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

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Abstract
The life cycle of lesser grain borer, *Rhyzopertha dominica*, on wheat 1105 was studied for seasonal variation at room temperature during winter at 21±7 ºC in winter and at 28±5 ºC in rainy season. The result shows that more fecundity (306.8±16.36 eggs) was in rainy season as compare to winter (170.8±16.08 eggs). The incubation period was very similar in both seasons i.e. (11.5±3.44 days) in winter and (11.4±1.50 days) in the rainy season. The total larval and pupal period was (35.8± 2.78 days) and the developmental period was (47.2±3.01days) in rainy season as compare to longer (81.7±5.89 days) and (88.62± 2.98 days) in winter, respectively. The seasonal variations also have the impact on the longevity of male: female, which was longer (38.9±3.91: 41.7±3.49 days) in winter and shorter (28.9±2.68: 32.75±2.82 days) in rainy season. The sex ratio was 0.84: 1.04 in winter and 0.90: 1.10 in the rainy season. Higher mean growth index 2.01 was recorded in rainy season and lower growth index 1.02 was observed in winter.

Keywords: Wheat, seasonal variation, lesser grain borer, *Rhyzopertha dominica*, biology

Introduction
The lesser grain borer, *R. dominica* (Coloeoptera: Bostrichidae), is an important internal and primary feeders of stored grain [1]. The lesser grain borer, is a polyphagous and cosmopolitan pest in tropical and subtropical regions of the world, but it can also been surviving in warm and temperate regions of the world [2, 3]. *R. dominica* was an important pest of all cereals. Both larvae and adults were entered into the grains and feed on it. In undamaged grains, adults frequently attacked on germs. Not only the whole grains, it could develop on milled rice and cereals flour. It can feed on dried cassava and many pulses [4]. Insect development and population growth rates are directly affected by temperature, moisture, and relative humidity. The temperature and relative humidity increased, the developmental period of *R. dominica* was significantly decreased and vice-versa. The shortest developmental period of *R. dominica* 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 [5]. Both larvae and adults of lesser grain borer stay inside the whole grains and cause damage on sound grains and broken/damaged grains as well. *R. dominica* can complete a short developmental time and high population growth when there are getting favorable abiotic factors such as temperature and relative humidity and it might affect on the growth and development of stored product insects which can be different due to different crops [6]. Egg, larval, pupal and total developmental period of *R. dominica* were shorter when reared on wheat which its primary food source [7]. In order to achieve the effective, economic and least dangerous control measure for the pest, detailed and accurate knowledge of its biology is important which can lead to focusing of population levels and various mortality factor related to abiotic factors such as temperature and relative humidity to record the unfavorable conditions for their growth and development as different seasonal variations. Keeping this in the view, and the economic importance of this pest, the present study was conducted on influence of seasonal variation in the biology of lesser grain borer on stored wheat under laboratory conditions

Materials sand Methods

The biological studies of lesser grain borer were conducted on wheat variety WH 1105 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 21± 7 ºC and 60±5 percent RH in winter and at 28±5 ºC temperature and 70 ±5 percent RH in rainy season.

In order to study the various stages of *R. dominica*, the adults (10 pairs) were released in plastic containers containing 50 g wheat seeds for egg laying. Likewise 10 sets were prepared for each crop.

Maintenance of stock culture

The adult of lesser grain borer were collected from godown of wheat section, Department of Genetics and Plant Breeding, CCSHAU to initiate stock culture. Mass multiplication for stock culture was done on stored wheat grains which were sterilized at 55 ˚C temperature in an oven for 4 hrs. The sterilized grains were brought to room temperature before inoculation of insects. The adults of *R. dominica* were released in the glass jar (21 × 15 cm) which containing wheat grain (WH1105). The top of glass jar was secured with muslin cloth and tied with rubber band to avoid the escape of the insect. Dead beetles and frass were checked properly to avoid storage mite infestation and secondary infection. The stock culture was maintained under laboratory conditions throughout the experimental period. The adults were emerged from the stock culture were used for further experiments.

Fecundity

The observations on fecundity was recorded by counting the number of eggs laid by each females on wheat and paddy seeds daily in the morning till the death of the female from each containers.

