, morphological abnormalities, and reduced fecundity in females. Moreover, exposure of normal eggs to fenoxycarb prevented hatching in 37.2%-57.2% of eggs, indicating its gonadotropic action (Begum and Qamar, 2016). In an effort to optimize rearing conditions for *C. cephalonica*, nine dietary formulations were tested, incorporating various combinations of rice, wheat, sorghum, and groundnut. The diet comprising sorghum and groundnut (T6) yielded the best results, with the shortest larval (30.33 days) and pupal (7 days) periods, the lowest total developmental period (47.33 days), and the highest rates of adult emergence (82%) and fecundity (312.33). This diet also resulted in the longest female longevity (9.67 days) and highest male longevity (8.33 days), contributing significantly to

mass rearing efforts for the large-scale production of *C. cephalonica* (Arun Kumar *et al.*, 2018).

This research offers valuable insights into the biology, pest control, and rearing optimization of *C. cephalonica*, highlighting the potential of fenoxycarb as an effective management tool and providing suitable diets for large-scale production.

Keywords: Life cycle, Rice moth, *Corcyra cephalonica, Lepidoptera, Pyralidae.*

Introduction

The rice moth (*Corcyra cephalonica*) is a moth of the family Pyralidae and kingdom anamalia. This small moth can become a significant pest. *Corcyra cephalonica* the rice moth can be considered the Indian meal moth of the tropics. It is found in Hawaii and occasionally in some southern U.S. ports. The larvae are general feeders and prefer warm climates and occur commonly in the equatorial regions of Asia, Africa, and Caribbean. It is much less common on the mainland than the Almond moth, (*Ephestia cautella*), which it is often misidentified (Sedlacek *et al.*, 1996). Its caterpillars feed on dry plant stuffs such as seeds , including cereals (e.g. Rice). Other recorded foods are flour and dried fruits (Hill *et al.*, 2002).

Rice moth, *Corcyra cephalonica*, is economically an important stored grain pest in Asia, Africa, North America and Europe. Its larval stages cause serious damage to rice, gram, sorghum, maize, groundnut, cotton seeds, peanuts, linseeds, raisins, nutmeg, currants, chocolates, army biscuits and milled products. While feeding the larvae leave silken threads which produce dense webs containing their faecal matter and cast skin which contaminate the grains (Ayyar *et al.*, 1934).

Moth is usually seen in large numbers on walls, poles, or containers where grains are stored. The larvae are exceptionally good at producing “paper thick” webbing for its cocoons. The caterpillars produce a large amount of frass (in which they hide) compared to other stored food moths. This material can attract other stored food pests such as Flour Beetles (*Tribolium* spp). (Tripathi *et al.*, 2018).

Corcyra cephalonica is industrialized for many of the natural enemies mass-bred in the laboratory for use in field against crop pests, which are dependent on either egg or larval stages of *C. cephalonica* because it is easier and cheaper to produce natural enemies on different stages of *C. cephalonica* than on their original hosts (Kumar and Murthy, 2000).

The rice meal moth, *Corcyra cephalonica* Stainton is one of the serious insect pests of stored milled rice and other milled cereal products in India. 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. The biology and bionomics of this pest under controlled

