RELATIVE COLD TOLERANCE OF BOLL WEEVILS FROM MISSOURI, MISSISSIPPI, AND COASTAL TEXAS

Clyde E. Sorenson
University of Missouri Delta Center
Portageville, MO
Roy D. Parker
Texas A&M University
Corpus Christi, TX
M. Blake Layton
Mississippi State University
Mississippi State, MS

Abstract

Boll weevils (*Anthonomus grandis grandis* Bohman) from near Portageville, MO; Starkville, MS; and Corpus Christi, TX were exposed to temperatures of approximately -4, -7, -9, -12, and -15°C for 6 hours to determine if there were differences in the cold tolerance of these populations. No statistically significant differences were observed between these populations; survival at -3.9°C averaged 82.7 percent; at -6.7°C, 72.2 percent; and at -9.4°C, 61.5 percent. Survival at -12 and -15°C was negligible across populations. While boll weevils have been quite facile in adapting to varying winter climates by acquiring diapause, these data suggest that little adaptation to cold temperature has occurred at the northern limits of the boll weevil's range.

Introduction

The boll weevil (*Anthonomus grandis grandis* Bohman) has been present in Southeastern Missouri for approximately 80 years (Hunter and Coad 1923); during this period there may have been between 160 and 320 generations. Weather-induced over-winter mortality is one of the most important factors in annual population regulation through much of the insect's North American range (Bondy & Rainwater, 1942, Gaines 1943, Pfrimmer & Merkl, 1981); this is particularly so at the northern limits of the range. The boll weevil has been a sub-economic pest in Southeastern Missouri over most of the years since its first occurrence, due apparently to periodic very severe winters; however, it is a significant pest in some years.

The severe winter temperatures in Southeastern Missouri (and other northern extremes of boll weevil distribution) would seem to act as a strong selection agent for increased cold tolerance in local boll weevil populations, if residual populations persist through most or all winters.

Slosser et al. (1994) developed a cold bath technique to determine the diapause status of boll weevils. They found that a six hour exposure to -7.5°C was discriminating for diapause in Texas weevils. Sorenson and House (1995) used the cold bath technique to investigate the cold tolerance of Missouri boll weevils and found that mortality increased from approximately 35 % at -9.4°C to approximately 85 % at -12.2°C.

The studies described below were conducted to determine if there were differences in cold tolerance between weevils from different latitudes.

Materials and Methods

We collected adult boll weevils from pheromone traps in late September and October. Weevils were collected in the vicinity of Portageville, MO (latitude 36°30'N), south of Starkville, MS (latitude 33°30'N) and Corpus Christi, TX (latitude 27°45'N). Weevils from each area were caged separately. All weevils were fed for at least two weeks on fresh cotton squares and small bolls under a short (11:14h light: dark), cool day (18.3:15.6°C light: dark) regimen. After this feeding period, the weevils were transferred to ventilated, plastic sweater boxes filled with damp, shredded paper toweling and held at 5°C in complete darkness until used conditions (Sorenson and House 1995). Approximately 30 weevils from each collection were dissected after this feeding period to assess the development of fat bodies; in all three populations, between 83 and 90% of weevils had well-developed fat bodies indicative of diapause condition.

Groups of weevils from each test population were exposed to temperatures of approximately -3.9, -6.7, -9.4, -12.2, and -15°C for a six hour period. Each temperature was replicated five times in a randomized complete block design with time as the blocking factor. In other words no one of the five temperatures was repeated until the other four temperatures within a block had been tested.

Weevils from each population were placed in separate steel cans together with the thermistor from a temperature logger (Stowaway™, Onset Computer Corp.). In previous cold bath work, plastic containers were used to hold weevils; test runs with temperature loggers indicated that plastic containers did not equilibrate to target temperatures as rapidly as metal containers and that equilibration times were substantially longer at the colder target temperatures in plastic containers than in metal containers. The temperature logger was isolated from the weevils by a plastic partition to prevent them from using the logger as a refuge from the cold exposure. Hook-and-loop fastening tape was affixed to the lid of the steel can for attachment to the inside lid of the cold bath.

