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Effect of seasonal variation on the biology of lesser grain borer, *Rhyzopertha dominica*, (Fabricius) on paddy

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Abstract
The life cycle of lesser grain borer, *Rhyzopertha dominica*, on paddy var Pusa 1121 was studied for seasonal variation at room temperature during winter at 14 to 22±5 ºC in winter and at 25±6 ºC in rainy season. The result shows that fecundity was more in rainy season (247.6± 13.12 eggs) as compare to winter (123±18.49 eggs). The incubation period was very similar in both seasons i.e. (11.1± 1.52 days) in winter and (11.4±1.50 days) in the rainy season. The total larval and pupal period was 39±3.19 days and the developmental period was 49.8± 4.26 days in rainy season as compare to 81.7±5.89 days and 93.2±9.84 days in winter, respectively. The seasonal variations also have the impact on the longevity of male: female, which was longer (36.5±3.71: 39.3±3.41 days) in winter and shorter (29.1±2.88: 34.9±2.07 days) in rainy season. The sex ratio was 0.80: 1.19 in winter and 0.90: 1.1 in the rainy season. Higher mean growth index 2.91 was recorded in rainy season and lower growth index 1.21 was observed in winter.

Keywords: Seasonal variation, paddy, lesser grain borer, *Rhyzopertha dominica*, biology

Introduction
Insects can damage a great amount of losses to stored grains and products ranging from 5 to 10 per cent losses in temperate regions and 20 to 30 per cent in the tropical regions [1]. They also mentioned that in India, post- harvest losses showed as high as to 12 per cent by insect pests. Among the stored grains pests, lesser grain borer, *Rhyzopertha dominica* (F.), can damage crops from the fields to the stored grain and may cause economic damage in the storage [2]. The lesser grain borer, *R. dominica* belongs to the genus *Rhyzopertha* under subfamily Dinoderinae and the family Bostrichidae. It is notoriously famous as an internal feeder pest on so many crops especially cereals including paddy, wheat, maize and sorghum, millets and pulses and also on the dried cassava roots [3]. *Rhyzopertha dominica* infested as the major pest on the cereal crops *viz.* paddy, sorghum, wheat and maize. Both the adults and grubs of *R. dominica* cause qualitative damage to the grains by feeding inside grains [4]. Heavily infested grains became hollowed out leaving only thin shells. The lesser grain borer is a polyphagous and cosmopolitan pest in tropical and subtropical regions of the world, but it can also been survived in warm and temperate regions [5]. The lesser grain borer is thought to originate from Indian subcontinent and it has spread out worldwide and created problematic conditions by feeding both on the germ and endosperm of wheat kernels [6]. When the infestation is seriously high, all grains are destroyed and adults produce a considerable amount of frass, spoiling more than what they can eat. It can give negative impact not only on the reduction in quantity but also deteriorate the quality of grain and its products [7].
Keeping the view of the economic importance of this pest, these laboratory studies were conducted to know the biology of this pest on one of the major cereal crops, paddy under different seasonal variation i.e. winter season (temperature 14 to 22±5 ºC and 45 to 60±5 per cent RH) and rainy season (temperature 25±6 ºC and 55 to 70 ±5 per cent RH) to know the effect of abiotic factors on growth and survival of the insect.

Materials and Methods
The biological studies of lesser grain borer were conducted on paddy variety (Pusa 1121) at room temperature in Storage Laboratory, Department of Entomology, CCS HAU, Hisar, during winter season (November - December, 2018) and rainy season (July –August, 2019). The observations were taken in the laboratory at room temperature 14 to 22±5 ºC and 45 to

60±5 per cent RH in winter and at 25±6 ºC temperature and 55 to 70 ±5 per cent RH in rainy season.

Maintenance of test insect culture

At first, 1 kg of paddy grains was disinfested at 60º C for half an hour before using as stock culture. To get stock culture of lesser grain borer, twenty pairs of lesser grain bore were released in glass jars containing 500g paddy var Pusa 1121. The stock jar was covered with the muslin cloth and tied with rubber bend. The jar was kept to get new generations. The freshly emerged ten pairs of adults were used in the present studies. Dead beetles and frass were checked properly to avoid storage mite infestation and secondary infection.