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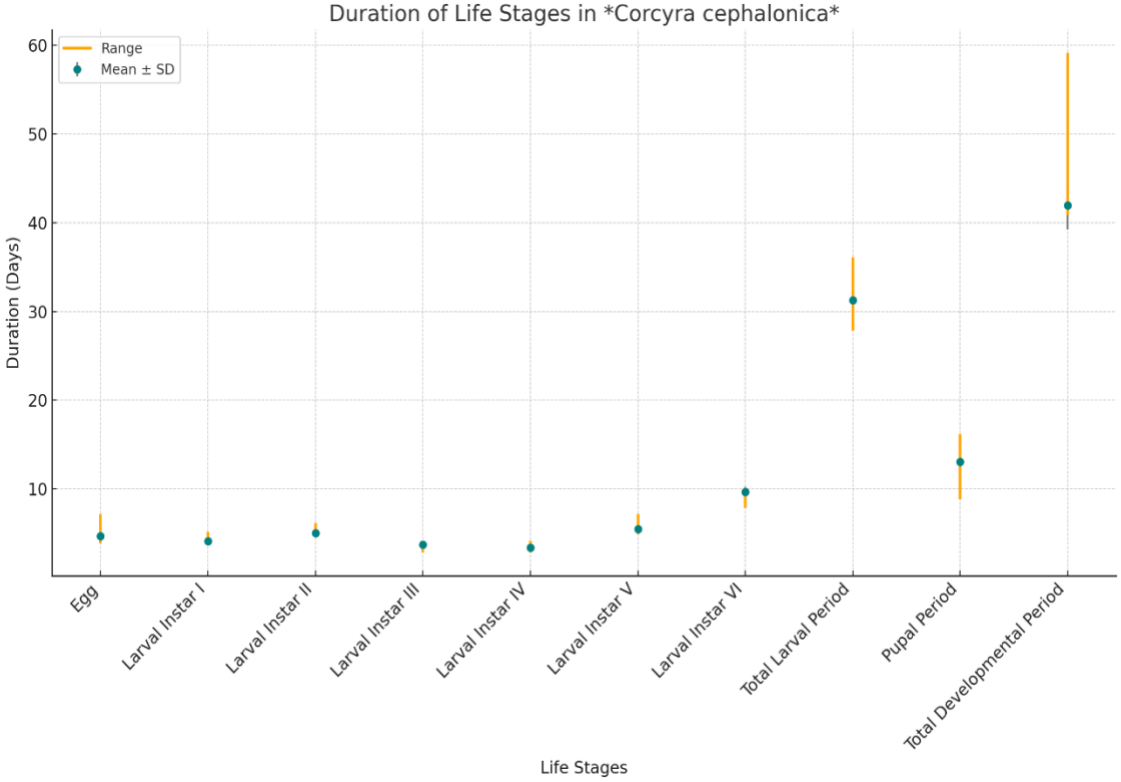
laboratory conditions was studied. An experiment was conducted during July 2015 to October 2015 in the Biological Control laboratory, Department of Entomology, IGKV, Raipur at 27 0C + 20 0C (and 75+5% RH to study the different diet performance on the biology and bionomics of rice moth, *C. cephalonica*. Five cereals viz., rice, wheat, pearl millet (jowar), sorghum (bajra) and maize were tested solely along with their combinations. The female moth had longer body length and weight as compared to male moth. Both male and female reared on mixed diet with a combination of (rice+jowar+maize) had maximum body weight and body length. There was a high positive co-relation between fecundity and female body weight. The mixed diet of rice jowar maize was highly superior, in comparison to others for mass production of *C. cephalonica*. The shortest life cycle was found in the combinations of bajra jowar maize up to 35 and 40 days respectively and longest life cycle was found in rice extending of 60 to 70 days.(Bhardwaj *et al.*, 2017).

Freshly laid egg was glistening, pearly white in colour with irregularly sculptured surface having small divided uneven areas on the surface. Egg was pear shaped and gently rounded at one end and pointed at the pedicel end with brownish tinge. Egg duration ranged from 4-7 days with average of 4.66 days. The larval development was inside the grain cluster. Larva was dirty white with brownish head. The larval period ranged from 4 to 5, 5 to 6, 3 to 4, 3 to 4, 5 to 7 and 8 to 10 days with a mean of 4.13, 5.04, 3.73, 3.40, 5.46 and 9.69 days, respectively for six larval instars (Table 1). The above results are in conformity with studies made by Ayyar (1934) who recorded 57 days on sorghum and Seshagiri Rao (1954) reported 47 to 57 days on broken maize. Predominance of females was observed among the population raised in the laboratory culture with female: male ratio of 1.51:1 and female: male ratio of 1.79:1 in the collections from godown was observed (Table 2). Dominance of females over males was also recorded by Ayyar (1934) and Teotia and Singh (1975). Mating period ranged from 60 to 130 minutes with mean of 90.55 minutes. The per-oviposition period ranged from 1 to 2 days which is slightly different from Ayyar (1934) who reported 2 to 3 days on paddy. (Jagadish *et al.*, 2010).

