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Impact of different wheat cultivars on lesser grain borer, *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) under storage conditions

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Abstract
Wheat is one of the most important staple foods of India and is infested by several stored grain insect-pest in storage. Out of all these, lesser grain borer, *Rhyzopertha dominica* (F.) is the economically important one causing substantial losses to various cereals including wheat. The present investigations were carried out to know about the differences in certain biological parameters of lesser grain borer feeding on different wheat cultivars. Out of all seven cultivars screened, HPW-155 had maximum adult emergence (111.67), susceptibility index (11.69), orientation preference (24.44) and shortest developmental period (40.33), while, HPW-349 had minimum adult emergence (54.00), susceptibility index (7.40), orientation preference (7.67) and longest developmental period (54.00) and the rest cultivars had mediocre values. The borer completed its life cycle on all the cultivars, however, HPW-349 was found to be least susceptible one and should be preferred over others in future for long storage purpose.

Keywords: Wheat, storage, *Rhyzopertha dominica*, biological parameters, orientation

1. Introduction
Rhyzopertha dominica (F.), is a primary pest of stored grains and their products, spoiling more than what they eat. They mainly feed on corn, rice, wheat and in other substrates containing starch. *R. dominica* is frequently spotted in forest habitats and under grain storage conditions.
Wheat contributes about 35% of total food grain production of the country. The grain infested by this pest is rendered unfit for human, animal consumption and also for any industrial use. A dozen of insect species infests wheat during storage, *R. dominica* being one of the major pests. Annual loss of grains due to insect-pests under storage condition is estimated to be 5.90 million tonnes. For the control of stored grain insect-pests, synthetic insecticides are used in several countries, however, their indiscriminate use has resulted into resistance of pest species and toxic residues in food grains used for human consumption and control failures (Isman 2006; Koul *et al*. 2008) [1, 2]
One of the alternatives is to utilize stored grain resistance to various insect-pests in their management. All the stored grain pests exhibit the phenomenon of preference or non-preference for the grains of different varieties rendering them less suitable or unsuitable for feeding, oviposition and development of insect-pests (Sarin and Sharma 1983) [3]. Thus, comparing the biological parameters on different cultivars can serve as a potential tool for avoiding the storage of susceptible cultivars.
In Himachal Pradesh, wheat is very important cereal crop and several insect-pests have been reported to damage stored grains in the state (Thakur *et al*. 2007) [4], however, very scanty information is available regarding susceptibility of commonly cultivated wheat cultivar against lesser grain borer in stored wheat. Therefore, the present investigations were carried out to evaluate the preference and ease of completing life cycle of *R. dominica* on these cultivars.

2. Materials and Methods
The present studies were conducted under lab conditions in the Department of Entomology, College of Agriculture, CSKHPKV, Palampur. The healthy, pure and pest free seeds of seven wheat varieties (Table 1) were obtained from the Department of Seed Science and Technology, CSKHPKV, Palampur and Rice and Wheat Research Station, Malan. The seeds were further critically examined for any foreign materials and were disinfected by placing them in oven at 60±2 °C for four hours.

Table 1: Different wheat varieties used for screening against *Rhyzopertha dominica*

Treatments	Varieties	Remarks
T_1	HPW-155	Timely sown, large sized and hard grains
T_2	HPW-236	Timely sown, low, mid and high hills, large sized and moderately hard grains
T_3	HPW-249	Timely sown, mid hills, small sized grain
T_4	HPW-349	Timely sown, solid grains
T_5	HPW-360	Early sown, low and mid hills, hard grains
T_6	HS-490	Late sown, low and mid hills, large sized and moderately hard grains
T_7	VL-892	Late sown, low and mid hills, hardy grains

2.1 Culture of *R. dominica*
The pure culture of *R. dominica* was maintained in one plastic jar of 2 kg capacity, open-top of which was covered with clean sterile muslin cloth and properly tightened with rubber band. Five hundred newly emerged adults were released in each jar containing one kg of mixed wheat grains of different cultivars and were placed in the rearing chamber (insectary) with 26±2º C and 70% RH. After allowing the borer to oviposit for one week, they were removed from the jar using a sieve and were discarded. Adults which started to emerge were used for further experimentation and some of them were transferred to fresh grains and the process was repeated to maintain the culture.

