FATE OF STARVED BOLL WEEVIL LARVAE AS A FUNCTION OF LARVAL WEIGHT

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Abstract

Desiccation and high temperatures have been reported as major determinants of natural mortality of immature boll weevils. However, direct examination of these mechanisms is effectively precluded by the difficulty of manipulating temperature and desiccation independently. Thus, the mechanisms involved in natural mortality are not well understood. Desiccation is reported to act by rendering the square unfit for larval consumption, resulting in starvation. Therefore, we examined the impact of food removal on larval survival and development to indirectly assess the role of food deterioration in natural mortality. Four hundred twenty-four 3rd instars ranging in weight from 1.81 to 34.43 mg were removed from squares and held without food. No larvae weighing <5 mg survived to the pupal stage while a high proportion of larvae weighing >5 mg survived to the pupal and adult stages (86% and 81%, respectively). When only larvae >5 mg were considered, the proportion of larvae surviving to subsequent stages was not related to larval weight. Our results question the status of food deterioration as a primary mechanism of natural mortality, and provide insight to future efforts to investigate this important phenomenon.

Introduction

Natural mortality is recognized as an important factor limiting boll weevil population growth (Smith 1936, Sturm et al. 1990, Sturm and Sterling 1990). However, the underlying mechanisms responsible for natural mortality are not completely understood. Models describing mortality patterns of boll weevils in fallen squares assume that desiccation of the larval food supply, rather than exposure to high temperatures, is the major cause of mortality (Curry et al. 1982). These models consider that the primary role of high temperatures is to hasten square desiccation (DeMichele et al. 1976, Curry et al. 1982). Square desiccation sufficient to prevent larval feeding presumably results in death of the larva, unless resources adequate for completion of development were previously acquired. Yet the point at which the larva can complete development without further feeding has not been determined.

Alternatively, Fye and Bonham (1970) identified high temperature as the primary cause of boll weevil mortality in fallen squares. Sterling et al. (1990) suggested that both high temperatures and desiccation contribute to natural mortality. However, they examined these effects in bolls, which do not normally abscise. Thus, their findings do not directly address natural mortality as it occurs in the field.

A clearer understanding of the mechanisms of natural mortality may improve our ability to maximize this effect by cultural means. Direct examination of the mechanisms of natural mortality is effectively precluded by the difficulty of independently manipulating temperature and desiccation. However, the potential adverse effects of food deterioration caused by square desiccation may be indirectly examined using food removal techniques. Our objective was to determine the developmental consequences of food removal in relation to the size of 3rd instar boll weevils.

Materials and Methods

Larvae were obtained by collecting oviposition-punctured squares from cotton plants. Squares were held in an environmental chamber at 29.4±1°C with a 13:11 [L:D] h photoperiod until predominantly 3rd instars were present. Third instars were identified based on a head capsule diameter of about 0.9 mm (Parrott et al. 1970). Third instars were removed from the squares and individually weighed. Each larva was placed on a platform constructed of a plastic diet-cup lid enclosed in a 100 X 15-mm petri plate. Each petri plate also contained a cotton wick saturated with deionized water to maintain a high relative humidity. Petri plates were returned to the environmental chamber and larvae were observed daily until they pupated or died. Upon pupation, each pupa was weighed, returned to the environmental chamber, and monitored daily for eclosion or death. Upon eclosion adults were weighed.

The relationships between larval weight and survival to the pupal and adult stages, respectively, were examined in contingency tables using the CHISQ option of the SAS procedure PROC FREQ (SAS Institute 1988). Larval weights were grouped into six 5-mg weight classes which were used as rows in the tables. Survival status (survived, died) to the pupal or adult stage was used as columns in the respective tables. Because of the small number of larvae in the lowest larval weight class, valid chi-squares could not be computed in the analyses. Thus, the analyses were repeated after omitting the lowest weight class. The relationship between pupal weight and survival to the adult stage was similarly examined except there were only 5 pupal weight classes and no data were omitted.

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Results

Overall, a total of 424 3rd instars were weighed, with weights ranging from 1.81 mg to 34.43 mg. These larvae resulted in 365 pupae ranging in weight from 3.03 mg to 24.48 mg, and 344 adults with weights ranging from 1.61 mg to 21.49 mg.