For these experiments, ten separated boxes were used as ten replications and filled with 50 g paddy grains in each box. Similarly, 50 eggs were kept separately in ten petri plates as ten replications with the help of fine camel hair brush and added a few sound grains to these plates to study for further development including incubation periods (days), larval and pupal development, sex ratio, adult longevity (days) and adult emergence and total developmental periods. Growth index can be calculated by using following formula:

Growth index= Per cent adult emergence/ Average developmental period (days)

Observations to be recorded

- Fecundity (no.of eggs laid/female)
- Incubation periods (days)
- Oviposition period (days)
- Post-oviposition period (days)
- Larval period and pupal period
- Adult longevity of male and female
- Sex ratio (M:F)
- Adult emergence (%)
- Total developmental period

Fecundity

Fecundity was counted as the number of eggs laid during the oviposition period per female daily.

Oviposition

Newly emerged 10 pairs of adult from stock culture of lesser grain bores were kept separately into 10 boxes with 10 g of sterilized paddy grains to record the number of eggs laid by female daily. The grains containing eggs were collected every day morning. The oviposition period was recorded in two parts *viz*. oviposition period and post-oviposition period. The oviposition period was counted as the date of starting of egg-laying to the date of stopping of egg-laying by an individual female.

Incubation period

The incubation period was the duration of time taken from egg laying to hatching with the appearance of dark tips of the larva through the egg chorion. This experiment was kept for further development till adult emergence and then continuously collected data till adult emergence, adult longevity and sex ratio

The larval and pupal period

The duration of larval period was taken from the larval emergence till the last instar going for pupation. The larvae of *R. dominica* were internal feeder, it was not easy to recognize change of larval instars by observing molted off the skin. Larval and pupal periods can be recorded as the date of hatching of egg to the emergence of adult.

Total developmental period

The developmental period was noted as the period between egg- laying and the emergence of the adult.

Sex ratio

The 50 randomly newly emerged adults from experimental grains were observed as male and female under laboratory conditions. Then, the sex ratio was recorded. The identification of male and female adults was done on the presence of a transverse groove on the fifth abdominal sternum of male while it was absent in females.

Longevity

The longevity of males and females was recorded from the period of adult emergence until the period of adult death .The life span of lesser grain borer adults was recorded by enclosing male and female adults in glass test tubes with food and without food with ten replications.

Statistical analysis

The data were subjected to statistical analysis under analysis of variance (ANOVA) technique to draw the inference at 1 % level of significance. For biology studies, results were expressed in Range and Mean ±S.D.

Results and Discussions

Fecundity

The fecundity was counted daily for the number of eggs laid during the whole oviposition period per female. During the winter , fecundity ranged from 92 to 155 with an average of (123± 18.49) at 14 to 22±5 ºC and 45 to 60±5 per cent RH whereas in the rainy season, it laid 225-266 (247.6± 13.12) eggs at 25±6 ºC temperature and 55 to 70 ±5 per cent RH (Table1). Similar results were observed by Kumar *et al*.[8] the fecundity of lesser grain borer was recorded with an average of 220.43±12.75 eggs on paddy *var.* Sumati, the lowest fecundity was 128.73±11.70 on maize hybrid, DHM-111 and the highest fecundity rate was observed in sorghum *var*. M 35-1 (233.23±13.90) . Gururaj[9] and Kumawat [10], they also reported that the average fecundity of 28.57 eggs on finger millet and 115 to 135 at 25±1 °C and 284 to 307 on wheat at 30±1 °C, at 65 to 85±5 per cent RH, respectively. Under optimum conditions, the egg laying capacity of females reaches up to 500 eggs during their lifetime, which may develop to adults within 25 days. In this experiment, the number of eggs per female per day on paddy was (7-17.4 eggs/ day) at 25±6 ºC in rainy season and (2-5 eggs/ day) at 14 to 22±5 ºC in winter whereas the moisture content of paddy grain was 9- 10%. Very similar results were observed by Howe[11] and he reported that fecundity of *R. dominica* was influenced by temperature and moisture content of the food, and it was highest at temperature range of 26 -34°C and moisture content of grains was 9-14% . Females can lay eggs in stored commodities at moisture levels as low as 8% can still hatch and develop [12]. According to Thompson[13], there was fewer or no eggs were deposited in wheat grain having less than at temperatures below 18 °C the rate was somewhat lower (6.5 eggs/day) but for beetles reared at 25 °C and 75 per cent RH, maximum egg per day was 33 eggs . The stored grains kept at a sufficiently low moisture level can be stored for many years without any significant loss in quality. The variation observed in fecundity during different seasons may