Oviposition

Ten replications were maintained with one pair in every container along with the wheat and paddy grains to observe the oviposition and post- oviposition periods. 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.

Post- oviposition

Period between stopped egg laying to death of female beetles was recorded as post - poviposition period.

Incubation period

The incubation period was the duration of time taken from egg laying to hatching. The oviposited grains were collected from containers and examined under binocular microscope and kept under observation till hatching. After hatching of the eggs, new larvae individually transferred to new petri plates with the help of fine camel hair brush and kept with few grains for further development. Likewise 10 replicates were prepared with grains.

Larval and pupal period

Lesser grain borer, *R. domininca* is an internal feeder, it is very difficult to observe the exact larval and pupal period. After hatching, first instar larvae stayed outside of the grain for 24 – 36 hours and then entered the grain. Larva found feeding individually inside the grain. To observe the different larval stages, grains were dissected. The insect undergo three molts and four instars. Larval development took place inside. The width of head capsule helped to determine the larval instars (Sharifi and Mills, 1971) [8]. The duration of larval period was taken from the larval emergence till the last instar going for pupation. Total larval and pupal periods were recorded as the period between emergence of larva to the emergence of adults.

Sex ratio

The 50 randomly newly emerged adults were observed under binocular microscope for their colour, size and examination of the abdomen to find out the male and female. 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 [9].

Adult emergence

Total number of adults emerged were observed twice (morning and evening) in a day to work out the total developmental period (egg to adult) and percent adult emergence on the basis of eggs placed in each specimen tube.

Longevity

The longevity of males and females was recorded from the date of adult emergence till the adult death. The life span of lesser grain borer adults was recorded by enclosing male and female adults separately in glass test tubes with food in ten replications.

Growth Index

Growth index of *R dominica* was computed by dividing percent adult emergence to average developmental periods (days). Growth index was calculated as per the following formula [10].

$$\text{Growth index} = \frac{\text{Percent Adult Emergence}}{\text{Average Developmental Periods (days)}}$$

Statistical analysis

The data were subjected to statistical analysis using 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

Fecundity

The lesser grain borer laid a group of 7 to 30 eggs in the food grains. The fecundity was recorded daily to count the number of eggs laid during the whole oviposition period by female. On wheat, the fecundity ranged from 123- 215 (170.8±16.08) eggs in winter and it ranged from 285 - 398 (306.8±16.36) eggs in the rainy season. Fecundity was more in rainy season in comparison to winter on wheat.

Oviposition period

On wheat, the oviposition period ranged from 23 – 27 days with an average of 22.7± 2.11 days in winter and 22 - 33 (27.6±4.19) days in rainy season. Oviposition period was in rainy season.

Post- oviposition period
The post-oviposition period varied 5-6 days with an average of (5.5±0.52) days on wheat in winter and 4-5 days with an average of (4.6± 0.51 days) in rainy season.

Incubation periods
In present experiment, the incubation period on wheat was 9 - 14 days with a mean of (11.5±3.44 days) in the winter and 9 to 13 days with a mean of (11.4± 1.50 days) in rainy season. However, while comparing both rainy and winter season, the longer incubation period was found in winter season on wheat.

Larval and pupal period
The larva (grub) of lesser grain borer had four different larval instars. The larva developed inside the grain. It was apodous, short, stout, yellowish white brown coloured head with a curved spine at the terminal abdominal segment. The first instar larva was an active and campodeiform when hatched from egg. The second instar larva closely resembled the first instar larva except for the larger size and absence of process at the terminal abdominal segment. The thorax had three pairs of small legs. Body was covered with small setae. The second larval stage was differed markedly from the two preceding stages. Third larval stage was scarabeiform with retracted head but is capable of active locomotion. The fourth larval stage was also scarabaeiform and was largely immobile. The pupa was soft, white to yellowish in colour and exarate in form (antennae, legs and wings pads were not glued to the body) .The larval and pupal period varied from from 75-90 (81.7±5.89) days on wheat in winter season and 33-40 (35.8±2.78) days on wheat in rainy.