Duration of Life Stages, Biological Parameters, and Sex Ratio of *Corcyra cephalonica*

Parameter	Range	Mean ± SD
Egg	4 - 7 days	4.66 ± 0.50
Larval Instars		
- Instar I	4 - 5 days	4.13 ± 0.16
- Instar II	5 - 6 days	5.04 ± 0.31
- Instar III	3 - 4 days	3.73 ± 0.25
- Instar IV	3 - 4 days	3.40 ± 0.23
- Instar V	5 - 7 days	5.46 ± 0.35
- Instar VI	8 - 10 days	9.69 ± 0.52

Total Larval Period	28 - 36 days	31.26 ± 1.16
Pupal Period	9 - 16 days	13.06 ± 0.86
Total Developmental Period (Egg + Larva + Pupa)	41 - 59 days	41.95 ± 2.68
Mating Period	60 - 130 minutes	90.55 ± 11.83
Pre-Ovipositional Period	1 - 2 days	1.35 ± 0.32
Ovipositional Period	6 - 8 days	7.70 ± 0.44
Post-Ovipositional Period	1 - 3 days	2.20 ± 0.51
Adult Longevity	9 - 12 days	9.58 ± 0.79
Sex Ratio (Female: Male)		
- Mated Males	4 - 6	5.53 ± 0.43
- Laboratory Culture		1.51: 1 ± 0.31
- Godown Culture		1.79: 1 ± 0.30



The moths are nocturnal and each female lays 90-200 eggs having 5 days incubation period, 23-25 larval period, 10 days of pupal period and adult life span of 1 week. *Corcyra cephalonica*, the so far known only living member of the genus Corcyra. The larvae of Corcyra feeds on almost all sorts of stored food commodities like cereals, cereal products, oilseeds, pulses, spices, dried fruits, nuts, and biscuits. Rice

moth is an external feeder of all kinds of grains. The life cycle shows complete metamorphosis. The damage is mainly caused by the larvae which feed on grains under silken webs and render them useless for human consumption (Bhandari *et al.*, 2009). Rearing Corcyra on efficient food media resulted in production of robust moths and robust eggs. The size of the egg considered as one of the criteria for assessing the health of the insect. For rearing of egg parasitoids utilization of robust host eggs is important (Pathak *et al*., 2010).

The larvae cause damage to broken grains by forming silken webs and feeding inside them. When infestation is high the entire stock of grains may be converted into a webbed mass. The pest causes both quantitative and qualitative losses. Storing grain in store houses, to keep them free from being damaged by insect pests is a problem confronted by every householder, whether a cultivator or user. The success achieved so far in making the stored grains free from insect pests has been based largely on pesticidal usage. Increasing awareness of the hazards caused due to the use of chemical pesticides and several reported cases of food poisoning has created renewed interest in the use of plant products as grain protectants (Jhala *et al.*, 2018*)*.

Six different concentrations viz. 0.025%, 0.05%, 0.1%, 0.25%, 0.5% and 1.0% of fenoxycarb were topically applied at 2µl dose to the last instar larvae of rice moth, *Corcyra cephalonica*. There was a concentration-based and time-dependent response with respect to various life cycle parameters as quantified in the present work. The larvae treated with 0.5% and 1.0% fenoxycarb did not reach the adult stage as the mortality occurred owing to direct knockdown, incomplete mounting and unsuccessful metamorphosis. At concentration 0.05% and 0.025% fenoxycarb resulted in retardation of metamorphosis and developmental rate of the surviving *C. cephalonica* larva/pupae which, during developmental path, showed morphological abnormalities. The females that emerged from treated stock exhibited malformed reproductive system along with reduced fecundity and hatchability. Furthermore, when the normal eggs were contact exposed to fenoxycarb (0.025% to 1.0%) the hatching was prevented in 37.2%-57.2% eggs; thus, indicating the gonadotropic action of the current juvenoid. Therefore, fenoxycarb appears to be a promising agent for the control of *C. cephalonica* with the pronounced effects on the development and reproduction.(Begum and Qamar, 2016)

Nine experimental dietary formulations (T1-T9) were prepared which composed of rice, wheat, sorghum, rice groundnut, wheat groundnut, sorghum groundnut, rice sesamum, wheat sesamum and sorghum sesamum as base diet to rear and maintain the rice moth, *Corcyra cephalonica* under laboratory conditions. All the diets were fortified with baker's yeast 5 g, wettable Sulphur @ 5 g, and Streptomycin sulphate 50 mg. The parameters studied in the present work were eggs hatching percentage, incubation period, larval period, pupation percentage, pupation period, total developmental period, percent adult moth emergence, percent male and female moth emergence, male and female longevity and fecundity. The Diet T6 (sorghum 1000 g groundnut 50 g) was found to outperform other dietary formulations as it resulted in lowest larval period (30.33 days), lowest pupation period (7 days), lowest total development period (47.33 days), highest adult emergence (82%), highest adult female emergence (52.11 days), highest male longevity (8.33 days), highest female longevity (9.67 days) and highest fecundity (312.33). The obtained results provide suitable diets for mass rearing, thus contributing significantly for the large

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scale production of *C. cephalonica*.(Arun Kumar *et al.*, 2018).