be the effect of temperature and relative humidity on oviposition behavior of female beetle.

Oviposition period

The oviposition period of *R. dominica* ranged from 13 to 26 days (20.4±3.80) days in winter (November –December) at 14 to 22±5 ºC and 45 to 60±5 per cent RH and it was 20 - 29 (24 ±2.82) days at 25±6 ºC temperature and 55 to 70 ±5 per cent RH in rainy season (July-August) (Table 1). Similar results are mentioned by Ajaykumara [14], he reported that oviposition period of *R. dominica* on maize varied from 13 to 29 (19.88) days during *kharif* season but during summer season it was in the range of 14 to 26 (17.88) days. Earlier, Jagadish *et al.* [15] observed that the oviposition period of *R. dominica* ranged from 28 to 45 days with an average of 34.20 days on finger millet. Shilakshmi *et al.* [16] mentioned that oviposition period of *R. dominica* was in the range of (20-25) days with an average of (22.05 ± 2.12) days. But, Bharati [17] found longer oviposition period as (21- 42) days. Kumar *et al.* [8] observed that oviposition period of *R dominica* was (33.80± 1.92) on paddy, (31.33±2.41) on maize, and (35.43±1.89) on sorghum. Imura and Nakakita [18] and Mainali *et al.*[19] reported that the oviposition period of, rice weevil, *Sitophillus oryzae* , on rice was shorter at 35 °C and maximum oviposition period was observed at 30 and 35 °C while Okelana *et al.*[20] mention that it was observed at range of 50-70% R.H. In present investigations, the egg- laying rate was maximum in first five days then declined and again increased after eight- day of oviposition period (Fig. 1). Golebioska[21] also recorded that oviposition capacity was the highest during the first few days, then decreasing progressively till the 10th day, and increasing up to the 24th day and again decreasing towards the end. Riaz *et al.* [22] also recorded that that maximum rate of oviposition of *Trogoderma granarium* was obtained at 30 °C or 35 °C while it was reduced less or high at 20 °C or 40 °C. Therefore, the oviposition capacity by female of *R. dominica* increased as temperature increased and vice versa.

Post- oviposition period

The post oviposition period lasted for 5-6 days in winter with average 5.5±0.52 days and 5-7 days with average (6±0.66) days in the rainy season (Table 1). Linda [23] mentioned that females can survive for several days after oviposition stopped. Ajaykumara [14] recorded that the post oviposition period of *R. dominica* on maize was from 6 to 9 days with an average of 7.67 ± 1.02 days with an average of 23.63 ± 0.97˚C and with an average of 46.74 ± 6.23 per cent RH. Kumar *et al.* [8] (2017) observed that the post-oviposition period of *R dominica* was (7.57± 1.10) on paddy, (6.13±0.73) on maize, and (7.03±0.89) on sorghum.

