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Biology of lesser grain borer (*Rhyzopertha dominica* Fab.), under different temperature and humidity at laboratory condition

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Abstract
The present investigations entitled "Studies on biology and eco-friendly management of lesser grain borer (*Rhyzopertha dominica* Fab.), under laboratory conditions" in Eastern part of Uttar Pradesh" were carried out in the laboratory of the department of Entomology of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad. 2015, revealed that the lesser grain borer, *Rhyzopertha Dominica* Fab. Is the most commonest species, causing considerable damage to wheat grain by affecting the quality and quantity of grain. Life cycle of *Rhyzopertha Dominica* Fab. Was found to be completed in shorter duration at greater temperature as compared to lower temperature. Biology of *Rhyzopertha Dominica* Fab. carried out on wheat variety PBW-154 under controlled conditions of at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature and 60 ± 5, 70 ± 5, 75 ± 5 and 85 ± 5 percent relative humidity. Average duration for complete of the life cycle egg to adult was 57.33, 48.33, 40.33 and 34.00 days at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature and 60 ± 5, 70 ± 5, 75 ± 5 and 85 ± 5 percent relative humidity.

Keywords: Lesser grain borer, biology, temperature and humidity

1. Introduction
India has attained the distinction as the second largest wheat producer in the world, from an area of about 27 million hectare with record production of over 76 million metric tones during the 1999-2000 crop season. During 2002-03, estimated production of wheat in India was about 70.26 million tones from an area of 24.23 million hectares with productivity of 2.9 t/ha. About 90% of total wheat production is contributed by five states *viz*., U.P., Punjab, Haryana, M.P., and Rajasthan**.** India stands second in wheat production in the world with annual production of 93.4 million hectare land with productivity of 88.4 tonnes per ha. And yield 2872 Kg./ha. Wheat contributes about 35% of total food grain production of the country. (Agricultural Statistics at a glance 2015) [1].

Wheat which has an important role in the nutrition of human beings, animals and several cottage industries in India is attacked by lesser grain borer during storage. The grain infested by this pest is rendered unfit for human, animal consumption and also for any industrial use. Out of a dozen insects species infesting on wheat, 7 important ones are as follows ; Lesser grain borer, *Rhyzopertha dominica* (Fab.); Rice weevil, *Sitophilus oryzae* (Linn.); Khapra beetle, *Trogoderma granarium* (Everts); Red rust flour beetle, *Tribolium castaneum* (Herbst), Almond moth, *Ephestia cautella* (Walker); Angoumois grain moth, *Sitotroga cerealella* (Olivier); Rice moth, *Corcyra cephalonica* (Staint). Lesser grain borer, Rice weevil and Angoumois grain moth feed on endospermic content of wheat. Germ portion is damaged by Khapra beetle, Rust red flour beetle and Almond moth (Yadav 1993) [11].

Lesser grain borer (*Rhyzopertha Dominica* Fab.) is the major pest of all cereals and also known as Australian wheat weevil. It was described in 1972 from specimen of South America. The original home of lesser grain borer is said to be India (Pruthi and Singh 1950) [6].

Rhyzopertha dominica can survive at minimum seed moisture content of 9.0 to 10.0% while, the optimum survival is 11.0 to 14.0% (Yadav 1993) [11]. The original home of lesser grain borer is said to be India (Pruthi and Singh 1950) [6]. The females generally lay eggs on the seed near the embryo end which is comparatively soft and allows the young larvae to enter easily. A single female may lay 300-500 eggs. The duration of egg stage is five to six days in summer and longer in winter. The newly hatched larva is quite active and campo dei form in shape.

It burrows at once into the seed and feeds inside and if it does not get chance, crawls actively feeding on loose starchy materials. It moults four and five times and the full grown larva is dirty white with a light brown head and curved abdomen. A average larval period is 44 days. The pre-pupal and pupal periods last for 7 to 8 days. Total life cycle from egg to adult takes about two months. The beetle is a strong flier and may spread rapidly and often found attacking wheat in field (Cotton, 1938 and Dean, 1947) [4].

2. Materials and method

The investigations were carried out in the laboratory of the department of Entomology of Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Faizabad (U.P.) in a complete randomized block design with 4 treatments and three replications.