Total development period
Developmental period on wheat was recorded as 42 – 53 (47.2± 3.01 days) in rainy season, and 85-95 (88.62± 2.98 days) in winter season. In winter, the developmental period of lesser grain borer was longer whereas it was shorter in rainy season.

Sex ratio
The male was mostly uniform brown colour on the ventral side and a female was light yellowish colour. They became reddish brown in colour after 4 to 5 days of emergence. The existence of a distinct transverse, punctuate groove on the fifth abdominal sternite of the male of *R. dominica*, which is never present in females. On wheat, it was 0.84: 1.04 in the winter season and it was: 0.90: 1.10 in the rainy season. The observations made on sex ratio indicated the predominance of females over males.

Longevity of male and female adult
The longevity of male ranged from 30 -45 (38.9± 3.91) days in winter and 25-33 (28.9± 2.68) in rainy season on wheat. The female longevity varied from 36-48 (41.7± 3.49) days in winter and 30-36 (32.75± 2.82) days in rainy season on wheat. The present investigation was evident that female had longer longevity than male on both crops as well as in both seasons.

Adult emergence
Adult emergence of ranged from 95-100 (95%) in rainy season and 84-92 (90.50%) in winter on wheat. Adult emergence was higher in rainy season as compared to winter season.

Growth index
The growth index of lesser grain (1.02) was observed on wheat in winter and (2.01) in rainy season. Lower mean growth index was recorded in winter in comparison to rainy season while growth index was higher on wheat.

Discussion
Fecundity
The present study revealed that fecundity on wheat was ranged from 123- 215 (170.8±16.08) eggs in winter and it ranged from 285 - 398 (306.8±16.36) eggs in the rainy season. On wheat, the fecundity was high in rainy season in comparison to winter. The present findings are in agreement with the reports of Gururaj [11] and Kumawat [12] they observed the average fecundity of lesser grain borer was 115 to 135 at 25±1 °C and 284 to 307 at 30±1 °C and 65 to 85±5 percent RH on wheat. The present findings are in close agreement with Singh *et al.* [13] who revealed that the a female of *R. dominica* laid an average 303 eggs and 314 eggs on wheat varieties, Kalyan Sona and Sonalika, respectively in its total life cycle. Current findings are parallel with Kumawat [12], who found the maximum fecundity of *R dominica* was (307.3 eggs /female) at 30±1 °C temperature and 75±5 percent RH while the minimum fecundity (60.0 eggs /female) at 40±1 °C temperature and 65±5 percent RH. Faroni and Garcia [14] also observed that the total number of *R. dominica* eggs laid by a female increase up to a maximum of 423 eggs at 32 ˚C on wheat grains.

Oviposition period
On wheat, the oviposition period ranged from 23 – 27 days with an average of 22.7± 2.11 days in winter and 22 - 33 (27.6±4.19) days in rainy season. Oviposition period was longer on wheat than paddy while it was shorter in rainy season on both the crops. The current findings are parallel with Ajaykumara [14], he reported that oviposition period of *R. dominica* varied from 13 to 29 (19.88) days during *kharif* season and it was 14 to 26 (17.88) days during summer season on maize. 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. Kumar *et al.* [11] (2017) 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. Baldassari *et al.* [16] (2005) reported that the ovipositional period of *R. dominica* varied from 28 to 45 days with a mean of 34.20 days on sorghum, while Mason [17] observed that oviposition period of *R. dominica* ranged from 15 days to 4 months on sorghum.

Post- oviposition period
The post oviposition period varied from 5-6 days with an average of (5.5±0.52) days on wheat in winter and 4-5 days with an average of (4.6± 0.51 days) in rainy season. The present results were in confirmation with the results of Ajaykumara [14], who recorded that the post-oviposition period of *R. dominica* was ranged from 6 to 9 days with an average of 7.67 ± 1.02 days at 23.63 ± 0.97˚C temperature and with an average of 46.74 ± 6.23 percentRH on maize. Similarly, Kumar *et al.* [18] observed that the post-oviposition period of *R dominica* was (7.57± 1.10) days on paddy, (6.13±0.73) on maize, and (7.03±0.89) on sorghum.

