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Population Fluctuation of Red Flour Beetle, *Tribolium castaneum* (Herbst.) (Coleoptera: Tenebrionidae) on Different Cereal Foods in Laboratory

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Abstract.- Present study was conducted on the abiotic factors and their influence on population of red flour beetle in various cereal foods. Findings of the study would be helpful in management of the pest in different food materials. To explore the food preferences of the red flour beetle, flour cereal foods, namely corn flake, white flour, semolina and biscuit were used for present study. The results revealed that white flour was most preferred food to *Tribolium castaneum* with the highest mean population (272.25 beetles) and followed by semolina (65.88 beetles), corn flakes (8.5 beetles) and biscuits (6.16 beetles), respectively during period under study. Relatively higher correlation between population of the pest in white flour and temperature was recorded to be 0.596 ($p<0.05$). Using various linear and non-linear regression models, vapor pressure model was proposed for beetle population and number of weeks of observations. Geometric curve was proposed to define the relationship between insect population and temperatures during the study period.

Key words: Red flour beetle, population, cereal foods.

INTRODUCTION

The red flour beetle, *Tribolium castaneum* (Herbst) has had a long association with human stored food. It attacks stored grain products such as flour, cereals, meals, crackers, beans, spices, pasta, cake mix, dried pet food, dried flowers, nuts, seeds and even dried museum specimens (Via, 1999; Weston and Gourd, 2000; Shafique *et al.*, 2006). These beetles have chewing mouthparts, but do not bite or sting. The flour beetle may elicit an allergic response (Alanko *et al.*, 2000), but is not known to spread disease and does not feed on or damage the structure of a home or furniture. This beetle is one of the most important pests of stored products in the home and grocery stores. This grain pest is found in temperature areas and also survives the winter in protected places, especially where there is central heat (Tripathi *et al.*, 2001). The red flour beetle may be present in large numbers in infested grain. The adults are attracted to light, but go towards cover when disturbed. Typically, these beetles can be found not only inside infested grain products, but in cracks and crevices where grain may have spilled. They are attracted to grain with high moisture content and can cause a grey tint to the grain they are infesting (Ahmed and Ahmed, 2002). The beetles give off a displeasing odor, and their presence encourages mold growth in grain. The present study on the abiotic factors and their influence on population of red flour beetle in different cereal foods would be helpful in management of the pest in different stored food materials.

MATERIALS AND METHODS

Four cereal foods *viz.*, corn flake, white flour, semolina and biscuit were used for present studies. The standard weight of 200 g, kept in one kilogram capacity plastic jar covered with muslin cloth and banded with rubber strips. The experiment was replicated 4 times. The culture of *Tribolium castaneum* (Herbst.) were obtained from grain storage research laboratory, Karachi University. Then pairs of beetles of same age were released in each jar. Observations were taken regularly at weekly interval and aline beetles were counted. The mode of damage in each cereal food was also

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observed. The temperature and relative humidity was recorded daily in the laboratory during the entire period of study.

Statistical Package for Social Sciences (SPSS 11 version) and Curve Expert 1.3, computer packages were used to analyze the experimental data. Correlation matrix was constructed to find the linear relationship between variables. In case of higher correlation between independent variables, considering multi-co-linearity problem, multiple regression was avoided. Using the automatic function of the Curve Expert 1.3, best regression model was explored and reported.

RESULTS AND DISCUSSION

Experiment was conducted to determine the food preferences of red flour beetles as well as to explore the relationship between the beetle population with function of weeks, relative humidity, and temperature. For screening purpose and to avoid multicollinearity problem in regression model development, correlation matrix was constructed. Figure 1 shows that there were high correlations between variables, and all the variables were found significant or highly significant at 0.05 or 0.01, level of significance, respectively. Because of multicollinearity problem, the idea to develop a regression model of red flour beetle population in function of different kinds of foods offered to them in laboratorial conditions, weeks after the experiment, mean temperature during the weeks, and relative humidity was abandoned. However, the relationship between beetle population and weeks and temperature were exclusively studied.