2.1 Collection of infested samples of wheat

The initial test insect was obtained from 200 g seeds of the different varieties of wheat obtained from Seed Technology department of N.D. University of Agriculture and Technology, Kumarganj Faizabad and its culture was reared on sterilized wheat grains obtained from the local market.

2.2 Rearing of test insect

The collected insects were examined for their taxonomic characters (Personal Communication with Division of Entomology, I.A.R.I, New Delhi), the species of *Rhyzopertha Dominica* Fab. (Bostrichidae: Coleoptera). The mass rearing of the test insect was carried out on the wheat grains contained in three cylindrical glass jars each of 15 x 10 cm size. The mouth of each glass jar was covered with muslin cloth and tied with the help of rubber bands. The glass jars were kept in an incubator at a constant temperature of 30 ± 2 ^{0}C and 75 ± 5% relative humidity.

2.3 Copulation in adults of *R. Dominica*

Since it was difficult to distinguish males and females on morphological basis, a pair of newly emerged 2-4 days old adults taken in vials. These vials in which adults copulated were selected and marked as containing pair of opposite sex. During copulation, the female remains under neath the male and thus both sexes could easily be separated in different petri plates marked with male and female and thus the measurement of individuals of both sexes were carried separately.

2.3 Stock Culture

For preparing the special culture, 250 g wheat flour bought from the local market of Kumarganj, Faizabad and sterilized it at 55 ^{O}C temperature for 24 hours in the oven, kept in a glass jar of 15x10 cm size outside the laboratory. 100 adults of the test pest were introduced in that jar placed at 30 ± 2 ^{0}C temperature and 75 ± 5% relative humidity in the incubator. Adults were removed from jar after 20 days of introduction and flour was turned over as quickly. To get the newly emerged adults, upto 3 days older pupae were sieved out with the ordinary sieve and kept in two petridishes of 9.50 x 1.30 cm size each covered with another petridish of 10.00 x 1.50 cm size, kept at 30 ± 2 ^{0}C temperature and 75 ± 5% relative humidity.

2.4 Biology of the pest

The various experiments were carried out on PBW-154 variety of wheat under controlled condition at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2^0 and 35 ± 2 ^{0}C temperature, respectively, at 60 ± 5, 70 ± 5, 75 ± 5 and 80 ± 5% relative humidity.

2.5 Maintain temperature

The temperature levels of 25.0 ^{0}C, 27.0 ^{0}C, 30.0 ^{0}C & 35 ^{0}C were maintained in laboratory by using B.O.D (Biological oxygen Demand) incubators**.**

2.6 Maintain humidity levels for biology of *R. Dominica*

75% relative humidity level was set in B.O.D Incubator and other required humidity levels of 60, 70, & 80% were maintained in desiccators (20 cm) by using different salt solution (Solomon, 1951) [9]. The details are given in

Table 1: Maintain humidity levels for biology of *R. Dominica*

Salt Solutions	Quantity	Relative humidity (%)
KOH	41.84g/100ml water	60
KOH	33.33g/100ml water	70
$(NH_4)_2$ So_4	Saturated solution/100ml	80

2.7 Mating of *R. Dominica*

For observing the mating of *R. dominica*,10 pairs of newly emerged male and female adults isolated from the special culture were introduced as a single pair in each transparent plastic specimen tube of 6.00x2.70 cm size containing 25 healthy wheat grains. The mouth of each tube was covered with its perforated lid as made with the help of a needle. The eggs were isolated with the help of camel brush after each oviposition and counted under 10x hand lens. Observations of mating was recorded from each pair.

2.8 Eggs laying, incubation period and hatching capacity of *R. Dominica*

One pair of both sexes introduced in a specimen tube containing 25 wheat grains some of them humbled, kept under controlled conditions. Since the eggs were laid on grains in masses and loosely laid among the frass also, they could easily be detected with the help of 10 x hand lens after turning the grains in petridish and recorded daily for each specimen tube.

To obtain incubation period, 30 pairs of both sexes of adults introduced in 10 specimen tubes, each containing with 100 grains of PBW-154 variety and the grains changed daily. Eggs collected 100, 110, 201, 109 eggs arranged in rows on glass plate kept in the neat and clean petridish of 9.3x1.30 cm size, covered with another petridish of 10.00x1.50 cm in size. These eggs were observed daily, egg laying and hatching were recorded to find out the egg period. The observations were made on no. of egg shells and newly emerged larvae. The petridish was replaced daily. The hatching per centage was calculated accordingly.

