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Do Cardinal Directions in Different *Acacia* Tree Species Affect Biological Activities of Bruchid Beetle, *Bruchidius buettikeri* Decelle (Bruchidae: Coleoptera), in Riyadh Region, Saudi Arabia

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Abstract: Biological activities of bruchid beetle: *Bruchidius buettikeri* Decelle (Bruchidae: Coleoptera) were studied in four cardinal directions of *Acacia* tree species in Huraimila and Salbouk. In Huraimila, two species of *Acacia*; *A. gerrardii*, subspecies *A. g. negevensis* (Iraqi) and *A. g. nagednsis* (Najdi); and *A. ehrenbergiana* (Salam) were sampled. In Salbouk, *A. tortilis radiana* (Samar) was sampled. No significant differences were observed for entrance and exit holes per pod and beetles emergence until 45 days on four cardinal directions of different *Acacia* tree species, except for entrance holes at Dam and Farm locations on Najdi in Huraimila. However, greater activities were observed in south and east direction in farm locations whereas, in the valley (Abu Gatada, Alyata and Dam locations) more bruchid activities were observed in north and south on Najdi and samar while east and west on Iraqi. Moreover, activities were greater on *Acacia* trees with greater number of seed per pod. Greater bruchid infestation per pod was found on East direction in the farm locations but in the valley locations no distinct trend was observed. Results showed a significant, positive correlation between bruchid activities and temperature but similar strength negative correlation was observed for rest of various abiotic factors. Moreover, a strong positive correlation was recorded between neonate entrance and number of beetle emergence.

Key words: Bruchidae, *Acacia gerrardii negevensis*, *Acacia gerrardii nagednsis*, *Acacia ehrenbergiana*, *Acacia tortilis radiana*, biological activities, cardinal directions

INTRODUCTION

Acacia trees are socio-economically important because they provide high quality animal fodder, firewood, timber, gum and tannins, also they improve soil fertility through nitrogen fixation (Fagg and Stewart, 1994). The genus *Acacia* contains about 600-900 species (Hopper and Maslin, 1978) and 12 species have been reported from Saudi Arabia (Migahid, 1978; Collenette, 1985).

Most of *Acacia* species, including both indehiscent and dehiscent *Acacia*, are attacked by bruchid beetles (Coe and Coe, 1987). Bruchid beetle attack seeds of almost all *Acacia* species (Miller, 1995; Miller and Coe, 1993). Except Antarctica, bruchid species exist in every continent, but the majority of species are inhabitant of tropical regions of Asia, Africa and Central and South America (Southgate, 1979). Fifteen species of Bruchidae have been reported from Saudi Arabia, where six of them, are belonging to the genus *Bruchidius* as *Bruchidius arabicus*, *B. asiricus*, *B. baharicus*, *B. buettikeri*, *B. sahelicus* and *B. saudicus* (Decelle, 1979).

Bruchidius raddianae eggs hatch in five to seven weeks and, except for first instar, develop inside the seed then pupate for three weeks, in late summer, after that adults emerge out by making exit hole in the seed (Derbel *et al*., 2007). *Mimosestes nubigens* and *M. mimosae* developed in 33.6±2.41 days during two fruiting seasons (February and May) of *Acacia farnesiana* and did not differ between the two species, seasons, or among bruchid females (Traveset, 1991). In another study, life cycle of *Bruchidius uberatus* in seeds of *Acacia nilotica* under field and laboratory conditions showed that eggs hatched in 15 to 22 days, larvae developed in 3 to 11 months and minimum life-span of adult beetles varied between 4 to 40 days (Ernst *et al*., 1990). Adults mate immediately after emergence and explore for appropriate pods for oviposition and flowers presence on the host plant inhibits oviposition behavior while it is triggered by pods presence (Yates and Saiz, 1989). Females lay eggs on the remaining pods of the previous season, resulting in a high bruchid population in the following season (Saiz, 1993).

Female beetles oviposit on green pods or seeds and newly hatched larvae bore into seeds and feed on embryos and endosperms (Wilson and Janzen, 1972). Bruchid larvae grow inside seeds (Southgate, 1979) and can consume 9 to 100% of the cotyledons (Ernst, 1992).

Bruchid beetles consumption of endosperms and embryonic portions of *Acacia* seeds result into poor seed germination (Al Jabr, 2008).

Mean number of *Aspidiotus neri* per leaf on *Acacia saligna* (Labill.) collected from four cardinal directions did not show any significant difference in population on the north, south and west side of the tree (Karaca *et al*., 1999). No significant differences were observed between mean number of scales on leaves on the south and west sides of the tree but greatest scale population was always recorded on the west except during winter where leaves on the south had greater scale population (Al-Ahmed and Badawi, 1991).

The aim of the present research was to compare some biological activities of bruchid beetles: *Bruchidius buettikeri* Decelle (Bruchidae: Coleoptera) in four cardinal directions of different *Acacia* tree species in Huraimila city and Salbouk village, Riyadh Region, Saudi Arabia.

