POPULATION DENSITY AND SEX RATIO DYNAMICS OF OVERWINTERING MAIZE WEEVILS (COLEOPTERA: CURCULIONIDAE) INFESTING FIELD CORN

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ABSTRACT

Natural infestations of the maize weevil, *Sitophilus zeamais* (Motschulsky) were monitored in selected corn fields located in each of five major climatic or edaphic environments of Georgia. The population density and sex ratio of each population was recorded on a monthly basis during the fall and winters of 1982 - 83 - 84. Females suffered higher winter mortality than males, resulting in increasingly male-skewed sex ratios (from 0.8/1.0 to 1.6/1.0) as winter progressed. The degree of male-skewedness was positively correlated with the amount of subzero weather experienced by each population. Surviving weevil populations decreased in size as winter progressed, with the greatest reductions at the higher latitudes. No weevils survived through spring north of 33° 57'N where winter weather extremes of -15°C occurred. No true diapausing stage was found; however, cold tolerance tests indicated that winter-collected weevils were significantly more cold hardy than laboratory-reared weevils.

Key Words: Maize weevils, *Sitophilus zeamais,* field corn, overwintering, density, sex-ratio.

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INTRODUCTION

The maize weevil, *Sitophilus zeamais* Motschulsky, is not only an important stored grains pest but also can be a significant field pest. Although extensive studies have elucidated many aspects of its biology in stored grains, the details of its field biology are unclear.

In the United States, the maize weevil's ability to overwinter in the field is believed to be poor, although reproduction may continue through the winter in storage bins (Fenton 1952; Little 1972). Observations of weevils migrating from storage bins to the field (Kirk 1965; Douglas 1941) have prompted the assumption that field populations are primarily re-established by weevils originating from stored grain. Thus, the ability to overwinter in the field would seem unnecessary for continued field infestations to occur. However, Chestnut (1972) found that maize weevils migrating from storage bins failed to infest fields farther than 0.25 miles away.

If recurring field infestations are dependent on the ability of field populations to overwinter, the degree of field infestations should be correlated with field overwintering success. Observations of corn fields infested with maize weevils in Georgia range from nearly 50% survival of adults in the extreme south to less than 1% in the north (Dix and All, unpublished). This study was conducted to determine the overwintering capability of the maize weevil within this range to see if the various degrees of infestation could be explained by differing overwintering success in the field.

MATERIALS AND METHODS

Natural infestations of the maize weevil were monitored in conventionally grown field corn at the University of Georgia Experiment Station located near Griffin, GA, and at the Tifton, Midville, Griffin, Athens, and Calhoun, GA, experiment stations from September to March of 1982 - 83 and 1983 - 84, respectively.

Due to the presence of sparce infestations, the weevil populations in Griffin, Athens, and Calhoun were supplemented with sixty weevil-infested corn ears that were removed from Midville on September 27, 1983. These transplanted weevils comprised > 75% of the weevils monitored in Griffin and Athens, and 100% of the weevils monitored in Calhoun.

Daily maximum and minimum temperature readings were recorded at each location from October 1 through March 1. A "cold factor" parameter was calculated as the product of the number of days of subzero °C and the mean minimum temperature of subzero days. The survival trends of each overwintering population were examined by monthly collections of 10 to 20 weevil-infested corn ears. Adult weevils were removed from the ears and scored as living or dead. The corn ears were subsequently placed in individual zip-lock plastic bags and held at 27°C for six weeks to evaluate larval survival. Ears collected during March were observed through July to check for the emergence of diapausing weevils. All recovered weevils were sexed by examining rostrum widths and punctuation (Reddy 1951; Halstead 1963). Weevils with ambiguously-shaped rostrums were dissected and sexed by examination of the genitalia. Chi-square goodness of fit analysis was utilized to test for significant deviations in sex ratio (Zar 1974).

Soil samples were collected to a depth of 10 cm under weevil-infested corn ears which had fallen to the ground (January 1983 and 1984, Griffin only). The soil was returned to the laboratory and examined for the presence of maize weevils. The fallen corn ears were examined for the presence of live weevils during the beginning and end of the study period to determine if migrations off the ears were occurring.