Control and Management

Accessing the effectiveness and parasitism by *Trichogramma evanescens* to prevent *Corcyra cephalonica* from infesting rice in paper and jute bags. Eight small jute or paper bags filled with 5 kg of organic rice grains were prepared and the openings sealed. Sentinel egg cards were prepared with thirty fresh eggs of *C. cephalonica* glued onto small pieces of paper cardboard. Eight sentinel egg cards were introduced into a plastic box measuring 60 × 40 × 21 cm, i.e. four cards on top surface of the bag and the box bottom, respectively. Approximately 500 adults of *T. evanescens* were released 10–30 cm away from the egg cards. The control boxes contained no parasitoids; there were five replicates for all treatments and controls. Two experimental conditions were tested, i) placing a single *T. evanescens*-release unit with sentinel egg cards placed every 3–4 days without any further replacement of the release unit for three weeks, ii) both new host eggs and *T. evanescens* release units were replaced every 3–4 days. Mean emergence of *C. cephalonica* was significantly ($p > 0.001$) suppressed by the release of *T. evanescens*. There was statistically no significant difference on the number of emerged moths on paper bag compared to jute bag. All sentinel egg patches were visited by *T. evanescens*. There was no correlation between the distance (10–30 cm) at which the sentinel egg cards were placed away from the *T. evanescens* release point and the number of parasitized *C. cephalonica* eggs. There was no decrease in parasitism over time. The results demonstrate that *T. evanescens* has the potential for host-location ability and parasitism of *C. cephalonica* both on paper and jute bags. This parasitoid could be a promising candidate for the biological control of moth pests in bagged stored products. The life cycle of *Corcyra cephalonica* was studied under ambient laboratory conditions (temperature range 27.5–30°C and 60–73% RH) on groundnut, bambara groundnut and cowpea. The mean developmental period ranged from 33.2±0.2 to 45.3±1.8 days on whole, broken and powdered forms of the food media. Egg hatchability was found to be 83%, while adult longevity ranged from 1.5±0.5 to 11.9±1.3 days for males and 1.5±0.5 to 16.5±1.2 days for females. Sex ratio (♂: ♀) of emerged adults ranged from 1:1 to 1:2.1. Mean fecundities ranged from 128±5 to 157±8 on the food media. In experiments to assess the insecticidal potential of three plant materials against *C. cephalonica*, *Eichhornia crassipes* powder showed a higher efficacy than both *Citrus sinensis* peel powder and the leaf powder of *Chromolaena odorata* at dosages of 0.5–2.0 g per 40 g of legume seed. At the higher dosage of 2.5 g, *C. sinensis* was more effective and reduced the population of *C. cephalonica* by half when compared to the population in control jars over a period of 1.5 months. Adarkwah *et al., (2015).*

Both male and female moths produce pheromones that attract each other. The moths are excellent fliers, and a typical grid pattern can be established to monitor for their presence and population trends. These moths will not be attracted to the pheromones of other stored food moths such as Indianmeal moths and Almond moths. Separate traps and lure combinations should be used to monitor each species efficiently if both species are present. Adams et *al*., (2017).

Besides being a pest, it is the factitious host for 75 natural enemies of which 60 of parasitoids and 15 of predators including a few that are host-specific in nature. It is also served as a host for nematodes and mites. Its wide acceptability is unique and turned out to be a boon for mass production of bio-control

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agents. In South Asia at different commercial insectaries the rice moth, *C. cephalonica* (Stainton) (Lepidoptera: *Pyralidae*), is mass reared as a host for egg parasitoids of the genus *Trichogramma*, the larval parasitoid, *Braconhebetor* (Say) (Hymenoptera: *Braconidae*), and as prey for the predator, *Chrysoperlacarnea* (Stephens) (Neuroptera: *Chrysopidae*). In India, it is being utilized for mass production of number of natural enemies in various bio-control research, developmental and extension units. Chaudhuri *et al*., (2017).