2.2 Total developmental period, Adult emergence and Susceptibility index
Seven commonly cultivated wheat varieties under different agro-climatic conditions in Himachal Pradesh (Table 1) were evaluated for their influence on *R. dominica* under lab conditions. Before conducting various experiments, their important characters were noted down. 20g of each variety was filled in 50g capacity plastic boxes. Five pairs (10 adults) of *R. dominica* were added to each plastic box (50g). Each treatment was replicated 3 times. Minute holes were made on the lid of the boxes using a sharp pin to facilitate proper aeration. After a period of 8 days, adults were removed using a number 10 mesh sieve and were discarded. The grains were examined daily. Newly emerged adults were counted to find out the total adult emergence. Total developmental period of the borer was recorded as the total no. of days taken by it for completing its life cycle from oviposition to adult emergence on different varieties of wheat. The susceptibility index of each variety was calculated by applying the formula suggested by Dobie (1977) [5] as given below:

$$\text{Susceptibility index} = \frac{\text{Natural log F x 100}}{\text{D}}$$

Where,
F = Number of adults emerged
D = Mean developmental period

2.3 Orientation of adults (Free choice test)
Orientation of adults was evaluated by adopting methodology used by Mehta (2018) [6]. Twenty-gram grains of each variety were kept in small boxes which were further placed in circular manner in a large plastic box. One hundred adults of *R. dominica* were released in the centre of the trough and minute holes were made with sharp pin on the box lid. The experiment was replicated three times. The number of adults oriented towards each variety was counted at 24, 48 and 72 hours of initial release.
The data obtained were subjected to statistical analysis in completely randomized design using OPSTAT software. The significance of treatments was evaluated by critical difference (C.D.) at p= 0.05 after subjecting to appropriate transformations.

3. Results
3.1 Developmental period, Adult emergence and Susceptibility index
Data on total developmental period of *R. dominica* have been presented in Table 2. The average number of days taken by the borer to complete its developmental period on different varieties varied significantly from 40.33 to 54.00 days. Maximum developmental period (54.00 days) was observed in HPW-349 which was statistically at par with variety HPW-249 (52.67 days). In comparison to these two varieties, the developmental period of the borer was significantly less on rest of the varieties. Minimum developmental period (40.33 days) was in variety HPW-155, statistically at par with that recorded on variety HPW-236 (43.00). Perusal of data presented in Table 2 also indicates that adult emergence varied significantly from 54.00 to 111.67 among seven wheat varieties. Maximum number of adults emerged from variety HPW-155 which was followed by HPW-236 (96.33) and HS-490 (88.67). Significantly lowest number of adults emerged in case of variety HPW-349. Susceptibility index of different wheat varieties was calculated on the basis of number of adults emerged and total developmental period of the borer. Its value varied from 7.40 to 11.69 among different varieties. The highest value of susceptibility index was computed for HPW-155. This value differed significantly from the susceptibility indices of rest of the varieties. Significantly least value of susceptibility index was calculated in case of HPW-349 which was at par with that of HPW-249 (7.94).

3.2 Orientational studies
A separate experiment was conducted to study orientation of *R. dominica* adults towards different varieties of wheat after 24, 48 and 72 hrs of release (Table 3). Data of the experiment revealed that, after 24 hrs of release, maximum orientation of adults was recorded in variety HPW-155 (24.00) and minimum orientation was recorded towards HPW-349 (7.67) followed by HPW-249 (9.00), while the rest of the varieties had orientation between 10-20.67 adults. After 48 hrs of release, maximum adults were oriented towards HPW-155 (25.00) and minimum towards HPW-349 (8.00) followed by HPW 249 (9.33). After 72 hr of release, minimum number of adults were found on HPW-349 (7.33) followed by HPW-249 (9.00) and maximum adults were found on HPW-155 (24.33). The differences in minimum and maximum number of adults oriented towards different varieties after 24, 48 and 72 hr of release were highly significant. Thus, the mean orientation preference of *R. dominica* was in following decreasing order: HPW-155>HPW-236> HS-490> VL-892>HPW-360>HPW-249>HPW-349.

Table 2: Total developmental period and adult emergence of *Rhyzopertha dominica* in different varieties of wheat

Treatments	Developmental period (Days)	Number of adults Emerged	Susceptibility index
HPW-155	40.33 (6.43)	111.67 (10.61)	11.69
HPW-236	43.00 (6.63)	96.33 (9.86)	10.62
HPW-249	52.67 (7.33)	65.67 (8.16)	7.94
HPW-349	54.00 (7.42)	54.00 (7.42)	7.40
HPW-360	49.00 (7.07)	76.33 (8.79)	8.85
HS-490	43.67 (6.68)	88.67 (9.47)	10.29
VL-892	46.00 (6.86)	81.67 (9.09)	9.57
CD (P=0.05)	(0.23)	(0.55)	0.76

Figures in the parentheses are square root transformed values

4. Discussion

This work cannot be compared with earlier researches as the cultivars used in this investigation have not been tested before, however, there are certain reports of *R. dominica* on other cultivars which supports our study. In an investigation conducted by Deshwal *et al*. (2018) [7], duration required to complete the life cycle of *R. Dominica* (F.). from egg to adult was found to be 57.33, 48.33, 40.33 and 43.00 days at 25±2 ºC, 27±2 ºC, 30±20 and 35±2 ºC and 60±5, 70±5, 75±5 and 80±5% RH respectively.