MATERIALS AND METHODS

Experiments were carried out during 2001, in Huraimila and Salboukh located in the North of Riyadh region, Saudi Arabia. Samples of *Acacia* pods were collected from three *Acacia* species, *Acacia gerrardii*, with two subspecies *Acacia gerrardii negevensis* (*Acacia* called Iraqi) and *Acacia gerrardii nagednsis* (*Acacia* called Najdi); *Acacia ehrenbergiana* (*Acacia* called Salam); and *Acacia tortilis radiana* (*Acacia* called Samar).

Huraimila was inhabited by two species of *Acacia,* one was *Acacia gerrardii* having two subspecies, Iraqi and Najdi; and the other was Salam. Whereas, Salboukh contained only one *Acacia* species, Samar.

In Huraimila, samples were collected from 4-locations including Alyata, Abu Gutada, Dam (Valley) and farm. Then each location was divided into three sampling units located in the west, center and east.

Similarly in Salboukh, two locations were selected for sampling comprising of farm and valley. Both farm and valley locations were divided into three sampling units located in the west, center and east.

The samples were collected from 12 and 6 sampling units at Huraimila and Salboukh, respectively. From each sampling unit in Huraimila and Salboukh, one *Acacia* tree of each available *Acacia* species/subspecies was randomly selected for pod sampling. In total, 22 *Acacia* trees were selected including 4- Iraqi, 6- Najdi, 6-Salam from Huraimila and 6 Samar from Salboukh. From each *Acacia* tree 4 samples, each containing 4-fullygrown green *Acacia* pods, were collected from all geographical directions (East, West, North and South) i.e., 16 pod/ tree. In Huraimila, flowering of *Acacia gerrardii* started in November and pod formation initiated in beginning of December. Therefore, the first sampling was made on Dec. 15, 2001 and pods were observed for bruchid entrance and exit hole. But pods were devoid of any bruchid entrance and exit holes. Therefore, pod sampling was made on January, 19, 2001. Flowering season of Salam started in late April and fruiting began in early May, 2001. Therefore, first sampling was made on May 24, 2001. In Salboukh, flowering of Samar started in late March and fruiting began in early April. Therefore, the first sampling was made on April 8, 2001. All samples were collected in brown paper bags. Samples were collected fortnightly until pods on the trees were fully matured and dry. Samples were transferred to entomological research laboratory in the Department of Plant Protection at the College of Food and Agriculture Sciences, King Saud University, for processing. In the laboratory, each pod was observed for number of Bruchid beetles, namely *Bruchidius buettikeri* Decelle (Bruchidae: Coleoptera), entrance and exit holes. Entrance and exit hole were distinguished base on presence of small black puncture hole for egg laying as entrance while exit holes were recognized as big round open holes in the pod. Pod length (cm) and number of seeds per pod were also recorded. For least interruption to the developing bruchid beetles inside, seeds were counted without opening the pod. The pods were stored and number of beetles emerged were recorded until 45-days after sampling. After 45-days, pods were opened and the total and number of seeds infested by bruchid beetle were counted to calculate the infestation percentage:

$$\text{Infestation percentage per pod} = \frac{\text{No. of infested pod}}{\text{Total No. of pods}} \times 100$$

$$\text{Infestation percentage per seed} = \frac{\text{Number of infested seeds}}{\text{Total No. of seeds}} \times 100$$

Ecological data including average temperature, average relative humidity, average wind speed and average rainfall, average atmospheric pressure local and average atmospheric pressure sea level were obtained from Meteorological Department, King Khalid Airport, Riyadh, Saudi Arabia. Ecological data was correlated with average number of entrance, exit hole, Pod length and number of seeds per pod to calculate Pearson correlation coefficient (r) using SAS (2002).

The experiments were laid out in Randomized Complete Block Design (RCBD), where the locations were taken as blocks and *Acacia* species/subspecies as treatments with 16-replication each replication containing one *Acacia* pod. Data was analyzed using the Analysis of Variance (ANOVA) PROC GLM procedure of SAS (2002) and means were separated using the Duncan's Multiple Range Test (p = 0.05).

RESULTS AND DISCUSSION

Location wise comparison of bruchid activities such as entrance, exit and total exit (sum of exit holes observed at the time of pod collection and number of beetle emerged until 45 days) on different *Acacia* species for different cardinal directions revealed no significant differences except for entrance holes at Dam and Farm locations on Najdi. On Dam location significantly greater number of entrance holes (F = 4.83; df = 3; p = 0.004) were observed on pods collected from north direction followed by south, west and east. On Farm location, significantly greater number of entrance holes (F = 3.31; df = 3; p = 0.02) were observed on pods collected from east direction followed by South, North and West ones. Results indicated no significant differences for number of seeds per pod between North, South, East and West sides of *Acacia* trees.

