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Bionomics and non-chemical management of rice moth, *Corcyra cephalonica* (Stainton)

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Abstract
The eggs of rice moth were pearly white, oval in shape and measured on an average 0.35±0.03 mm in length and 0.33±0.02 mm in breadth. The average incubation period was 4.08±0.80 days with hatchability was 86.07±4.82 percent. The larvae passed through seven distinct instars. The average length (mm) and breadth (mm) of first to seventh instar larvae were 1.13±0.19, 1.71±0.14, 3.56±0.20, 6.52±0.09, 7.35±0.19, 7.47±0.20, 8.36±0.14 and 0.20±0.03, 0.31±0.03, 0.61±0.07, 1.31±0.05, 1.52±0.14, 1.71±0.07, 1.73±0.05, respectively. From first to seventh instar larvae, the average duration was 4.08±0.80, 5.00±0.75, 5.20±0.75, 6.80±0.85, 5.60±0.94, 5.36±0.93 and 5.96±0.77 days, respectively. The average length, breadth and duration of pupa were 3.80±0.46 mm, 1.45±0.11 mm and 10.64±1.05 days, respectively. Adult male and female of the rice moth were pale grey to brown in colour, with uniformly dark grey wings. The average length, breadth and wing expansion of male moth were 1.76±0.03, 1.25±0.02 and 1.66±0.03 mm respectively, while average length, breadth and wing expansion of female moth were 2.27±0.16 mm, 1.24±0.02 mm and 1.69±0.05 mm, respectively. The lowest (48.27%) weight loss recorded in the treatment of neem leaves powder at 28 days after treatment.

Keywords: Rice moth**,** bionomics, non-chemical

Introduction
Rice (*Oryza sativa* L.) stands as the paramount and extensively cultivated food crop globally, serving as the staple for over 60 percent of the world's population, with the Asian continent, particularly India, holding a significant share of consumption. India, boasting the largest rice cultivation area worldwide, contributes substantially to global rice production, second only to China. Rice cultivation in India spans both *kharif* and summer seasons, with harvesting often coinciding with rain or high moisture content, predisposing the harvested grains to significant storage losses annually (Prakash *et al*., 1981) [8]. The post-harvest storage phase emerges as a critical operation, as the unpredictable weather patterns and fluctuating environmental conditions in the country necessitate the proper storage of food commodities, especially rice, for extended periods. Traditional and primitive storage structures account for approximately 70 percent of food grain storage in India, making stored materials vulnerable to various insect pests and non-insect threats such as mites, molds, and rodents (Lal, 1990) [5]. In India, annual storage losses were estimated at 14 million tonnes of food grains, accounting for a substantial monetary loss (Mohan and Kavitharaghavan, 2008) [6]. stored grain pests, particularly lepidopterans and coleopterans, are known to cause maximum damage during storage (Usman, 1957) [12]. Among the multitude of stored grain pests, the rice moth (*C. cephalonica*) emerges as a significant threat to stored cereals, contributing to substantial economic losses.

Materials and Methods
Rice moth (*C. cephalonica*) culture was initiated with specimens from the Main Rice Research Center, NAU, Navsari. Sterilized rice grains were used for rearing, and 10 pairs of moths were released in a galvanized tray. The tray covered with muslin cloth, facilitated observation and egg collection, with the life cycle completed in approximately 30 days. The experiment conducted in the Biocontrol Laboratory at NAU, Navsari in 2022, the bionomics study focused on broken rice grains at 27-30 °C and 69-87 percent relative humidity. Twenty-five eggs were collected and observed daily for color, shape, and size. Incubation period and hatchability were also recorded. Twenty-five larvae were collected, and larval instars, duration, and total larval period were determined. Larvae were observed daily for moulting. Twenty-five pupae were examined for color, size, and pupal period.

Measurements were taken using an ocular micrometer. Newly emerged adults were observed, killed, and preserved for later examination. Sexual differences were studied, and adult size measured using an ocular micrometer. Observations on pre-oviposition, oviposition, and post-oviposition periods were made. Fecundity was recorded by counting eggs laid by each female.

The experiment of plant powders against *C. cephalonica* was conducted in completely randomized design (CRD) with three repetition and ten treatments. Plant materials (leaves of neem, karanj, mahua and tulsi; turmeric rhizome; seeds of black pepper and neem; bulb of onion and clove of garlic) were collected, washed, dried, and ground into fine powder. 5 gm of different protectants mixed with 100 g broken rice grain were infested with 10 pairs of rice moth adults.