2.9 Larval period of *R. Dominica*

With the view to study the larval instar, the experiment was carried out for 60 and 90 newly hatched larvae reared in neat and clean petridish with about 3 g wheat flour passed through fine cotton cloth to prevent the brown colored husk of grains. Observations were made on number of moult skins of larvae, counted under 10 x hand lens on their presence in the petridish and removed later on. Number of died and without moulted larvae were excluded from the counting of moulting.

After first moulting the feeding material was replaced. The days noted date-wise between moultings of larvae and sum of the duration of larval instar considered to be larval period. Another work carried out for measuring the all larval instars under 5 x microscope with the help of ocular and stage micro scope.

2.10 Pupal period and number of pupa of *R. Dominica*

The observations recorded on 36, 45, 65 and 69 pupae, work carried out in petridish under controlled conditions. Adult emergence were also recorded to find out the pupal period.

2.11 Number of adult of *R. Dominica*

For recording male and female adults, 24, 36, 50 and 28 adults took place in transparent plastic specimen tubes as one pair in each tube and observed on the basis of their copulation. Those adults which were not mated replaced by others. This process repeated upto three times to find out exact pair of both sexes counted to find out sex ratio.

3. Results and Discussion

Biology of *Rhyzopertha Dominica* Fab. carried out on wheat variety PBW-154 under controlled conditions of at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature and 60 ± 5, 70 ± 5, 75 ± 5 and 85 ± 5 per cent relative humidity. On the basis of significant effects of temperature and relative humidity on the biology of *R. Dominica* morphometric measurement of eggs to adult (length × breadth) (Table- 8 & 9), incubation period (Table-3), larval period (Table-4), pupal period (Table-5), adult longevity and life cycle (Table-7) was calculated.

Table 2: Mating period, egg laying and hatching of *R. Dominica* in different temperature & relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Mating Period (minutes)	Number of egg laying/ tube	Number of eggs hatching/ tube
T_1	25±2	60±5	5.16	99	77
T_2	27±2	70±5	4.83	110	84
T_3	30±2	75±5	4.83	200	163
T_4	35±2	85±5	3.5	108	81
SEm ±			0.28	1.73	1.52
CD at 5%			0.86	5.19	4.58

The mating period of *R. dominica* was varied from 5.17, 4.83, 4.83 and 3.50 minutes, the post-oviposition period of the female was recorded with an average of 6.33, 5.00, 4.33 and 6.00 days at 25 ± 2^{0}C, 27 ± 2 ^{0}C, 30 ± 2^0 and 35 ± 2 ^{0}C temperature and at 60 ± 5, 70 ± 5, 75 ± 5 and 80 ± 5% relative humidity, respectively. The incubation period of eggs of the test pest was worked out under controlled condition and it observed 9.17, 8.17, 6.83 and 5.83 days at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature, respectively, at 60 ± 5, 70 ± 5, 75 ± 5 and 80 ± 5% relative humidity. These observations are supported by finding of workers and (1966), (Prakash 1982) [7], (Atwal 1986) [2] and (Elek 1994) [5] reported that incubation period was recorded 7 to 11 days, 10.00, 9.7 to 6.4, 8.7 to 6.3 days respectively at 29 ± 0.5 ^{0}C and 75 ± 5 per cent relative humidity, 28 ± 2 ^{0}C and 73 ± 2 per cent relative humidity, 25 ^{0}C to 30 ^{0}C and 26 ^{0}C to 30 ^{0}C temperature and 56 per cent relative humidity.

Egg laying capacity of the females were 99, 110, 200 and 108 eggs, post-oviposition period of female was observed with an average of 6.33, 5.00, 4.33 and 6.00 days, incubation period was observed with an average of 9.17, 8.17, 6.83 and 5.83 days respectively at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature and 60 ± 5, 70 ± 5, 75 ± 5 and 85 ± 5 per cent relative humidity, respectively. (Table-2)

The eggs were typical oval with one end slightly broadend and other more or less tapering. The newly laid eggs were glistening white but they had turned into pinkish colour and became opaque later on. These finding are supported by (Brich, 1945) [3], (Thomson 1966) [10], (Koehler *et al*. 2015).