Literature Review

Allotey and Azalekor., (2000) Studied the life cycle of *Corcyra cephalonica* under ambient laboratory conditions (temperature range 27.5–30°C and 60–73% RH.) on groundnut, bambara groundnut and cowpea. The mean developmental period ranged from 33.2±0.2 to 45.3±1.8 days on whole, broken and powdered forms of the food media. Egg hatchability was found to be 83%, while adult longevity ranged from 1.5±0.5 to 11.9±1.3 days for males and 1.5±0.5 to 16.5±1.2 days for females. Sex ratio of emerged adults ranged from 1:1 to 1:2.1. Mean fecundities ranged from 128±5 to 157±8 on the food media. In experiments to assess the insecticidal potential of three plant materials against *C. cephalonica*, Eichhornia crassipes powder showed a higher efficacy than both Citrus sinensis peel powder and the leaf powder of *Chromolaena odorata* at dosages of 0.5–2.0 g per 40 g of legume seed. At the higher dosage of 2.5 g, C. sinensis was more effective and reduced the population of *C. cephalonica* by half when compared to the population in control jars over a period of 1.5 months.

Coelho *et al*., (2007) tested Annona coriacea lectin (ACLEC) for insecticidal activity against larvae of two pyralid moths, *Anagasta kuehniella* and *Corcyra cephalonica*. ACLEC produced ~ 50% mortality and mass loss in *A. kuehniella* larvae when incorporated into an artificial diet at levels of 1.5% and 1.0% (w/w), respectively. In contrast, the inclusion of up to 2% ACLEC in the diet did not significantly decrease the survival or weight of *C. cephalonica* larvae. The nutritional indices for *A. kuehniella* and *C. cephalonica* suggested that ACLEC had a multi-mechanistic mode of action and was an antifeedant for both insects. The toxicity in *A. kuehniella* apparently resulted from a change in the gut membrane environment and consequent disruption of digestive enzyme recycling mechanisms. Affinity chromatography showed that ACLEC bound to midgut proteins of *A. kuehniella* and *C. cephalonica*. However, the 14 kDa subunit of ACLEC was not digested by midgut proteases of *A. kuehniella* but was degraded by the corresponding *C. cephalonica* proteases within a few hours. These findings suggest the possibility of using ACLEC to engineer crop plants.

Jagadish *et al*., (2010) Investigated the biology of rice moth *Corcyra cephalonica* Stainton on foxtail millet during 2006- 2007 at the Project Co-ordination Cell of the AICSMIP, University of Agricultural Sciences, GKVK, Bangalore. Stock culture of *C. cephalonica* was collected from National Bureau of Agriculturally Important Insects, Bangalore. The culture was maintained on foxtail millet grains with 12 per cent moisture content, kept in plastic jars of 3 kg capacity. The jars were filled with 2 kg of broken foxtail millet grain and infested with 1 cc of Corcyra eggs and covered with muslin cloth. Freshly emerged adults were collected and transferred to egg laying cage. This cage was kept on a conical flask to collect eggs. Freshly emerged adults were released into the glass funnel covering the upper opening with musclin cloth and eggs were collected at the bottom fitted with wire

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mess. Collected eggs were used to study the biology parameters. On hatching, the larva was released into glass specimen tubes containing two-gram broken foxtail millet grains and 15 larvae were observed for the development. Larvae were observed under calibrated stereo binocular microscope to determine the larval stages. The observations on pupal period, mating behaviors, pre-ovipositional, Ovi positional period and sex ratio were recorded.

Hodges *et al.*,(1979) concluded that *Corcyra cephalonica* (Stnt.), a pest of stored products (especially rice), and its control using pesticides and biological agents. In addition, an indication is given of areas in which further research could lead to more effective control of this species.

Khani *et al.*, (2012) stated that rice weevil, *Sitophilus oryzae* and rice moth, *Corcyra cephalonica* are major and cosmopolitan insect. Adults of S. oryzae (male and female) and both larvae are insatiable feeders on a great variety of grains. This study was conducted to estimate the insecticidal effect of essential oils from peppermint, *Mentha piperita L.* and black pepper, Piper nigrum L. against two major stored product insects. Essential oils from two species of plants were obtained by clevenger-type water distillation. The major compounds in these essential oils were identified using gas chromatography- mass spectrometry and their insecticidal effect was tested against adults of the rice weevil, Sitophilus oryzae L. and the 3rd instars larvae of rice moth, *Corcyra cephalonica* (St.). The major compounds found in peppermint were menthol, isomenthone, limonene and cineole and in black pepper were limonene, α and β pinene and caryophyllene. Highest toxicities were observed against S. oryzae populations treated with M. piperita and P. nigrum essential oils with LC50 values of 85.0 and 287.7 µL/L air after 72 hours after commencement, respectively. In the case of *C. cephalonica* larvae, the LC50 values were 343.9 and 530.5 µL/L air for M. piperita and P. nigrum essential oils at 72 hours after commencement, respectively. These results are attributed to the compounds present in essential oils of M. piperita and *P. nigrum*. It was resulted that M. piperita and P. nigrum oils have insecticidal effects against S. oryzae and *C. cephalonica*. For this reasons, the selected plant oils have potential for development of novel insecticides.