Similarly, no significant differences were recorded for pod lengths in various directions except for Iraqi in Abu Gatada location where significantly greater pod length (F = 4.19; df = 3; p = 0.009) was recorded in north followed by east, south and west directions. Generally, more bruchid activities were found on south and east directions in the farm location. But in valley (Abu Gatada, Alyata and Dam locations) more bruchid activities were seen in north and south on Najdi and Samar and east, west on Iraqi, respectively (Table 1).

Table 1: *Acacia* species/Location wise comparison of bruchid infestation in Huraimila and Salbouk

Areas	Locations	*Acacia* species	Direction	Entrance hole	Exit hole	Total exit	Seeds/Pod	Pod length
Huraimila	Abu Gatada	Najdi	South	1.19±0.25a	0.25±0.11a	0.69±0.21a	8.19±0.51a	7.53±0.37a
			East	0.56±0.19a	0.13±0.09a	0.31±0.12a	6.50±0.77a	7.47±0.35a
			West	0.75±0.19a	0.13±0.09a	0.69±0.34a	6.13±0.82a	6.84±0.34a
			North	0.81±0.21a	0.31±0.18a	1.00±0.48a	8.00±0.78a	7.66±0.40a
Huraimila	Abu Gatada	Iraqi	South	0.50±0.18a	0.06±0.06a	0.19±0.12a	8.13±0.39a	9.56±0.29bc
			East	0.63±0.18a	0.06±0.06a	0.13±0.07a	8.56±0.34a	10.19±0.31ab
			West	0.56±0.20a	0.06±0.06a	0.06±0.06a	6.56±0.62a	9.06±0.44c
			North	0.19±0.10a	0.00±0.00a	0.00±0.00a	7.63±0.69a	10.84±0.44a
Huraimila	Alyata	Najdi	South	1.31±0.24a	0.19±0.14a	0.38±0.13a	5.88±0.51a	6.94±0.45a
			East	1.25±0.19a	0.44±0.16a	0.56±0.06a	6.50±0.67a	7.69±0.48a
			West	1.25±0.27a	0.38±0.15a	0.56±0.24a	6.38±0.80a	7.25±0.34a
			North	1.38±0.26a	0.31±0.12a	0.38±0.13a	7.19±0.72a	7.59±0.40a
Huraimila	Alyata	Iraqi	South	0.31±0.15a	0.00±0.00a	0.00±0.00a	8.31±0.79a	12.13±0.77a
			East	0.06±0.06a	0.00±0.00a	0.00±0.00a	7.50±1.06a	14.69±1.09a
			West	0.38±0.15a	0.13±0.09a	0.50±0.34a	9.19±0.91a	13.56±0.85a
			North	0.38±0.13a	0.19±0.10a	0.19±0.19a	7.44±0.70a	13.00±0.94a
Huraimila	Dam	Najdi	South	0.31±0.12b	0.00±0.00a	0.13±0.07a	4.81±0.68a	9.06±0.60a
			East	0.13±0.09b	0.00±0.00a	0.13±0.07a	4.00±0.58a	8.63±0.68a
			West	0.19±0.10b	0.00±0.00a	0.13±0.07a	3.69±0.57a	8.81±0.67a
			North	0.87±0.26a	0.07±0.07a	0.06±0.06a	4.40±0.67a	10.00±0.59a
Huraimila	Dam	Iraqi	South	0.06±0.06a	0.00±0.00a	0.00±0.00a	5.44±0.86a	9.97±0.44a
			East	0.31±0.15a	0.06±0.06a	0.19±0.06a	6.19±0.68a	11.13±0.51a
			West	0.50±0.12a	0.00±0.00a	0.19±0.19a	6.25±0.64a	10.81±0.33a
			North	0.38±0.15a	0.00±0.00a	0.06±0.06a	5.75±0.58a	10.75±0.50a
Huraimila	Farm	Najdi	South	0.77±0.12ab	0.17±0.07a	0.50±0.15a	6.08±0.39a	10.44±0.35a
			East	0.98±0.12a	0.04±0.03a	0.30±0.11a	6.46±0.41a	11.23±0.38a
			West	0.46±0.11b	0.06±0.05a	0.25±0.09a	5.95±0.33a	10.30±0.34a
			North	0.65±0.13ab	0.02±0.02a	0.21±0.07a	5.73±0.34a	10.14±0.31a
Huraimila	Farm	Iraqi	South	0.08±0.08a	0.00±0.00a	0.00±0.00a	5.67±1.00a	10.08±0.70a
			East	0.08±0.08a	0.08±0.08a	0.08±0.08a	8.75±0.57a	11.67±0.70a
			West	0.08±0.08a	0.00±0.00a	0.00±0.00a	7.08±0.62a	10.79±0.63a
			North	0.00±0.00a	0.00±0.00a	0.08±0.08a	6.83±0.81a	10.41±0.77a
Huraimila	Farm	Salam	South	0.00±0.00a	0.00±0.00a	0.00±0.00a	6.04±0.43a	8.08±0.44a
			East	0.00±0.00a	0.00±0.00a	0.00±0.00a	5.38±0.68a	7.71±0.51a
			West	0.00±0.00a	0.00±0.00a	0.00±0.00a	5.20±0.39a	6.95±0.41a
			North	0.00±0.00a	0.00±0.00a	0.00±0.00a	5.42±0.60a	7.50±0.66a
Salbouk	Valley	Samar	South	0.28±0.08a	0.23±0.08a	0.30±0.12a	5.48±0.41a	10.59±0.38a
			East	0.20±0.07a	0.13±0.06a	0.17±0.12a	5.75±0.48a	11.09±0.42a
			West	0.28±0.10a	0.23±0.09a	0.43±0.16a	5.83±0.49a	11.19±0.53a
			North	0.28±0.10a	0.25±0.10a	0.40±0.19a	5.60±0.44a	11.33±0.52a
Salbouk	Farm	Samar	South	0.44±0.12a	0.38±0.12a	0.77±0.25a	6.33±0.43a	12.20±0.48a
			East	0.58±0.16a	0.41±0.14a	0.73±0.20a	6.08±0.41a	11.90±0.49a
			West	0.42±0.11a	0.25±0.09a	0.58±0.29a	5.81±0.46a	12.49±0.49a
			North	0.35±0.11a	0.26±0.09a	0.40±0.16a	6.46±0.42a	12.74±0.52a