It was found that the most preferable food of the red flour beetle was wheat flour (77% of overall population), followed by semolina (19%), corn flakes (2%), and biscuits (2%). Since red flour beetle population (77%) in wheat flour was higher compared to other foods, beetle population in wheat flour was used for further statistical analysis and for development of the regression models. Red flour beetle population against different weeks is plotted in Figure 1. During initial two weeks (1^{st} and 2^{nd}) of the experiment, the beetle populations were very low (35.25 and 53.50 respectively). However, during 3^{rd} week (Sept. 02) the population increased dramatically and reached to 428.50. Following the same trend during 4^{th} week reached close to its highest population. Thereafter, slight increase was recorded during 5^{th} and 6^{th} week of the experiment, which corresponded to Sept. 09 and Sept 16, respectively. After reaching maximum (542) population during 6^{th} week, started declining. However, the declining trend was not so steep as recorded during the starting 2^{nd} and 3^{rd} week of the experiment (between August 26 and Sept. 02) when population increased sharply. Nonetheless, following a certain trend, the population reached nearby its bottom level during the 14^{th} week of the experiment (Nov. 18) and converged in a constant trend even recoded during the last week of the experiment (Dec. 30). Using Curve Expert 3.1 computer package, the Vapor Pressure Model was proposed for the present data to study relationship between insect population and weeks. The model was proposed on the basis of two parameters: (i) higher correlation coefficient and (ii) lower standard error. The general formula of Vapor Pressure Model is as follows:

$$Y = e \quad \frac{a + b}{x} + c \text{ In}$$

After plugging the estimates (a = 13.98, b = -14.45, and c = -2.94), the Vapor Pressure Model for red flour beetle in function of weeks of experiment is as follows:

$$\text{Population} = e \quad 1398 - \frac{14.45}{\text{weeks}} - 2.94 \text{ In (weeks)}$$

The calculated correlation coefficient for the above model was reported to be 0.98. The coefficient of the determinant was calculated to be 0.96 (Square of correlation coefficient), which indicates that about 96% of the red flour beetle population was explained by the above model in function of weeks.

Temperature and relative humidity are considered to be the main factors responsible for the pest population fluctuations. Therefore, the regression model was tried to fit to the experimental data to explain the relationship among them.