Zagatti *et al.*, (1987) observed that behavioral observations of the rice moth (*Corcyra cephalonica*, *Pyralidae*, *Galleriinae*) in the laboratory have shown that a male wing-gland pheromone induces attraction of female moths. This pheromone was identified as a blend of (E, E) and (Z, E)-farnesal. Wing-gland extracts or synthetic compounds were shown to be attractive to females by inducing walking.

Chiang *et al.*, (1986) studied defense reaction of the midgut cells in the rice moth larva, *Corcyra cephalonica*, infected with *Bacillus thuringiensis* was studied by using scanning and sectioning techniques. Following infection, the epithelial cells became loose and separated from each other; approximately 10% of the columnar cells swelled. Several newly developed cells were found at the basal portion of the epithelium. Along with the development of these immature cells, the swollen columnar cells were pushed out and discharged into the lumen and replaced by the newly formed cells. Simultaneously mucous layer covering surface of the epithelial cell to protect new cells from toxic attacks. Since these defense functions reacted from the midgut epithelium, the lifespan of infected larvae was prolonged.

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Wu *et al.*, (2012) conducted experiment on complete mitochondrial genome (mitogenome) of the rice moth, *Corcyra cephalonica* Stainton (Lepidoptera: *Pyralidae*) was determined as a circular molecular of 15,273 bp in size. The mitogenome composition (37 genes) and gene order are the same as the other lepidopterans. Nucleotide composition of the *C. cephalonica* mitogenome is highly A+T biased (80.43%) like other insects. Twelve protein–coding genes start with a typical ATN codon, except for cox1 gene, which uses CGA as the initial codon. Nine protein–coding genes have the common stop codon TAA, and the nad2, cox1 , cox2 , and nad4 have single T as the incomplete stop codon. 22 tRNA genes demonstrated cloverleaf secondary structure. The mitogenome has several large intergenic spacer regions, the spacer1 between trnQ gene and nad2 gene, which is common in Lepidoptera. The spacer 3 between trnE and trnF includes microsatellite–like repeat regions (AT)18 and (TTAT)3. The spacer 4 (16 bp) between trnS2 gene and nad1 gene has a motif ATACTAT; another species, *Sesamiainferens* encodes ATCATAT at the same position, while other lepidopteran insects encode a similar ATACTAA motif. The spacer 6 is A+T rich region, include motif ATAGA and a 20-bp poly(T) stretch and two microsatellite (AT)9, (AT)8 elements.

Abdi *et al.*, (2021) observed biological control efficiency can be improved by developing effective mass-rearing systems to produce large numbers of high-quality parasitoids. This study explored an alternative host for rearing *Sclerodermus brevicornis* (Kieffer) (Hymenoptera: *Bethylidae*), a potential bio control agent for the suppression of exotic and invasive wood-boring longhorn beetle (Coleoptera: *Cerambycidae*) populations in the European agro forestry ecosystems. We tested larvae of the rice moth, *Corcyra cephalonica* Stainton (Lepidoptera: *Pyralidae*), as host for the parasitoid. We quantified the probability and timing of host attack and parasitism as well as reproductive success, offspring production, and the characteristics of adult offspring. As S. brevicornis is a quasi-social species (multiple females, communally produced offspring broods), *C cephalonica* larvae prior to presentation. We identified the conditions within our experiment that maximized offspring production per host and offspring production per adult female parasitoid. We found that *C. cephalonica* is suitable as a factitious host and, as it is considerably more straightforward for laboratory rearing than cerambycid species; it is a good candidate for adoption by future *S. brevicornis* mass-rearing and release programmers.