Three samples of 30 live weevils collected from Griffin in December 1982 were placed in one-dram plastic vials with cracked corn and held at -10°C for 12, 24, and 48 hr. They were then returned to room temperature and scored as living or dead. Three groups of laboratory-cultured weevils were placed under the same conditions as controls.

A container with 50 pounds of shelled corn was artificially infested with approximately 100 field-collected adult maize weevils in August 1982. These weevils were left to multiply under ambient conditions through September 1982, at which time the container was placed at -10°C until June 1983. Upon returning the corn to room temperature, all adult weevils were removed and scored as living or dead. The corn was then held for four months and examined weekly for the presence of emerging weevils.

RESULTS AND DISCUSSION

The locations were chosen as representative of the major climatic or edaphic environments of the South (Fig. 1 a, c). Tifton and Midville lie in the Southern Coastal Plain soil province typified by flatlands and gentle slopes underlain by

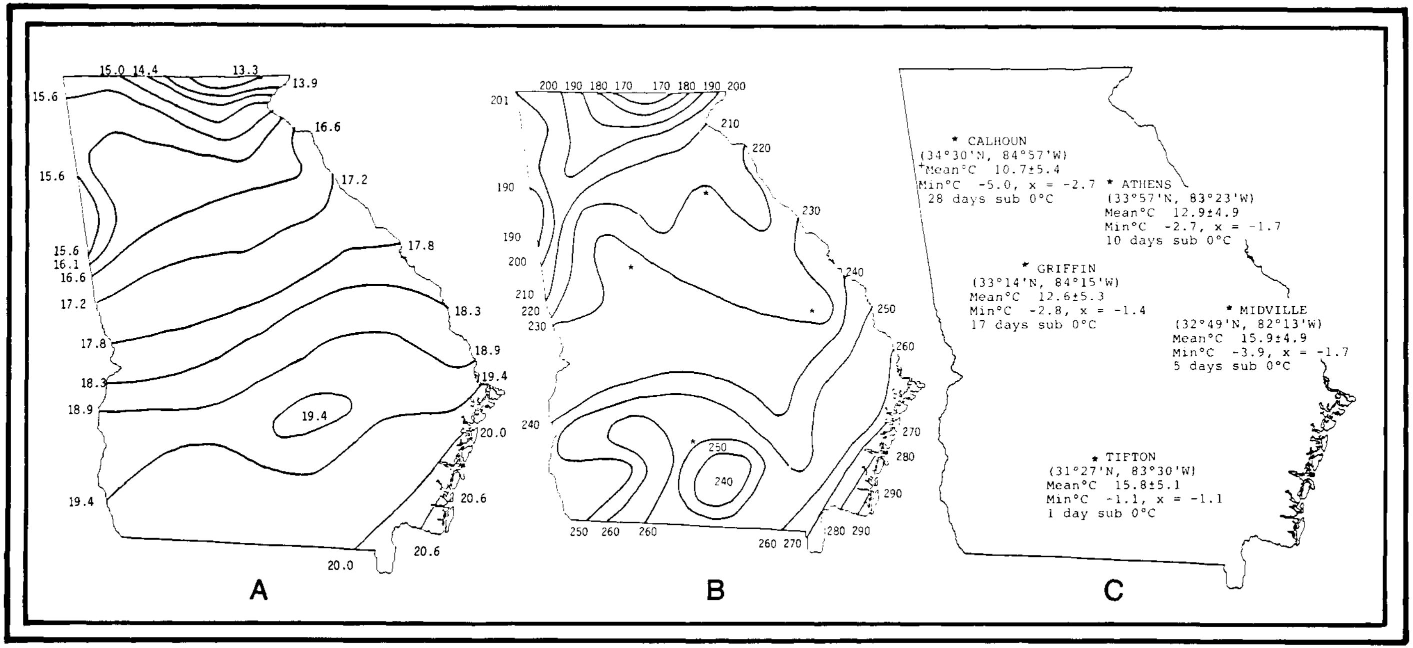

Fig. 1. Summation of the significant weather events influencing the biology of the maize weevil overwintering in Georgia. A = Mean annual temperature (°C) for period 1936 - 1965. B = Mean annual number of frost-free days. C = Description of study sites. Location selected for study, latitude-longitude, temperature data (°C) from October 1, 1983 through December 20, 1983; mean temperature, minimum °C, mean °C of subzero days, number of subzero days.