Sample size for the Texas and Missouri populations was 25 weevils; the sample size for the Mississippi population was reduced to 15 due to more limited weevil supplies.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:715-717 (1996)
National Cotton Council, Memphis TN

Temperatures tested were -3.9, -6.7, -9.4, -12.2, and -15°C (these correspond to 25, 20, 15, 10 and 5°F). Containers containing weevils were placed in the cold bath for a six hour period. After removal from the cold bath, the insects were placed in plastic jars and held at room temperature for 24 h. Weevils were then rated “alive” (active and fully mobile), “down” (alive but unable to right themselves), or “dead” (immobile and completely unresponsive to probing or pinching the rostrum with forceps).

Data were subjected to ANOVA with means sepeeration by LSD (a = 0.05) (SAS Institute 1988). Data were arcsine transformed prior to analysis.

Results

No differences were found between populations for any variable analyzed through ANOVA (Table 1). No significant interactions between population and temperature were identified for any of the variables.

No weevils from any of the three populations survived -15°C unharmed and only one weevil in 325 survived -12.2°C. (Table 2). Survival at approximately -3.9°C was significantly greater than at -9.4°C. The proportion of “downed” weevils was greatest at -12.2° and lowest at -6.7 and -3.9. Tables 3-5 contain means for alive, down and dead insects at all five temperatures for the three populations.

Steel containers equilibrated at target temperatures in 5 minutes or less, compared to up to 45 minutes for plastic containers.

Discussion

Boll weevils from the most northern locality were not more cold tolerant than weevils from either of the two more southerly localities.

The lack of differences in response to these temperatures from weevils collected across such a wide latitudinal gradient suggests that there has been very little adaptation to cold temperatures in the northern-most populations of boll weevils. (This is a separate issue from the acquisition of diapause and regional variation in diapause acquisition).

Possible explanations for the lack of adaptation to low temperatures include periodic local extinctions or near extinctions of northern populations due to very severe winters or series of winters; genetic inflexibility with respect to adaptation to low temerpatures; or dilution of adapted, selected populations by regular immigration from more southern populations. Historical weather data and observations of boll weevil numbers and economic significance in Missouri (see Cotton Insect Loss reports in Proceedings of the Beltwide Cotton Conferences, 1980-95) would suggest that the periodic extinction hypothesis is more likely.

However, boll weevils have been a much more persistent presence in central Mississippi since their first occurrence; the lack of differences in cold tolerance between Mississippi and Texas weevils in spite of some selective pressure at the more northern site would suggest either genetic inflexibility or dilution.

Mean survival at the two higher temperatures was lower in these experiments than those obtained in last year using plastic containers (Sorenson and House 1995). Survival at -12.2°C was also lower, while survival at -9.4°C was very similar between years and populations. The comparatively rapid cooling of the insects in steel containers may have had some impact on their survival relative to that in plastic containers, and thus data between years may not be directly comparable.

Survival rates for both years in the -6.7°C treatment are comparable to those described for diapausing weevils at -7.5°C by Slosser et al. (1994), and the survival rates we observe at -9.4°C are considerably higher than those they observed at -10°C. These observations suggest that the weevils we were testing were in diapause condition.

Acknowledgments

We thank Paula Ezell, Sanjay Bajaj, Ben Harlow, and Jeff House for their technical assistance. We also thank Jeff Slosser and his colleagues for developing the cold bath technique and for valuable advice. This project was funded by a grant from Cotton Incorporated State Support Funds.

References

1. Bondy, F. F. and C. F. Rainwater. 1942. Boll weevil hibernation, survival, and emergence under South Carolina conditions. J. Econ. Entomol. 35: 495-498.