Means in column within each location followed by the same letter are not significantly different $\alpha = 0.05$. *Acacia gerrardii negevensis* (Iraqi), *Acacia gerrardii nagednsis* (Najdi), *Acacia ehrenbergiana* (Salam), *Acacia tortilis radiana* (Samar)

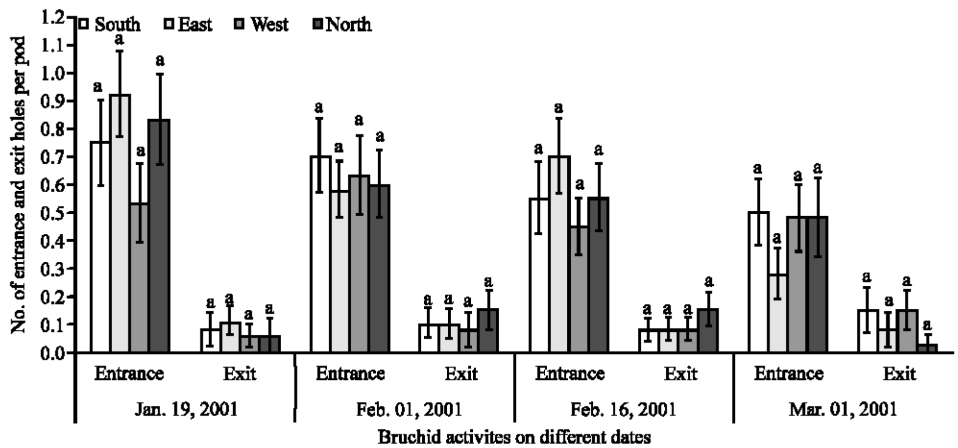

Fig. 1: Directional wise comparison of average bruchid activities on *Acacia gerrardii* var. *negevensis* (Iraqi) and *Acacia gerrardii* var. *nagednsis* (Najdi) during different dates in Huraimila Area

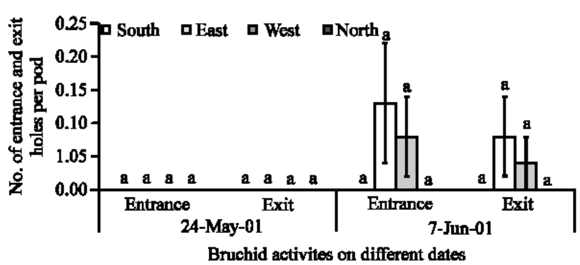

Fig. 2: Directional wise comparison of average bruchid activities on *Acacia ehrenbergiana* (Salam) during different dates in Huraimila Area