Incubation periods

Incubation period is from the egg- laying date to till the egg hatching time. The eggs were typically oval with one end slightly broadened and the other more or less tapering. The newly laid eggs were glistening white and gradually turn yellowish with the advancing incubation period. The freshly laid egg can be seen as white in colour and were translucent. In present experiment, the incubation period was 9 - 13 days with an average of 11.1±1.52 days in the winter at 14 to 22±5 ºC and 45 to 60±5 per cent relative humidity and it was 8 to 14 days with an average10.8±1.93 days at 25±6 ºC temperature and 55 to 70 ±5 per cent relative humidity in rainy season, respectively (Table 1). Present findings are in agreement with Panji and Shobha [24], who also recorded that eggs were gradually turned yellowish during the advancing incubation period. Bains [25] reported that the incubation period was less as 5.50 days at 39˚C temperature and 70 per cent relative humidity (RH), while it was high as 8.82 days at 27˚C temperature and 70 per cent RH. Kumawat [10] reported similar results that the incubation period was 9.3 days at 25±1 °C and 65±5 per cent relative humidity on wheat. The eggs were hatched out in about 7-8 days depending upon temperature [26]. Faroni and Garcia [27] recorded that incubation periods were (6.8±0.2) on sorghum, highest on maize (6.9 ±0.1), and shortest on paddy (6.8±0.1).The findings of Kumar *et al.* [8] also observed that incubation periods were (7.03±0.90) on sorghum, highest on maize (7.72±0.85) ,and shortest on paddy (6.57±0.54). Similarly, Teetes *et al.* [28] and Sattigi *et al.* [29] reported that the incubation period of *R. dominica ranged* from 5 to 11 and 5 to 9 days on sorghum, respectively. But Mason and McDonough [30] findings, they reported that egg development takes only five days at high temperature 36°C although it takes until 32 days at less temperature 18.1°C. So, these statements all are in support of the present findings.

Larval and pupal period

The total larval and pupal period varied from 73- 92 (82.17±7.14) days in the winter season but 33-42 (39±3.19) days in rainy season (Table 1). Similar results observed by Kumar *et al.* [8] (2017), they mentioned that the total larval and pupal period was (39.08± 1.58) days on paddy, shortest on sorghum (35.35±1.95), and longest on maize (43.85±1.45). Bains [25] revealed that the combined larval and pupal stage of *R. dominica* was 28.3 days at 33˚C temperature. Previously, Singh *et al.* [31] reported that the larval and pupal period of *R.dominica* was 36.60 days on wheat and sometimes varied from 24.2 to 44.8 days [10]. These variations could be due to the differences in seed physical and biochemical quality parameters of different cereals as well as the effect of weather conditions prevailing in their locations during larval development period.

Total development period

The shorter developmental period 42-55 (49.8±4.26) days was recorded in the rainy season (July- August) at 25±6 ºC temperature and 55 to 70 ±5 per cent RH in rainy season whereas longer periods 82-105 (93.2±9.84) days in the winter season at 14 to 22±5 ºC and 45 to 60±5 per cent RH in winter (Table 1). The results of rainy season are closely related to previous the findings of Gururaj[9], Kumawat [10] and Sujatha *et al.* [32] , they found that the mean total developmental period of 45.69 days on finger millet, 46.49 days on wheat and 44.99 days on maize at 30±1 °C under laboratory conditions, respectively. Kumar *et al.* [8] found that the total developmental period of *R. dominica* on paddy was (44.53± 1.66) in male and (45.93±1.46) in female. According to Astuti *et al.* [33], the shortest developmental time of *R. dominica* on barley was 25 days at 36°C with 80% RH and the longest developmental time 106.33 days was observed at 20°C with 60% RH. In past, Singh *et al.* [31] and Astuti *et al.* [33], recorded that the mean developmental periods of *R. dominica* were 44.5 days on wheat and 44.67 days on finger millet, respectively. As the temperature increased during rainy season during developmental periods, the feeding and metabolic activities of insects also increase; thereby larval development was faster and completed its development with a

shorter duration as compared to that winter season. Potter [3] also found that the complete life-cycle from egg to adult was about 58 days. He mentioned that the developmental period was 42-55 days at 24°C to 30°C with 40 to75 per cent RH under laboratory conditions in the rainy season. In some authors mentioned as total life cycle lasts from 24-133 days according to the temperature [34]. Riaz *et al*. [22] found that total developmental period of *Trogoderma granarium* was lowest at 35 °C but extended at 25 °C. Rolania *et al*. [35] conducted study on the effect of temperature and relative humidity on growth and development of *Lasioderma serricorne* on fennel seeds, and observed that the longest developmental period was as 69.0 days at 20°C and 90 RH, while shortest developmental period was 42.2 days at 30 °C and 70 RH. In present experiment, total development period was with longer days of 82-105 days in the winter season (Table 1). These differences observed might be due to variation in the host used and prevailing climatic conditions.