2. Gaines, R. C. 1943. Relation between winter temperatures, boll weevil survival, summer rainfall and cotton yields. J. Econ. Entomol. 36: 82-84.

3. Hunter, W. D., and B. R. Coad. 1923. The boll-weevil problem. USDA Farmer’s Bulletin 1329. (A1.9:1329)

4. Pfrimmer, T. R. & M. E. Merkl. 1981. Boll weevil: winter survival in surface woods trash in Mississippi. Environ. Entomol. 10: 419-423.

5. SAS Institute. 1988. SAS Users Guide , Release 6.03 Edition. Cary, NC SAS INstitute, Inc. pp 1028.

6. Slosser, J. E., R. Montandon, D. R. Rummel, T. W. Fuchs, and l. T. Wilson. 1994 A cold bath technique for determining diapause status of the boll weevil, pp. 990-991.

In Proc. 1994 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

7. Sorenson, C. E., and J. House. 1995. Winter habitat microclimate and winter cold tolerance of boll weevils in Missouri: a preliminary report. pp. 1025-1029. In Proc. 1995 Beltwide Cotton Conf., National Cotton Council, Memphis, TN.

Table 1. Analyses of Variance for several boll weevil cold tolerance variables measured on groups of weevils exposed to five temperatures for six hours. "Alive" is the proportion of weevils surviving exposure unharmed; "Down" is the proportion of weevils alive but impaired by the exposure; "Dead" is the proportion of weevils killed.

Variable	Source	DF	F	Prob>f
Alive				
	Model	18	154.95	0.0001
	Error	56		
	Population	2	0.25	0.7827
	Replicate	4	2.66	0.0420
	Temperature	4	691.31	0.0001
	Pop. * Temp.	8	1.60	0.1460
Down				
	Model	18	3.76	0.0001
	Error	56		
	Population	2	1.30	0.2794
	Replicate	4	0.68	0.6103
	Temperature	4	13.80	0.0001
	Pop. * Temp.	8	0.90	0.5193
Dead				
	Model	18	6.04	0.0001
	Error	56		
	Population	2	1.13	0.3292
	Replicate	4	1.32	0.2734
	Temperature	4	24.53	0.0001
	Pop. * Temp.	8	0.38	0.9275

Table 2. Alive, down, and dead boll weevils after a six hour exposure to five temperatures, averaged across populations.

Temperature, °C	% Alive	% Down	% Dead
-15	0 a	26.2ab	73.8a
-12.2	0.4a	46.1a	53.4a
-9.4	61.5 b	22.5 b	20.6 b
-6.7	72.2 bc	7.2 c	16.0 b
-3.9	82.7 c	7.9 c	9.4 c

Means with same letter not significantly different at p=0.05, LSD

Table 3. "Alive" boll weevils (those apparently unimpaired) from three populations at five temperatures after a six hour exposure.

Temperature,		% Alive	
°C	Missouri	Mississippi	Texas
-15	0	0	0
-12.2	0	0	0.8
-9.4	63.2	49.3	72.0
-6.7	67.2	73.3	76.0
-3.9	83.2	80.0	84.8

Table 4. "Down" boll weevils (those alive but severely impaired) from three populations at five temperatures after a six hour exposure.

Temperature,		% Down	
°C	Missouri	Mississippi	Texas
-15	29.1	20.0	29.3
-12.2	48.0	44.0	46.4
-9.4	20.0	34.7	12.8
-6.7	10.4	4.0	7.2
-3.9	8.8	5.3	9.6

Table 5. "Dead" boll weevils (those totally unresponsive) from three populations at five temperatures after a six hour exposure.

Temperature,		% Dead	
°C	Missouri	Mississippi	Texas
-15	70.8	80.0	70.4
-12.2	52.0	54.7	53.6
-9.4	16.8	16.0	15.2
-6.7	22.4	22.7	16.8
-3.9	8.0	14.7	8.8