Begum and Qamar., (2016) investigated those six different concentrations viz. 0.025%, 0.05%, 0.1%, 0.25%, 0.5% and 1.0% of fenoxycarb were topically applied at 2µl dose to the last instar larvae of rice moth, *Corcyra cephalonica*. There was a concentration-based and time-dependent response with respect to various life cycle parameters as quantified in the present work. The larvae treated with 0.5% and 1.0% fenoxycarb did not reach the adult stage as the mortality occurred owing to direct knockdown, incomplete moulting and unsuccessful metamorphosis. At concentration 0.05% and 0.025% fenoxycarb resulted in retardation of metamorphosis and developmental rate of the surviving *C. cephalonica* larva/pupae which, during developmental path, showed morphological abnormalities. The females that emerged from treated stock exhibited malformed reproductive system along with reduced fecundity and hatchability. Furthermore, when the normal eggs were contact exposed to fenoxycarb (0.025% to 1.0%) the hatching was prevented in 37.2%-57.2% eggs; thus, indicating the

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gonadotropic action of the current juvenoid. Therefore, fenoxycarb appears to be a promising agent for the control of *C. cephalonica* with the pronounced effects on the development and reproduction.

Devi *et al*., (2013) concluded the result of morphometric measurements revealed that the average length and breadth of egg were 0.42 and 0.31, respectively. The mean length and breadth of 1st, 2nd, 3rd, 4th, 5th and 6th instars larvae were 2.72, 3.74, 5.63, 7.55, 9.20, 11.21 and 0.31, 0.39, 0.95, 11.16, 1.35, 1.59 mm, respectively. The average length of pupa was 4.05 and breadth was 1.10 mm. The average length and breadth of male and female were 10.75 and 12.24 mm, respectively.

Behal *et al.*,(1998) studied ten-day-old larvae of *Corcyra cephalonica* were exposed to oils of neem (*Azadirachta indica*), sweet flag (*Acorus calamus*), citronella (*Cymbopogon nardus*), eucalyptus (*Eucalyptus citriodora*), cloves (*Syzygium aromaticum*), dill (*Anethum sowa*), cedar (*Cedrus deodara*), neem (deodorized), mustard (Brassica juncea), sunflowers (*Helianthus annuus*) cotton (*Gossypium arboreum*), soyabeans (*Glycine max*) or pongam (*Pongamia glabra*). The concentrations were 0.1, 0.3 or 0.5%. Sweet flag oil repelled the larvae at all the concentrations, whereas clove, cedar wood, citronella and eucalyptus oils were effective at the higher concentrations. The cotton seed oil and neem (deodorized) at 0.5% attracted the larvae.

Morya *et al*., (2010) conducted experiment on powder leaves of Lantana camara (L.) (*Lamiales Verbenaceae*), Clerodendrum inerme (L.) (*Lamiales Verbenaceae*) and Citrus limon (L.) (*Sapindales Rutaceae*) were tested for their efficacy against the stored grain insect pest *Corcyra cephalonica* (Stainton) (Lepidoptera *Pyralidae*). Seven different doses ranging from 0.05 to 2.0 g (0.05, 0.1, 0.15, 0.5, 1.0, 1.5, and 2.0 g) per 20.0 g of rice were tested against this common insect pest of rice to evaluate their effect on its life cycle and mortality. Three higher doses were further tested for their effect on physiological parameters like Total Hemocyte Count (THC), total protein content and glycogen level along with starved insects. L. camara and *C. inerme* exhibited bio pesticidal activity as evidenced by the high mortal- its rate in treated insects while C. limon was ineffective against *C. cephalonica* in the tested conditions. There was also a significant reduction in the THC (39-53%), protein (30-38%) and glycogen (40-61%) content in L. camara and *C. inerme* treated larvae with respect to their controls. This was however like the results observed in starved groups (52.0, 39.0 and 82.0% respectively for THC, protein and glycogen) which mimic a physiological condition like them.

Alasady *et al*., (2010) studied the survivorship from egg to adult emergence and fertility of *Apertochrysa* sp. fed on *Corcyra cephalonica* were studied in laboratory and population parameters of *Apertochrysa* sp. were used for construction of life table under ideal condition in laboratory free from natural enemies. The highest mortality occurred in eggs (44.3%) followed by mortality (15.4%) in 2nd instar larva and in pupal stage (11.4%). The sex ratio (proportion of female to male) was 1:1.4. The maximum life span of female was 38 days. The highest number of eggs produced per female was 6.33 at seventh day of oviposition. The gross reproductive rate (GRR) was 19.48 females per female per generation. The net reproductive rate (Ro) was 2.28 females per female per generation. Mean generation time (T) was 40.6 days, while the intrinsic rate of natural increase (r) was 0.02 female per female per day. The finite rate of increase (λ) was 1.02 females per female per day.

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The population double time (DT) was within 14.8 day.