Mortality count was recorded after 72 hrs of release of moth at each interval. The percentage of mortality of adult corrected by using formula given by Abotts (1925) [1].

$$\text{Percent corrected mortality} = \frac{\text{Mortality in treatment - Mortality in control}}{\text{100 - Mortality in control}} \times 100$$

Weight loss of grain recorded after 2 months of infestation. The weight loss calculated as per methodology suggested by Adams and Sculten (1978) [2].

$$\text{Weight loss (\%)} = \frac{\text{(U*Nd) - (D*Nu)}}{\text{U (Nd + Nu)}} \times 100$$

Where,
U= Weight of undamaged grains,
Nu= Number of undamaged grains,
D=Weight of damage grains,
Nd= Number of damage grains

Table 1: Details of plant extracts used during the present investigation

T. No.	Common name	Scientific name	Plant part used
T_1	Neem	*Azadirachta indica* L.	Leaves
T_2	Karanj	*Pongamia pinnata* L.	Leaves
T_3	Tulsi	*Ocimum basilicum* L.	Leaves
T_4	Black pepper	*Piper nigrum* L.	Seed
T_5	Neem	*Azadirachta indica* A. Juss	Kernel
T_6	Garlic	*Allium sativum* L.	Clove
T_7	Onion	*Allium cepa* L.	Bulb
T_8	Turmeric	*Curcuma longa* L.	Rhizome
T_9	Mahua	*Madhuca longifolia* L.	Leaves
T_{10}	Control	-	-

Photo 1: Bio-efficacy of different grain protectants against rice moth, *C. cephalonica*

Results and Discussion

The eggs of rice moth were pearly white, oval in shape with a rough surface and yellowish in colour and measured on an average 0.35±0.03 mm in length and 0.33±0.02 mm in breadth. Ramanaji *et al.* (2020) reported that the average length and breadth of freshly laid eggs of *C. cephalonica* were 0.39±0.03 mm and 0.30±0.02 mm, respectively on ground nut seeds.

The average incubation period was 4.08±0.80 days with hatchability was 86.07±4.82 percent on broken rice grains. Kumar *et al*. (2002) discovered that the incubation periods of *C. cephalonica* were 3.64 days on grains of rice.

The larvae of rice moth, *C. cephalonica* passed through seven distinct instars. The average length (mm) and breadth (mm) of first to seventh instar larvae was 1.13±0.19, 1.71±0.14, 3.56±0.20, 6.52±0.09, 7.35±0.19, 7.47±0.20, 8.36±0.14 and 0.20±0.03, 0.31±0.03, 0.61±0.07, 1.31±0.05, 1.52±0.14, 1.71±0.07, and 1.73±0.05, respectively. Devi *et al.* (2013) reported the mean length and breadth of 1st to 6th instars larvae of rice moth, *C. cephalonica* were 2.72, 3.74, 5.63, 7.55, 9.20, 11.21 mm and 0.31, 0.39, 0.95, 1.16, 1.35, 1.59 mm, respectively. From first to seventh instar larvae, the average duration was 4.08±0.80, 5.00±0.75, 5.20±0.75, 6.80±0.85, 5.60±0.94, 5.36±0.93 and 5.96±0.77 days, respectively. The total length of the larval period was 38.00±1.81 days. Ramanaji *et al.* (2020) [9] studied bio-ecology of rice moth, *C. cephalonica* on groundnut seeds and found that the duration of 1st to 7th instars larvae were 3.85±0.74, 5.05±0.68, 6.05±0.68, 6.10±0.71, 6.90±0.71, 7.30±0.47 and 8.40±0.51 days, respectively.

The average length and breadth of pupa were 3.80±0.46 mm and 1.45±0.11 mm, respectively. The pupa lived for 10.64±1.05 days. Babu *et al*. (2020) [13] stated that the average length and width of pupa of *C. cephalonica* were 8.40 mm and 1.80 mm, respectively. The results showed different observations on pupal measurements than those reported by Babu *et al*. (2020) [13] due to weather conditions and also depend on food.

Table 2: Morphometric parameters of *C. cephalonica* reared on broken rice grains

Stages	Length(mm)	Width (mm)
	Mean±SD	**Mean±SD**
Egg	0.35±0.03	0.33±0.02
Larva	Length (mm)	Breadth (mm)
1st instar	1.13±0.19	0.20±0.03
2nd instar	1.71±0.14	0.31±0.03
3rd instar	3.56±0.20	0.61±0.07
4th instar	6.52±0.09	1.31±0.05
5th instar	7.35±0.19	1.52±0.14
6th instar	7.47±0.20	1.71±0.07
7th instar	8.36±0.14	1.73±0.05
Pupa	3.80±0.46	1.45±0.11
Adult	Length (mm)	Breadth (mm)
Male	1.76±0.03	1.25±0.02
Female	2.27±0.16	1.24±0.02

Adult male and female of the rice moth were pale grey to brown in colour, with uniformly dark grey wings. The average length, breadth and wing expansion of male moth were 1.76±0.03 mm, 1.25±0.02 mm and 1.66±0.03 mm respectively, while average length, breadth and wing expansion of female moth were 2.27±0.16 mm, 1.24±0.02 mm and 1.69±0.05 mm, respectively. Rao (1954) [10] reported that the adult male of rice moth, *C. cephalonica* had wing expansion of 13 to 18 mm and body length 6.5 to 9.5 mm, whereas female had 15 to 21 mm wing expansion and 7.5 to 10.5 mm body length. The results showed different observations on adult measurements than those due to different diet and weather conditions.