Table 3: Orientation of *Rhyzopertha dominica* towards different varieties of wheat

S. No.	Varieties	Number of adults oriented after			Mean
		24hr	48hr	72hr	
1.	HPW-155	24.00 (4.89)	25.00 (4.99)	24.33 (4.93)	24.44 (5.04)
2.	HPW-236	20.67(4.55)	18.33 (4.28)	20.00 (4.47)	19.67 (4.55)
3.	HPW-249	9.00(2.99)	9.33 (3.05)	9.00 (2.99)	9.11 (3.18)
4.	HPW-349	7.67(2.77)	8.00 (2.83)	7.33 (2.69)	7.67 (2.94)
5.	HPW-360	10.00 (3.33)	12.00 (3.46)	12.00 (3.46)	11.56 (3.54)
6.	HS-490	15.67 (3.96)	15.00 (3.87)	14.67 (3.94)	15.22 (4.03)
7.	VL-892	12.33 (3.51)	13.33 (3.65)	12.33 (3.51)	12.67 (3.69)
	CD(P=0.05)	(0.25)	(0.21)	(0.33)	

*Figures in parentheses are square root transformed values

Elek (1994) [8] found the total developmental period to be 44 days at 26ºC and 56% RH. Kumawat (2007) [9] studied effect of abiotic actors on biology of *R. dominica* on wheat and reported that the total developmental period of female (from egg to egg) lasted for 35.9- 62.1 days at various temperature and humidity levels. Similarly, another study revealed that total developmental period of female lasted for 35.9-62.1 days at various temperature and humidity levels (Sharma and Bajracharya 2006) [10]. A little contrasting to our results, Thomson (1966) [11] has reported a developmental period of 38 days from egg to adult at 29 ± 0.5 ºC and 75 ± 5% RH and Doug (2009) [12] reported that development from egg to adult requires about 25 days under ideal conditions of 930 F and 12% moisture. This variation may be due to the adaption of the borer to cold temperate conditions in Himachal Pradesh as compared to others, where environmental conditions are moderate. Some researchers have studied the impact of different cultivars on adult emergence; Kakde *et al*. (2014) [13] screened eight wheat varieties by releasing a single pair of *R. dominica* in each treatment and found that F1 adults emerged was in the range of 7.00-26.00 with minimum from variety Raj-3765 (7.00) followed by Raj-1482 (14.00). A similar study was conducted by Abhai *et al*. (1996) [14] who reported variety Raj-911 as least preferred on the basis of adult emergence. As far as susceptibility index is concerned, a similar study was carried out by Bhanderi *et al*. (2015) [15] who screened sorghum genotypes against rice weevil on the basis of susceptibility index. They observed that most susceptible genotype had higher susceptibility index (15.33) and the least susceptible genotype had lowest susceptibility index (3.67).

Orientation studies have not been studied so far in case of *R. dominica* feeding on different cultivars under free choice test, however, orientation of rice weevil towards different varieties of wheat under free choice conditions have been reported earlier (Tiwari, 2016; Mehta, 2018) [16, 6].

Thus, these differences in biological parameters of the borer can be attributed to grain's morphological and more precisely to biochemical factors. Tiwari and Sharma (2002) [17] evaluated sixty wheat genotypes for resistance to two major storage insect pests viz. *S. oryzae* and *R. dominica* using no-choice progeny test and found that susceptibility to *R. dominica* was positively correlated with grain size and negatively correlated with grain hardness and protein content of the grains. Although the varieties used in present investigation were not analysed for their biochemical parameters, but the reasons for differences in their susceptibility/preference to *R. dominica* may be found after studying biochemical parameters of different varieties and working out their relationship with the biological parameters of the borer.

5. Conclusion

On the basis of these results, it can be concluded that none of the variety resisted the borer development. Overall, varieties HPW-349, HPW-249 and to some extent HPW-360 were less preferred by the borer while other four were more preferred with HPW-155 being the most desirable one for development.

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