Characterizing Larval Movement of Western Bean Cutworm, *Striacosta albicosta,* in Maize

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Introduction

Western bean cutworm (WBC) (*Striacosta albicosta*) is in the family Noctuidae (Figures 1 and 2)

- Endemic to the western parts of the United States.
- Since 1999: Eastward expansion in the USA (Figure 3).
- Economic damage in maize is caused by larval feeding (Figure 4).

Damage

- Larval feeding can reduce quality and yield up to 40%.
- Yield loss ranges from 248 to 1000 kg/ha (Paula Moraes et al 2013).

Larval Movement

- Integrated pest management (IPM) and insect resistance management (IRM) demand a comprehensive understanding of insect behaviors, including larval movement. WBC larvae are known to move on and between plants during 3 distinct periods. WBC IPM and the design and implementation of IRM strategies will be improved with an understanding of larval movement during these 3 periods.

Fig 1. WBC moth

Fig 2. WBC larvae

Fig 3. Expansion of WBC

Fig 4. Feeding damage

Objectives

The objective was to evaluate WBC larval movement in maize during three critical larval movement periods; soon after eclosion, during late 3rd/early 4th instar, and during later instars after reaching the ear.

Material and Methods

The study was conducted in 2016 at the University of Nebraska Haskell Agricultural Laboratory, Concord, NE.

- Twelve to sixteen ~9 m long x 13 row (76 cm) plots/movement period were arranged in a random design, each plot being a replication.
- Captured feral moths were allowed to oviposit on pre-tassel maize in oviposition cages placed on the top of the central plant in each plot for 1st and 2nd periods (Figure 5).
- For 3rd period infestation, 4th instars were placed in the ear tip of the central plant.
- Data was collected at 2 days (1st period) and 14 days (2nd period) after hatching, and 19 days after infestation (3rd period).
- Number of larvae, on-plant position, and plant-to-plant position were recorded in each plot.
- Distance data and count data were analyzed using a generalized linear model (GLM) with a Poisson distribution, or a quasi-Poisson distribution (over-dispersion), using the R software 3.4.1. ANOVA was performed by the F test ($p < 0.05$). When significant differences were observed, the Tukey multiple comparisons test was applied ($p < 0.05$), using the glht function multicomp and sandwich packages with adjusted *P*.

Fig 5. WBC oviposition cage.

Results

For the 1st movement period, significantly more larvae were recovered from above the ear than below (Fig 6a). Generally, larvae were recovered at or above the ear, with numerically more above the ear. For the 2nd and 3rd movement periods, almost all larvae were recovered from the ear.