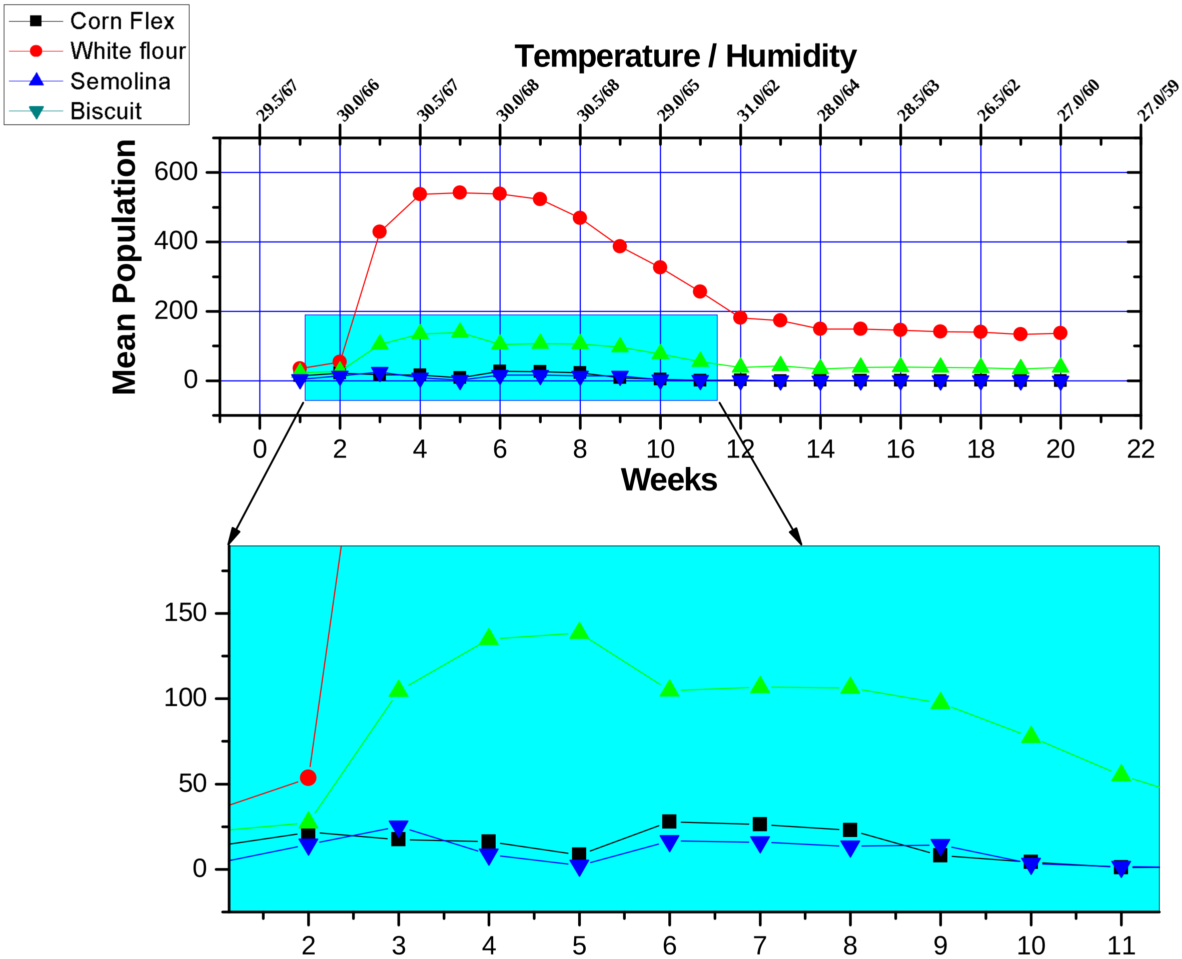

Fig. 1. Correlation between weekly mean population of red flour beetle, *Tribolium castaneum* (Herbst) on different foods, temperature, and relative humidity.

However, high correlation (0.811) between temperature and humidity was recorded which indicated that either of the factor (temperature or humidity) can be studied at the same time to find the relationship with the beetle population recorded during various weeks of the experiment. Because temperature was highly correlated with the red flour beetle population in white flour (0.596, $p<0.01$), as compared to relative humidity (0.503, $p<0.05$), the temperature was taken as independent variable and humidity was dropped. The Geometric Curve defined the positive curvilinear relationship between red flour beetle population in wheat flour and temperature. After deleting two initial observations of the first and second weeks when population was very low, but mean temperature was quite high between 29.5 and 30°C, the correlation coefficient of the Geometric Curve was recorded to be 0.89. the coefficient of determination was calculated to be 0.79 by squaring correlation coefficient. This indicates that about 79% variation of the population was accounted for by the temperature using the Geometric Curve. The general formula of the Geometric Curve is $Y = ax^{bx}$. The formula in terms of calculated estimates (a = 22.62 and b = 0.029) for the population of red flour beetles in function of temperature is as follows:

$$\text{Population} = 22.62 * temp^{0.029*\text{temp}}$$

Because of high value of correlation

coefficient and low value of standard error (79.80), it was concluded that Geometric Curve fit well to red flour beetles and temperatures. These results show that temperature and relative humidity have significant role in the population buildup of red flour beetle. The present results fully support the work of other researchers (Zaklandnoi and Ratanova, 1987; Lhaloni *et al.*, 1988; White and Jayas, 1989; Irshad and Talpur, 1993; Khalil and Irshad, 1994; Anwar *et al.*, 1995; Dars *et al.*, 2001) who reported that optimal temperature for the development of this pest is about 30^{o}C. At this temperature level the female lays an average of 300-400 and the maximum of 1000 eggs. They further stated that this species is fairly constant to high temperatures and more sensitive to low temperatures.

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