Table 3: Post oviposition and incubation period of *R. Dominica* in different temperature and relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Post Oviposition period (days)	Incubation period (days)
T1	25 ± 2	60 ± 5	6.3	9
T2	27 ± 2	70 ± 5	5	8
T3	30 ± 2	75 ± 5	4.33	7
T4	35 ± 2	85 ± 5	6	6
SEm±			0.47	0.33
CD at 5%			1.41	0.99

Table 4: Development period of different larval instars (days) of *R. Dominica* in different temperature and relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	1st instar larval period (days)	2nd instar larval period (days)	3rd instar larval period (days)	4th instar larval period (days)
T_1	25 ± 2	60 ± 5	6.83	8.16	7.16	9.16
T_2	27 ± 2	70 ± 5	5.83	6.83	6.83	7.83
T_3	30 ± 2	75 ± 5	5.83	5.83	4.83	6.83
T_4	35 ± 2	85 ± 5	4.83	4.83	3.83	5.83
SEm±			0.33	0.33	0.33	0.33
CD at 5%			0.99	0.99	0.99	0.99

The larval period of *R. Dominica* was observed 31.34, 27.32, 23.32 and 19.32 days, respectively at mentioned temperature and relative humidity. Above finding are similar to those reported by (Thomson 1966) [10] and (Koehler *et al*. 2015). He revealed that the first instar larva has small oval shaped body with tiny brown head. Head and abdomen are darker in the

second instar larvae appear almost straight from lateral view but third instar is pointed at the posterior end. Head is somewhat retracted into thorax in the fourth instar larvae and the front portion appears blunt and round. Abdomen is slender than thorax. Both third and fourth in stars are curved at mid-dorsal side when viewed from the side. The pupal period was noted to be 10.50, 7.83, 5.83 and 4.83 days respectively, under said controlled conditions. Complete life cycle of *R. dominica* egg to adult was 57.33, 48.33, 40.33 and 34.00 days at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2 ^{0}C and 35 ± 2 ^{0}C temperature and 60 ± 5, 70 ± 5, 75 ± 5 and 85 ± 5 per cent relative humidity, respectively. (Prevett 1959) [8] revealed that pupae are darker brown to black brown in colour and 3 mm in length. (Table- 4 & 5)

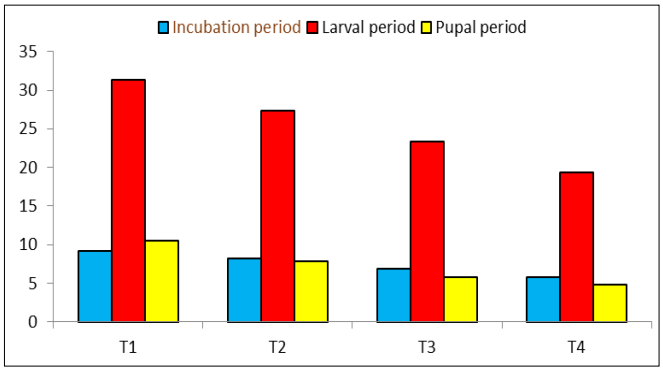

Fig 5: Incubation period, larval period, pupal period of *R. dominica* at different temperature and relative humidity

Table 5: Number of pupa, pupal period (days) of *R. Dominica* in different temperature and relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Number of pupa observed	Pupal period (days)
T_1	25 ± 2	60 ± 5	36	10.5
T_2	27 ± 2	70 ± 5	45	7.83
T_3	30 ± 2	75 ± 5	65	5.83
T_4	35 ± 2	85 ± 5	38	4.83
SEm±			0.85	0.35
CD at 5%			2.54	1.06

Table 6: Number of adult male and female sex ratio of *R. Dominica* in different temperature and relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Number of adult observed	Males	Females
T1	25 ± 2	60 ± 5	24	10	14
T2	27 ± 2	70 ± 5	36	15	21
T3	30 ± 2	75 ± 5	50	18	32
T4	35 ± 2	85 ± 5	28	12	17
SEm±			0.74	0.89	0.52
CD at 5%			2.23	2.69	1.58

There was no morphological difference in both sexes in adults however, female had its slight robust body compare to male. According to (Thomson 1966) [10], adult female had a pale yellow colour on ventral side of its 5th abdominal segment while male had a uniform brown colouration.