Incubation periods

In present study, it was evident that in winter, the incubation period on wheat was 9 - 14 days with a mean of 11.5±3.44 days whereas in rainy season, it was 9 to 13 days with a mean of 11.4± 1.50 days. The similar results were reported by Kumawat [12] who found that the incubation period of *R. dominica* was 9.3 days at 25±1 °C temperature and 65±5 percent relative humidity on wheat. The incubation period of *R. dominica* ranged from 5 to 11 and 5 to 9 days on sorghum [19, 20]. Bains [21] reported shorter incubation period as 5.50 days at 39 ˚C temperature and 70 percent relative humidity (RH), while it was high as 8.82 days at 27 ˚C temperature and 70 percent RH. Presents results are not in agreement with findings of Faroni and Garcia [22], who recorded that the incubation periods as 6.8±0.1days on paddy. Moreover, Kumar *et al*. [18] also observed the incubation period was (7.03±0.90) days on sorghum and 6.57±0.54 days on paddy. These variations may be due to changes in temperature and relative humidity in different seasons.

Larval and pupal period

The results of the present investigation revealed that the larval and pupal period varied from 73- 92 (82.17±7.14) days in the winter season while it was shorter 33-42 (39±3.19) days in rainy season on paddy. The larval and pupal period of *R. dominica* ranged from 76-83 (77.12 ±2.22) days in winter and 33-40 (35± 2.78 days) days in rainy season on wheat. Similar results were observed by Kumar *et al*. [18] they mentioned that the total larval and pupal period of *R. dominica* was 39.08± 1.58 days on paddy. Previously, Singh *et al*. [13] reported that the larval and pupal period of *R. dominica* was 36.60 days on wheat and sometimes it varied from 24.2 to 44.8 days [18]. These findings were not in close agreement with Pruthi and Singh [23] who reported the total larval period ranged from 20 to 30 days on wheat and Hashem [43] observed the total larval period was 19 days on wheat. These variations might be due to the differences in seed physical and biochemical quality parameters as well as the effect of weather conditions prevailing in their locations during the larval period.

Total development period

In present study the shorter developmental period on wheat was recorded as 42 – 53 (47.2± 3.01 days) in rainy season and 85-95 (88.62± 2.98 days) in winter season. The present findings are supported by Singh *et al*. [13] and Astuti *et al*. [5] recorded the mean developmental periods of *R. dominica* was 44.5 days on wheat and 44.67 days on finger millet. The present results are closely related to the findings of Gururaj[10] , Kumawat [21] and Sujatha *et al*. [25] they found that the mean total developmental period of *R. dominica* was 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.

Moreover, Potter [2] also found that the developmental period was 42-55 days at 24 °C to 30 °C with 40 to75 percent RH under laboratory conditions in the rainy season. Ripa [26] observed the total developmental period of *R. dominica* was 42 to 56 days at 27 °C and 70 percent RH on wheat. As the temperature increased during rainy season the feeding and metabolic activities of insects also increased, thereby larval development was faster and completed its development with a shorter duration in rainy season as compared to winter.

Sex ratio

The sex ratio (male: female) of *R. dominica* on wheat, it was 0.84: 1.04 in the winter season and 0.90: 1.10 in the rainy season. Singh *et al*. [12] reported that the sex ratio of *R. dominica* was 1: 1.23 on wheat. Kumawat [12] observed the sex ration of *R. dominica* on wheat was 1: 1.15 at 30±1 °C in the rainy season and 1: 1.14 at 35±1 °C in summer season. Ajaykumara [14] (2015) reported that the sex ratio of *R. dominica* on maize was 1:1.10 during the rainy season and the sex ratio was 1: 1.13 in summer season. These differences may be due to variation in nutritional quality of different hosts.