marine sands, loam, and/or clay. Elevations range from 76 and 152 m above sea level and mean annual rainfall is between 102 - 132 cm. Griffin and Athens lie in the Southern Piedmont soil province characterized by foothills and broad interstream areas underlain by acid crystalline and metamorphic rock. Elevations range from 152 - 457 m above sea level and annual rainfall is 112 to 142 cm. Calhoun is located in the Southern Appalachian Ridges and Valleys soil province characterized by limestone ridges and sloping valleys. Elevation ranges from 183 to 457 m above sea level and annual rainfall is between 132 and 142 cm. Mean midwinter minimum temperatures for each location are: Tifton, 33.3°C; Midville, 32.2°C; Griffin and Athens, 0 to 2.2°C; and Calhoun, 0°C. Mean annual temperatures and frost free days for each location are influenced by latitude as well as local topographic factors (Fig. 1).

Figure 1 depicts the typical weather patterns for all locations and summarizes the significant weather events occurring in 1983 - 84. The 1982 - 83 weevil population located in Griffin successfully overwintered despite 14 subzero nights ranging from -1.9°C to -5.0°C. Although only 0.03% of the sampled weevils were found dead, the sex ratio of both adults and immatures became increasingly male skewed ($P < 0.05$) as the winter progressed (Fig. 2a). This trend was also observed in the grouped data for the overwintering populations examined during 1983 - 1984 (Fig. 2b).

Extreme cold (-12.7°C to -18.3°C from Tifton to Calhoun, respectively) on December 25, 1983, killed 99% of the weevils in the Tifton and Midville test populations and exterminated the test populations in Griffin, Athens, and Calhoun. Comparisons between the various populations were therefore limited to events occuring before December 25.

Data from all locations showed that as exposure to subzero weather increased, a trend towards smaller populations with fewer females occurred (Figs. 3 and 4). Females, which made up an average of 62% of initial overwintering populations, comprised only 37% of the surviving December populations, indicating males are more cold tolerant. Immatures proved to be less cold hardy than adults, generally showing greater male-skewedness and reductions in population size with equal exposure to subzero weather.

The product of the number of subzero nights and the intensity of the cold (cold factor) served as the best predictor of population and sex ratio trends. As long as the minimum temperature remained above -5°C, the two factors appeared to be equally important in regulating maize weevil survival.

Repeated examination of infested corn ears found on the ground revealed over 90% (41/45) of the weevils remained on the ears. Random sampling of the top six inches of the soil under fallen weevil-infested ears in Griffin in January of 1983 and 1984 failed to reveal any subterranean weevils. It would therefore seem unlikely that a significant proportion of the maize weevil population avoids the cold by burrowing. Hinds and Turner (1911) and Kiritani (1965) found that *Calandra oryzae* (L.) (probably = *S. zeamais*) and *S. zeamais*, respectively, could be found passing the winter under debris. This is comparable to the protection afforded by remaining within the corn husk.

The laboratory studies supported the findings of disproportional winter mortalities between the sexes and between adults and immatures. The maize weevil produces a female-skewed sex ratio (0.7/1.0) when reared on stored corn at 28°C (Dix and All 1985). Upon thawing the weevil-infested corn, which had been