Date wise comparison of bruchid activities on Huraimila on Iraqi and Najdi revealed no significant differences (F = 1.29; df = 3; p = 0.28), (F = 0.24; df = 3; p = 0.87); (F = 0.19; df = 3; p = 0.90), (F = 0.32; df = 3; p = 0.81); (F = 0.70; df = 3; p = 0.55), (F = 0.65; df = 3; p = 0.58); (F = 0.78; df = 3; p = 0.51), (F = 1.07; df = 3; p = 0.37) for entrance and exit holes on dates of observations, respectively, on four cardinal directions (Fig. 1). Salam, an *Acacia* species in Huraimila with very short flowering and fruiting season, also indicated no significant differences (F = 0.00; df = 0; p = 0.00), (F = 0.00; df = 0; p = 0.00); (F = 1.31; df = 3; p = 0.27), (F = 1.23; df = 3; p = 0.30) for entrance and exit holes on dates of observations, respectively, on four cardinal directions (Fig. 2). However, More bruchid activities were observed in the beginning of the season which gradually decreased during successive dates. Similarly, in Salbouk, no significant differences were observed in bruchid biological activities (F = 0.00; df = 0; p = 0.00), (F = 0.00; df = 0; p = 0.00); (F = 0.61; df = 3; p = 0.61), (F = 0.00; df = 3; p = 0.00); (F = 0.70; df = 3; p = 0.56), (F = 0.00; df = 3; p = 0.00); (F = 0.14 df = 3; p = 0.93), (F = 0.21; df = 3; p = 0.89); (F = 0.02; df = 3; p = 0.99) for entrance and exit holes on dates of observations, respectively, on four cardinal directions (Fig. 3). Contrary to Huraimila, in Salbouk low bruchid activities were observed in the beginning of the season with a gradually progress leading to greatest activities by the end of the seasons.

Bruchid infestation percentages per pod and seed were also calculated for four cardinal directions which showed no significant differences except for Najdi (F = 2.80; df = 3; p = 0.050) at farm location in Huraimila, where greater bruchid infestation per pod was observed on east direction. Generally, greater bruchid infestation per pod was found on East direction in the farm locations but in the valley locations no distinct trend was observed (Table 2). Infestation of bruchid beetles highly varied between years (Ernst *et al*., 1989). Bruchid infestations rate are also influenced by time of year, where infestation rate remain lower in the beginning of the season. Moreover, varying life histories of bruchid species also affect the rate of infestation. Range of infestations have been reported in the literature: 47-52%, 71-90% (Ernst *et al*., 1990) and 54-96% of seeds (Barnes, 2001). Bruchid population densities on *Acacia* are more restricted by natural enemies and severe weather conditions as compared to intra- or inter-specific competition (Traveset, 1991).

In general, average number of Bruchid entrance (F = 0.31; df = 3; p = 0.82), exit hole (F = 0.12; df = 3; p = 0.95) and total beetle (F = 0.32; df = 3; p = 0.81) emerged per pod until 45 days later in the storage did not show any significant differences between North, South, East and West sides of *Acacia* tree. Though results revealed no significant differences for bruchid activities

Table 2: *Acacia* species per location directional wise comparison of bruchid infestation in Huraimila and Salbouk

Area	Location	*Acacia* species	Direction	Infestation /Pod	Infestation /Seed
Huraimila	Abu Gatada	Najdi	South	68.75±15.73a	8.49±2.55a
			East	47.92±8.59a	5.32±1.79a
			West	62.50±12.50a	9.42±4.39a
			North	56.25±21.35a	11.73±4.88a
Huraimila	Abu Gatada	Iraqi	South	37.50±21.65a	2.15±1.40a
			East	50.00±17.68a	1.41±0.81a
			West	37.50±16.14a	0.81±0.81a
			North	25.00±14.43a	0.00±0.00a
Huraimila	Alyata	Najdi	South	75.00±10.20a	7.13±2.44a
			East	81.25±11.97a	9.87±2.99a
			West	68.75±11.97a	12.99±8.52a
			North	75.00±10.21a	5.86±2.60a
Huraimila	Alyata	Iraqi	South	25.00±10.21a	0.00±0.00a
			East	6.25±6.25a	0.00±0.00a
			West	31.25±6.25a	5.68±4.04a
			North	37.50±21.65a	1.92±1.92a
Huraimila	Dam	Najdi	South	35.42±20.51a	4.45±2.72a
			East	12.50±12.50a	2.88±1.67a
			West	18.75±11.97a	4.44±2.96a
			North	56.25±15.73a	1.14±1.14a
Huraimila	Dam	Iraqi	South	6.25±6.25a	0.00±0.00a
			East	25.00±10.20a	3.03±1.03a
			West	50.00±10.20a	5.00±5.00a
			North	31.25±11.97a	1.04±1.04a
Huraimila	Valley	Salam	South	0.00±0.00a	1.39±0.89a
			East	8.33±5.27a	0.00±0.00a
			West	8.33±5.27a	0.00±0.00a
			North	0.00±0.00a	0.93±0.93a
Huraimila	Farm	Salam	South	0.00±0.00a	0.00±0.00a
			East	0.00±0.00a	0.00±0.00a
			West	0.00±0.00a	0.00±0.00a
			North	0.00±0.00a	0.00±0.00a
Huraimila	Farm	Najdi	South	56.25±8.77ab	8.63±2.91a
			East	68.75±10.72a	5.07±2.12a
			West	31.25±8.21b	4.89±1.64a
			North	47.22±9.80ab	3.82±1.20a
Huraimila	Farm	Iraqi	South	8.33±8.33a	0.00±0.00a
			East	8.33±8.33a	0.88±0.88a
			West	8.33±8.33a	0.00±0.00a
			North	0.00±0.00a	1.28±1.28a
Huraimila	Farm	Salam	South	0.00±0.00a	0.00±0.00a
			East	0.00±0.00a	0.00±0.00a
			West	0.00±0.00a	0.00±0.00a
			North	0.00±0.00a	0.00±0.00a
Salbouk	Valley	Samar	South	18.33±5.70a	4.52±1.91a
			East	16.67±6.30a	2.26±1.57a
			West	21.67±6.39a	6.25±2.37a
			North	16.67±5.27a	5.66±2.54a
Salbouk	Farm	Samar	South	25.00±9.80a	9.16±2.91a
			East	58.93±23.67a	9.55±2.79a
			West	26.92±7.20a	7.33±3.81a
			North	23.08±8.71a	4.62±1.96a