Table 3: Duration of different life stages of *C. cephalonica* reared on broken rice grains

Stages	Particulars	Mean±SD (Days)
Egg	Egg	4.08±0.80
Larva	1st instar	4.08±0.80
	2nd instar	5.00±0.75
	3rd instar	5.20±0.75
	4th instar	6.80±0.85
	5th instar	5.60±0.94
	6th instar	5.36±0.93
	7th instar	5.96±0.77
Total		38.00±1.81
Pupa	Pupa	10.64±1.05
Adult	Pre oviposition	1.44±0.50
	Oviposition	2.52±0.98
	Post oviposition	1.56±0.50
	Fecundity	126.36±22.48
	Male	5.12±0.91
	Female	6.52±1.14
Sex-ratio	Male: Female	1:1.10

The average durations of pre-oviposition, oviposition, and post-oviposition were 1.44±0.50, 2.52±0.98 and 1.56±0.50 days, respectively. Rasool *et al.* (2018) discovered that the pre-oviposition and oviposition period of rice moth, *C. cephalonica* were 1 to 2 and 3 to 5 days respectively on different food media.

The average female fecundity was 126.36±22.48 eggs. Male and female moths had average lifespans of 5.12±0.91 and 6.52±1.14 days, respectively. The sex ratio of *C. cephalonica* was 1:1.10. The sex ratio of *C. cephalonica* recorded was 1: 1.10 to 1: 1.22 on different commodities by Patel and Patel (2007) [7].

The highest mortality percent of *C. cephalonica* was recorded in the treatment of neem leaves powder @ 5 g/kg (71.03%) whereas the lowest mortality percent was recorded in the treatment of mahua leaves powder @ 5 g/kg (20.63%). The lowest weight loss recorded in the treatment of neem leaves powder @ 5 g/kg after 1, 3, 5, 7, 14, 21, and 28 days of treatment was 0.00, 3.67, 6.20, 16.27, 32.03, 44.37 and 48.27 percent, respectively.