Sex ratio

The male and female ratio was based on 50 adults emerged. The sex ratio (male: female) was 0.84:1.19 in the winter season and it was 0.90: 1.10 in rainy season. The observations made on sex ratio indicated the predominance of females over males (Table 1). Singh *et al*. [31] reported that the sex ratio was 1: 1.23 on wheat varieties Kalyan Sona and Sonalika, respectively. Similar results obtained by Kumawat [10] for sex ration on wheat were 1: 1.15 at 30±1°C in the rainy season and 1: 1.14 at 35±1 °C in summer season. Kumar *et al*. [8] found that sex ratio was 1: 1.20 on paddy, 1: 1.20 on maize and 1: 1.32 on sorghum, respectively. Ajaykumara [14] reported that the sex ratio on maize was 1.10:1 during the rainy season and it was observed with high sex ratio 1: 1.13 in summer season. These differences may be due to variation in nutritional quality of hosts and different habitat conditions prevailed in different seasons under laboratory conditions.

Adult longevity

The longevity of male was 30-42 (36.5±3.71) days in the winter season and 23-33(29.1±2.88) days in the rainy season, while female longevity ranged from 37-42 (39.3±3.41) days in winter and 34-38 (34.9±2.07) days in rainy season, respectively (Table 1). The results showed that adult longevity of both sexes were relatively longer in winter season than in rainy season. During the winter season the prevailed temperature and relative humidity favoured slower development. Present results are in confirmation with the results of Kumawat [10], he reported that the longevity of the males was less than that of females on wheat. Mean female longevity was 36.5±3.71 days at 20±1 °C and 34.9 days at 30±1 °C, whereas mean male longevity lasted for 36.5±3.71 days at 20±1 °C and 29.1 days at 30±1 °C and 65 to 85±5 per cent relative humidity. But Sattigi *et al.* [29] and Gururaj [9] observed that, the longevity for females and males was from 41 to 87 days and 37 to 78 days on sorghum grains and 43 to 71 days and 37 to 54 days on finger millet respectively. These results indicated that, adult longevity of both sexes was considerably lower as compared to other host grains, this may be due to hardness of kernels and biochemical constituents present in wheat and paddy seeds. The longest longevity of male and female was 46.13±3.09 and 48.47±2.84 days were observed on sorghum *var*. M 35-1 while the shortest longevity of male and female of *R. dominica* 37.13±2.61 and 37.97±2.66 days were recorded on Maize Hybrid, DHM-111. According to three different hosts, it is evident that female lived longer than male [8]. All these variations with respect to different developmental stages during different seasons may be due to the climatic factors that prevailed during those periods.

Adult emergence

Adult emergence per cent can be calculated from the number of adult emergence from the tested numbers of pupae and it ranged from 90 -100 (95%) at 25±6 ºC temperature and 55 to 70 ±5 per cent RH in rainy season and 84-90% (89.77%) at 14 to 22±5 ºC and 45 to 60±5 per cent RH in winter, respectively. The adult emergence of *Trogoderma granarium* also took more time at low temperature and humidity while its time period was also decreased as temperature rose up to 30 and 35 °C in combination of high relative humidity (60 and 65%) [22]. Riaz *et al*. [22] mentioned that total developmental period was lowest at 35 °C but extended at 25 °C. No larva was converted into pupa at extreme temperature and growth was restricted at both extreme temperatures while showed maximum development at 35 °C.

Growth index

Growth index can be computed by dividing per cent adult emergence to average developmental periods (days). The growth index of lesser grain borer was 2.43 at 25±6 ºC temperature and 55 to 70 ±5 per cent RH in rainy season and 1.19 at 14 to 22±5 ºC and 45 to 60±5 per cent RH in winter season, respectively. Similarly, Rolania *et al*. [35] also mentioned that the growth index of *Lasioderma serricorne* on fennel seed was maximum at 30°C and 70 %RH, whereas it was minimum at 20°C and 60% RH.