Hashem *et al*., (2018) observed the effect of modified atmospheres (MAs) containing CO2 at 20, 40, 60 and 80% or containing N2 at 97 and 98% on the mortality of *Corcyra cephalonica* Stainton (Lepidoptera: *Pyralidae*) sixth instar larvae was studied to determine the LT values at 30 °C. The respiration rates of untreated and treated larvae with 60% CO2 and/or 98% N2 at LT50 were measured using Q-Box RP1LP low range respirometry package. Total protein and triglycerides of treated and untreated larvae were assayed. Complete larval mortality was recorded after 72 and 144 h of treatment with 60% CO2 and 98% N2, respectively. Calculated LT50 values were 39.3 at 60% CO2 and 87.5 h at 98% N2 MAs. Respiration quotient (RQ) in the light of consumed O2 and produced CO2 of untreated larvae was 1.0 while it was 0.85 at 60% CO2 and 0.72 at 98% N2. Duration time necessary for produced CO2 curve to reach the maximum point (2000 ppm) was significantly shorter at untreated larvae (27.64 min) in comparison with that recorded at CO2 (35.48 min) which also significantly less than that obtained at N2 (98.54 min). At all treatments, total protein was decreased while triglycerides were increased in comparison with control.

Summary

Growth studies of rice moth larvae (*Corcyra cephalonica*) have been carried out in groundnut meal and wheat bran contaminated with *A. flavus*, *A. oryzae*, *P. purpurogenus* and *P. rubrum*. It was observed that the diets contaminated with A. flavus only are toxic to these larvae. Wheat bran contaminated with A. flavus is more toxic than contaminated groundnut meal. The higher toxicity of wheat bran contaminated diet has been discussed. Aflatoxins produced in different substrata are shown to differ when analyzed chromatographically. Growth studies of rice moth larvae have also been carried out with aflatoxin and the susceptibility of these larvae has been established.

Development of *Corcyra cephalonica* larvae on a variety of cereals and millets, pulses, oilseeds or spices has been studied. Of the various foodstuffs tested, flour of pearl millet and broken grain of wheat proved the best media for the growth of this insect. Results of feeding trials with the various commodities have been discussed in the light of the basal food requirements and the composition of the food offered. The larvae can flourish in media with relative low protein content. On the basis of the results obtained by feeding the larva on fortified media, the factors responsible for a poor development on pulses and other foodstuffs have been outlined. These are the quality of the carbohydrate content and the growth inhibitors. Also, the factors which may determine the degree of infestation by Corcyra, i.e., whether this insect can be a major or minor pest of a particular commodity have been enumerated. These factors include physical condition of the food and its chemical composition.

Conclusion

Therefore, it can be concluded that fortification with 3% dextrose/yeast improved the values of all the developmental and reproductive parameters over solo grains in case of Italian millet and scented rice. Italian millet fortified with dextrose and yeast performed the best among the food grains taken in the present study. On the other hand, wheat performance of solo grain was better over fortification with dextrose and yeast. In scented rice all the

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parameters were significantly lower than the other rearing media and formed a completely separate group in dendrogram. Considering all aspects including local availability of grains and performance, Italian millet alone and/or fortified with 3% dextrose and yeast as well as wheat is proved to be the most suitable rearing media for mass production of *C. cephalonica* Stainton.

Based on results, *M. piperita* and *P. nigrum* oils showed toxic effects on two serious insect pests of stored grains rice weevil, *S. oryzae* and rice moth, *C. cephalonica*. Due to easily available of these products, the farmers and public can use these oils to protect of stored grains, which are non-toxic in handling and use. For these reasons, the studied oils have potential for development of Bio-insecticides.

Based on overall findings, it can be concluded that fenoxycarb is toxic to *C. cephalonica*, as it mimics the action of JH and maintains the insect in an immature state. This action keeps the insects from moulting successfully or reproducing normally. Fenoxycarb caused mortality in larvae and produced abnormal adults and it also affected the fecundity of the *C. cephalonica*. Thus fenoxycarb may be considered as a leading target compound having the potential to control *C. cephalonica* and can therefore form an important component of various Integrated Pest Management (IPM) programs for other such insects.

Apertochrysa sp., could be mass successfully cultured in the laboratory under ambient condition (25ºC, 55-85% RH & 12L: 12D photoperiod). Low value of r and high mortality indicated lower suitability of a *C.cephalonica* eggs as prey for the predator *Apertochrysa* sp. The first laboratory generation of *Apertochrysa* sp., had very few fertile females. However, the oviposition during the medium life span was high advantage for the population growth.

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