Means in column within each location followed by the same letter are not significantly different $\alpha = 0.05$. *Acacia gerrardii negevensis* (Iraqi), *Acacia gerrardii nagednsis* (Najdi), *Acacia ehrenbergiana* (Salam), *Acacia tortilis radiana* (Samar)

Table 3: Direction wise comparison of Bruchid beetles infestation on *Acacia* species

Directions	Ave. No. of entrance holes	Ave. No. of exit holes	Total exit until 45 days	Ave. No. of seed per pod	Ave. pod length (cm)
South	0.43±0.04a	0.16±0.03a	0.33±0.06a	6.24±0.16a	10.00±0.17a
East	0.44±0.04a	0.15±0.03a	0.28±0.05a	6.24±0.18a	10.39±0.19a
West	0.39±0.04a	0.13±0.03a	0.33±0.07a	5.98±0.17a	10.15±0.20a
North	0.41±0.04a	0.14±0.03a	0.26±0.06a	6.09±0.17a	10.34±0.20a

Means within a column followed by the same letter are not significantly different $\alpha = 0.05$

in four cardinal directions, a trend for bruchid activities was there. More bruchid neonate entrance holes and beetle emergence holes at the time of pod sampling and total number of beetle emerged until 45 days later in the storage were recorded on south and east directions (Table 3). Mean number of *Aspidiotus neri* on *Acacia*

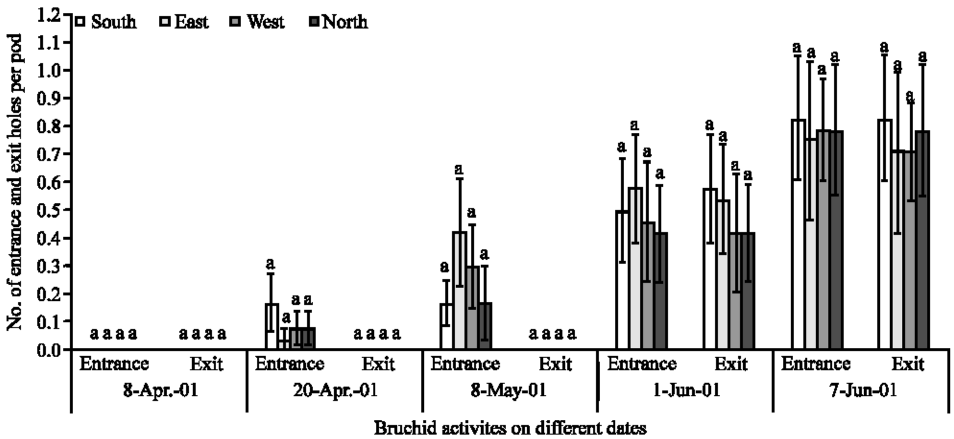

Fig. 3: Directional wise comparison of average bruchid activities on *Acacia tortilis* var. *tortilis* (Samar) during different dates in Salbouk Area

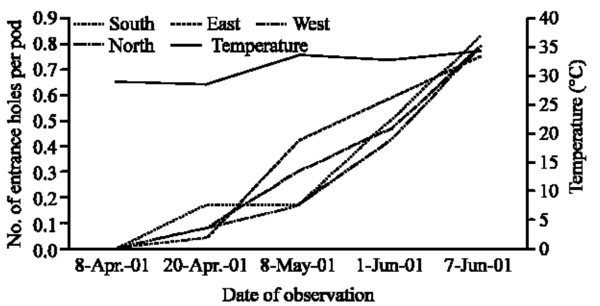

Fig. 4: Relationship between temperature and number of bruchid entrance holes per pod in four cardinal directions