Adult longevity

The longevity of male ranged from 30 -45 (38.9± 3.91) days in winter and 25-34 (28.9± 3.31) days in rainy season on wheat. The female longevity varied from 36-48 (41.7± 3.49) days in winter and 34-42 (38.4± 3.90) days in rainy season on wheat. The present results were confirmed with the results of Kumawat [12] he reported that the longevity of the males was less than the females on wheat. He found the mean female longevity was 36.5±3.71 days at 20±1 °C temperature and 34.9 days at 30±1 °C temperature, whereas mean male longevity lasted for 36.5±3.71 days at 20±1 °C temperature and 29.1 days at 30±1 °C temperature and 65 to 85±5 percent relative humidity. The present findings are not in close agreement with Sattigi *et al*. [20] observed that the longevity of females and males was ranged from 41 to 87 days and 37 to 78 days, respectively on sorghum grains. Gururaj [11] reported longevity of females and males was 43 to 71 and 37 to 54 days, respectively on finger millet. Kumar *et al*. [18] mentioned that the longest longevity of male and female was 46.13±3.09 and 48.47±2.84 days on sorghum *var*. M 35-1 while the shortest longevity of male and female of *R. dominica* as 37.13±2.61 and 37.97±2.66 days, respectively were recorded on Maize Hybrid, DHM-111.

Adult emergence

On wheat crop the percentadult emergence ranged from 90 - 100 (95%) in rainy season and 84-92 (90.50%) in winter. In present findings, the percent adult emergence was mainly respond to seasons. The present findings are supported by Barbhuiya and Kar [27] studied the biology and host preference of rice weevil under laboratory conditions. They observed that total number of eggs laid per female was 54, 115, 160 and 225 on rice, maize, sorghum and wheat, respectively and maximum adult emergence (95%) of S. oryzae was observed on rice, Chakwal -86 cultivars . Riaz *et al*., [28] recorded that the adult emergence of *Trogoderma granarium* took more time at low temperature and humidity. They observed 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 extreme temperatures while showed maximum development at 35 °C.

Growth index

The growth index of lesser grain borer on wheat the growth index was 1.02 in winter and 2.01 in rainy season. The present results are supported by Singh *et al.* [20] who reported that the growth index of *R. dominica* was 1.06 in wheat variety PBW226 and 1.74 in HD 2285. The current findings are parallel with Singh *et al.* [12] who reported susceptible varieties produced the higher growth index. They found 1.19 growth index in wheat variety Kalyan sona and high (2.48) in susceptible wheat variety K 8121 for *R. dominica*. Very similar results were mentioned by Rolania *et al*. [29] who

recorded that the growth index of *Lesioderma serricorne* on different fennel varieties was ranged from 0.71 to 1.71.

Conclusion

It can be concluded from the present study, while comparing seasons the longer incubation period was found in winter season on wheat and longer larval and pupal periods (81.7±5.89) days were recorded in winter and shorter (35.8±2.78) days in rainy season. The shorter developmental period on wheat was (47.2± 3.01) days in rainy season and (88.62± 2.98) days in winter season. Female was slightly longer than male. Sex ratio (male: female) on wheat was 0.84: 1.19 in winter and 0.90:1.1 in the rainy season on wheat. The growth index of lesser grain borer was recorded 1.02 in winter and 2.01 in rainy season on wheat. Our studies showed that in rainy reason at 28±3 ºC temperature and 70 ±5 percent RH, insect development is fast and it was more favorable as compare to winter season at 21±7 ºC and 60±5 percent RH.

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Table 1: Biology of *Rhyzopertha dominica* on wheat (var WH 1105) during winter and rainy seasons

Seasons / Parameters	Winter (Nov-Jan)		Rainy (July- Aug)	
	Range	Mean ± S.D.	Range	Mean ± S.D.
Fecundity (eggs/female)	123-215	170.8±16.08	285-398	306.8±16.36
Oviposition (days)	23-27	22.7±2.11	22-33	27.6±4.19
Post-oviposition period (days)	5-6	5.5±0.52	4-5	4.65±0.51
Incubation (days)	9- 14	11.50± 3.44	9- 13	11.4 ± 1.50
Larval and pupal period (days)	76- 83	77.12±2.22	33-40	35.8 ± 2.78
Total developmental period (days)	85- 95	88.62±2.98	42-53	47.2±3.01
Longevity (days)				
Male	30-45	38.9±3.91	25-33	28.9±2.68
Female	36-48	41.7±3.49	30- 36	32.75±2.82
Sex Ratio (Male: Female)	-	0.84: 1.04	-	0.90:1.1
Adult emergence (%)	84-92	90.5	90 -100	95
Growth index	-	1.02	-	2.01

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