Table 7: Life cycle (days) of *R. Dominica* in different temperature and humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Complete life cycle (days)
T_1	25 ± 2	60 ± 5	57
T_2	27 ± 2	70 ± 5	48
T_3	30 ± 2	75 ± 5	40
T_4	35 ± 2	85 ± 5	33
SEm±			1.09
CD at 5%			3.29

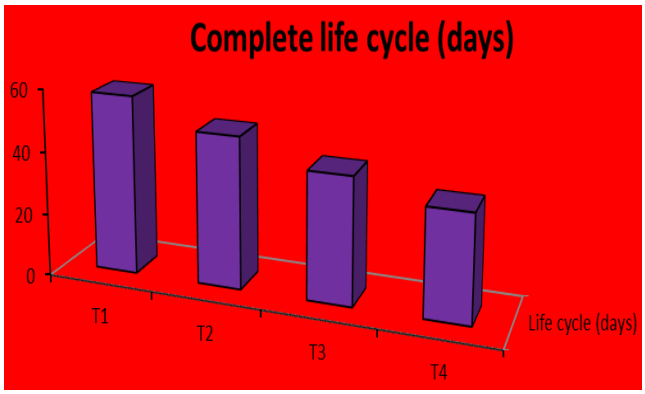

Fig 2: Complete life cycle (days) of *R. Dominica* in different temperature and humidity

The average duration required to complete the life cycle of *R. Dominica* Fab. from egg to adult was recorded 57.33, 48.33, 40.33 and 43.00 days at 25 ± 2 ^{0}C, 27 ± 2 ^{0}C, 30 ± 2^0 and 35 ± 2 ^{0}C temperature, respectively, at 60 ± 5, 70 ± 5, 75 ± 5 and 80 ± 5% relative humidity. (Table-7) (Thomson 1966) [10] Revealed that 38 days required to complete the life cycle from egg to adult at 29 ± 0.5 ^{0}C temperature and 75 ± 5 per cent relative humidity. (Elek 1994) [5] Estimated the total development at time (egg to adult) of 44 days at 26 ^{0}C temperature and 56 per cent relative humidity.

Table 8: Morphological measurement of eggs and different instar larvae (m.m) of *R. Dominica* in different temperature and relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Eggs (m. m)		Measurement of larvae (m.m)							
					1st instar		2nd instar		3rd instar		4th instar	
			Length	Breadth	Length	Width	Length	Width	Length	Width	Length	Width
T_1	25 ± 2	60 ± 5	0.86	0.47	0.69	0.20	1.20	0.73	2.43	1.17	3.63	1.97
T_2	27 ± 2	70 ± 5	0.60	0.47	0.69	0.20	1.21	0.73	2.44	1.18	3.64	1.98
T_3	30 ± 2	75 ± 5	0.63	0.47	0.69	0.20	1.20	0.73	2.44	1.18	3.65	1.98
T_4	35 ± 2	85 ± 5	0.83	0.47	0.68	0.20	1.20	0.73	2.43	1.17	3.63	1.98
SEm±			0.185	0.003	0.003	0.005	0.004	0.003	0.003	0.003	0.004	0.004
CD at 5%			0.554	0.009	0.010	0.014	0.011	0.009	0.010	0.010	0.012	0.011

Table 9: Morphological measurement of pupa and adult (m.m) of *R. Dominica* in different temperature relative humidity

Treatments	Temperature ^{0}C	Relative Humidity %	Measurement of Pupa (m. m)		Measurement of Adult (m. m)			
					Male		Female	
			Length	Breadth	Length	Breadth	Length	Breadth
T_1	25 ± 2	60 ± 5	4.56	2.56	3.40	1.88	3.70	2.11
T_2	27 ± 2	70 ± 5	4.56	2.56	3.41	1.89	3.70	2.10
T_3	30 ± 2	75 ± 5	4.56	2.56	3.42	1.89	3.71	2.11
T_4	35 ± 2	85 ± 5	4.55	2.55	3.42	1.88	3.70	2.10
SEm±			0.004	0.004	0.004	0.004	0.004	0.004
CD at 5%			0.012	0.012	0.012	0.012	0.013	0.012

4. Conclusion

The most suitable combination of temperature and relative humidity was recorded 30±2 ^{0}C and 75±5 per cent respectively for the growth, development and infestation of *Rhyzopertha Dominica* Fab. Life cycle of *Rhyzopertha Dominica* Fab. Was found to be completed in shorter duration at greater temperature as compared to lower temperature.

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