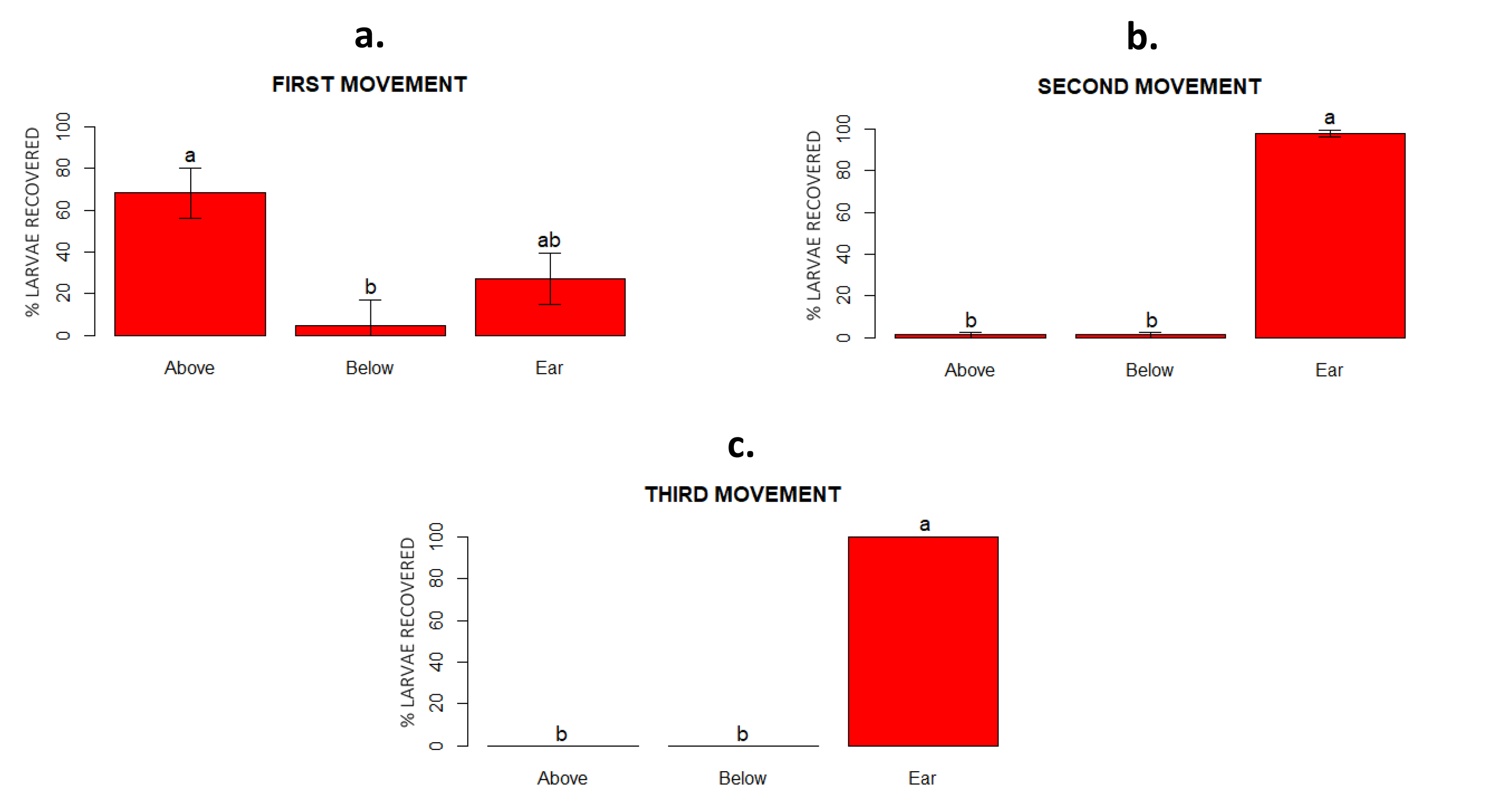

Figure 6a, b, and c. Mean percentage (± SE) of western bean cutworm per plant zone based on the number of larvae recovered per experimental unit **a.** First movement 6 replicates **b.** Second movement 4 replicates **c.** Third movement 15 replicates

For the 1st movement period, most larvae were recovered on the infested plant (Table 1), and almost all larvae were recovered within 40 cm of the infested plant in the infested row (Fig. 7a, Table 1). For the 2nd and 3rd movement periods, most larvae were recovered off the infested plant (Table 1), with a broader distribution among plants and rows (Table 1, Fig. 7b and c). Most larvae from the 2nd and 3rd movement periods were found 40-160 cm from the infested plant. No directional movement was observed (data not shown).