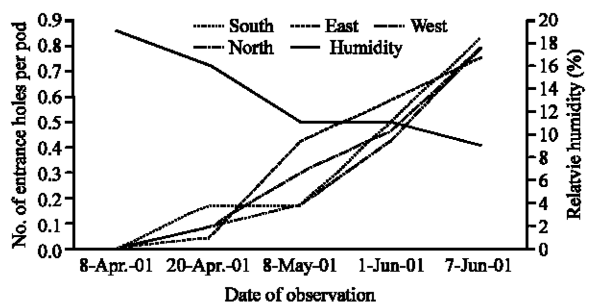

Fig. 6: Relationship between relative humidity (%) and number of bruchid entrance holes per pod in four cardinal directions

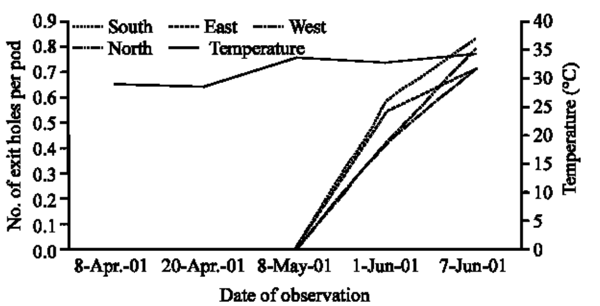

Fig. 5: Relationship between temperature and number of bruchid exit holes per pod in four cardinal directions

saligna (Labill.) collected from four cardinal directions did not show any significant difference in population on north, south and west side of the tree (Karaca *et al*., 1999). More biological activities of bruchid beetles on south might be due to longer exposure of south side of trees to sun rays in winter season (Al-Ahmed and Badawi, 1991).

Though there was no significant differences for mean number of seeds per pod ($F = 0.56$; df = 3; $p = 0.64$) and pod length ($F = 0.86$; df = 3; $p = 0.46$) collected from North, South, East and West directions, more number of seeds were recorded on south and east directions which could be another reason for the greater biological activities on South direction because of the fact that mother beetles had plentiful availability of food resources for the development of their neonates.

Relationship between bruchid activities and various abiotic factors for four cardinal directions was presented in Fig. 4-13. Results showed a significant, positive correlation between entrance and exit holes and average temperature but negative correlation was recorded in rest of the abiotic factors. A strong significant positive correlation was observed between neonate entrance and beetle emergence holes indicating host suitability for bruchid beetles development. There was also a significant, positive correlation between bruchid activities and no. of seeds per pod and pod length, indicating maternal care for selection of the host (Table 4). The result

Table 4: Correlation between bruchid activities and various abiotic factors in four cardinal directions

Cardinal directions	Study parameters	Correlation coefficient (R^2) Seeds per pod	Pod length (cm)	No. of exit holes	Ave. temp. (°C)	Ave. R.H (%)	Ave. wind speed (m sec^{-1})	Ave. atm. pressure (kpa)	Ave. vapour pressure (atm.)
North	Entrance hole	0.12	0.13	0.90**	0.29*	-0.31*	-0.36*	-0.28*	-0.35*
	Exit hole	0.13	0.19*		0.31*	-0.33*	-0.42**	-0.31*	-0.40**
South	Entrance hole	0.33*	0.41**	0.89**	0.28*	-0.31*	-0.36*	-0.26*	-0.37**
	Exit hole	0.30*	0.44**		0.32*	-0.35*	-0.41	-0.28*	-0.43**
East	Entrance hole	0.29*	0.31*	0.85**	0.31*	-0.31*	-0.27*	-0.24*	-0.31*
	Exit hole	0.22*	0.31*		0.26*	-0.28*	-0.32*	-0.21*	-0.34*
West	Entrance hole	0.27*	0.22*	0.83**	0.31*	0.33*	-0.35*	-0.29*	-0.35*
	Exit hole	0.24*	0.25*		0.29*	-0.31*	-0.39**	-0.28*	-0.39**

*Indicating significance at $p<0.05$; **Indicating significance at $p<0.001$

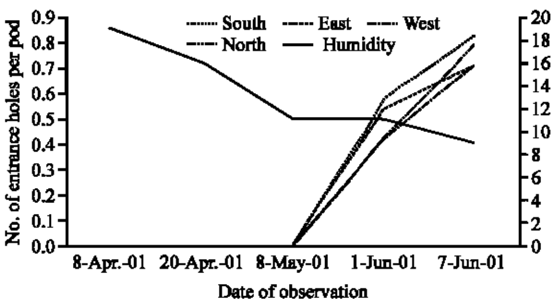

Fig. 7: Relationship between relative humidity (%) and number of bruchid exit holes per pod in four cardinal directions

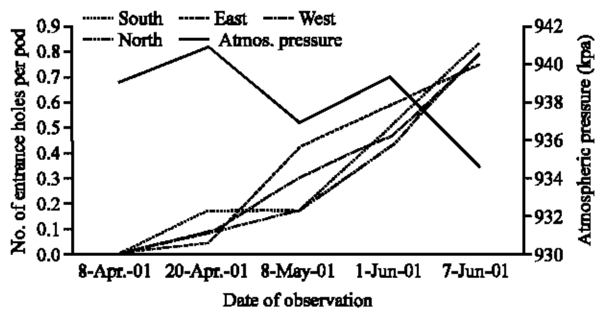

Fig. 10: Relationship between atmospheric pressure and number of bruchid entrance holes per pod in four cardinal directions