The initial analysis indicated a significant relationship between larval weight class and survival to the pupal stage (χ^2=46.734, df=5, P<0.01). However, because all larvae of the lowest weight class ($\leq$ 5 mg) died before pupation (Fig. 1), presence of a zero cell count precluded calculation of a valid chi-square statistic. The analysis excluding the lowest weight class indicated no significant differences in survival to the pupal stage among larval weight classes (χ^2=2.965, df=4, P=0.564) (Fig. 1).

Results of analyses of larval survival to the adult stage were similar to those examining larval survival to the pupal stage. No differences in survival to the adult stage among the upper five larval weight classes were detected (χ^2=2.698, df=4, P=0.610) (Fig. 1.). Neither were differences in survival to the adult stage observed among pupal weight classes (χ^2=2.527, df=4, P=0.640) (Fig. 2).

Discussion

Third instar boll weevils weighing <5 mg at the time of food removal failed to survive to subsequent stages. However, a high proportion of larvae weighing >5 mg survived to the pupal and adult stages (86% and 81%, respectively). When only larvae >5 mg were considered, the proportion of larvae surviving to the pupal and adult stages was not related to larval weight. Therefore, the critical weight of 3rd instars that ensured a high proportion of larval survival to subsequent stages without further feeding was about 5 mg. The scarcity of 3rd instars weighing $\leq$5 mg prevented a more precise determination of the critical weight.

Squares normally abscise when the infesting boll weevils are 2nd and 3rd instars (Coakley et al. 1969). The duration of the 2nd stadium is <2 days (Bacheler et al. 1975). Given our estimate of the critical weight of 3rd instars, if deterioration of food resources by square desiccation was the primary mechanism of natural mortality, it would have to occur within the first 2-3 days following abscission.

Our results question the role of food deterioration by square desiccation as a primary mechanism of natural mortality. More research will be necessary to clarify these mechanisms, and our findings should facilitate future efforts to examine the mechanisms by more direct means.

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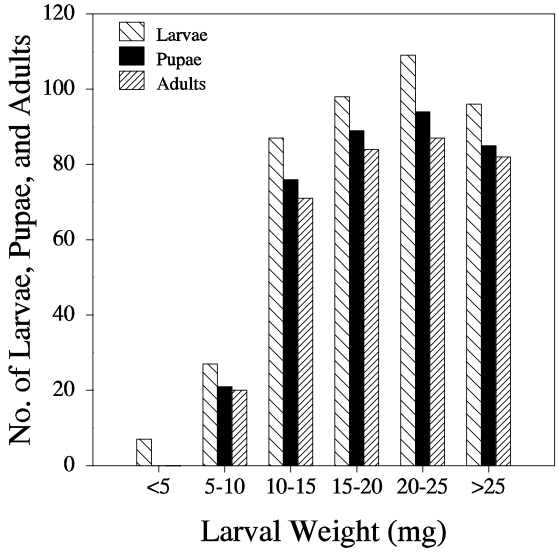

Figure 1. Survival of 3rd instar boll weevils to pupal and adult stages by larval weight class at the time of food removal (*n*=424 larvae).

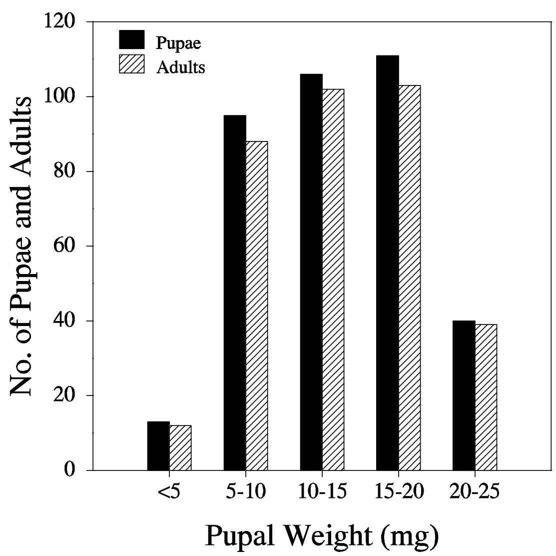

Figure 2. Survival of boll weevil pupae to adulthood by pupal weight class (*n*= 365 pupae).