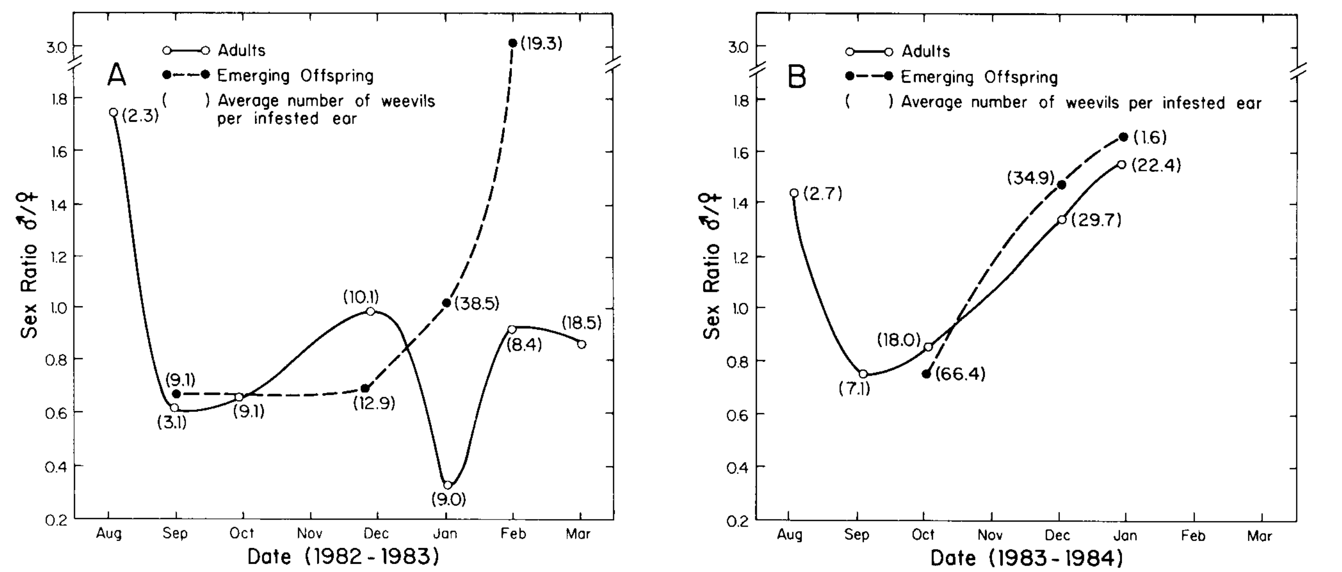

Fig. 2. Sex-ratio dynamics in overwintering populations of the maize weevil near Griffin, GA. A = August 1982 through March 1983. B = August 1983 through March 1984.

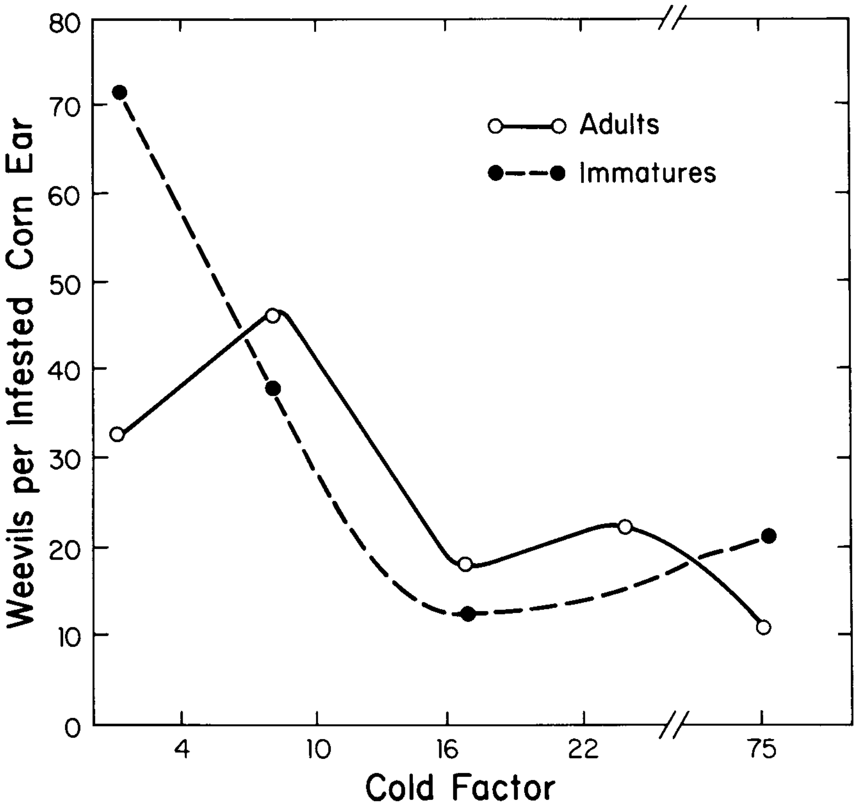

Fig. 3. Temperature-induced variations in the population density of overwintering maize weevils. Cold factor equals the product of the number of days of subzero °C × the mean minimum temperature of subzero days.

stored at -10°C from October through May, 0.6% (18/3,021) of the adult weevils were found to have survived. Of these, 83% were males, resulting in a sex ratio of 5.0/1.0. Subsequent examination of the corn indicated that no immature weevils survived.

