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Survival and Body Weight Loss of Starved Adults of Lesser Grain Borer, *Rhyzopertha dominica* (Coleoptera: Bostrichidae) at Different Relative Humidities

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Abstract.- Survival and body weight loss of two populations Chichawatni (C), the most resistant, and Multan (M), the most sensitive, strains of *Rhyzopertha dominica* were evaluated in adult beetles at various relative humidities (r.h.) (8%, 38%, 51%, 75% and 97%), in isolated (single) beetle and in groups of 10 and 20 under starvation conditions. The maximum weight loss was 44% in C population in group of 10, and 51% in M population in group of 20 at 38% r.h. The insects of both C and M strains lost maximum body weight at 38% r.h. when in groups of 10 and 20. The single beetle showed maximum weight loss at 38% r.h. in M population and at 75% r.h. in C population. The highest weight loss was observed in beetles in groups (16%-35% in C and 15%-51% in M populations) as compared to single beetles, at various r.h.

Key words: Humidity, moisture, survival, body weight loss, stored grain pest, *Rhyzopertha dominica*, environmental factors, beetes, insect.

INTRODUCTION

Stored product losses resulting from insects have been controlled through the use of pesticides. The development of resistance to widely used insecticides (Haliscak and Beeman, 1983; Horton, 1984) and considerations over chemical residue in foods dictate that alternative control measures be investigated. Aeration, used to modify grain temperature and moisture content combined with biological control are effective management tactics for controlling many stored grain insect pests (Flinn, 1998). Then control of lesser grain borer, rice weevil and red flour beetle with chlorpyrifos-methyl and subsequent aeration is also achieved (Arthur, 1995). The infestation of *Rhyzopertha dominica* to storage grain facility can be controlled by altering environmental conditions *e.g.*, temperature, humidity and light (Dowdy, 1994). Furthermore, stress of this type has been exploited in *Sitophilus zeamais* (Sedlacek *et al*., 1991). Likewise, effectiveness of environmental factors such as relative humidity on larvae and adults of *Tribolium castaneum* has also been reported by Saleem and Shakoori (1984, 1986) and on termites by Ahmad *et al*., 1982).

The objective of the present report was to determine the effect of five different relative humidities on *R. dominica* under starvation conditions. This paper therefore, reports the effect of these humidities on survival and body weight loss of two strains of adult *R. dominica* (the most sensitive and the most resistant), when kept isolated or in groups of 10 and 20.

MATERIALS AND METHODS

The most resistant and susceptible population of *R. dominica* previously obtained from godowns of Chichawatni and Multan (Pakistan), was maintained in a small culture room at 32±°C, where relative humidity was adjusted at 65±5%. The food medium was phosphine treated whole berry wheat.

Different relative humidities were prepared by making saturated solutions in distilled water of K_2SO_4 (97% r.h.), NaCl (75% r.h.), Ca $(NO_3)_2.4H_2O$ (51% r.h.), $CaCl_2.6H_2O$ (38% r.h.) and $ZnCl_2$ (8% r.h.) (O'Brien, 1948; Ernst, 1957; Minnick *et al*., 1973). A period of 48 hours was allowed to establish different relative humidities in the desiccators before putting the beetles in them. Single individuals and beetles in groups of 10 and

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20 were weighed and immediately transferred to the glass vials (diameter, 2 cm; height, 4 cm) which were then placed in desiccators maintaining different relative humidities at a temperature of 32±2°C, according to the method described by Ahmad *et al.* (1982). Each test was performed in triplicate. During the experiment no food was supplied to the beetles. Individuals were weighed for the percent weight loss every 24 hours. The living individuals were selected for this observation, while the dead ones were discarded.

RESULTS AND DISCUSSION

Body weight loss

Isolated single beetles

The body weight loss by single beetle of both C (insecticide resistant) and M (insecticide sensitive) strains is approximately less at all relative humidities over the entire period they survived as compared with those kept in groups of 10 and 20 (Table I). The maximum loss of body weight (27%) was seen in C strain adults at 75% relative humidity, which gradually decreased with the decrease in relative humidity, whereas the loss was minimum (2%) at 8% relative humidity. The adults of M strain lost maximum body weight (23%) at 38% relative humidity, which almost decreased with increasing relative humidity (15% and 75% r.h.) but it increased to 20% at 97% relative humidity which may due to cuticular absorption of water from the surrounding wet environment. The minimum weight loss (12%) of the adults of M strain was at 8% relative humidity.

A group of 10 beetles

The maximum loss of body weight was observed in adults of C (44%) and M (29%) strains when kept in group of 10 at 38% relative humidity. This weight loss gradually decreased with increasing relative humidity. It is 40%, 19% and 14% in C strain and 26%, 18% and 16% in M strain at 51%, 75% and 97% relative humidity, respectively. At 8% relative humidity, C strain showed 37 losses whereas M strain showed 15% loss (Table I).

A group of 20 beetles

The trend in body weight loss in beetles kept in group of 20 was the same as in group of 10. The maximum weight loss was 35% in C and 51% in M strain at 38% r.h. This weight loss decreased with the increasing relative humidities in C strain (Table I). The body weight loss in C population was 25% at 8% r.h. and 16% at 97% r.h. In M strain it was 15% and 16%, respectively, at 8% and 16% r.h.