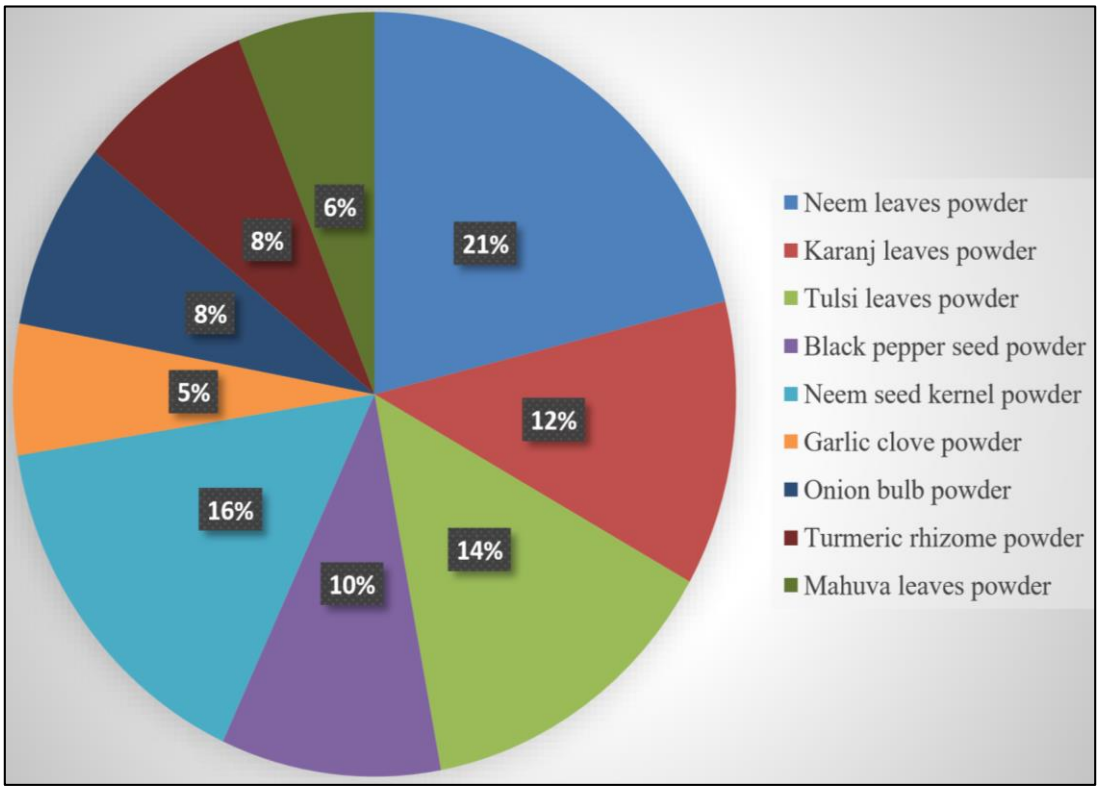

Fig 1: Percent corrected mortality of rice moth, *C. cephalonica*

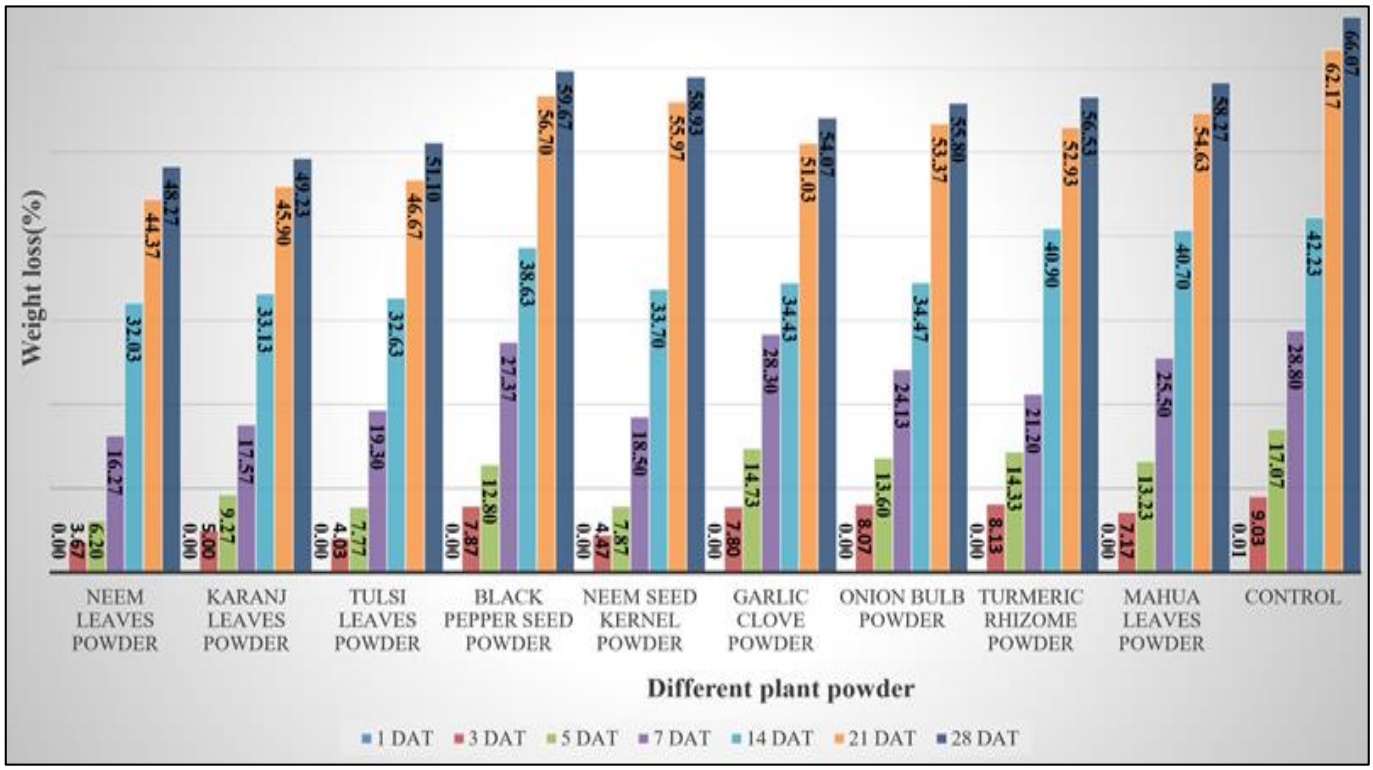

Fig 2: Effect of plant powders on grains weight loss cause by rice moth, *C. cephalonica*

Conclusion

Minimum percent weight loss was observed in neem leaves powder @ 5 g/kg grains. However, other treatments of different plant powders were found less effective against rice moth, *C. cephalonica*. The neem leaves powder treatment @ 5 g/kg was found significantly superior over other treatments with regards to weight loss. It can be concluded that neem leaves powder @ 5 g/kg is effective against *C. cephalonica* in rice.

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