Comparisons of laboratory and overwintering field weevils indicated laboratory-reared weevils were considerably more cold sensitive. Although 30, 50, and 0% of the field weevils exposed to -10°C for 12, 24, and 48 hours, respectively, survived, all laboratory-reared weevils exposed under the same conditions were killed. In experiments with *C. oryzae* (possibly = *S. zeamais*), Solomon and Adamson (1955) state that 15 hours at -10°C was sufficient to kill adult weevils but indicated conflicting data exist as to the relative cold tolerance of the immature stages (Mathlein 1938; Ushatinskaya 1950). Comparison of our results with the preceding studies (which apparently utilized laboratory-reared weevils) suggests adult cold tolerance is developed during the immature stages or in the preceding generation. Laboratory-reared weevils would, therefore, be expected to show different cold tolerances than overwintering weevils collected from the field.

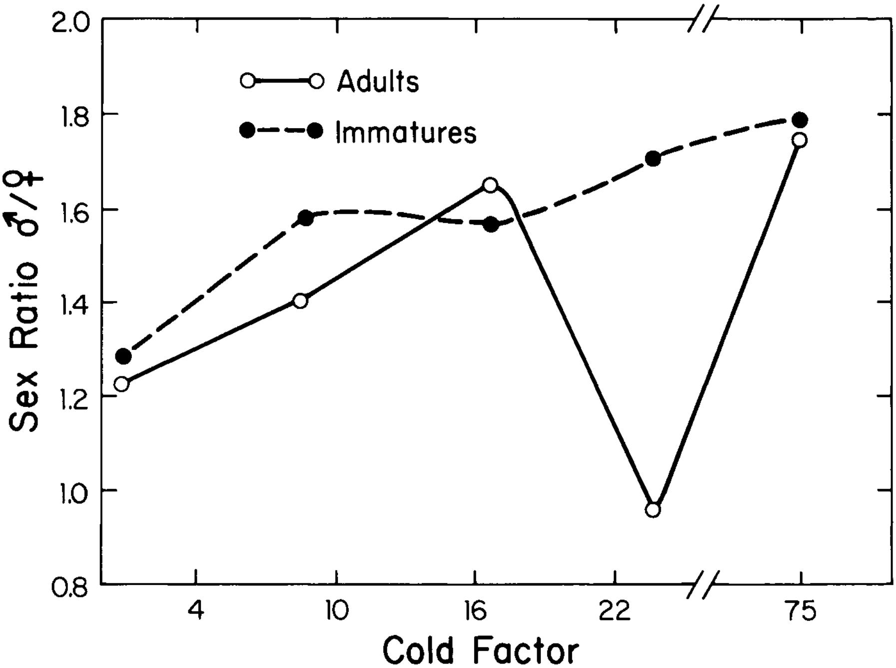

Fig. 4. Temperature-induced variations in the sex ratio of overwintering maize weevils. Cold factor equals the product of the number of days of subzero °C × the mean minimum temperature of subzero days.

The larger weevil populations observed in the southern locations were probably due to a combination of warmer winter temperatures and longer reproductive seasons (Fig. 1). Corn fields are routinely planted two to four weeks earlier in southern Georgia than in northern Georgia. This, in conjunction with a later first frost, allows an extra generation of weevils to develop in the deep South. As more northerly fields are invaded, fewer adult offspring could be produced before the onset of inclement weather. Therefore, even if winter mortality in the various locations was similar, smaller spring populations would occur in northern climates.

The widespread occurrence of field populations of the maize weevil thus would seem dependent on their ability to overwinter in the field as well as their success in stored grain. Whether or not these populations reach damaging proportions in the field seems dependent on the amount of time the corn is available to reproducing adults.

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