Conclusion

It can be concluded from the present study, the total developmental period of *R. dominica* 82-105 (93.2± 9.84) days at 14 to 22±5 ºC and 45 to 60±5 per cent RH in winter season was longer than 42-55 (49.8 4.26) days in rainy season . Higher mean growth index 2.43 was in the rainy season and lower growth index 1.19 was in winter season. Our studies showed that in rainy reason (at 25±6 ºC temperature and 55 to 70 ±5 per cent RH), insect development is fast and it was more favourable as compare to winter season (at 14 to 22±5ºC and 45 to 60±5 per cent RH).

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Table 1: Biology of *Rhyzopertha dominica* on paddy in winter and rainy seasons

Seasons/Parameters	Winter (14- 22±5 °C)		Rainy (25±6 ºC)	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Fecundity(eggs/female)	92-155	123±18.49	225-266	247.6±13.12
Oviposition (days)	13-26	20.4±3.80	20-29	24±2.82
Post-oviposition period (days)	5 – 6	5.5±0.52	5 -7	6±0.66
Incubation (days)	9 – 13	11.1±1.5	8 – 14	10.8±1.93
Larval and pupal period (days)	73-92	82.17±7.14	33-42	39±3.19
Total developmental period (days)	82-105	93.2±9.84	42-55	49.8±4.26
Longevity (days)				
Male	30-42	36.5±3.71	23-33	29.1±2.88
Female	37-42	39.3±3.41	34-38	34.9±2.07
Sex Ratio (Male: Female)		0.84:1.19		0.90:1.1

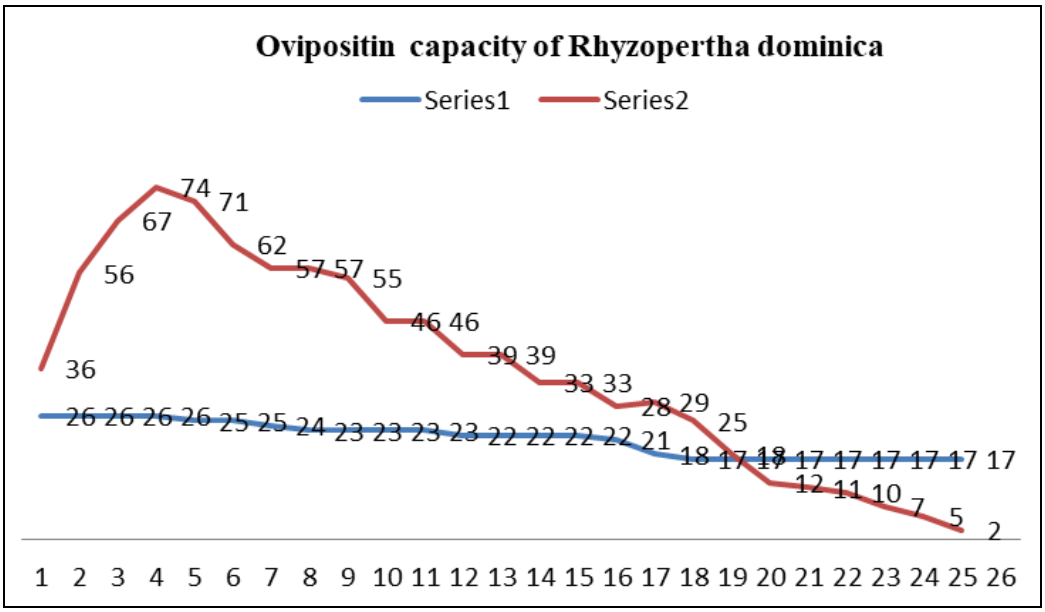

Fig 1: Ovipostion capacity of *Rhyzopertha dominica* decreased while temperture decreased during winter season (November -December)

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