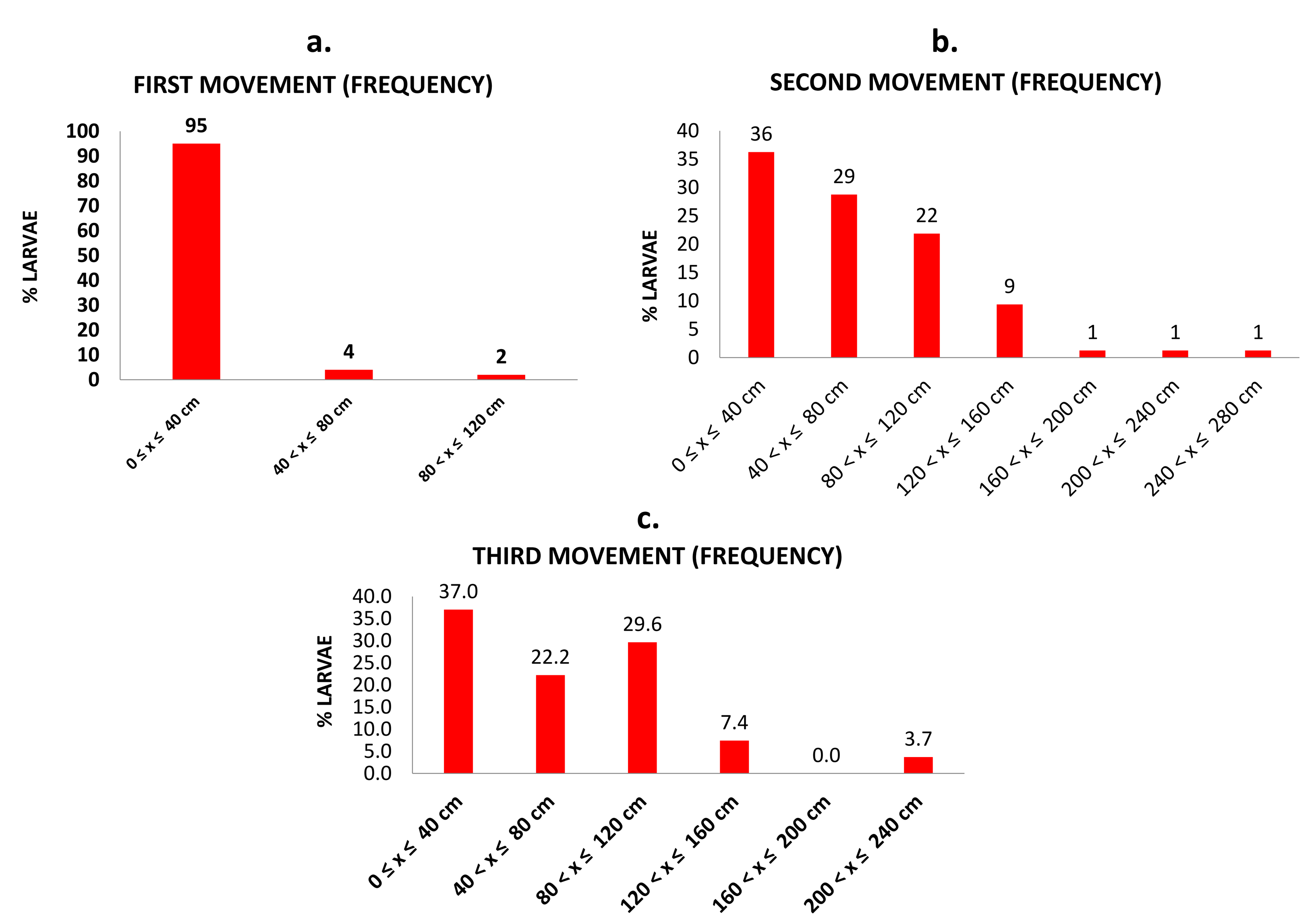

Figure 7a., b., and c. Percentage of western bean cutworm larvae recovered in each distance interval. **a.** For the first movement the total number of larvae found in 6 replicates was 184. **b.** For second movement the total number of larvae found in 4 replicates was 160 **c.** For third movement the total number of larvae found in 15 replicates was 27.

Table 1. Mean percentage (± SE) of western bean cutworm based on the total number of larvae recovered per experimental unit.

	MEAN PERCENTAGE OF LARVAE		
	FIRST MOVMENT	SECOND MOVEMENT	THIRD MOVEMENT
Infested Plant	73.2 (07.7) a	22.9 (07.8) b	20.6 (09.2) b
Other Plants	26.8 (07.7) b	77.1 (07.8) a	79.4 (09.2) a
P value	0.029	0.040	0.007
Infested Row	94.9 (02.6) a	65.5 (10.5) a	42.8 (12.0) a
Other Rows	5.1 (02.6) b	34.5 (10.4) a	57.2 (12.0) a
P value	1.23e-05	0.235	0.556
Row1	------------	0.0 (00.0) c	------------
Row2	------------	0.3 (00.3) c	0.0 (00.0) b
Row3	0.3 (00.3) b	15.2 (06.1) bc	31.6 (10.6) ab
Row4*	94.9 (02.6) a	65.5 (10.4) a	42.8 (12.0) a
Row5	4.8 (02.6) b	16.2 (03.1) b	23.9 (10.5) ab
Row6	------------	2.5 (01.4) c	1.7 (01.7) b
Row7	------------	0.3 (00.3) c	------------
P value	2.55e-10	2.78e-07	0.008

Conclusion

Plant-to-plant larval recovery was fairly conserved during the 1st movement period, but relatively broad during the 2nd and 3rd movement periods, with furthest movement occurring during the 2nd movement period. Our results were consistent with previous studies indicating that WBC exhibits non-directional plant-to-plant movement in field maize (Pannuti et al. 2016). These results indicate that the 2nd and 3rd movement periods are important with respect to WBC larval dispersal within a maize field.

Significance

Lepidoptera larval movement studies in maize, including those with WBC, are limited because of the difficulties in designing experiments and analyzing data (Zalucky et al 2002). Our research provides baseline data on ultimate dispersal of WBC larvae in maize, but also for dispersal with respect to the three WBC larval movement periods. This is important for the improvement of IPM programs, such as for scouting, but also for IRM. Larvae that disperse among plants, particularly after initial instars, can be problematic for transgenic maize IRM strategies that employ seed blends (i.e. refuge-in-a-bag, RIB). Older larvae may be less susceptible to toxins produced by transgenic plants and confound the goal of producing the toxin-susceptible individuals necessary for IRM strategies. We believe these results will contribute to the development of IRM strategies appropriate for pest species with high larval dispersal.

Future Directions

Further studies will address WBC larval movement under different larval densities, in Bt transgenic corn, and under refuge-in-a-bag planting designs meant to mimic current and possible future commercial transgenic maize seed blends.

Acknowledgments

This project was supported by Biotechnology Risk Assessment Grant Program competitive grant no. 2016-33522-25631 from the U.S. Department of Agriculture, the University of Nebraska-Lincoln, and São Paulo State University, Botucatu, Brazil.

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