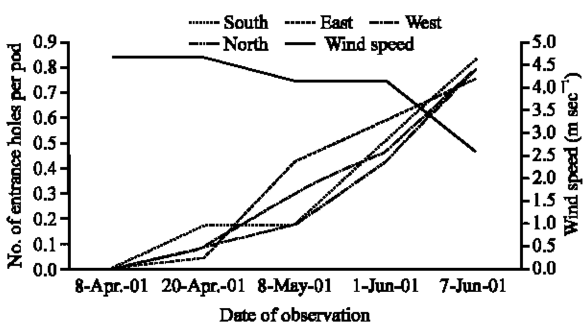

Fig. 8: Relationship between wind speed and number of bruchid entrance holes per pod in four cardinal directions

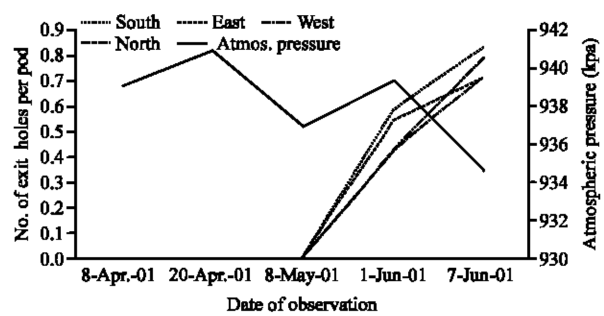

Fig. 11: Relationship between atmospheric pressure and number of bruchid exit holes per pod in four cardinal directions

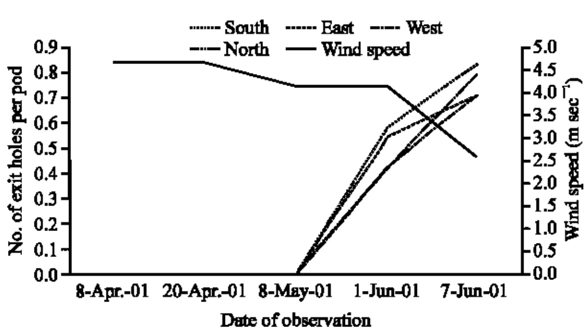

Fig. 9: Relationship between wind speed and number of bruchid exit holes per pod in four cardinal directions

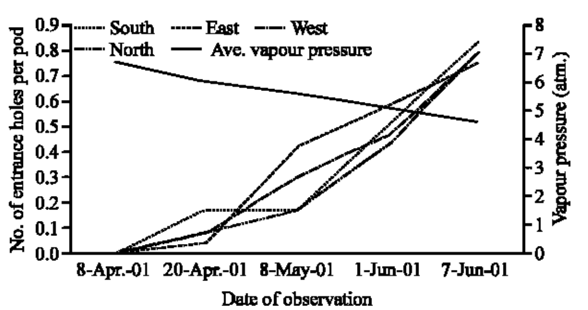

Fig. 12: Relationship between vapour pressure and number of bruchid entrance holes per pod in four cardinal directions

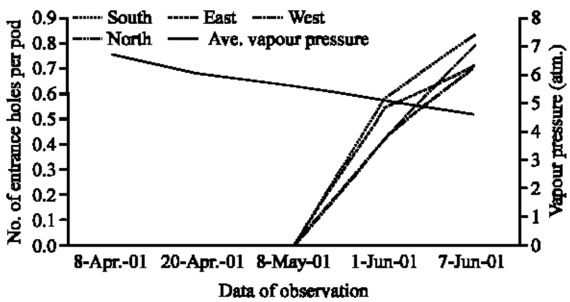

Fig. 13: Relationship between vapour pressure and number of bruchid exit holes per pod in four cardinal directions

presented more or less similar trend for correlation between bruchid activities and abiotic factors recorded for four cardinal directions.

CONCLUSIONS

There were no significant differences for entrance, exit holes per pod and beetles emergence until 45 days on four cardinal directions of different *Acacia* tree species. However, greater activities were observed in south and east direction in farm locations whereas, in the valley (Abu Gatada, Alyata and Dam locations) more bruchid activities were observed in north and south on Najdi and samar while east and west on Iraqi. Moreover, activities were greater on *Acacia* trees with greater number of seed per pod. Generally, greater bruchid infestation per pod was found on east direction in the farm locations, but in the valley locations no distinct trend was observed. There was a significant, positive correlation between bruchid activities and temperature but similar strength negative correlation was observed for rest of various abiotic factors. Moreover, a strong positive correlation was recorded between neonate entrance and number of beetle emergence.

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