The loss of body weight in adult *R. dominica* showed the similar trend in every group of each relative humidity *i.e.* minimum at 8% r.h. and maximum at 38% r.h. in both strains with few exceptions *e.g.* group of single in C strain showed maximum loss at 75% r.h. Perhaps it may be due to the longest starvation of insects at this relative humidity. The most dreadful r.h. was found to be 38% at which all groups of insects of both strains lost maximum body weight *i.e.* 23%, 29% and 51% in M strain and 14%, 44% and 35% in C strain. The moisture loss was found to be inversely proportional to increasing number of beetles in both strains. It might be suggested that in the presence of big populations, due to availability of less surface area per beetle, low evaporation rate reduced the possibility of more body weight loss in the grouped beetles. This phenomenon can be referred to as "group tolerance". Body weight also decreased gradually on either extremes and maximum loss was at 38% and minimum loss was at 97% r.h. in C strain and at 38% r.h. in M strain indicating the extent of tolerance of insects do desiccation at different relative humidities.

Survival of beetles

Isolated beetles

Adult beetles of both C and M strain survived longer (7.00 and 9.25 days, respectively) when kept isolated at 75% relative humidity. The average survival decreased gradually on either side. At relative humidity of 8%, the beetles of C strain survived for 2.75 days, whereas they survived for 6.5 days at 97% r.h. In M strain adults, the beetles survived for 6.25 days at 8% r.h. and 7.5 days at 97% r.rh. (Table II). The lowest survival of the solitary beetles may perhaps be due to the more exposure of their body surfaces to the environment of the desiccators.

Table I.- Loss of body weight (in percentage) of *R. dominica* adults at different relative humidities under starvation conditions in C and M population.

Type of group	8% $ZnCl_2$	38% $CaCl_2$	51% $Ca(NO_3)_2$	75% NaCl	97% K_2SO_4
C strain					
1	2	14	18	27	23
10	37	44	40	19	14
20	25	35	30	16	16
M strain					
1	12	23	18	15	20
10	15	29	26	18	16
20	15	51	25	33	16

Table II.- Survival duration (in days) of adults of *R. dominica* in various groups at various relative humidities in C and M strains.

Type of group	8% $ZnCl_2$	38% $CaCl_2$	51% $Ca(NO_3)_2$	75% NaCl	97% K_2SO_4
C strain					
1	2.75±0.75	4.75±0.48	5.50±0.50	7.0±0.577	6.50±0.50
10	6.75±0.85	7.83±1.17	7.00±0.82	8.00±0.57	7.33±0.88
20	6.00±0.70	9.00±1.18	9.11±1.15	8.55±1.24	7.33±0.88
M strain					
1	6.25±1.25	8.25±2.28	9.75±1.34	9.25±2.98	7.50±0.65
10	5.00±0.58	10.00±1.35	8.00±1.39	11.30±1.63	6.00±0.71
20	6.00±0.71	8.13±1.30	9.79±2.62	10.00±1.43	7.00±0.82

A group of 10 beetles

Beetles kept in group of 10 showed maximum survival at 75% relative humidity in both C and M strains (8.00 days and 11.3 days, respectively). This survival almost decreased gradually on either side of relative humidities with minimum of 6.75 days and 7.3 days in C strain and 5.00 days and 6.00 days in case of M strain, respectively, at 8% and 97% r.h. (Table II).

A group of 20 beetles

When kept in group of 20, the longest survival in C beetles was observed at 51% r.h. (9.11 days) and at 75% r.h. in M strain (10 days). The shortest survival (6.00 days) is shown by both strains at 8% relative humidity (Table II).

The survival of grouped individuals in M strain was not significantly different from the isolated ones. Therefore, the phenomenon of group effect introduced by Grasse and Chauvin (1944) did not hold true in this case. In the case of C strain, only group of 20 proved to be the most successful with maximum survival of almost 9 days at 38%, 51% and 75% r.h. although it is not significantly different from the group of 10 with 8 days at 75% r.h. showing low tolerance for extremely dry conditions. The significant survival of both groups of 10 and 20 is perhaps due to their being in a group.

Mbata and Osuji (1983) observed that relative humidities of 70% and 80% were best for Indian meal moth, *Plodia interpunctella* (Hubner). According to Akhtar and Ali (1979) *Coptotermes heimi* survived better under 75% and 85% relative humidities. Similar effects of moisture content on *R. dominica* were also reported by Flinn (1998). Conclusion of the same type was also made on rice weevil by Evans (1982) and on termites by Ahmad *et al*. (1982).

The comparison of isolated and grouped beetles disclosed that beetles in population are capable of longer survival as compared to isolated

ones. This indicates that adult beetles of *R. dominica* can withstand unfavourable conditions (the dryness) when they are living together than singly. Likewise, larger populations could withstand better extreme dry or humid conditions. This study also revealed greatest susceptibility of both strains towards extreme desiccation (8% r.h.) at which they survived least both singly and in groups.

Similar effects at various relative humidities were also reported on different species of termites (Abushma, 1974; Akhtar and Ali, 1979; Ahmad *et al*., 1982). From these observations it could be concluded that the desiccation conditions are beneficial to eradicate the insects and phenomenon of group effect also holds true to some extent in *R. dominica*.

Sadlacek *et al*. (1991) reported that relatively small differences in moisture content can have a dramatic effect on the population dynamics of the maize weevil which do not reproduce at low or high moisture content.

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