

Combined Influence of Temperature and Moisture on Red Flour Beetle (Coleoptera: Tenebrionidae) Reproduction on Whole Grain Wheat

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J. Econ. Entomol. 81(2): 488-489 (1988)

ABSTRACT Reproduction of the red flour beetle, *Tribolium castaneum* (Herbst), was lower on whole grain than has been reported on milled grain in earlier studies. Generally, fecundity increased with increasing temperature (20-32°C) and moisture (10-16%). However, interaction of adult survival and fecundity caused net reproduction to peak at 27°C and 16% moisture. This resulted from greater adult survival with increasing moisture, but decreasing survival with increasing temperature.

KEY WORDS Insecta, stored grain, *Tribolium castaneum*, reproduction

RED FLOUR BEETLE (RFB), *Tribolium castaneum* (Herbst), is most often recognized as a pest of milled grain, but it also occurs in on-farm grain-storage situations. Birch (1947) and Daniels (1956) demonstrated that RFB reproduces on whole grain wheat. Temperature and humidity are key factors in determining the level of RFB reproduction (Howe 1962). However, data on the effects of these variables on reproduction and survival when RFB is reared on whole grain are limited to those reported by Daniels (1956) for three humidities at one temperature (26.7°C). This study reports the effects of combinations of grain moisture contents and temperature on reproduction and survival of adult RFB on whole grain wheat.

Materials and Methods

RFB from laboratory cultures were sexed as pupae, and virgin females were paired with males on whole grain wheat for 6 d to ensure mating. Females then were confined individually in sealed 5-ml vials with 4 ml whole grain wheat at the experimental moisture contents (6, 10, 12, 14, and 16%). Grain samples at the experimental moistures were obtained in sealed containers from the University of Nebraska Wheat Quality Laboratory. Dockage and fine materials were removed before moisture adjustment. Samples were then prepared using methods (No. 44-16) approved by the American Association of Cereal Chemists (Anonymous 1969) and held in full, tightly sealed containers. Thirteen vials prepared with grain at moisture con-

tents of 12, 14, and 16% were placed in environmental chambers at 20, 27, and 32°C. Thirteen vials with grain at 6 and 10% moisture content were placed at 27°C only. Thus, data for this study were based on observations of 143 individual female RFB.

Fresh wheat at the appropriate moisture content was provided every 3 d for the first 41 d, then weekly. Adult survival rate (l_x) for the 13 RFB at each combination of moisture content and temperature was obtained each time food was replaced. Each grain of wheat was removed and examined microscopically for the presence of eggs. Fecundity (m_x) was calculated as the mean number of eggs produced per female per 3 d. Net reproductive rates (R_0) were calculated as $R_0 = \sum l_x m_x$ (Southwood 1978).

Results and Discussion

RFB did not reproduce at or below 10% moisture content and survived <6 d at 6% and <18 d at 10%. Above 10% moisture content, adult survival increased with increasing moisture and generally decreased as temperature increased (Fig. 1). Fecundity increased with both increasing grain moisture and temperature. Thus, decreased survival rate was most important in reducing net reproductive rate between 27 and 32°C. Net reproductive rate increased with moisture content at 27 and 32°C. At 20°C, net reproductive rate was highest at 14% moisture content.

In all experimental environments, we obtained lower RFB reproduction on whole grain wheat than was reported by Howe (1962) on wheat flour under similar environmental conditions. Both greater fecundity and survival contributed to greater reproductive rates on wheat flour. The tendency of our data toward increased fecundity at higher tem-

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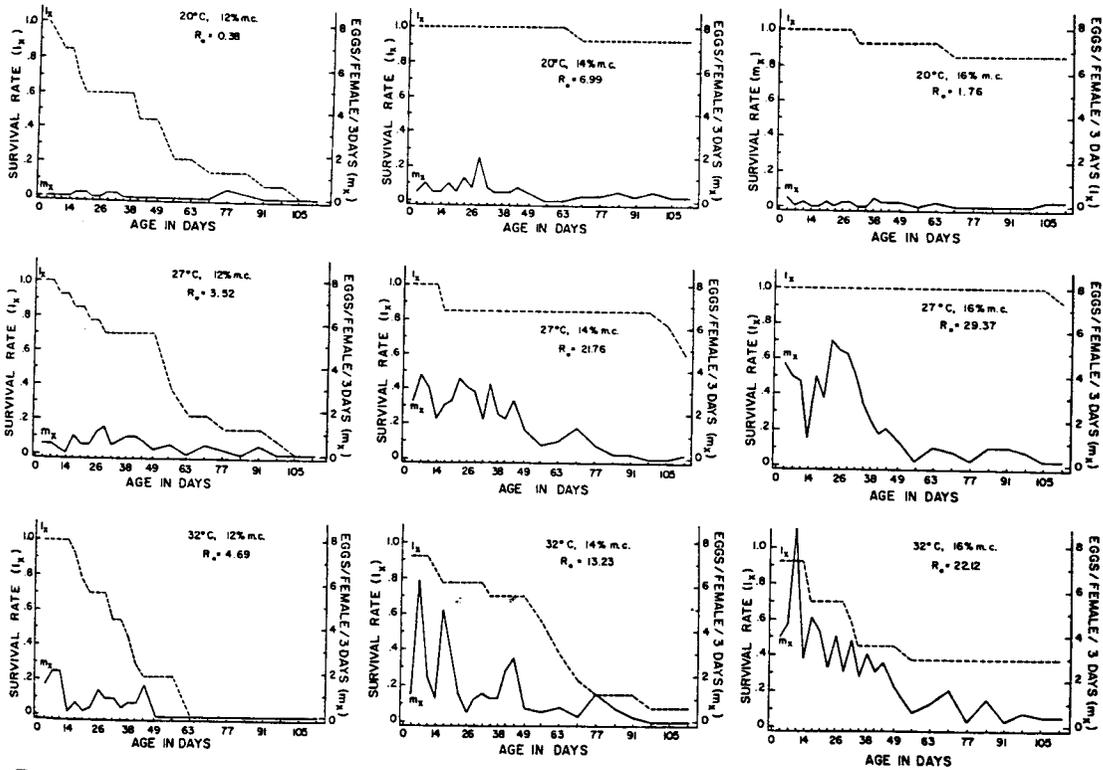


Fig. 1. Survivorship (l_x), fecundity (m_x), and net reproduction ($R_0 = \sum l_x m_x$) of *T. castaneum* on whole grain wheat at three temperatures ($^{\circ}\text{C}$) and three grain moisture contents (%m.c.).

temperatures and moisture contents parallels Howe's findings. In contrast to our study, Howe reported that most beetles survived for the full duration of his tests. Thus, our data support the conclusion of Birch (1947) and Daniels (1956) that RFB is capable of survival and reproduction on whole grain wheat. However, survival and reproduction are clearly lower on whole grain wheat than on wheat flour.

From the standpoint of management of farm-stored grain, our data indicate that grain held in storage at moisture contents of 10–12% is unlikely to develop economically damaging populations of RFB.

Acknowledgment

This article is published as Paper No. 8046 Journal Series, Nebraska Agricultural Experiment Station.

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Received for publication 19 May 1986; accepted 25 November 1987.

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